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Burden of cancer attributable to tobacco smoking in member countries of the Association of Southeast Asian Nations (ASEAN), 2012

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ABSTRACT

Background: Cancer is an increasing problem in ASEAN (Association of Southeast Asian Nations). Tobacco use is a well-established risk factor for many types of cancers. Evidence on burden of cancer attributable to tobacco is essential to raise public and political awareness of the negative effects of tobacco on cancer and to be used to stimulate political action aims at reducing smoking prevalence in ASEAN member countries. The objective of this study was to estimate burden of cancer attributable to tobacco smoking in ASEAN, 2012.

Methods: In this study, smoking prevalence was combined with Relative Risks (RRs) of cancer to obtain Smoking Attributable Fractions (SAFs). Cancer incidence and mortality data among individuals aged 15 years and older were derived from GLOBOCAN 2012. Fourteen types of cancer were included in the analysis. Sensitivity analyses were conducted to examine the impact of the use of alternative RRs and the use of alternative prevalence of smoking in some countries.

Results: The findings showed that tobacco smoking was responsible for 131,502 cancer incidence and 105,830 cancer mortality in ASEAN countries in 2012. In other words, tobacco smoking was accounted for 28.4% (43.3% in male and 8.5% in female) of cancer incidence and 30.5% (44.2% in male and 9.4% in female) of cancer mortality in ASEAN. When looking at the types of cancer, lung cancer showed the strongest association with tobacco smoking. Incidence of cancer and cancer mortality attributable to tobacco smoking varied by countries due to the differences in size of population, background risk of cancer, and prevalence of smoking in each country. According to the sensitivity analyses, RRs of lung cancer, pharynx cancer, and larynx cancer used in the estimates have significant impact on the estimates.

Conclusions: As about one-third of cancer incidence and mortality in ASEAN are attributable to tobacco smoking ASEAN member countries are strongly encouraged to put in place stronger tobacco control policies and to strengthen the existing tobacco control measure in order to effectively control cancer.

1. Introduction

Tobacco use is a well-established risk factor for many types of cancer including lung, lip/oral cavity/pharynx, esophagus, stomach, pancreas, liver, kidney, bladder, leukemia, and colorectal [1]. Globally, it was estimated that 1.6 million of the 7.4 million cancer deaths in 2004 were due to tobacco use [2], causing approximately 22% of cancer deaths (29% in high- income countries and 18% in low- and middle-income countries [3]. Despite the decline in smoking rates in the developed countries smoking rates are steadily climbing in less developed countries, mainly due to lack of adequate tobacco control and demographic structure. Consequently, it was estimated that the future burden of tobacco-related cancers on less-developed regions is expected to increase about 69.9% [3].

The Association of Southeast Asian Nations (ASEAN), consists of 10 countries [4] namely Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. The member countries have a combined population of approximately 625 million people, accounted for 9% of the world's population. Like other places in the world, cancer is an increasing problem in ASEAN due to ageing and a transition to western lifestyle. 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 [5]. Furthermore, these numbers were expected to

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increase [5], leading to substantial need for effective cancer control intervention and cancer service provision. Nevertheless, several ASEAN Governments have been slow to react to this problem, leading to cancer epidemic in the region. Recent study [6] indicated that over 75% of cancer patients in ASEAN experiencing death or financial catastrophe within one year.

At present, there are 121 million adult smokers (approximately 10% of world's smoker) in ASEAN countries [7]. It was found that approximately one-third of male adults in ASEAN smoke with the highest prevalence found in Indonesian male [7]. As strong evidence indicates that tobacco use is the single greatest avoidable cause of cancer [1,8] and that not smoking or using tobacco products is among the effective strategies for the control of cancer [2,8,9], ASEAN member countries must expand their national comprehensive tobacco prevention and control program as well as to enforce the existing tobacco laws for effectively cancer control. Since 2002, through the 6th Health Minister meeting, ASEAN governments committed to address tobacco control as a priority to promote healthy ASEAN living [7]. Nevertheless, tobacco control measures are still less well developed in some ASEAN member countries. Moreover, inadequate public awareness of tobacco control and the aggressive marketing by tobacco industry [10–13], has resulted in alarmingly high prevalence of tobacco smoking in some ASEAN countries.

One of the biggest obstacles in developing tobacco policy in ASEAN is lack of reliable data on disease burden attributable to tobacco. Evidence on burden of cancer attributable to tobacco is essential to raise public and political awareness of the negative effects of tobacco on cancer and to be used to stimulate political action to put in place effective tobacco control measures as well as to enforce existing tobacco laws and regulation in ASEAN member countries. Up to now, studies on burden of cancer attributable to tobacco were conducted in several western countries [14–16]. In Asian countries, the studies were conducted in China [17,18], Republic of Korea [18,19], Bangladesh [18], India [18], Japan [20], Singapore [18], and Taiwan [18]. Nevertheless, it should be noted that Asia is a very diverse continent, comprising high, low, and middle income countries with different way of lifestyle, and prevalence, type, and pattern of tobacco smoking. Despite the increasing incidence of cancer and tobacco smoking in ASEAN, to our knowledge, no study was conducted in ASEAN member countries except Singapore to estimate the burden of cancer attributable to tobacco before. As ASEAN is rapidly approaching a new milestone; the implementation of the ASEAN Economic Community (AEC) at the end of 2015, the region-specific burden of cancer attributable to tobacco is crucial in developing cancer prevention strategies tailored to the region. Thus, objective of our study is to estimate of the burden of cancer attributable to tobacco smoking in member countries of ASEAN in 2012.

2. Materials and methods

2.1. Tobacco smoking prevalence

The prevalence of current tobacco smokers among individuals aged 15 years and older was obtained from WHO global report on trends in prevalence of tobacco smoking, 2015 [21], as shown in Table 1. As the burden of cancer observed in 2012 reflects the past exposure of smoking, the prevalence in the year 2000 was used in our study to permit the comparison across countries. It should be noted that due to the data limitation, the prevalence in 2001 [22] was used for Singapore. As shown in Table 1, prevalence of tobacco smoking among male was the highest in Lao PDR (71.5%), followed by the Philippines (59.1%), and Malaysia (56.0%). On the other hand, prevalence of tobacco smoking among female in ASEAN member countries was quite low with the highest prevalence found in Lao PDR (19.9%), Myanmar (14.7%), and the Philippines (11.0%), respectively. It should be noted that the prevalence of tobacco smoking in 2000, which was derived from WHO global report on trend in prevalence of tobacco smoking, 2015 [21] was quite similar to the prevalence during 1995–2001 identified from WHO report 2002, except the prevalence in Indonesia, Lao PDR, and Myanmar. Based on the WHO global report 2002, prevalence of smoking in Indonesia 2001 was 69% in male and 3% in female [23]. On the other hand, prevalence of smoking in Lao PDR in 1995 was 41% for male and 15% for female [24] and prevalence of smoking in Myanmar 2001 was 42.9% for male and 21.9% for female [25].

2.2. Relative risk of tobacco smoking

Fourteen types of cancer, which showed convincing evidence for a positive association with tobacco smoking, were included in the analysis. These cancers include cancer of lip and oral cavity (C00-08), nasopharynx (C11), others pharynx (C09–10, C12–14), oesophagus (C15), stomach (C16), colorectal (C18–20), liver (C22), pancreas (C25), larynx (C32), lung cancer (C33–34), cervix uteri (C53), ovary (C56), kidney (C64–66), and urinary bladder (C67). Most Relative Risks (RRs) of tobacco smoking-related cancers were derived from recent *meta*-analysis [28], which consisted of 254 reports, of which 8 were from Africa, 28 were from Japan, 8 were from India, 39 were from China, 13 were from South America, and the others were from Western countries. According to this *meta*-analysis [28] no significant difference cancer risks across ethnicity was found. This global *meta*-analysis was selected because it is the most updated and that there is no formal *meta*-analysis conducted in Asia exists. The existing *meta*-analysis study conducted in Asia [18] did not explicitly report how the studies were identified for the review. In addition, the total number of

Table 1
Prevalence of tobacco smoking among ASEAN countries.

Country/Year	Number of population (Million) [26]	Prevalence of tobacco smoking 2000–2001 [21]		Prevalence of tobacco smoking 2015 [21]	
		Male (%)	Female (%)	Male	Female
Brunei/2000	0.4	29.4	4.8	29.3	3.1
Cambodia/2000	14.5	44.5	7.1	40.3	2.7
Indonesia/2000	237.7	54.8	4.9	75.9	3.3
Lao PDR/2000	6.4	71.5	19.9	54.6	8.8
Malaysia/2000	28.9	56.0	3.0	43.6	1.3
Myanmar/2000	60.4	55.2	14.7	31.4	6.3
Philippines/2000	95.8	59.1	11	43.2	7.7
Singapore [22]/2001	3.8	24.2	3.5	24.8[a]	4.5[a]
Thailand/2000	67.6	46.8	2.9	42.7	2.6
Vietnam/2000	87.8	49.4	1.6	48.0	1.3

[a] Prevalence of tobacco smoking in Singapore was estimated in 2013 from WHO report on the global tobacco epidemic 2015 [27].

studies conducted in Asia identified in those studies [18,19] was less than the total number of Asian studies identified from the recent global *meta*-analysis [28].

When comparing RRs identified from global *meta*-analysis [28] and the review in Asian countries [18], it should be noted that most RRs are comparable except for lung cancer, pharynx cancer, and larynx cancer in that the RRs identified in Asian countries were lower. As there is no information from the recent global *meta*-analysis [28], RRs for ovary cancer were derived from a *meta*-analysis conducted among Korean population [19] were used in our study while RRs for colorectal cancer were derived from recent review in Chinese and Korean population [18].

Regarding the gender, there is currently inconsistent epidemiological evidence to support that female is more susceptible than male to develop tobacco-related cancer [28–32]. According to the recent studies [18,28], the analysis of heterogeneity showed that gender significantly influence the RRs estimates only for stomach cancer and colorectal cancer. As the result, different RRs were used for male and female for stomach cancer and colorectal cancer.

2.3. Incidence and cancer mortality

The number of cancer incidence cases and cancer mortality in ASEAN member countries in 2012 were derived from GLOBOCAN 2012 [33,34]. GLOBOCAN estimated cancer incidence, mortality, and prevalence worldwide in 2012. The methods of estimation are country specific and the quality of the estimation depends upon the quality and on the amount of the information available for each country. Incidence data are derived from national cancer registries. If country data is not available, estimation by modelling, using incidence mortality ratios derived from recorded data in country or local cancer registries is used. Mortality statistics are based on national data that are collated and made available by the WHO for countries with vital registration.

2.4. Estimation of tobacco smoking attributable cancer incidence and mortality

To estimate tobacco smoking attributable cancer incidence and cancer mortality, smoking attributable fraction (SAF) was calculated using the following formula [35]:

$$SAF_i\ (\%) = 100\ ^{*}\ [P\ (RR_i - 1)/1 + P\ (RR_i - 1)]$$

Where P is the prevalence of current smokers in each country in 2000, obtained from WHO global report on trends in prevalence of tobacco smoking 2015 [21], except for Singapore, where the prevalence in 2001 obtained from WHO report 2002 [22] was used. RR_i is the relative risk of smoking for cancer i. For each type of cancer, the number of incidence case and mortality attributable to smoking were calculated by multiplying the total number of patients and mortality (aged 15 years or older) with the given cancer in each country by the corresponding SAFi.

2.5. Sensitivity analyses

Sensitivity analyses were conducted to examine the extent to which the results are affected by the choice of parameters used in the estimations. Specifically, the use of alternative RRs identified from Asian study [18] for lung cancer (3.56 for male/3.34 for female), pharynx (1.95), and larynx (1.95) was examined. In addition, the use of alternative prevalence of smoking in Lao PDR 1995 [24] (41% in male, 15% in female), Indonesia 2001 [23] (69% in male and 3% in female), and Myanmar 2001 [25] (42.9% in male and 21.9% in female) were investigated.

3. Results

Relative risks and Smoking Attributable Fractions (SAFs) of selected cancers in ASEAN countries were reported in Table 2. As shown in the table, tobacco smoking is attributable to about 66%–

Table 2
Relative risks and Smoking Attributable Fractions (SAFs) of selected cancers in ASEAN countries, 2012.

Gender	Cancers	RR	Smoking Attributable Fractions (SAFs)									
			Bru	Cam	Ind	Lao	Mal	Mya	Phi	Sin	Tha	Vie
Male	Lip, oral cavity	3.43	0.42	0.52	0.57	0.63	0.58	0.57	0.59	0.37	0.53	0.55
	Nasopharynx	1.95	0.22	0.30	0.34	0.40	0.35	0.34	0.36	0.19	0.31	0.32
	Pharynx	6.76	0.63	0.72	0.76	0.80	0.76	0.76	0.77	0.58	0.73	0.74
	Esophagus	2.5	0.31	0.40	0.45	0.52	0.46	0.45	0.47	0.27	0.41	0.43
	Stomach	1.74	0.18	0.25	0.29	0.35	0.29	0.29	0.30	0.15	0.26	0.27
	Colorectal	1.13	0.04	0.05	0.07	0.09	0.07	0.07	0.07	0.03	0.06	0.06
	Liver	1.56	0.14	0.20	0.23	0.29	0.24	0.24	0.25	0.12	0.21	0.22
	Pancreas	1.7	0.17	0.24	0.28	0.33	0.28	0.28	0.29	0.14	0.25	0.26
	Larynx	6.98	0.64	0.73	0.77	0.81	0.77	0.77	0.78	0.59	0.74	0.75
	Lung	8.96	0.70	0.78	0.81	0.85	0.82	0.81	0.82	0.66	0.79	0.80
	Cervix uteri	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ovary	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kidney	1.52	0.13	0.19	0.22	0.27	0.23	0.22	0.24	0.11	0.20	0.20
	Bladder	2.77	0.34	0.44	0.49	0.56	0.50	0.49	0.51	0.30	0.45	0.47
Female	Lip, oral cavity	3.43	0.10	0.15	0.11	0.33	0.07	0.26	0.21	0.08	0.07	0.04
	Nasopharynx	1.95	0.04	0.06	0.04	0.16	0.03	0.12	0.09	0.03	0.03	0.01
	Pharynx	6.76	0.22	0.29	0.22	0.53	0.15	0.46	0.39	0.17	0.14	0.08
	Esophagus	2.5	0.07	0.10	0.07	0.23	0.04	0.18	0.14	0.05	0.04	0.02
	Stomach	1.45	0.02	0.03	0.02	0.08	0.01	0.06	0.05	0.02	0.01	0.01
	Colorectal	1.4	0.02	0.03	0.02	0.07	0.01	0.06	0.04	0.01	0.01	0.01
	Liver	1.56	0.03	0.04	0.03	0.10	0.02	0.08	0.06	0.02	0.02	0.01
	Pancreas	1.7	0.03	0.05	0.03	0.12	0.02	0.09	0.07	0.02	0.02	0.01
	Larynx	6.98	0.22	0.30	0.23	0.54	0.15	0.47	0.40	0.17	0.15	0.09
	Lung	8.96	0.28	0.36	0.28	0.61	0.19	0.54	0.47	0.22	0.19	0.11
	Cervix uteri	1.83	0.04	0.06	0.04	0.14	0.02	0.11	0.08	0.03	0.02	0.01
	Ovary	2.07	0.05	0.07	0.05	0.18	0.03	0.14	0.11	0.04	0.03	0.02
	Kidney	1.52	0.02	0.04	0.02	0.09	0.02	0.07	0.05	0.02	0.01	0.01
	Bladder	2.77	0.08	0.11	0.08	0.26	0.05	0.21	0.16	0.06	0.05	0.03

Bru = Brunei, Cam = Cambodia, Ind = Indonesia, Lao = Lao PDR, Mal = Malaysia, Mya = Myanmar, Phi = Philippines, Sin = Singapore, Tha = Thailand, Vie = Vietnam.

85% of lung cancer in ASEAN male while accounted to approximately 11%–61% of lung cancer in ASEAN female.

Smoking attributable cancer incidence in ASEAN member countries was displayed by countries in Table 3. According to the estimates, tobacco smoking accounted for 131,502 of new cancer cases in ASEAN member countries in 2012 (114,775 in male and 16,727 in female). In male, the total number of smoking attributable cancer incidence was the highest in Indonesia (38,341), followed by Vietnam (24,261), and Thailand (19,286). On the other hand, the highest number of smoking attributable cancer incidence in female was found in Indonesia (5237), followed by Myanmar (3926) and Philippines (3379). In male, the number of patients with lung cancer attributable to smoking was the highest followed by liver cancer while, in female, the number of patients with lung cancer attributable to smoking was the highest followed by cervix uterine cancer.

Table 4 displays smoking attributable cancer mortality in ASEAN member countries. According to the estimates, smoking was responsible for 105,830 deaths in ASEAN member countries in 2012 (93,079 male, 12,750 female). In both male and female, the highest number of cancer deaths attributable to tobacco was due to lung cancer (52,765 in male and 7641 in female). In both male and female, the number of cancer deaths attributable to tobacco smoking was found to be the lowest in Brunei (38). On the other hand, the number of cancer death attributable to tobacco smoking was found to be the highest in Indonesia (34,293), followed by Vietnam (21,571), and Thailand (17,487), respectively.

As shown in Table 5, 28.4% of cancer incidence (43.3% in male and 8.5% in female) in ASEAN was attributable to tobacco smoking. Regarding mortality, 30.5% of cancer deaths (44.2% in male and 9.4% in female) in ASEAN were attributable to tobacco smoking.

As shown in Table 6, the total estimates for were changed by approximately 22–23% from base case when different RRs were used for lung, pharynx, and larynx cancer. On the other hand, the effect of changing prevalence in some countries has small impact on the total estimates.

4. Discussions

Our study found that tobacco smoking was responsible for 114,775 cancer incidence cases in male and 16,727 in female, accounted for about 28.4% of the new cases of cancer in ASEAN 2012. Our findings are slightly lower than those of previous study [16] conducted in 8 European countries, which found that about 36% of cancer incidence was attributable to tobacco smoking. In term of mortality, we found that tobacco smoking was accounted for 44.2% of cancer deaths (93,079) in male and 9.4% in female (12,750). For male, our findings are consistent with the studies conducted in Asia [17–20], France [14], and UK [15] although slightly higher. When looking at the cancer mortality for female, our findings are also in line with the studies conducted in Asia [17–20] but lower than those conducted in Western countries [14,15]. That is possibly due to the lower prevalence of smoking among female in Asia including ASEAN population.

When looking at types of cancer, similar to the previous studies [8,14–17], the strongest association with tobacco smoking was found for lung cancer. Our study found that tobacco smoking was responsible for 65.7% of cancer deaths among ASEAN population (80.4% and 27.6% of lung cancer deaths among ASEAN male and female, respectively). Our findings was higher than those of previous studies conducted in Asia [17,19,20] but lower than those of studies conducted in Western countries [14–16]. The different in RRs used in our analysis may account for these differences.

Table 3
Smoking attributable cancer incidence in ASEAN countries, 2012.

Gender		Smoking attributable cancer incidence 2012										
	Cancers	Bru	Cam	Ind	Lao	Mal	Mya	Phi	Sin	Tha	Vie	TOTAL
Male	Lip, oral cavity	4	144	1,714	30	237	1,037	730	46	1,146	753	5,842
	Nasopharynx	3	47	3,173	21	514	269	412	66	405	1,041	5,950
	Pharynx	0	116	1,122	19	153	1,478	612	44	791	837	5,172
	Esophagus	0	64	683	9	136	1,106	243	28	773	1,033	4,075
	Stomach	3	77	1,100	20	345	902	428	61	414	2,515	5,863
	Colorectal	2	24	1,062	17	174	139	333	46	369	275	2,439
	Liver	2	285	3,102	423	263	805	1,343	70	3,058	3,636	12,988
	Pancreas	1	13	835	7	97	111	244	34	242	129	1,713
	Larynx	1	58	1,728	16	294	567	864	71	782	818	5,199
	Lung	24	620	20,600	326	2,646	3,915	7,269	872	10,321	12,813	59,405
	Cervix uteri	–	–	–	–	–	–	–	–	–	–	–
	Ovary	–	–	–	–	–	–	–	–	–	–	–
	Kidney	0	10	415	6	89	55	146	30	119	92	963
	Bladder	2	53	2,809	35	356	298	345	79	868	320	5,164
	Total	42	1,513	38,341	929	5,304	10,682	12,970	1,447	19,286	24,261	114,775
Female	Lip, oral cavity	1	44	242	30	24	250	230	5	101	28	955
	Nasopharynx	0	4	163	4	15	44	50	4	14	24	322
	Pharynx	3	19	121	3	12	184	160	2	30	17	549
	Esophagus	0	7	46	2	8	180	27	1	18	8	298
	Stomach	0	6	47	3	10	112	47	4	16	34	280
	Colorectal	1	11	227	13	23	99	169	16	58	27	637
	Liver	0	31	125	63	7	113	131	3	91	46	610
	Pancreas	0	4	93	3	5	36	60	4	19	4	228
	Larynx	0	9	91	1	7	92	114	2	25	19	361
	Lung	7	149	2,630	97	224	1,990	1,516	142	1,202	652	8,610
	Cervix uteri	1	84	818	45	52	574	558	8	192	67	2,400
	Ovary	1	20	507	22	34	187	251	13	80	21	1,135
	Kidney	0	1	26	2	3	11	19	2	5	3	72
	Bladder	0	9	102	5	9	55	51	4	30	6	270
	Total	**12**	**397**	**5,237**	**293**	**433**	**3,926**	**3,379**	**212**	**1,881**	**956**	**16,727**
Total		**54**	**1,910**	**43,578**	**1,222**	**5,737**	**14,609**	**16,349**	**1,659**	**21,167**	**25,217**	**131,502**

Bru = Brunei, Cam = Cambodia, Ind = Indonesia, Lao = Lao PDR, Mal = Malaysia, Mya = Myanmar, Phi = Philippines, Sin = Singapore, Tha = Thailand, Vie = Vietnam.

Table 4
Smoking attributable cancer mortality in ASEAN countries, 2012.

Gender		Smoking attributable cancer mortality 2012										
	Cancers	Bru	Cam	Ind	Lao	Mal	Mya	Phi	Sin	Tha	Vie	TOTAL
Male	Lip, oral cavity	1	78	721	17	90	624	308	15	592	344	2,790
	Nasopharynx	1	31	1,802	14	184	184	215	31	243	615	3,322
	Pharynx	0	97	892	17	67	1,282	506	16	498	674	4,050
	Esophagus	0	60	629	9	96	1,030	211	26	691	965	3,717
	Stomach	2	71	990	18	153	846	363	40	333	2,295	5,111
	Colorectal	1	17	700	12	86	104	193	17	220	187	1,536
	Liver	2	273	2,941	406	320	762	1,298	61	2,902	3,459	12,422
	Pancreas	1	13	810	7	128	108	215	35	217	125	1,659
	Larynx	0	33	807	9	99	345	372	24	413	407	2,508
	Lung	22	551	18,324	283	2,271	3,473	6,315	713	9,342	11,471	52,765
	Cervix uteri	–	–	–	–	–	–	–	–	–	–	–
	Ovary	–	–	–	–	–	–	–	–	–	–	–
	Kidney	0	8	306	4	41	46	84	14	76	71	651
	Bladder	1	8	1,447	21	110	186	148	16	441	171	2,549
	Total	**30**	**1,239**	**30,370**	**817**	**3,645**	**8,991**	**10,226**	**1,008**	**15,969**	**20,784**	**93,079**
Female	Lip, oral cavity	0	24	104	16	7	151	95	1	53	13	463
	Nasopharynx	0	2	93	3	5	30	26	2	9	14	183
	Pharynx	0	16	93	9	6	158	140	1	19	14	450
	Esophagus	0	7	43	2	5	169	25	1	16	7	275
	Stomach	0	6	43	3	5	105	40	3	13	31	248
	Colorectal	0	8	151	9	12	74	92	5	34	18	405
	Liver	0	29	119	60	7	107	125	5	87	44	583
	Pancreas	0	3	90	2	7	36	53	5	17	4	217
	Larynx	0	5	42	1	1	57	54	1	13	9	183
	Lung	6	133	2,351	85	260	1,765	1,259	110	1,090	581	7,641
	Cervix uteri	0	44	371	24	15	326	237	3	106	32	1,159
	Ovary	0	15	351	16	20	140	151	6	43	15	758
	Kidney	0	1	19	1	1	9	11	1	3	2	49
	Bladder	0	5	53	3	2	34	22	1	15	3	139
	Total	**8**	**299**	**3,923**	**228**	**352**	**3,161**	**2,329**	**145**	**1,518**	**787**	**12,750**
Total		**38**	**1,538**	**34,293**	**1,045**	**3,998**	**12,152**	**12,555**	**1,153**	**17,487**	**21,571**	**105,830**

Bru = Brunei, Cam = Cambodia, Ind = Indonesia, Lao = Lao PDR, Mal = Malaysia, Mya = Myanmar, Phi = Philippines, Sin = Singapore, Tha = Thailand, Vie = Vietnam.

Table 5
Tobacco Smoking Attributable Fraction for cancer in ASEAN member countries, 2012.

	Tobacco Smoking Attributable Fraction for cancer										
	Bru	Cam	Ind	Lao	Mal	Mya	Phi	Sin	Tha	Vie	Total
Incidence case											
Male	28.2	37.4	44.4	39.0	43.1	47.8	47.6	27.0	41.2	42.0	43.3
Female	8.4	9.2	7.3	17.9	4.6	20.5	14.4	6.0	5.5	3.2	8.5
Total	18.4	22.8	27.5	30.4	26.5	35.2	32.3	18.7	26.2	28.6	28.4
Mortality											
Male	33.2	36.1	45.7	38.3	46.2	47.4	49.0	31.5	42.0	42.0	44.2
Female	10.8	9.8	8.2	17.7	6.7	21.6	15.9	7.4	6.2	3.4	9.4
Total	22.9	23.7	30.1	30.6	30.4	36.2	35.4	22.3	28.1	29.7	30.5

The RRs used in our analysis were derived from recent *meta*-analysis [28]. When compared with other previous Asian studies [17,19,20], RRs used in our study were similar in most cancer types except for lung cancer, larynx, and pharynx cancer, which was higher in our study especially lung cancer which is quite higher. On the other hand, when compared with study conducted in Western countries [14–16], RRs used for lung cancer, larynx and pharynx cancer were still lower in our study. Although the recent *meta*-anlaysis found no significant different cancer risks including lung cancer across ethnicity [28] it should be noted that some studies found that risk of developing lung cancer was lower in Asian population as compared to those in Western countries and African-American [36,37]. However, it should be noted that risk of developing cancer especially lung, pharynx and larynx cancer may not only depend on genetic susceptibility but also types of smoking including formulation of cigarette and pattern of smoking. According to the previous study, higher efficiency of filters in Japanese cigarettes and lower alcohol consumption among Japanese might also be accounted for lower risk of cancers among Japanese smokers than their western counterparts [38]. As our sensitivity analyses found that the effect of different RRs for lung cancer, larynx, and pharynx cancer has strong impact on the total estimates and that most of the studies conducted in Asia were conducted in Japanese population and that there is no study in ASEAN on the association between the risk of cancer and smoking exists, further study examining the risks of cancer related to tobacco smoking should be conducted among ASEAN population for more valid estimated in the future.

It should also be noted that different types of tobacco products are also associated with different types of diseases [39]. In our study, RRs used in calculating SAFs were based mainly on cigarette smoking. In fact, many smokers in ASEAN may use other tobacco products such as kreteks, and Roll-your-own (RYO) cigarettes. As the result, SAF estimates in our study may not accurately reflect the proportion of cancer attributable to all types of tobacco smoking. At present, long term health effects of kreteks and RYO cigarettes are not as well documented as for conventional cigarette smoking. Further studies should be conducted to identify the association between these types of tobacco smoking and cancer risks.

When looking at each countries, we found that the number of cancer cases and cancer deaths attributable to tobacco smoking varied by countries. The highest numbers of deaths attributable to cancer death were highest in Indonesia (34,293), Vietnam (21,571), and Thailand (17,487), respectively. On the other hand, the numbers of deaths attributable to tobacco smoking were only 38 in Brunei, 1045 in Lao PDR, and 1153 in Singapore. These can be explained by the difference in size of the population, background risk of cancer, and prevalence of smoking in each country.

Table 6
Sensitivity analyses.

	Gender	Incidence	Mortality	% change in Incidence from base case	% change in mortality from base case
Change RRs for pharynx, larynx, and lung cancer	Male	91,698	74,071	−20.11	−20.42
	Female	10,852	7,663	−35.12	−39.90
	Total	102,550	81,734	−22.02	−22.77
Change prevalence of smoking in Lao PDR	Male	114,549	92,877	−0.20	−0.22
	Female	16,675	12,710	−0.31	−0.31
	Total	131,224	105,587	−0.21	−0.23
Change prevalence of smoking in Indonesia	Male	118,066	95,584	2.87	2.69
	Female	14,933	11,429	−10.73	−10.36
	Total	132,999	107,013	1.14	1.12
Change prevalence of smoking in Myanmar	Male	113,748	92,211	−0.89	−0.93
	Female	17,801	13,584	6.42	6.54
	Total	131,549	105,794	0.04	−0.03
Base case	Male	114,775	93,079		
	Female	16,727	12,750		
	Total	131,502	105,830		

Although, we included all cancers with sufficient evidence of carcinogenicity related to tobacco smoking in our analysis the following limitations should be acknowledged. First, it should be noted that the duration of lag time between smoking exposure and cancer occurrence used in our study is only 12 years due to the limitation on data availability. In this study, prevalence in 2000 was used across countries to permit the direct comparison. Although the longer lag time between 15 and 20 years or the prevalence of smoking in the year 1997–1992 may better reflect burden of tobacco smoking in 2012 our sensitivity analyses found that the changes in the year of prevalence used in some countries had small effect on the total estimates. As the result, we are certain in some levels that even though the prevalence in the year 1997 (latency period = 15 years) was used the total estimates will not change dramatically. Nevertheless, due to the substantial economic development in ASEAN, smoking prevalence might be changed dramatically so that the SAF may need to be re-estimated. Lastly, our estimates might have been underreported because burden of second-hand smoking was not included. In addition, it should also be noted that smokeless tobacco which are more common in Cambodia and Myanmar were not included in our analysis.

5. Conclusions

Based on our study, tobacco smoking was responsible for about 131,502 cancer cases (28.4%) and 105,830 cancer deaths (30.5%) in ASEAN 2012. As many ASEAN countries are in the early stage of the tobacco epidemic, it is likely that the burden of cancer attributable to tobacco will continue to rise over the next decades. Such high number of cancer deaths and cancer cases attributable to tobacco smoking in ASEAN calls for political awareness and effective tobacco control measure. Consistent with the current evidence [16], we recommended that tobacco control program must be a priority in reducing tobacco-related cancer burden in ASEAN.

Conflict of interest

The authors declare no conflict of interest.

Authorship and contribution

1) Conception and design, acquisition of data, analysis and interpretation of data: SK, DE, MT.

2) Drafting the article or revising it critically for important intellectual content: SK, DE, MT.

3) Final approval of the version to be published: SK, DE, MT.

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