RESEARCH ARTICLE

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# A Cost-Effectiveness Analysis of Tobacco Generational Endgame Scenarios in Malaysia: A Comparison of a Total Ban versus Smokeless-Only Policies

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## Abstract

**Introduction:** The use of tobacco products is associated with the treatment costs of lung-related diseases. The Tobacco Generational Endgame (GEG) strategy can improve efficiency in managing medical costs. **Methods:** Three GEG scenarios were identified. In Scenario 1, the GEG policy was not implemented. Scenario 2 prohibited the use of all tobacco products. Scenario 3 allowed only smokeless tobacco products. Secondary data obtained from the Ministry of Health (MOH) Malaysia were analysed using the Incremental Cost-Effectiveness Ratio (ICER) and sensitivity analysis. **Results:** In 2019, the Ministry of Health (MOH) spent MYR 71,527,032.50 on the treatment of chronic obstructive pulmonary disease and MYR 38,112,229.30 on lung cancer. The estimated annual cost for the Tobacco Control Programme was MYR 142,389,194.40. Analysis shows that Scenario 3 is the most cost-effective. **Conclusions**: The results of this study can serve as a guide for the government in formulating policies that maximise the benefits of GEG implementation.

**Keywords:** COPD- cost-effectiveness- generational end game- lung cancer- tobacco

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## Introduction

Globally, 1.18 billion people around the world use tobacco, which resulted in seven million deaths recorded in 2020 [1]. Tobacco is a plant from the Solanaceae family; its leaves are dried and fermented to be placed in tobacco products. Tobacco use is the main source of nicotine absorption in the body. Nicotine is a natural alkaloid found in plants. It can cross the blood–brain barrier and is extensively metabolized in the liver to form a variety of metabolites [2]. The health risk to an individual is influenced by the nicotine content of the tobacco and the method by which the nicotine is absorbed into the body [3]. Based on the National Strategic Plan for Non-Communicable Diseases 2016–2025, the target indicator for Malaysia in 2025 is a 30% reduction in the prevalence of tobacco use among individuals aged 15 years and above [4]. This aligns with the global targets for non-communicable diseases, as adapted from the World Health Organization (WHO) and discussed at the World Health Summit, which established nine global targets, including a reduction in tobacco use.

Tobacco use is divided into two types: smoked tobacco and smokeless tobacco. Smoked tobacco is a product that involves the burning of tobacco materials that produce cigarette smoke. These include cigars, shisha cigarettes (waterpipe tobacco), self-rolling tobacco (cigarillos), pipe tobacco, and bidi cigarettes [5]. Smoked tobacco products are dangerous because the quantity of poisonous substances in cigarettes and the smoke produced causes the level of nicotine absorption in the body to be high [3]. Smokeless tobacco products do not emit smoke and come in various forms including chewing tobacco, snuff, snus, and dissolvable tobacco products [3]. These products are gaining traction in the market, with more than 300 million users globally recorded [6].

In Malaysia, the National Health Morbidity Survey in 2019 showed that 6.5% of smokers aged 15 and above use smokeless tobacco products. This indicates a decrease in user prevalence compared to the 2015 health survey, where 10.9% of smokers used smokeless tobacco products (Ministry of Health Malaysia, 2019) [7].

Globally, premature deaths caused by tobacco are estimated at 6 million people a year. 'Early death due to smoking' is defined as a death that could have been avoided if the individual had not smoked and could have died from other causes instead at a later time [8]. Most of these deaths involve individuals who have stopped smoking, but the effects of smoking have already had a negative impact on their health, causing them to lose 10 years of their life. Smokers who continue to smoke lose an average of 10 years of life expectancy compared with

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individuals who have never smoked. Smokers will also begin to face diseases of old age 10 years earlier than individuals who do not smoke [9].

With the development of technology for tobacco use, various health complications also increase for individuals because of using tobacco products in large quantities for a long time. In Malaysia, non-communicable diseases are the leading cause of death and disability [10]. The three main causes of death associated with smoking are cancer (mainly lung cancer), lung disease (mainly chronic obstructive pulmonary disease [COPD]), and heart disease (mainly coronary heart disease) [8]. A systematic review that analyzed several studies involving the health impact of tobacco use showed that smoking tobacco users were more likely to have chronic obstructive pulmonary disease (COPD), ischemic heart disease, ischemic stroke, lung cancer, and oral cancer; smokeless tobacco users were more likely to have oral cancer, stomach cancer, ischemic heart disease, and ischemic stroke [11]. According to a literacy study conducted in China, the population attributable fraction (PAF) for COPD patients who smoke is 49% [12]. This means that an estimated half of COPD cases could have been avoided if the patient had not smoked. A literacy study in Norway showed that PAF for lung cancer patients caused by smoking was 85.3% [13].

Evidence shows that the unregulated use of electronic cigarettes (e-cigarettes) or vaping has adverse effects on the respiratory system. Vitamin E acetate in e-cigarettes was found to cause e-cigarette and vaping-associated lung illness (EVALI). Vitamin E increases the viscosity of the lung surface, and this interferes with the dynamic expansion and compression of the respiratory cycle. This can cause a lack of oxygen absorption into the blood [14]. Therefore, the sale and content of e-cigarettes should be regulated by the government to ensure that e-cigarettes are safe for use.

Health complications due to tobacco exposure adversely affect not just human health but also the national economy, in terms of high health expenses and losses in productivity [15]. WHO estimates the total cost of health expenditure involving tobacco use to be as much as USD 1.4 trillion per year, equivalent to 1.8% of the world's gross domestic product [16]. In Malaysia, a study estimated the cost of health care for three diseases closely related to smoking (i.e., COPD, lung cancer, and heart problems) to be 2,924,756,050.30 Malaysian Ringgit (MYR), 790,474,608 US dollars (USD), which is 16.49% of the total national health expenditure in Malaysia or 0.74% of the country's gross domestic product [17].

In order to address the issues faced, the main objective of this study is to analyze the cost-effectiveness of tobacco control programs, lung disease costs, and Generational End Game (GEG) implementation in Malaysia. This can be done by analyzing the cost of tobacco control programs as well as the cost of treating COPD and lung cancer caused by tobacco products.

## Materials and Methods

This cross-sectional economic study compares three tobacco cessation generation end game (GEG) scenarios, involving 59 casemix hospitals out of a total of 144 government hospitals in Malaysia, from January 2019 to December 2019. Scenario 1 is the current situation in which tobacco GEG was not implemented. Scenario 2 implemented GEG, prohibiting the use of all tobacco products. Scenario 3 implemented GEG that prohibits the use of smoked tobacco products but allows the use of smokeless tobacco products. All patients with chronic obstructive lung disease (COPD) or lung cancer as a primary diagnosis were included. Patients with these conditions as secondary diagnosis and full-paying patients admitted to government hospitals were excluded. Data were analyzed in three phases: the cost analysis phase, the cost-effectiveness analysis phase, which utilized the incremental cost-effectiveness ratio (ICER); and the sensitivity analysis phase, which focused on tobacco tax and illegal cigarettes.

*First phase: cost analysis*

The first phase analyzed the cost of treating tobacco-related COPD and lung cancer and the cost of tobacco control. Secondary data on 17,941 COPD patients and 4,372 lung cancer patients were extracted from the casemix unit of the Ministry of Health (MOH) of Malaysia. Costs were calculated according to their severity in the diagnostic-related groups (DRG) classification. For each level of severity in the DRG, the average length of stay (ALOS) and the allocated treatment costs were identified. The cost of tobacco control (i.e., the costs of enforcement, the stop-smoking clinic, health education, and officer training) was obtained from the tobacco-control sector and the Framework Convention on Tobacco Control (FCTC), MOH. However, since some of the data were confidential, certain costs were estimated from literature review.

*Second phase: cost minimization analysis*

The second phase analyzed the cost minimization of the three scenarios. Then, the ICER formula was used to calculate the cost-effectiveness difference between the three scenarios as follows:

Scenario interaction 1 & 2:

$$ICER = \frac{Cost\ GEG_T - Cost\ GEG_{AT}}{LD_T - LD_{AT}}$$

Scenario interaction 1 & 3:

$$ICER = \frac{Cost\ GEG_T - Cost\ GEG_{ST}}{LD_T - LD_{ST}}$$

AT: all tobacco products. GEGST: GEG only allows smokeless tobacco. LDT: lung diseases, allows use of all tobacco products. GEGT: No GEG implemented, allows use of all tobacco products. GEGAT: GEG prohibits use of all tobacco products. LD: lung diseases. LDAT: lung diseases when GEG prohibits use of all tobacco products. LDST: lung diseases when GEG allows smokeless tobacco but not smoked tobacco. ST: smokeless tobacco. T: tobacco

*Third phase: sensitivity analysis*

The third phase, sensitivity analysis, refers to factors that influence the implementation of GEG: illegal cigarettes and tobacco tax. If tobacco products were banned, addicted individuals would try to obtain cigarettes at any cost, legally or illegally. With the increased use of illegal cigarettes, dangerous substances in unregulated illegal cigarettes could cause more serious lung problems. Consequently, the number of patients with COPD or lung cancer and the costs to treat these lung diseases would increase. Conversely, if GEG were implemented, the country would not earn tax revenue from the sale of tobacco, reducing national income.

Cost minimization analysis was calculated for each scenario, considering dependent variables of illegal cigarettes and tobacco tax. The results of this costing are calculated using the ICER formula for comparing the three scenarios. Each variable has its own ICER value. With this, the ICER comparison will be done between each GEG scenario.

## Results

In 2019, 1,653,542 patients of all ages were admitted to 59 casemix hospitals in government hospitals, and 17,941 (1.09%) patients were diagnosed with COPD, while 4372 (0.26%) were diagnosed with lung cancer. Majority of patients were male, Malay, aged 51–70 years, treated at state hospitals, and confined for less than 5 days (Table 1).

*Cost analysis*

The casemix unit classified disease severity using DRG coding. For each DRG severity level, average length of stay (ALOS) and treatment costs were determined. Both COPD and lung cancer had the lowest ALOS and treatment costs at DRG severity level 1. However, the overall cost at this level was highest due to the large number of cases. Total expenditure was MYR 71,527,032.50 for COPD and MYR 38,112,229.30 for lung cancer (Table 2).

For the costing of tobacco control, data show that a total of 5955 law enforcers from MOH, Sunway Group, Kuala Lumpur City Hall (DBKL), auxiliary police, and MARA University of Technology (UiTM) were assigned. The estimated amount to pay all salaries was as much as MYR 10,683,270 per month (MYR 128,199,240 per year).

Regarding the cost of the stop-smoking clinic, a study conducted at Universiti Sains Malaysia estimated an annual cost of up to MYR 9,500 for each health facility [18]. KKM has 822 facilities, resulting in an estimated annual total cost of MYR 7,709,000.

Regarding cost of health education, a study conducted in five health clinics in Malaysia (Hidayati et al., 2020) estimated the annual cost for each health facility to be MYR 44,572.60 [19]. In 2019, we had 144 hospitals, with a total estimated cost of MYR 6,418,454.40.

Regarding officer training, an estimate was made based on the training provided by specialists in Malaysia, which totals MYR 62,500 per year. This brings the estimated annual total cost of tobacco control to MYR 142,389,194.40.

*Cost minimization analysis*

For cost minimization analysis, several assumptions were made for each of the GEG scenarios. For scenario 1, the numerator for ICER consisted of costs obtained from the MOH and literature review. Total treatment cost for COPD and lung cancer was MYR 110 million. The total cost of tobacco control was MYR 142 million. That sums up to MYR 252 million. The number of patients according to the PAF of COPD was 49% of 17,941; for lung cancer, 85.3% of 4,372 patients. This sums up to 12,520 patients. MYR 252 million divided by 12,520 patients shows that MYR 20,127.80 is spent on every patient with lung disease.

For assumption in scenario 2, a 10% reduction in cases of COPD and lung cancer is associated with a 4% reduction in costs, as budgeted [20]. Hence, 60% of RM110 million is MYR 66 million. However, cost for tobacco control is expected to increase by 0.03% (Ait Ouakrim et al, 2023) and hence the final cost is MYR 142 million [21]. Hence, total cost for the ICER numerator was found to be MYR 208 million. For the denominator, there will be a reduction of 15.8% in lung disease cases, from 12,520 patients to 10,542 patients. MYR 208 million divided by 10,542 patients shows that MYR 19,730.90 is spent on every patient with lung disease.

For the assumption in scenario 3, a meta-analysis study shows that there is no association between lung cancer and the use of smokeless tobacco [22-24]. Therefore, it was assumed that no lung cancer cases would be reported. Study shows that PAF for COPD is 19% [22], which brings total number of cases to 3,408 patients. The 0.03% assumed increase in the cost for tobacco control gives a value of MYR 142 million. Hence, the numerator for ICER is MYR 13 million added to MYR 142 million, totalling MYR 155 million. This is then divided by 3,408 cases, which shows that MYR 45,470.68 is spent for every patient with lung disease.

For CEA, the ICER between scenarios 1 and 2 is shown below:

$$ICER = \frac{Cost\ GEG_T - Cost\ GEG_{AT}}{LD_T - LD_{AT}}$$

$$= \frac{RM\ 252\ million - RM\ 208\ million}{12{,}520\ patients - 10{,}542\ patients}$$

*=RM 22,244.69 for every patient who has lung disease*

The ICER between scenarios 1 and 3 is calculated as follows:

$$ICER = \frac{Cost\ GEG_T - Cost\ GEG_{ST}}{LD_T - LD_{ST}}$$

$$= \frac{RM\ 252\ million - RM\ 155\ million}{12{,}520\ patients - 3{,}408\ patients}$$

*=RM 10,645.30 for every patient who has lung disease*

Table 1. Descriptive Analysis of COPD and Lung Cancer Patients

| Condition | COPD (N=17941) | | | Lung cancer (N=4372) | | |
|---|---|---|---|---|---|---|
| Variable | n | % | Statistical value | n | % | Statistical value |
| Gender | | | | | | |
| Male | 14,888 | 83 | | 2,988 | 68.3 | |
| Female | 3,053 | 17 | | 1,384 | 31.7 | |
| Age (years) | | | | | | |
| 0 –17 | 575 | 3.2 | | 10 | 0.2 | |
| 18–30 | 78 | 0.4 | Mean (SD): | 32 | 0.7 | Average (SD): |
| 31–50 | 1,258 | 7 | 65.5 (15.8) | 744 | 17 | 61.4 (1.5) |
| 51–70 | 9,073 | 50.6 | Range :0–100.9 | 2,761 | 63.2 | Range:0.5–95.2 |
| 71-90 | 6,872 | 38.3 | | 820 | 18.8 | |
| ≥91 | 85 | 0.5 | | 5 | 0.1 | |
| Race | | | | | | |
| Malay | 12,274 | 68.4 | | 2,187 | 50 | |
| Chinese | 2,637 | 14.7 | | 1,570 | 35.9 | |
| Indian | 1,830 | 10.2 | | 222 | 5.1 | |
| Bumiputera Sabah/Sarawak | 423 | 2.4 | | 206 | 4.7 | |
| Orang Asli Semenanjung | 63 | 0.4 | | 30 | 0.7 | |
| Others | 485 | 2.7 | | 112 | 2.6 | |
| Foreigner | 205 | 1.1 | | 45 | 1 | |
| Hospital category | | | | | | |
| State hospital | 8,588 | 47.9 | | 3,015 | 69 | |
| Major specialist hospital | 3,005 | 16.8 | | 586 | 13.4 | |
| Minor specialist hospital | 2,002 | 11.2 | | 90 | 2.1 | |
| Non-specialist hospital | 4,329 | 24.1 | | 88 | 2 | |
| Special medical institution | 17 | 0.1 | | 593 | 13.6 | |
| Type of discharge | | | | | | |
| House | 17,230 | 96 | | 4,187 | 95.8 | |
| Hospital transfer | 318 | 1.8 | | 70 | 1.6 | |
| At-own-risk | 338 | 1.9 | | 111 | 2.5 | |
| Abscond | 55 | 0.3 | | 4 | 0.1 | |
| Length of stay (days) | | | | | | |
| Short (≤5) | 12,713 | 70.9 | Mean (SD): 5.3 (10.3) | 3,019 | 69.1 | Mean (SD): 5.6 (6.4) |
| Medium (6–10) | 4,106 | 22.9 | Range: 1–1060 | 797 | 18.2 | Range: 1–106 |
| Long (>10) | 1,122 | 6.3 | | 556 | 12.7 | |

Scenario 2 has the lowest expenditure of MYR 19,730.90 for every lung disease case. However, scenario 3 is the most cost-effective, as the ICER indicates that cost of lung disease treatment is MYR 10,645.30 (Table 3).

*Sensitivity analysis*

*Illegal cigarettes*

For scenario 1, factoring in illegal cigarettes and tobacco tax, the calculated cost is MYR 20,127.80, and number of patients is 12,520.

Regarding the illegal cigarette factor, several estimations were made. For scenario 2, the Illicit Cigarette Study in Malaysia shows that if the GEG policy is implemented, the percentage of illegal smoking trade is expected to rise 3.3% [25]. Hence, it is assumed that the cost of tobacco control and number of patients will also rise 3.3%, which gives a total cost of MYR 215 million and total number of patients of 10,890. The CMA for scenario 2, which allocates MYR 215 million among 10,890 patients, reveals that MYR 19,742.88 is spent per patient with lung disease.

For scenario 3, study found that eliminating the illegal cigarette trade globally would reduce cigarette consumption by 2% [26]. Hence, it was assumed that the cost of implementation and number of lung disease patients would be reduced by 2%. This gives a total cost of MYR 204 million and 3,340 patients. CMA for scenario 3, which involves MYR 204 million and 3,340 patients, indicates that MYR 61,077.84 is spent per patient with lung disease.

The ICER between scenarios 1 and 2, factoring in the presence of illegal cigarettes, is shown below:

Table 3. Summary of Cost-Effectiveness Analysis

| Scenario | Summary of CEA | | Summary of CEA (illegal cigarettes) | | Summary of CEA (tobacco tax) | |
|---|---|---|---|---|---|---|
| | Cost minimization analysis (MYR per case of lung disease) | ICER calculation (MYR per case of lung disease) | Cost minimization analysis (MYR per case of lung disease) | ICER calculation (MYR per case of lung disease) | Cost minimization analysis (MYR per case of lung disease) | ICER calculation (MYR per case of lung disease) |
| 1 | 20127.8 | - | 20127.8 | - | 20127.8 | - |
| 2 | 19730.9 | 22244.69 | 19742.88 | 22699.39 | 19719.1 | 22611.64 |
| 3 | 45470.68 | 10645.3 | 61077.84 | 5228.76 | 61093.05 | 5327.82 |

MYR, Malaysian ringgit; CEA, Cost effectiveness analysis.

Table 2. Cost Analysis for COPD and Lung Cancer

| | | | COPD (N=17941) | | | | | | Lung cancer (N=4372) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DRG code | Severity level | ALOS (days) | DRG cost/ individual (MYR) | n (%) | Overall cost (MYR) | DRG code | Severity level | ALOS (days) | DRG cost/ individual (MYR) | n (%) | Overall cost (MYR) |
| 4541 | 1 | 4.5 | 3492.35 | 9854 (54.9) | 34413616.9 | 4521 | 1 | 4.3 | 6734.15 | 2320 (53%) | 15623228 |
| 4542 | 2 | 5.2 | 4258.1 | 6526 (36.37) | 27788360.6 | 4522 | 2 | 4.6 | 9311.3 | 1598 (36.6%) | 14879457.4 |
| 4543 | 3 | 6.9 | 5973.77 | 1561 (8.7) | 9325054.97 | 4523 | 3 | 7.1 | 16761.11 | 454 (10.4%) | 7609543.94 |
| Total | | | | 17941 (100) | 71527032.5 | TOTAL | | | | 4372 (100%) | 38112229.3 |

ALOS, average length of stay; COPD, chronic obstructive pulmonary disease; DRG, diagnostic related groups; MYR, Malaysian ringgit.

$$ICER\ (illegal\ cigarette) = \frac{Cost\ GEG_T - Cost\ GEG_{AT}}{LD_T - LD_{AT}}$$

$$= \frac{RM\ 252\ million - RM\ 215\ million}{12{,}520\ patients - 10{,}890\ patients}$$

*=RM 22,699.39 for every patient who has lung disease*

The ICER between scenarios 1 and 3 is shown below:

$$ICER\ (illegal\ cigarette) = \frac{Cost\ GEG_T - Cost\ GEG_{ST}}{LD_T - LD_{ST}}$$

$$= \frac{RM\ 252\ million - RM\ 204\ million}{12{,}520\ patients - 3{,}340\ patients}$$

*=RM 5,228.76 for every patient who has lung disease*

Results show that scenario 2 has the lowest expenditure of MYR 19,742.88 for every lung disease case. However, scenario 3 is the most cost-effective, as the ICER shows that the cost of lung disease treatment is MYR 5,228.76, which is lower than the cost in scenario 2 (Table 3).

*Tobacco tax*

For scenario 1, the costing and number of patients were similar to the status quo.

For scenario 2, a study on optimal cigarette tax in Malaysia shows that the revenue from tobacco tax accounts for 2% of the total tax collected by the government [27]. Hence, if tax is eliminated and consumers can easily access cigarettes at a cheap price, the cost required for the full implementation of GEG is expected to increase by 2% from the initial cost of MYR 208 million to MYR 212 million. On the other hand, the number of lung disease patients is expected to decrease by 6.4% [27], or 10,751 patients. MYR 212 million divided by 10,751 patients translates to MYR 19,719.10 spent on every patient with lung disease.

For scenario 3, a modelling study on economic effects of a country-level tobacco endgame strategy shows that the reduction in government tobacco tax revenue is on average 2.5%, caused by the decreased cost of selling cigarettes [21], from a total expenditure of MYR 208 million to MYR 203 million. Regarding the number of lung disease patients, a 2.5% reduction from 3,408 patients is 3,323 patients. MYR 203 million divided by 3,323 patients translates to MYR 61,093.05 spent for every patient with lung disease.

The ICER between scenarios 1 and 2, factoring in the presence of tobacco tax, is shown below:

$$ICER\ (tobacco\ tax) = \frac{Cost\ GEG_T - Cost\ GEG_{AT}}{LD_T - LD_{AT}}$$

$$= \frac{RM\ 252\ million - RM\ 212\ million_{AT}}{12{,}520\ org - 10{,}890\ org_{AT}}$$

*=RM 22,611.65 for every patient who has lung disease*

The ICER between scenarios 1 and 3 is shown below:

$$ICER\ (tobacco\ tax) = \frac{Cost\ GEG_T - Cost\ GEG_{ST}}{LD_T - LD_{ST}}$$

$$= \frac{RM\ 252\ million - RM\ 203\ million}{12{,}520\ patients - 3{,}323\ patients}$$

*=RM 5,327.82 for every patient who has lung disease*

These results show scenario 2 as having the lowest expenditure of MYR 19,719.10 for every lung disease case, while scenario 3 has the lowest ICER at MYR 5,327.82, lower than that of scenario 2.

## Discussion

Globally, tobacco use causes premature death in approximately 6 million people, and the main causes of tobacco-attributed death include COPD and lung cancer [8]. The descriptive data show that majority of patients, for both COPD and lung cancer, are male. This matches findings from a study done in Qingdao, China, which found that in males, lung cancer showed the greatest PAF (68%), followed by COPD (48%) and nasopharynx cancer (45%). However, in females, COPD showed the greatest PAF (52%), followed by lung cancer (51%) and oral cancer (30%). In all age categories, PAFs were higher in men than women for all age categories [12]. Additionally, the 2019 Global Adult Tobacco Surveillance in Malaysia found a smoking prevalence of 40.5% (95% CI: 37.90, 43.06) among males and 1.2% (95% CI: 0.84, 1.70) among females [7].

Studies also show that these lung diseases can occur at all ages. Evidence from a series of studies conducted at the National Heart and Lung Institute in London, including participants from birth to old age, shows that a gene may exert an antenatal influence on lung growth and increase a child's risk of COPD in the future [28]. Regarding lung cancer, although the histological variant is the same between children and adult patients, the frequency of cancer occurrence is different [29].

The total cost of treatment for lung disease is MYR 110 million (COPD, MYR 72 million; lung cancer, MYR 38 million. The cost for tobacco control is higher, at MYR 142 million. However, these numbers do not include the cost of all the health problems caused by tobacco products; when that is factored in, the cost of treating diseases caused by tobacco products could be greater than the cost of tobacco control.

We also need to consider that the per-patient cost of lung disease treatment is lowest at severity level one. However, due to the high number of patients at severity 1, the total cost is the highest among all levels. This proves that the level of COPD symptom control and lung cancer screening at the community level is low, causing patients with severity level 1 to be admitted to the ward. Enhancing primary care is crucial for managing these patients.

Annual national spending on tobacco control is estimated at MYR 142.4 million. This covers the salaries of enforcement personnel, stop-smoking clinic operations, health education, and officer training. These investments support current enforcement and cessation efforts and

form the baseline financial commitment for transitioning to a GEG model.

Data on tobacco control costs are also limited from MOH due to confidentiality. Furthermore, certain data are not stored by the MOH but are instead closely monitored by various agencies, such as the Royal Malaysian Customs Department and the Ministry of Finance. These mostly involve data on illegal cigarettes and tobacco taxes. To obtain these data, a complicated process must be completed and involves the Director General of Health. Hence, some costing data were obtained from literature review to include in the ICER and compare the costs involved.

A lower total cost per lung disease case indicates greater cost-effectiveness. According to CMA calculations, scenario 2 has the lowest cost per case. However, according to the ICER calculations, scenario 3 is more cost-effective because the cost of lung disease treatment is lower than in scenario 2. By considering the sensitivity analysis that factors in illegal cigarette and tobacco tax, the results of the best scenario for CMA and ICER are the same.

*Limitations*

This analysis used key parameters from secondary literature because locally measured data were unavailable. As a result, certain assumptions may affect estimate precision and introduce uncertainty. The study did not use long-term modelling approaches such as Markov or lifetime models, which limits assessment of chronic disease progression and cumulative economic effects. Productivity losses and broader societal measures, disability-adjusted life years (DALYs) and quality-adjusted life years (QALYs), were excluded due to data constraints. These limitations suggest the long-term and societal economic burden may be underestimated.

In conclusions, this study finds that GEG, which bans all tobacco products, results in the lowest treatment costs for tobacco-related diseases. In Malaysia, however, GEG is most cost-effective when only smoked tobacco products are banned, and smokeless tobacco products remain permitted. Implementing tobacco cessation GEG is feasible when it delivers economic benefits to both the public and the government.

## Author Contribution Statement

SEWP and NFR conceived the research question and the design of the study; were responsible for data collection, analysis and interpretation; drafted the manuscript; critically reviewed the manuscript drafts; and read and approved the final version of the manuscript.

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*General*

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*Approval*

Medical Research & Ethics Committee (MREC) has approved National Medical Research Register (NMRR) with the NMRR ID-23-01112-B7L (IIR). This study forms part of the author's postgraduate thesis.

*Ethical Declaration*

Ethical approval for this study was obtained from the Medical Research & Ethics Committee (MREC), Ministry of Health Malaysia. All procedures adhered to relevant national and institutional research ethics guidelines.

*Data Availability*

Upon reasonable request, the corresponding author will provide the data that support the findings of this study.

*Study Registration*

This study is registered with the National Medical Research Register (NMRR), Malaysia (NMRR-23-01112-B7L (IIR)). No additional clinical trial or guideline registry was required for this type of analysis.

*Conflict of interest*

The authors declare no conflict of interest.

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