Cost Effectiveness Analysis Of High-Risk Group Tb Screening In Malaysia

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Abstract

Background: Screening of high-risk groups for TB is considered as the cornerstone for TB elimination but the measure of cost-effectiveness is also crucial in deciding the strategy for TB screening. This study aims to measure the cost-effectiveness of TB screening between the various high-risk groups in Malaysia.

Methods: A decision tree model was developed to assess the cost-effectiveness of TB screening among the high-risk group from provider perspective using a secondary data from year 2016 to 2018. The outcome is presented in term of cost per TB case detected and the ICER. Deterministic and Probabilistic Sensitivity Analysis were also performed to measure the robustness of the model.

Results: The most cost-effective strategy was TB screening among PL HIV, with MYR 2,597.00 per one TB case detected. This is followed by elderly, prisoners and smokers with MYR 2,868.62, MYR 3,065.24 and MYR 4,327.76 per one TB case detected respectively. There was an incremental costs of MYR 2.49 per screening, and 3.4 TB case detection per 1000 screening for TB screening among PL HIV in relation to TB screening among prisoners. The probability of symptomatic cases diagnosed as TB was the key driver for increasing cost effectiveness efficacy among PL HIV.

Conclusions: Results of the study suggest prioritization of high-risk group TB screening programme by focusing on the most cost-effective strategy such as screening among PL HIV, prisoners and elderly, which has lower cost per TB case detected.

1. Background

Tuberculosis (TB) remains as public health challenge and a leading cause of morbidity and mortality. It continues to kill more than a million people annually, despite the availability of effective medication with high cure rates since the 1960s (1). About two-thirds of global TB cases are in Western Pacific region, of which Malaysia is part of. Malaysia is classified as an intermediate TB burden country with a notification rate of less than 100 cases per 100,000 population (1).

Detection of active TB can either be done through mass screening, or targeted screening, wherein, it focusses on selected high-risk groups (2). Based on published reports, various groups were identified as having higher risk for TB and given priority in TB screening program (3). Compared to the general population, TB incidence are generally much higher among individuals with the Human Immunodeficiency Virus (HIV), alcoholics, drug abusers, prisoners, homeless and recent immigrants from TB endemic areas (3, 4). Past study revealed that the total prevalence of TB among high risk groups was around 0.5% (3).

Malaysia have initiated HRG screening since 2016 in line with WHO End TB Strategy recommendation under Pillar 1. For years, Ministry of Health (MOH), Malaysia has been focusing TB screening among those high risk of developing TB. This include a close contacts to TB cases (both household and none-
household contacts), immunocompromised patients such as those suffering from Diabetes Mellitus, Rheumatoid Arthritis and Person Living with Human Immunocompromise Virus (PL HIV), substance abusers and cigarette smokers, living in overcrowded conditions such as incarceration and institutionalisation (whether in Cure and Care Rehabilitation Centres (CCRC), residents of old folks home, prisoners and etc) and an elderly (5).

Chest X-Ray (CXR) has been the main screening tool in Malaysia for diagnosing TB among the asymptomatic high-risk population (5). However, it is known to give an unreliable result when used for diagnosing TB among the asymptomatic (6). Whereas, for the symptomatic, both CXR and sputum smear remains the mainstay of TB screening tool. (5). Based on a study done in Malaysia on CXR screening among the asymptomatic, HIV was found to have the highest yield (25%), followed by smokers (20.7%), End Stage Renal Failure (ESRF) (20%), individual with substance abuse (13.3%), diabetic patients (10.6%), institutionalised individual (7.2%), and close contacts of TB cases (4.4) (7).

Despite that, for an effective TB screening programme, prioritization of key interventions and target groups are necessary (8). Unsystematic and poorly targeted screening may not lead to the desired outcomes. In the contrary, it can be very expensive, and gives minute impact in TB case detection (8, 9). Hence, screening for active tuberculosis should target those with high risk, while taking into account the measures of effectiveness (8).

For the past few years, MOH Malaysia has allocated substantial amount of resources for TB screening among the high-risk groups. However, there has not been any measure of efficiency done for this programme in term of economic efficacy. Ergo, this study aims to measure the cost-effectiveness analysis (CEA) of TB screening between various high-risk groups in the purpose of identifying the low-cost and most effective screening strategy to ensure the optimal use of resources from the perspective of health care provider, i.e. the Ministry of Health.

2. Methods

A decision tree model was developed to estimate the relative cost effectiveness measure of TB screening between different high-risk groups. Subsequently, costing and probability data were calculated and introduced into the model. The effectiveness parameters used were the probability of each screening strategy manage to detect one TB case. These take into the form of probability for the symptomatic or the asymptomatic screening for each high-risk group results in TB case detection (Table 2). Data were obtained from various source as shown in Table 1. The costs per screening, cost per TB case detected and incremental cost-effectiveness ratio (ICER) for each high-risk group were presented as the final outcome of this study. In order to assess the robustness of the model, sensitivity analysis was also conducted. All costs were valued in 2018 and presented in Malaysia Ringgit (MYR). The discounted value of 3% was used where necessary. Willingness-to-pay was capped at MYR 120,000 as of 3 times GDP per capita as suggested by World Health Organisation (WHO) (10, 11). In 2018, Malaysia GDP per capita was valued around MYR 40,000 (~ USD 9,660) (12).
Table 1
Source of Data

| Data                                | Type of Data | Source of Data                                      |
|-------------------------------------|--------------|-----------------------------------------------------|
| Capital Cost                        | Secondary    | Disease Control Section, MOH                         |
| Personnel Cost                      | Secondary    | Disease Control Section, MOH                         |
| Consumables Cost                    | Secondary    | Disease Control Section, MOH                         |
| TB Screening for High Risk Group    | Secondary    | TBIS 204S for year 2016 to 2018 from Sabah and Sarawak State Health Departments |

*Tb is Tuberculosis Information System, MOH Ministry of Health*

2.1 Decision Tree Model

A Decision Tree Model was developed using TreeAge Pro version 2019 by TreeAge Software, Inc. (Fig. 1). The model was constructed in concordance to the high-risk group TB screening guideline from MOH Malaysia (5). A total of 11 high risk groups were included in the decision model, which were: 1) CCRC inmates; 2) Old folks home residents; 3) ESRF patients; 4) Prisoners; 5) Diabetes Mellitus patients; 6) Methadone Clinic clients; 7) Rheumatoid Arthritis patient; 8) PL HIV; 9) Chronic Obstructive Airway Disease (COAD) patients; 10) Smokers, and; 11) Elderly (60 years and above). In this model, each high-risk group was branched out as symptomatic or asymptomatic.

Analysis of decision tree model were executed based on few assumptions. Firstly, all screening procedures were assumed to be standardized, wherein, no significant variation in term of number of personnel, machineries, consumables used and times consumed. Thus, no difference of cost incurred despite of different screening done in different setting. Secondly, the TB screening programme is strictly following the guideline from MOH, in which the asymptomatic would only be screened through CXR, while the symptomatic is screened using both CXR and SAFB test.

2.2 Estimation for Probabilities of TB Case Detection

Secondary data on high risk group TB screening was used to estimate probabilities of TB case detected per screening of each high-risk group. This data was based on three years Sabah and Sarawak State Health Department data on TB screening among high-risk groups, from 2016 to 2018 recorded in TBIS 204S for each State Health Departments. Cases of pending for investigation results, referral to specialist for TB diagnosis, TB diagnosis by other modalities than Chest X-Ray (CXR) and sputum AFB (SAFB), and contact screening were excluded from this study. There were total of 65,400 cases included for estimating the probabilities parameters. Probabilities parameters measured is shown in Table 2 consisted of the probabilities for individual in each high-risk group having any symptom (i.e. symptomatic). Whereas, the effectiveness parameters include the number of TB case detected per 1000 screening for symptomatic and asymptomatic cases (Table 3).
Table 2
Clinical Input Data for Probabilities

| Probability Parameters                  | Probability Value | Range† | Distributions§ |
|----------------------------------------|-------------------|--------|----------------|
| Symptomatic COAD patients              | 0.2132            | 0.1599–0.2665 | Beta           |
| Symptomatic CCRC inmates               | 0.0341            | 0.0256–0.0426 | Beta           |
| Symptomatic Diabetes Mellitus patients | 0.0749            | 0.0562–0.0936 | Beta           |
| Symptomatic ESRF (Haemodialysis)       | 0.0449            | 0.0337–0.0561 | Beta           |
| Symptomatic Smokers                    | 0.2198            | 0.1649–0.2748 | Beta           |
| Symptomatic PL HIV                     | 0.2086            | 0.1565–0.2608 | Beta           |
| Symptomatic Methadone Clinic clients   | 0.0833            | 0.0625–0.1041 | Beta           |
| Symptomatic Prisoners                  | 0.0567            | 0.0425–0.0709 | Beta           |
| Symptomatic Old Folks Home residents   | 0.0416            | 0.0312–0.0520 | Beta           |
| Symptomatic Rheumatoid Arthritis patients | 0.1875          | 0.1406–0.2344 | Beta           |
| Symptomatic Elderly (60 years and above) | 0.2796           | 0.2097–0.3495 | Beta           |

COAD Constrictive Obstructive Airway Disease, CCRC Cure and Care Rehabilitation Centre, ESRF End Stage Renal Failure, PL HIV Person Living with Human Immunodeficiency Virus, TB Tuberculosis, na not available

† The probability parameter values are varied by ± 25%.

§ Selection of distributions for each parameter are believed to be the best practice. Beta distribution is best used for probability value due to its properties, which ranges from 0 to 1.
| Effectiveness Parameters | Value (TB case detected per 1,000 screening) | Range† | Distributions§ |
|--------------------------|---------------------------------------------|--------|----------------|
| **COAD patients**        |                                             |        |                |
| Symptomatic             | 20.4                                        | 15.3–25.5 | Beta          |
| Asymptomatic            | 1.8                                         | 1.4–2.3 | Beta          |
| **CCRC inmates**         |                                             |        |                |
| Symptomatic             | 0.0                                         | na     |                |
| Asymptomatic            | 3.3                                         | 2.5–4.1 | Beta          |
| **Diabetes Mellitus patients** |                                         |        |                |
| Symptomatic             | 23.4                                        | 17.6–29.3 | Beta          |
| Asymptomatic            | 1.5                                         | 1.1–1.9 | Beta          |
| **ESRF (Haemodialysis)** |                                             |        |                |
| Symptomatic             | 75.3                                        | 56.5–94.1 | Beta          |
| Asymptomatic            | 1.0                                         | 0.8–1.3 | Beta          |
| **Smokers**             |                                             |        |                |
| Symptomatic             | 37.6                                        | 28.2–47.0 | Beta          |
| Asymptomatic            | 2.4                                         | 1.8–3.0 | Beta          |
| **PL HIV**              |                                             |        |                |
| Symptomatic             | 57.5                                        | 43.1–71.9 | Beta          |
| Asymptomatic            | 6.1                                         | 4.6–7.6 | Beta          |
| **Methadone Clinic clients** |                                         |        |                |
| Symptomatic             | 0.0                                         | na     |                |
| Asymptomatic            | 0.0                                         | na     |                |
| **Prisoners**           |                                             |        |                |
| Symptomatic             | 97.3                                        | 73.0–121.6 | Beta      |

† The effectiveness parameter values are varied by ± 25%.

§ Selection of distributions for each parameter are believed to be the best practice. Beta distribution is best used for effectiveness since this value also represents probability.
| Effectiveness Parameters      | Value (TB case detected per 1,000 screening) | Range§ | Distributions§ |
|------------------------------|---------------------------------------------|--------|----------------|
| Asymptomatic                 | 8.4                                         | 6.3–10.5 | Beta           |
| **Old Folks Home residents** |                                             |        |                |
| Symptomatic                  | 0.0                                         | na     |                |
| Asymptomatic                 | 0.0                                         | na     |                |
| **Rheumatoid Arthritis patients** |                                           |        |                |
| Symptomatic                  | 0.0                                         | na     |                |
| Asymptomatic                 | 0.0                                         | na     |                |
| **Elderly (60 years and above)** |                                           |        |                |
| Symptomatic                  | 46.9                                        | 35.2–58.6 | Beta           |
| Asymptomatic                 | 3.5                                         | 2.6–4.4 | Beta           |

The effectiveness parameter values are varied by ± 25%.

Selection of distributions for each parameter are believed to be the best practice. Beta distribution is best used for effectiveness since this value also represents probability.

### 2.3 Estimation of Costs

This study only includes direct costs from the perspectives of MOH. This consist of capital, personnel and consumables costs (Table 1). The costs were calculated using a mixed of step-down and Activity Based Costing (ABC) methods.

Capital costs comprise of medical equipment and yearly maintenance costs for both Chest X-Ray (CXR) and Sputum for Acid Fast Bacilli (SAFB). Whereas, personnel costs include both staff’s salaries and allowance per year based on the pay slip and claim forms received from administrative department. This was apportioned according on the duration it took to complete one whole procedure, which was based on expert panels. Finally, the consumables costs consist of all materials used as part of the procedures.

In measuring the cost for conducting one symptomatic screening and asymptomatic screening, the of cost for running one CXR and SAFB procedure were estimated. Based on the guidelines from MOH, cost for one symptomatic screening is equal to cost of one CXR and SAFB, while the cost for asymptomatic screening only consist of a cost for one CXR procedure (Table 4).

### 2.4 Cost-Effectiveness Analysis
The cost-effectiveness analysis was performed comparing all the high-risk groups in line with the guideline from MOH. The final outcomes of the study were presented in term of the cost per TB screening, cost effectiveness (CE) measure, which is the cost per one TB case detected, and ICER. The initial reference case strategy for ICER was chosen based on the lowest cost for TB screening among the high-risk groups. Subsequently, the reference case is replaced by the dominant strategy as the analysis process move on. (Table 4).

Table 4
Cost Input Data

| Cost Parameters          | Unit Cost (MYR) | Range (MYR) | Distributions |
|--------------------------|-----------------|-------------|---------------|
| **Chest X-Ray**          |                 |             |               |
| Capital                  | 5.12            |             |               |
| Personnel                | 31.56           |             |               |
| Consumables              | 3.59            |             |               |
| **Total Cost for Chest X-Ray** | 40.27       |             |               |
| **Sputum AFB**           |                 |             |               |
| Capital                  | 3.18            |             |               |
| Personnel                | 5.07            |             |               |
| Consumables              | 8.13            |             |               |
| **Total Cost for SAFB**  | 16.38           |             |               |
| **Asymptomatic screening** |               |             |               |
| Cost for Chest X-Ray     | 40.27           | 30.20–50.34 | Gamma         |
| **Total**                | 40.27           |             |               |
| **Symptomatic screening** |               |             |               |
| Cost for Chest X-Ray     | 40.27           | 30.20–50.34 | Gamma         |
| Cost for SAFB             | 16.38           | 12.29–20.48 | Gamma         |
| **Total**                | 56.65           |             |               |

*SAFB Sputum for Acid Fast Bacilli,*

* The cost parameters values are varied by ± 25%.

§ All cost parameters are assigned with gamma distributions, which is the best practice. Gamma distribution is considered with parameters that have skewed distribution. It confined only to positive values and thus, is used in representing uncertainty for cost parameters.
2.5 Deterministic Sensitivity Analysis (DSA)

One-way sensitivity analysis was performed to assess the model robustness toward change in parameters. Parameter values were changed with the corresponding minimum and maximum values, based on the range listed in Table 2, Table 3 and Table 4. The result is demonstrated in the form of Tornado Diagram as shown in Fig. 4. Tornado diagram is useful in identifying the key drivers for ICER values by demonstrating the changes in economic conclusion based on the variation of values of the selected parameters.

2.6. Probabilistic Sensitivity Analysis (PSA)

Bayesian methods such as PSA are often used to measure the uncertainty effect of model parameters ([13], [14]). In this study, PSA was performed by assigning the model parameters with appropriate distributions model as shown in Table 2, Table 3 and Table 4. The probabilities and costs parameters were allowed to varied and the effect of uncertainties were assessed by running a large number of simulations. PSA results are graphically demonstrated in cost-effectiveness plane scatter diagram and Cost-Effectiveness Acceptability Curve (CEAC).

3. Results

Results of cost-effectiveness analysis as shown in Table 5, consist of cost per TB screening, cost per TB case detected and the ICER. Figure 2 shows the cost-effectiveness plane of the analysis. TB screening among CCRC inmates had the lowest cost per screening with MYR 40.83, while TB screening among elderly was the highest with MYR 44.85 per screening. The results also showed that TB screening among PL HIV as the most cost-effective strategy with MYR 2,597.00 per TB case detected. This was followed by screening of TB among elderly, prisoners and smokers with MYR 2,868.62, MYR 3,065.24 and MYR 4,327.76 per TB case detected respectively.

As the initial reference point, TB screening among CCRC inmates would costs MYR 40.83 per screening, resulted in 3.2 TB case detection per 1000 screening and costs MYR 12,809.08 per one TB case detected. TB screening among old folks’ home residents revealed increment of MYR 0.12 cost per screening and less 3.2 TB case detected per 1000 screening. This was a case of dominated strategy, providing worse outcomes but at much higher cost. TB screening among ESRF patient on the other hand, resulted in extended dominated. Both the costs per screening and also TB cases detection increased by for MYR 0.18 and 1.1 per 1000 screening respectively. The subsequent strategy, which is TB screening among prisoners was a dominant case, with much better outcomes, even though the costs is slightly higher than screening the ESRF patients, resulting in positive ICER. Screening TB among prisoners increased the costs as much as MYR 0.19 but resulted in increment of 9.1 TB case detection per 1000 screening. The next dominant strategy was TB screening among PL HIV. This strategy resulted in increment costs of
MYR 2.49 per screening, and 3.4 TB case detection per 1000 screening in relation to TB screening among prisoners. The other strategies resulted in dominated case with worse outcomes but at higher costs.

Table 5
Results of Cost-Effectiveness Analysis of Different High-Risk Group TB Screening

| Strategy                  | Cost Per Screening (MYR) | TB Cases Detected (per 1000 Screening) | Cost per TB Case Detected (MYR) | ICER                        |
|---------------------------|--------------------------|----------------------------------------|-------------------------------|-----------------------------|
| CCRC inmates              | 40.83                    | 3.2                                    | 12,809.08                     | Dominant*                   |
| Old Folks Home Residents  | 40.95                    | 0.0                                    | na                            | Dominated**                 |
| ESRF                      | 41.01                    | 4.3                                    | 9,456.83                      | Ext. Dominated***           |
| Prisoner                  | 41.20                    | 13.4                                   | 3,065.24                      | Dominant*                   |
| Diabetes Mellitus         | 41.50                    | 3.1                                    | 13,214.26                     | Dominated**                 |
| Methadone Clinic Client   | 41.63                    | 0.0                                    | na                            | Dominated**                 |
| Rheumatoid Arthritis      | 43.34                    | 0.0                                    | na                            | Dominated**                 |
| PL HIV                    | 43.69                    | 16.8                                   | 2,597.00                      | Dominant*                   |
| COAD                      | 43.76                    | 5.8                                    | 7,590.33                      | Dominated**                 |
| Smoker                    | 43.87                    | 10.1                                   | 4,327.76                      | Dominated**                 |
| Elderly (60 years and above) | 44.85                  | 15.6                                   | 2,868.62                      | Dominated**                 |

ICER incremental cost effectiveness ratio

* Better outcomes, lower costs
** Worse outcomes, higher costs
*** Better outcomes, lower costs but the subsequent strategy has a positive ICER

3.1 Sensitivity Analysis

Figure 2 shows the results of Deterministic Sensitivity Analysis for TB screening among PL HIV against the prisoners as the reference strategy (Fig. 3). Results showed that the ICER never falls below zero after the iterations, indicating TB screening among PL HIV would remain relatively dominant in comparison to the reference strategy. Probability of TB detection among symptomatic PL HIV is shown to be the key
driver for the ICER. As the probability of TB detection among symptomatic PL HIV is getting higher, the ICER value would be lower, and vice versa. Nevertheless, cost for CXR did not affect the ICER.

PSA results for TB screening among the high-risk groups is demonstrated in Fig. 4. The cost-effectiveness plane depicted 1,000 simulations of incremental cost and incremental effectiveness, which is the number of TB case detected per 1000 screening. Almost 100% of the time, screening among PL HIV was more expensive compared to screening among prisoners. However, 74.3% of the iterations were in quadrant 1, which showed screening among PL HIV was more effective compared to the prisoners. Whereas, the CEAC demonstrates the probability of screening among PL HIV was more effective compared to the prisoners throughout various willingness to pay threshold values until MYR 240,000. The results showed that screening among PL HIV was cost-effectives around 48.6% of the iterations, almost at full length of the corresponding values for willingness-to-pay.

4. Discussion

This study indicates that TB screening among PL HIV is the most cost-effective strategy. The result consistent with past studies, which revealed TB screening among HIV is cost effective in both community and hospital settings (15, 16). HIV is a well-known risk factor for TB infection in low- and middle-income countries (1). In comparison to the non-HIV, there are 16 to 27 times risks of getting TB infection among PL HIV. This is reflected in the prevalence of TB/HIV co-infection in Malaysia of 6% for 2018 (17). From the results of this study, it was also estimated that the cost to detect one TB case from PL HIV screening would be around MYR 2,597.00. The key driver for cost effectiveness model is the probability of TB case detected among the symptomatic cases. The higher the probability of TB case detected among the symptomatic, the lower the ICER; thus, the lower the cost for detecting one TB case.

In addition, TB screening among elderly and prisoners also showed to be cost-effective. It would cost around MYR 2,868.62 and MYR 3,065.24 to detect one TB case by screening the elderly and prisoners respectively. Studies done in US and Soviet Union also revealed similar results, in which screening of prisoners was more cost effective than those of conventional community screening (2). The high prevalence of TB among the jailed population is well documented in previous reports and studies (1). This is due to the environmental condition such as enclosed space and poor ventilation, which lead to poor air circulation and subsequently precipitate TB infection (18, 19). Apart from that, there was enough evidence to show that TB incidence increases with age. However, TB problem among elderly is likely underestimated due to the difficulty of diagnosing TB among older age group (20). Hence, there was suggestion that TB screening among elderly should focus on active case detection (21).

On the other hand, TB screening among Diabetic patient was shown to have the highest cost per one TB case detected among the high-risk groups, with MYR 13,214.26. This might be due to low TB case detection despite of large amount of screening done compared to the other high-risk groups. The association between TB and DM is well documented. However, there are several well-known micro factors that precipitate TB infection in DM patients (22). For example, patient with uncontrolled glycaemic level
and low BMI are known to have a higher risk of contracting TB (23). Thus, past studies recommend focusing on TB screening among low Body Mass Index (BMI), high Fasting Blood Sugar and low Triglycerides rather than the entire DM patients (24). Similarly, cost per one TB case detected was also high for CCRC inmates, with MYR 12,809.08. People Who Use Drugs (PWUD) is also known to be at higher risk for TB infection (25). Plus, living in a closed, packed and condensed environment such as in rehabilitation centre put them at much higher risk for TB infection (18, 19). A study done on TB screening at substance abuse treatment centres in Malaysia revealed that the PWUD is at much higher risk of Latent Tuberculosis Infection (LTBI), which can later progress into active disease (26). Nevertheless, MOH report showed only small percentage actually being diagnosed as TB (27).

The decision to focus TB screening on one strategy or to expand it to other strategies should depend on the ICER value. This study suggests that to implementation of TB screening among PL HIV will incur additional cost per screening even though the benefit outweigh the reference strategy, i.e. TB screening among the prisoners. Hence, it would cost additional MYR 735.82 to switch the strategy from prisoners to PL HIV with an additional one TB case being diagnosed. Considering the number of screening will affect the number of TB case detected, the availability of those specific high-risk group will affect how much it will cost for each TB screening strategy.

This study main strength is the comprehensiveness of analysis method with the inclusion of various high-risk groups. Hence, this study provides better understanding for TB screening among the high-risk groups in term of its’ cost-effectiveness. While providing better overview of each high-risk groups cost-effectiveness, this study will be useful for policy makers in strategizing future TB elimination programme. Besides that, this study also received input from MOH and programme owner, who directly involved in managing TB screening programme.

Notwithstanding the above, this study may provide significant input to the policy makers. Screening among high risk groups has been recognized as the cornerstone for TB elimination (28). However, different strategies are required due to the variability in term of resource availability and disease transmission in local setting (29). In re-strategizing national TB programme, prioritisation is necessary to make sure the current available resources are being allocated in the best possible manner. In a limited budget availability, focusing TB screening among the highly cost-effective strategies seems to be the way forward for the policymakers. For example, in Japan and US, older people are given priority for TB screening (30). Hence, in Malaysia, TB screening among PL HIV, elderly and prisoners should be the focus for TB screening programme as suggested by this study. In addition, this study is also useful for budgetary planning. By setting target for TB case detection, the cost for each TB case detection can be used to estimate the required budget for TB programme implementation.

Nevertheless, there are several limitations to this study. The measure of effectiveness used in this study was generic, i.e. cost per TB case detected. Most of the cost effectiveness studies among TB high risk group expressed the effectiveness measure using Quality Adjusted Life Years (QALY), Disability Adjusted Life Years (DALY) averted or death averted, but there are some which expressed the measure of
effectiveness in term of TB cases detected (2). The lack of standardisation for outcome measurement makes it difficult to compare the findings with other studies. Besides, the benefit of current study might be overestimated or underestimated due to this outcome measures. For example, the overestimation of benefit in screening among the elderly versus younger age group due to the effect of time horizon analysis, as well as the screening for cases in confined space versus non-confined space. Data used in this study also confined to Sabah and Sarawak state. Thus, probabilities for certain high-risk groups might not represents the exact probabilities for the country. This was particularly noticeable especially on probabilities for old folks’ home residents, clients of Methadone Clinic, and Rheumatoid Arthritis patients. By using secondary data, the current study also limits further detail analysis.

5. Conclusions

In conclusion, this study recommends prioritisation on several high risk-groups in TB screening programme based on the most cost-effective strategies, such as among PL HIV, elderly and prisoners. TB screening among other high-risk groups should be implemented based on the available resources. Therefore, to exercise strategic plan for TB screening, the policy makers must also take into account the effect of these factors and how it will benefit in long run. It is suggested that detail analysis to be conducted in future study, for example by looking at the cost effectiveness of TB screening between different sub-groups of DM. Future research should also focus on screening for latent TB in Malaysia. Despite of that, current study suggests that re-strategizing TB screening program among high-risk group should be the way forward. With the scarce resources and new modalities coming in for TB diagnosis, there is a need for prioritizing the TB screening programme. Hence, the limited resources can be used for the most cost-effective measures and to tackle other issues, while moving forward into eliminating TB.

List Of Abbreviations

CCRC Cure and Care Rehabilitation Center
CE Cost Effectiveness
CEAC Cost Effectiveness Acceptability Curve
COAD Chronic Obstructive Airway Disease
CXR Chest X-Ray
DALY Disability Adjusted Life Years
DM Diabetes Mellitus
DSA Deterministic Sensitivity Analysis
ESRF End Stage Renal Failure
Declarations

Ethics approval and consent to participate

This study has obtained ethics approval from Medical Research and Ethics Committee (MREC), MOH Malaysia and registered under National Medical Research Register, MOH Malaysia (NMRR-19-3443-51729).

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article.

Competing Interest
The authors declare that they have no competing interests.

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**Author Contributions**

Nor Zam Azihan Mohd Hassan performed the economic development model, and was involved in manuscript development and review. Asmah Razali was responsible for data collection and approved the economic model development. Ridzwan Shahari assisted in economic model development, assisted in data collection, giving technical advice and review the final manuscript. Mohd Shaiful Jefri assisted in data collection for costing and review the final manuscript. Juanita Halili assisted in literature review. Nur Amalina Zaimi, Mohd Shahri Bahari and Farhana Aminuddin were all assisted in analysis and review of final manuscript. All authors approved the final manuscript.

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