RESEARCH ARTICLE

Estimating the Burden of Cancers Attributable to Smoking Using Disability Adjusted Life Years in Indonesia

Susi Ari Kristina*, Dwi Endarti, Natalia Sendjaya, Octy Pramestuty

Abstract

Tobacco use is a well-established risk factor for many types of cancers. Recent data on selected cancer incidence and mortality related to smoking in the Indonesian population are provided in this study. Morbidity and mortality data were derived from GLOBOCAN 2012 and the population attributable fraction (PAF) was estimated using the standard methodology developed by the World Health Organization. Using these data, we calculated disability adjusted life year (DALY) values for smoking-related cancer. The DALY was estimated by summation of the years lived with disability (YLD) and years life lost due to premature death (YLL). The cancer cases related to smoking in Indonesia numbered 45,132, accounting for 35,580 cancer deaths. The morbidity and mortality of lung cancer can be considered as the highest priority in both men and women. Furthermore the greatest YLD due to smoking in Indonesian men and women were from pancreas and lung cancers. For YLL among men, the highest years lost were from lung and liver cancers. On the other hand, among women lung oral cavity and lip were most important. Based on the DALY indicator, burden priorities for Indonesian men were lung cancer (298,980), liver cancer (60,367), and nasopharynx (46,185), while among Indonesian women they were lung cancer (34,119), cervix uteri (9,213) and pancreas cancer (5,433). In total, Indonesian burden of cancers attributed to smoking was 638,682 DALY. This study provides evidence about the burden of cancers caused by smoking as a rational basis for initiating national tobacco control policies in Indonesia.

Keywords: Burden of disease - tobacco - cancer - DALY - Indonesia

Asian Pac J Cancer Prev, 17 (3), 1577-1581

Introduction

Tobacco smoking is the single leading factor responsible for non-communicable diseases include the increased cancer cases and thus the cancer mortality (IARC Working group on the evaluation of carcinogenic risks to humans, 2004; World Health Organization, 2009). According to current research, smoking is the most important cause of disease burden which are known to cause malignant cancers, respiratory, and birth defects (Ezzati et al., 2005; U.S. Department of Health and Human Services, 2010). Therefore, smoking is now widely regarded as the most risky behavior engaged in by the general population.

It has been projected that total smoking deaths will rise from 5.4 million in 2005 to 6.4 million in 2015 and 8.3 million in 2030. The trends are predicted to decline by 9% between 2002 and 2030 in developed countries, but to double increase from 3.4 million to 6.8 million in low and middle income countries (Mathers and Loncar, 2006). At present, there are 121 million adult smokers in ASEAN countries (Southeast Asia Tobacco Control Alliance (SEATCA), 2014). It was found that approximately one-third of male adults in ASEAN smoke with the highest prevalence found in Indonesian (Southeast Asia Tobacco Control Alliance (SEATCA), 2014). It was recently estimated that there were over 700,000 new cases of cancer and 500,000 cancer deaths in ASEAN in the year 2008 (Kimman et al., 2012).

Kretek cigarette is very common in Indonesia and is considered culturally appropriate in the of the country (Palipudi et al., 2015) and has obvious consequences of national health and economic burden. The estimates number of deaths due to smoking-related diseases in Indonesia 2013 is approximately 74,440 deaths and that the economic loss due to premature death caused by smoking-related diseases exceeded USD 1,309 million in 2013 (Kristina et al., 2015). Furthermore, the smoking rate among Indonesian male is the highest in ASEAN countries (Southeast Asia Tobacco Control Alliance (SEATCA), August, 2013). Among all cancers, lung cancer is the leading cause of death, accounted for 80% of all cancer death, are attributable to smoking. Thus, one-third of all cancers that result in death are caused by smoking. Moreover, in 2013, the burden of premature death due to smoking was 95% in male and 5% in female in Indonesia (Kristina et al., 2015).

Recently the World Health Organization (WHO)
developed global burden of disease methodology and
recommended that health indicators summary be used to
estimate health and economic burden of tobacco (World
Health Organization, 2011). The representative health gap
indicator used is disability adjusted life year (DALY).
Given this background, the present study was performed
to estimate the burden of cancers attributable to smoking
using indicators DALY consisted of years lived with
disability (YLD) and years life lost (YLL) as the first
study measuring DALY of major cancers in Indonesia.

Materials and Methods

To estimate the burden of cancers related to smoking
in Indonesian population, we followed four steps. First, we
selected smoking-related diseases by systematic review.
Second, we estimated population-related population
attributable risks (PAR) using relative risks and prevalence
of smoking. Third, we estimated smoking attributable
incidence and mortality from the number of incidence and
mortality multiply by PAR. Fourth, using above analysis
result, we calculated the YLD and YLL and DALY values
of cancers related to smoking in Indonesia.

Selection of smoking-related cancers

The selection of smoking-related cancers included in
this study was based on a systematic review. According to
the levels of evidence, we decided to include 14 smoking-
related cancer diseases. The prevalence of smoking was
obtained from WHO country report in 2002 since lag time
of the effects of smoking is believed to be 15-20 years
after initial exposure.

Estimation of population attributable risk (PAR) of
cancers due to smoking

To calculate PAR values due to smoking, three
parameters were considered: 1) the relative risks of
smoking for the different smoking-related cancers, and 2)
prevalence of smoking for male and female. The relative
risks for most cancers were obtained from meta-analysis
by Gandini et al. (2008). For the colorectal cancer and
ovary cancer, RR were obtained from (Zheng et al., 2014)
and respectively (Park et al., 2014).

Computation of DALY for cancer

To estimate years lived with disability (YLD),
epidemiological parameters were estimated as follows.
First, to estimate the number of incidence, GLOBOCAN
data in the current year (2012) (International Agency
for Research on Cancer, 2012) was derived. Second, to
estimate disability weight of each cancer, we use a recent
study conducted in Korea ( Choi et al., 2013) which is
assumed had similar characteristics among Asia Pacific
population. Third, we measure duration of selected cancers
by using computer model called DISMOD II software
developed by WHO (World Health Organization, 2015).
Under the DISMOD II model, it is assumed that any
individual or group that is susceptible to a specific cancer
at a certain point in time will trigger the incidence of the
cancer as they become infected. It is also assumed that
the remission of all cancers is not occurred. The fourth, we
calculate YLD from the number of smoking related cancer
incidence, duration, and disability weight.

To estimate years life lost (YLL), we developed
estimated of population and deaths due to smoking from
GLOBOCAN 2012 data. Population attributable risk was
used to estimate the number of smoking deaths attributable
to smoking. We use WHO standard expected years of life
in 2012 (World Health Organization, 2010) to calculate
the years of prematurely death. To estimate age-specific
YLL we applied the YLL formula as number of smoking
attributable deaths multiply by number of years remaining
to lives. To determine DALY values, we summed YLD
with YLL results. The formula of DALY was derived from
WHO economic of tobacco toolkit 2011 (World Health
Organization, 2011).

Results

As shown in Table 1, tobacco smoking is attributable
to about 85% of lung cancer in Indonesian men while
accounted to approximately 19% in Indonesian female.
Comparing the cancers, for male, SAF were the highest
in lung cancer while the second and third ranks were
identified in larynk cancer and pharynk cancer, 80% and
79% respectively. Similar pattern was found in female,
SAF were the highest in lung cancer (19%) while the
second and third highest were found in larynk and pharynk
cancer, 15% and 14% respectively.

Cancer morbidity and mortality related to tobacco
smoking are displayed by cancer types in Table 2. It
can be explained that smoking attributable morbidity
and mortality were accounted for 28.36% and 31.05% of
cancer morbidity and mortality respectively. The highest
proportion of male cancer cases was lung cancer,
colorectum cancer, and liver cancer, accounted for 25,332,
15,985, and 13,365 respectively. While the highest
number of female cancer cases was cervix uteri (20,928),
followed by colorectum cancer (11,787) and ovary cancer
(10,238). The number of cancer deaths among male, the

Table 1. Relative Risks and Population Attributable
Risks (PAR) Values Due to Smoking for Selected
Cancers

| Cancers               | Relative risks | Population attributable risks due to smoking (%) |
|-----------------------|----------------|-----------------------------------------------|
|                       | Male           | Female | Male   | Female  |
| Lip, oral cavity      | 3.43           | 3.43   | 62.6   | 6.79    |
| Nasopharynx           | 1.95           | 1.95   | 39.5   | 2.77    |
| Pharynx               | 6.76           | 6.76   | 79.9   | 14.7    |
| Esophagus             | 2.5            | 2.5    | 50.9   | 4.30    |
| Stomach               | 1.74           | 1.74   | 33.8   | 2.17    |
| Colorectal            | 1.13           | 1.13   | 8.23   | 0.38    |
| Liver                 | 1.56           | 1.56   | 27.9   | 1.65    |
| Pancreas              | 1.7            | 1.7    | 32.6   | 2.05    |
| Larynx                | 6.98           | 6.98   | 80.5   | 15.2    |
| Lung                  | 8.96           | 8.96   | 84.6   | 19.3    |
| Cervix uteri          | 0              | 1.83   | 0      | 3.11    |
| Ovary                 | 0              | 2.07   | 0      | 1.53    |
| Kidney                | 1.52           | 1.52   | 26.4   | 1.53    |
| Bladder               | 2.77           | 2.77   | 55.0   | 5.04    |
three highest were lung cancer (22,525), liver cancer (12,654), and colorectum cancer (10,559). On the other hand, among females, the three highest cancer deaths were cervix uteri (9,498), colorectum cancer (7,839), and lung.

Table 2. Smoking Attributable Morbidity and Mortality in Selected Cancers in Indonesian Population

| Cancers                  | Cancer morbidity | Morbidity due to smoking | Cancer mortality | Mortality due to smoking |
|--------------------------|------------------|--------------------------|------------------|--------------------------|
|                          | M    | F    | Total | M    | F    | Total | M    | F    | Total |
| Bladder                  | 3.002 | 2.327 | 5.329 | 1.88 | 1.158 | 3.039 | 1.263 | 0.987 | 2.25  |
| Kidney                   | 9.355 | 3.729 | 13.084 | 3.704 | 1.033 | 4.737 | 5.283 | 2.108 | 7.391 |
| Oesophagus               | 1.479 | 0.555 | 2.034 | 1.182 | 0.82  | 2.004 | 1.263 | 0.426 | 1.689 |
| Stomach                  | 1.513 | 0.678 | 2.191 | 0.770 | 0.29  | 0.960 | 1.394 | 0.629 | 2.023 |
| Colorectum               | 3.811 | 2.601 | 6.412 | 1.288 | 0.48  | 1.776 | 3.43  | 1.976 | 5.406 |
| Liver                    | 15.985 | 11.787 | 27.772 | 1.316 | 0.46  | 1.776 | 10.559 | 7.839 | 18.398 |
| Pancreas                 | 13.365 | 4.756 | 18.121 | 3.725 | 0.79  | 4.524 | 12.654 | 4.521 | 17.175 |
| Larynx                   | 3.011 | 2.818 | 5.829 | 0.981 | 0.58  | 1.569 | 2.576 | 2.719 | 5.295 |
| Bladder                  | 2.255 | 4.02 | 6.275 | 1.815 | 0.61  | 2.426 | 1.876 | 1.053 | 2.929 |
| Lung                     | 25.322 | 9.374 | 34.696 | 21.422 | 1.807 | 23.229 | 22.525 | 8.379 | 30.904 |
| Cervix Uteri             | 0.29 | 20.928 | 20.928 | 0.651 | 0.651 | 1.302 | 0.949 | 0.949 | 2.897 |
| Kidney                   | 1.203 | 2.97 | 4.173 | 1.157 | 0.157 | 1.314 | 0.705 | 0.705 | 1.41 |
| Bladder                  | 5.705 | 1.232 | 6.937 | 3.123 | 0.64  | 3.767 | 2.94  | 0.659 | 3.609 |
| Total                    | 86.896 | 72.197 | 159.093 | 41.772 | 3.360 | 45.132 | 66.697 | 47.869 | 114.566 |

*M = Male; F = Female

Table 3. Years Lived with Disability (YLD) and Years Life Lost (YLL) in Selected Cancers Related to Smoking in Indonesian Population

| Cancers                  | Years lived with disability (YLD) | Years life lost (YLL) |
|--------------------------|-----------------------------------|-----------------------|
|                          | (person-years)                    | (person-years)        |
| Lip, Oral Cavity         | 1.658                             | 1.577                 |
| Nasopharynx              | 3.094                             | 4.518                 |
| Other Pharynx            | 2.465                             | 2.079                 |
| Oesophagus               | 3.374                             | 4.505                 |
| Stomach                  | 2.378                             | 1.728                 |
| Colorectum               | 2.238                             | 1.428                 |
| Liver                    | 2.496                             | 5.781                 |
| Pancreas                 | 4.464                             | 6.81                  |
| Larynx                   | 610                               | 627                  |
| Lung                     | 4.317                             | 294.664               |
| Cervix Uteri             | 0.562                             | 0.658                 |
| Kidney                   | 995                               | 9.923                 |
| Bladder                  | 651                               | 19.915               |
| Total                    | 28.882                            | 50.05                 |

Table 4. Disability adjusted life years (DALY) in Selected Cancers in Indonesian Population

| Cancers                  | Disability adjusted life years (DALY) |
|--------------------------|---------------------------------------|
|                          | (person-years)                        |
| Lip, Oral Cavity         | 16.504                                |
| Nasopharynx              | 46.185                                |
| Other Pharynx            | 22.544                                |
| Oesophagus               | 15.498                                |
| Stomach                  | 19.606                                |
| Colorectum               | 16.469                                |
| Liver                    | 60.367                                |
| Pancreas                 | 18.499                                |
| Larynx                   | 13.281                                |
| Lung                     | 298.98                                |
| Cervix Uteri             | 0.921                                |
| Kidney                   | 10.917                                |
| Bladder                  | 20.566                                |
| Total                    | 559.419                               |
According to the estimates in Table 2, tobacco smoking accounted for 45,132 of cancer cases in Indonesian in 2012 (41,772 in male and 3,360 in female). In male, the total number of smoking attributable cancer cases were the highest in lung cancer (21,442), followed by liver cancer (3,725), and nasopharynx cancer (3,704). On the other hand, the highest number of smoking attributable cancer cases in female was found in lung cancer (1,807), followed by cervix uteri (651), and lip, oral cavity (158). When looking at the mortality of cancer, it was found that tobacco smoking is accounted for 19,056 of lung cancer male deaths 3,527 liver cancer deaths, and nasopharynx cancer deaths 2,092. On the other hand, it was responsible for 1,615; 295, and 109 deaths of Lung cancer, uterine cancer, and ovary cancer among Indonesian female, respectively.

Based on calculation considered the duration of cancer and disability weight, the YLD in Indonesian population, cancer burden priorities due to smoking in Indonesian men were pancreas cancer (4,464), lung cancer (4,317), and oesophagus cancer (3,374). For Indonesian female, the highest burden of cancers in term of YLD were pancreas cancer (4,542), followed by lung cancer (3,969), and oesophagus cancer (3,414) (Table 3).

The years lost due to premature deaths of cancers related to smoking are displayed in Table 3. Among men, the highest years lost was lung cancer (294,664), followed by liver cancer (57,871) and nasopharynx cancer (43,092). On the other hand, the YLL among women attributed by lung cancer (30,150), lip, oral cavity (1,577), and nasopharynx cancer (1,518) (Table 3).

Based on DALY indicator, burden priorities for Indonesian men were Lung cancer (298,980), liver cancer (60,367), and nasopharynx (46,185). While among Indonesian women were Lung cancer (34,119), cervix uteri (9,213) and pancreas cancer (5,433). In total, during 2012, Indonesian burden of cancers attributed to smoking was 638,682 DALY (Table 3).

Discussion

The present study estimated the burden of cancers related to smoking using DALY indicator in Indonesia. The indicator, which is composite measure of the summation of years lived with disability (YLD) and years life lost due to premature death (YLL) provide comprehensive picture in evidences of tobacco impacts on society as a whole. This evidence positively influence health policy making especially in developing countries which is the smoking rates is elevated (Murray C JL et al., 2002). Since the introduction of these indicators by Murray et al in 1997 (Murray C JL and Lopez AD, 1997), some potential applications of these parameters are increasing. These measures able to compare the population health for different health system and to facilitate the effects of health risk behaviors include smoking and alcohol consumption on overall population health. Finally, they provide information on priorities for public health program planning in country level.

The present study shows that disease burden by tobacco smoking is about 28.36% for morbidity and 31.05% for mortality caused by smoking. The highest mortality and morbidity due to smoking was lung cancer. Based on cohort study conducted in Thailand, current smokers were more likely to die than never smokers and the excess mortality was greatest for lung cancer (Kamsaard et al., 2013). It has been acknowledged that survival time of the patients with lung cancer is very short (Abazari et al., 2015), while early diagnosis may improve the life expectancy effective treatment is not available in most countries. The findings were coherent with the burden of diseases related to tobacco in Indonesia, using national data, showed that estimated 74,440 people in Indonesia died prematurely as a result of cancers attributable to smoking, accounted for 30.6% of the total deaths (Kristina et al., 2015). A recent study conducted in UK, cancers has been responsible for about 109.164 (19% of all deaths, 27% deaths in men and 11% of deaths in women (Allender et al., 2009). These patterns highlight that as prevalence of smoking in developing countries is emerging since past 10 years, the morbidity and mortality due to smoking is increasing in current years and projected to elevate dramatically in next 10-20 years as mentioned by Mathers et al. 2006 (Mathers and Loncar, 2006).

The results of the present study show that the rankings of major cancers burden due to smoking assessed by DALY values. The burden ranking of cancers for Indonesian men were highest in lung cancer, liver cancer, and nasopharynx cancer. While among Indonesian women were lung cancer, cervix uteri, and pancreas cancer. In total, during 2012, Indonesian burden of cancers attributed to smoking was 638,682 DALY. These results indicate that lung cancer burden due to smoking is higher than other cancers burden attributable to smoking in Indonesia. This findings was consistent with Korean study, showed that DALY for lung cancer was 96.6 per 100,000 people, as the first priority burden in Korea (Lee et al., 2006). In US, burden of lung cancer measured by DALY was 550 thousand, accounted for 3.6% DALY of total 20 top selected diseases and attributed to 5.7% of total deaths (McKenna et al., 2005). Since the same methods are used to estimate Indonesia specific, and international DALYs, these disparities can also be placed in a global context. Health service and policy researchers have encouraged the use of summary health measures to assess the performance of health systems, prioritize public health research agendas, and evaluate the appropriateness of health expenditures (Murray et al., 2002).

Although, we included all cancers with sufficient evidence of carcinogenicity related to tobacco smoking in our analysis the following limitations should be acknowledged. First, RRs used in our analysis were not limited to ASEAN population. Further study examining the risk of cancer related to tobacco smoking should be conducted among ASEAN population for more valid estimated in the future. Secondly, it should be noted that the same RRs were used for both incidence and mortality with the assumption that tobacco smoking does not affect survival. Separate RR estimates for cancer mortality and cancer incidence should be used in the future study. Lastly, our estimates might have been underreported because...
burden of second-hand smoking was not included due to lack of prevalence data. In addition, it should also be noted that secondhand smoke which are more than 80% of Indonesian people affected was not included in our analysis.

Acknowledgements

This study funding was supported by the research grant of Faculty of Pharmacy, Gadjah Mada University.

References

Abazari M, Gholamnejad M, Roshanaei G, et al (2015). Estimation of survival rates in patients with lung cancer in West Azerbaijan, the Northwest of Iran. Asian Pac J Cancer Prev, 16, 3923-26.

Allender S, Balakrishnan R, Scarborough P, et al (2009). The burden of smoking related ill health in the UK. Tobacco control, 18, 262-67.

Choi KS, Park JH, Lee KS (2013). Disability weights for cancers in Korea. J Korean Med Sci, 28, 808-13.

Ezzati M, Henley J, Lopez AD, et al (2005). Role of smoking in global and regional cancer epidemiology: current patterns and data needs. IntJ Cancer, 116, 963-71.

Gandini S, Botteri E, Iodice S, et al (2008). Tobacco smoking and cancer: a meta-analysis. Int J Cancer, 122, 155-64.

IARC Working group on the evaluation of carcinogenic risks to humans (2004). Tobacco smoke and involuntary smoking. IARC Monographs Evaluat Carcinogenic Risks Human, 83, 1-1438.

International Agency for Research on Cancer (2012). GLOBOCAN 2012: estimated cancer incidence, mortality, and prevalence worldwide 2012 [Online].

Kamsa-ard S, Promthet S, Lewington S, et al (2013). Association between smoking and mortality: Khon Kaen Cohort Study, Thailand. Asian Pac J Cancer Prev, 14, 2643-47.

Kimman M, Norman R, Jan S, et al (2012). The burden of cancer in member countries of the Association of Southeast Asian Nations (ASEAN). Asian Pac J Cancer Prev, 13, 411-20.

Kristina SA, Endarti D, Prabandari YS, et al (2015). Burden of cancers related to smoking among the Indonesian population: Premature mortality costs and years of potential life lost. Asian Pac J Cancer Prev, 16, 6903-8.

Lee H, Yoon SJ, Ahn HS (2006). Measuring the burden of major cancers due to smoking in Korea. Cancer Sci, 97, 530-34.

Mathers CD, Loncar D (2006). Projections of global mortality and burden of disease from 2002 to 2030. PloS Med, s, 2012-30.

McKenna MT, Michaud CM, Murray CJL, et al (2005). Assessing the burden of disease in the United States using Disability-Adjusted Life Years. Am J Prev Med, 5, 415-23.

Murray CJL, Lopez AD (1997). Mortality by cause for eight regions of the world: Global burden of disease study. Lancet, 349.

Palipudi K, Msulo L, Kosen S, et al (2015). A cross sectional study of kretek smoking in Indonesia as a major risk to public health. Asian Pac J Cancer Prev, 16, 6883-88.

Park S, Jee SH, Shin HR, et al (2014). Attributable fraction of tobacco smoking on cancer using population-based nationwide cancer incidence and mortality data in Korea. BMC Cancer, 14.

Southeast Asia Tobacco Control Alliance (SEATCA) (2014). ASEAN tobacco control atlas.

World Health Organization (2010). Global Health Observatory Data Repository. Life expectancy: Life tables Indonesia [Online]. Geneva: WHO.