Cigarette smoking and tuberculosis in Cambodia: findings from a national sample

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Abstract

Background: Cambodia has very high rates of tuberculosis and smoked tobacco use among adults. Efforts to control both tobacco use and tuberculosis in Cambodia need to be informed by nationally representative data. Our objective is to examine the relation between daily cigarette smoking and lifetime tuberculosis (TB) history in a national sample of adults in Cambodia.

Methods: In 2011, a multi-stage, cluster sample of 15,615 adults (ages 15 years and older) from all regions of Cambodia were administered the Global Adult Tobacco Survey by interviewers from the National Institute of Statistics of Cambodia.

Results: Our findings include: 1) among daily smokers, a significant positive relation between TB and number of cigarettes smoked per day (OR = 1.70 [95% CI 1.01, 2.87]) and pack-years of smoking (OR = 1.53 [95% CI 1.05, 2.25]) 2) a non-significant 58% increase in odds of ever having been diagnosed with TB among men who smoked manufactured cigarettes (OR = 1.58 [95% CI 0.97, 2.58]).

Conclusion: In Cambodia, manufactured cigarette smoking was associated with lifetime TB infection and the association was most evident among the heaviest smokers (> 1 pack per day, > 30 pack years).

Introduction

Tuberculosis (TB) is the second most deadly infectious disease [1]. Global initiatives have set goals to reduce tuberculosis rates by half by 2015 through improved detection and treatment [2]. Recently, Basu et al. [2] noted that the millennium goals for TB cannot be achieved in high risk regions (Africa, South East Asia, Western Pacific Region) without major gains in reducing the number of current and future smokers. A causal pathway linking smoked tobacco to TB has been strongly supported by histopathologic evidence of lung damage in smokers that increases their vulnerability to deep lung infections [3].

During the past six decades, population-based evidence has accumulated that attributes a major TB burden to smoked tobacco [1,4]. Specifically, early evidence linking smoked tobacco to TB came from samples of high risk adults (i.e. health care workers, migrants, patients, elderly, prisoners) [5-7]. Recently, in a 2008 case control study of 1.1 million households in India, Jha et al. found that the TB death rate was 1.7 times higher in smokers as compared to nonsmokers [8]. In 2009, Jee et al. reported a significant 60% increase in risk of death among 1,294,504 South Korean adults [9], and a similar association with incident TB in men [9]. In the Taiwan National Health Interview Survey (n = 17,699, ≥ 12 y and older), Lin et al. [4] found a significant two-fold increase in risk of incident, active TB among current smokers [4].

In the present study, we examined the relation between cigarette smoking and TB infection in the 2011 National Adult Tobacco Survey of Cambodia (2011 NATSC). This was the largest national prevalence survey of adult tobacco use (n = 15,615, ages 15 years and older) conducted to date [10,11] and was completed as part of a Fogarty/NIH funded (Loma Linda University; National Institute of Statistics, Ministry of Planning (Cambodia); WHO Cambodia; Southeast Asia Tobacco Control Alliance) research capacity building program. For this analysis our specific aims are as follows: 1) To examine the relation between daily cigarette smoking and TB 2) To examine the...
relation between manufactured cigarette smoking and TB
3) To examine whether the intensity of cigarette smoking
(pack-years, number of cigarettes smoked) among daily
smokers further increased the likelihood of developing TB.

Methods
Study population
Using the 2008 census as a sampling frame, the 2011
NATSC sample was selected using a stratified, multi-stage
cluster sample described in detail elsewhere [10,11]. Briefly,
Cambodia was stratified into 17 census-derived survey
domains composed of 12 individual provinces and 5 groups
of similar provinces. For the first stage of sampling, 25–26
primary sampling units (PSU) were selected from each
domain (i.e. villages or comparable urban unit). There were
a total of 437 PSUs surveyed. In the second stage, a circular
systematic sampling method was used to select 12 households
from every urban PSU and 15 households
from every rural PSU. A total of 86 interviewers and
enumerators were trained by the National Institute of
Statistics and three of the report authors (DY, TK, PNS)
during a one-week session in Phnom Penh that preceded
the data collection efforts.

The sampling method resulted in 15,615 adults (ages
15 years and older) selected from 6,294 households in-
clusive of all private and single member households from
all provinces. The survey did not include institutional
households such as military barracks, prisons, hospitals,
and residents of temples.

Written informed consent was obtained from each
subject and an incentive provided for participation
(US$ 0.50). The study protocol was approved by the
Institutional Review Board of Loma Linda University
and the National Ethics Committee on Health (Ministry of
Health) in Cambodia.

Questionnaire
The questionnaire for the 2011 NATSC was designed
based on 1) qualitative studies to determine items on
tobacco use and other lifestyle variables and obtain
representative pictures for pictograms [12] 2) standardized
items of the Global Adult Tobacco Survey (GATS) [13] 3)
the 2006 national survey of tobacco use in Cambodia [10].
The final survey contained sections on demographics,
smoked tobacco, smokeless tobacco, cessation, second-
hand smoke, economics, media, knowledge, attitudes and
perceptions, diet, current health/access to health care, and
women’s health. In the section on current health, subjects
provided a self-report of infectious disease (tuberculosis,
HIV/AIDS, malaria) status using an item that asked “Has
a doctor or other health worker EVER diagnosed or told
you that you are suffering from (infectious disease)?”

Translation of the survey (English to Khmer) was
accomplished using methods described by Flaherty
[14]. Data entry and quality control was accomplished
using the Census and Survey Processing System
(CSPro; Suitland, MD).

Statistical analysis
The smoked tobacco use exposure variables used in the
analysis were created using a standardized coding method
for GATS items. To examine the relation between
smoked tobacco use as an exposure and self-reported
tuberculosis as an outcome we used a multivariable
logistic regression model. Age and other pertinent
confounders (gender, Second hand smoke, education,
rural dwelling, and income) were also tested and
retained if they substantially affected the exposure. The
continuous measures of intensity (number of cigarettes,
years smoked, pack-years) were modeled by log (to base e)
transforming each variable x such that the relation
between odds of TB and x could be described as:

\[ OR = e^{\beta \log x} = x^\beta \]

where a linear relation is modeled for \( \beta = 1 \), exponential
relation for \( \beta > 1 \), and root function (allowing threshold
effects) for \( \beta < 1 \) [15]. This more flexible set of functions
allows a hypothesized increase or decrease in odds of TB to
follow curvilinear positive or negative trends. Non-linear
trends were tested using spline regression [15].

To account for the stratified, multi-stage cluster design,
the variance for calculating 95% confidence intervals for
measures of effect (odds ratios), prevalence, and means
were computed using a Taylor series linearized method
that accounted for between and within cluster correlation.
Point estimates were further adjusted by sample weights.
Statistical analyses were preformed with SUDAAN
software release 9.0 (RTI International, Research Triangle
Park, NC, USA).

Results
Among NATSC 2011 subjects (n = 15,615) we found a
prevalence of ever having been diagnosed with Tuberculosis
(TB) of 1.19% [95% CI = 0.93 to 1.52]. Using the census
derived sampling weights, we computed that this weighted
prevalence estimate represents 88,859 cases [95% CI =
67,696 to 110,018] of lifetime TB infection among
adults ages 15 years and older during 2011. In Table 1,
we examined the how TB prevalence and number of
estimated cases varies by category of demographic
variables. The rate of TB approximately doubled between
adolescence (age 15–17 years) and age ≥ 45 years. A
higher burden of TB was found for adults who were
married or in cohabitation (est. 68,674 cases), rural
adults (est. 83,945 cases), adults earning < 1 USD per day
(est. 52,358), and those with < 6 y of education (est. 74,713
cases). By occupation, we found that most of the TB cases
Table 1: Prevalence of lifetime history of Tuberculosis [95% CI] and estimated number of cases of lifetime TB infection are given by demographic variables among 15,615 subjects of the 2011 National Adult Tobacco Survey of Cambodia (NATSC 2011)

| Demographic Variable | Total (Prevalence [95% CI] estimated number of cases) | Men (Prevalence [95% CI] estimated number of cases) | Women (Prevalence [95% CI] estimated number of cases) |
|----------------------|------------------------------------------------------|---------------------------------------------------|------------------------------------------------------|
| **Age**              |                                                      |                                                   |                                                      |
| ≥15 and ≤17          | 0.73[0.36, 1.50]                                     | 0.96[0.36,2.55]                                   | 0.50[0.20,1.24]                                      |
|                      | 4745                                                 | 3128                                              | 1617                                                 |
| >17 and ≤24          | 0.38[0.21, 0.69]                                     | 0.22[0.08,0.59]                                   | 0.54[0.26,1.10]                                     |
|                      | 4754                                                 | 1356                                              | 3398                                                 |
| >24 and <45          | 1.11[0.79, 1.56]                                     | 1.31[0.88,1.95]                                   | 0.96[0.64,1.43]                                     |
|                      | 33545                                                | 17491                                             | 16053                                                |
| ≥45 and <65          | 1.78[1.31,2.40]                                      | 1.62[1.05,2.49]                                   | 1.89[1.34,2.64]                                     |
|                      | 35225                                                | 13390                                             | 21835                                                |
| ≥65                  | 1.88 [1.11, 3.16]                                     | 1.74[0.81,3.73]                                   | 2.01[1.10,3.62]                                     |
|                      | 10587                                                | 4639                                              | 5947                                                 |
| **Ethnicity**        |                                                      |                                                   |                                                      |
| Khmer                | 1.18[0.92,1.51]                                       | 1.16[0.83,1.62]                                   | 1.19[0.93,1.52]                                     |
|                      | 85043                                                | 37931                                             | 47113                                                |
| Cham                 | 0.86[0.23,3.17]                                      | 0.21[0.02,1.80]                                   | 1.39[0.27,6.74]                                     |
|                      | 1001                                                 | 108                                               | 894                                                 |
| Chinese              | 2.58[0.90,7.17]                                      | 3.95[1.50,10.00]                                  | 1.43[0.39,5.17]                                     |
|                      | 2812                                                 | 1966                                              | 846                                                 |
| **Religion**         |                                                      |                                                   |                                                      |
| Buddhist             | 1.19[0.93,1.52]                                      | 1.18[0.85,1.64]                                   | 1.19[0.93,1.53]                                     |
|                      | 86356                                                | 38718                                             | 47637                                                |
| Muslim               | 0.88[0.24,3.20]                                      | 0.21[0.02,1.80]                                   | 1.44[0.29,6.91]                                     |
|                      | 1001                                                 | 108                                               | 894                                                 |
| Other                | 2.58[0.91,7.08]                                      | 4.17[1.42,11.64]                                  | 1.13[0.36,3.48]                                     |
|                      | 1392                                                 | 1071                                              | 321                                                 |
| None                 | 0.96[0.17,5.21]                                      | 1.72[0.31,8.92]                                   | _                                                   |
|                      | 108                                                  | 108                                               |                                                      |
| **Marriage**         |                                                      |                                                   |                                                      |
| Never married        | 0.46[0.28,0.78]                                      | 0.51[0.26,1.00]                                   | 0.42[0.21,0.82]                                     |
|                      | 8990                                                 | 5106                                              | 3884                                                 |
| Currently Married    | 1.34[1.03,1.75]                                      | 1.49[1.08,2.06]                                   | 1.21[0.91,1.62]                                     |
|                      | 63149                                                | 32835                                             | 30315                                                |
| Live together        | 2.49[1.34,4.60]                                      | _                                                 | 2.99[1.60,5.52]                                     |
|                      | 5525                                                 |                                                   | 5525                                                 |
| Widower/widow        | 1.77[1.05,2.94]                                      | 1.25[0.31,4.92]                                   | 1.85[1.07,3.21]                                     |
|                      | 8847                                                 | 922                                               | 7925                                                 |
| Divorced             | 2.62[0.69,9.43]                                      | 2.67[0.46,13.95]                                  | 2.59[0.86,7.50]                                     |
|                      | 2346                                                 | 1142                                              | 1203                                                 |
| **Education**        |                                                      |                                                   |                                                      |
| 0 years              | 2.03[1.52,2.71]                                      | 1.73[1.07,2.80]                                   | 2.16[1.56,2.97]                                     |
|                      | 35060                                                | 8619                                              | 26441                                                |
| Demographic Variable | 0-6 y (95% CI) | 7-9 y (95% CI) | 10-12 y (95% CI) | >12 y (95% CI) |
|----------------------|---------------|---------------|------------------|---------------|
| Age                  |               |               |                  |               |
| (<0-6 y)             | 1.25[0.93,1.69] | 1.55[1.07,2.24] | 1.00[0.71,1.41]  |               |
| (>6-12 y)            | 39653         | 22567         | 17085            |               |
| Income               |               |               |                  |               |
| <1 USD               | 0.50[0.28,0.89] | 0.53[0.26,1.09] | 0.46[0.21,1.02]  |               |
| 1-2 USD              | 8352          | 4830          | 3521             |               |
| >2-3 USD             | 0.68[0.34,1.38] | 0.87[0.44,1.75] | 0.44[0.15,1.31]  |               |
| >3 USD               | 5310          | 3805          | 1505             |               |
| Occupation           |               |               |                  |               |
| No Occupation        | 0.36[0.11,1.18] | 0.28[0.04,1.96] | 0.49[0.12,2.03]  |               |
| Professional         | 377           | 184           | 193              |               |
| Traditional Healer/  |               |               |                  |               |
| Faith Healer         |               |               |                  |               |
| Technician other     |               |               |                  |               |
| Professional         | 1.27[0.67,2.39] | 1.28[0.61,2.64] | 1.26[0.62,2.53]  |               |
| Service Workers      | 10662         | 6033          | 4629             |               |
| Fireman, Police,     |               |               |                  |               |
| Other Protective     |               |               |                  |               |
| Services            | 1.04[0.68,1.57] | 1.12[0.68,1.84] | 0.90[0.42,1.91]  |               |
| Sales                | 15387         | 10316         | 5069             |               |
| Farming Livestock    |               |               |                  |               |
| Labor                |               |               |                  |               |
| Trades and Crafts    |               |               |                  |               |
| Armed Forces         |               |               |                  |               |
| Rural/Urban          |               |               |                  |               |
| Urban                | 0.39[0.19,0.79] | 0.52[0.23,1.19] | 0.29[0.12,0.69]  |               |
| Non-Urban            | 4912          | 2846          | 2066             |               |
were occurring in agricultural workers (est. 63,886 cases). An unexpected finding was the very high prevalence of TB among traditional healers (14.2% among all traditional healers; 36.7% among male traditional healers).

Univariate associations between smoked tobacco, demographics, and TB

In Table 2, we provide the univariate models relating smoked tobacco, manufactured cigarette smoking, and pertinent demographic variables to odds of having ever been diagnosed with TB. For smoked tobacco, we found non-significant increases (30-42%) in odds of TB among all subjects and among men—the primary users of smoked tobacco in Cambodia.

The relation between manufactured cigarette smoking and TB was particularly evident in men (OR = 1.58 [95% CI [0.97, 2.58]). The lifetime TB prevalence and estimated number of cases of lifetime TB infection per 10,000 was higher for manufactured cigarette smokers (1.60 [95% CI [0.99, 2.56]); 160 cases per 10,000 men) than for non-smokers (1.02 [95% CI [0.72, 1.43]) per 102 cases per 10,000 men). Thus, manufactured cigarettes were contributing to an annual excess of 58 TB cases per 10,000 men.

Among the demographic variables we found the expected positive association with age indicating a significant 2% increase in odds of TB per year of age during adulthood. Rural residence was strongly associated with increased odds of TB (OR = 3.51 [95% CI [1.63, 7.58]). Higher education (>12 years) was associated with a more than five-fold decrease in odds of TB (OR = 0.17 [95% CI [0.05, 0.59]) relative to no schooling. Taken together, these data indicate that rural lifestyle patterns may be strong predictors of TB.

Table 1 Prevalence of lifetime history of Tuberculosis [95% CI] and estimated number of cases of lifetime TB infection are given by demographic variables among 15,615 subjects of the 2011 National Adult Tobacco Survey of Cambodia (NATSC 2011) (Continued)

| Rural            | 1.36[1.05,1.75] | 1.32[0.93,1.85] | 1.39[1.08,1.78] |
|------------------|----------------|----------------|----------------|
| 83945            |                |                |                |
| Alcohol          |                |                |                |
| No Alcohol       | 1.14[0.89,1.46] | 1.18[0.83,1.67] | 1.12[0.86,1.45] |
| 65,290           |                |                |                |
| Beer             | 1.05[0.52,2.13] | 1.04[0.47,2.27] | 1.09[0.37,1.31] |
| 6691             |                |                |                |
| Wine             | 1.31[0.71,2.41] | 1.35[0.68,2.68] | 1.13[0.30,1.13] |
| 7233             |                |                |                |
| Spirits          | 1.53[0.95,2.47] | 1.21[0.65,2.23] | 2.67[1.32,5.31] |
| 1,2164           |                |                |                |
| Palm Liquor      | 1.83[0.63,5.14] | 0.78[0.19,3.15] | 3.85[1.04,13.25] |
| 1,748            |                |                |                |

Tuberculosis and intensity of smoking habit among daily smokers

In Table 3, we examined whether the intensity of smoking further increased the odds of TB among daily smokers and considered three log-transformed measures of intensity: 1) number of cigarettes smoked per day 2) length of smoking habit 3) pack-years of cigarette smoking. These findings indicated that, among daily smokers, significant positive trends were found for number of cigarettes smoked per day and pack years. Moreover, these findings remained evident and even slightly stronger in multivariable analysis. Non-linear were tested using spline regression but were not evident.

In Figures 1, 2 we provide odds ratios for common values of number of cigarettes and pack-years (OR for pack years solved from the log transformed model) for ease of interpretation. In Figure 1, we modeled categories of number of cigarettes smoked and found that a smoking habit of at least a pack a day was associated with a more than 10-fold increase in odds of TB relative to < 5 cigarettes per day (OR [95% CI] for cigarettes/day = 1.00 [referent] for < 5; 6.79 [1.33, 34.77] for 5 to < 10; 6.11 [1.29, 29.01] for 10 to < 15; 10.07 [2.31, 43.89] for 15 to <25; 11.65 [2.10, 64.57] for ≥ 25). In Figure 2, we plot the association between the odds ratio for TB and log-transformed pack-years.

Also, noteworthy is that the association between length of smoking habit and TB given in Table 3, was much stronger when analyses were restricted to smokers of manufactured cigarettes (OR = 2.02 [0.91, 4.48]).

Multivariable models

In multivariable models, the addition of covariates (rural residence, Second hand smoke exposure, education,
alcohol, and income) in addition to age did not substantially alter the measures of effect for the tobacco variables.

Discussion

We examined the association between cigarette smoking and tuberculosis (TB) among 15,615 adults (ages 15 years and older) enrolled in the largest survey of adult tobacco use ever conducted in Cambodia [10,11]. Our major findings include: 1) a non-significant 58% increase in odds of ever having being diagnosed with among men who smoked manufactured cigarettes (OR = 1.58 [95% CI 0.97, 2.58]) 2) Among daily smokers, a significant positive relation between TB and log transformed variables for number of cigarettes smoked per day (OR = 1.70 [95% CI 1.01, 2.87]) and pack-years of smoking (OR = 1.53 [95% CI 1.05, 2.25]).

Our findings from a large, representative national sample of Cambodia add to the evidence from India [8], South Korea [9], Taiwan [4], Thailand [3], and Malaysia [16] that identify smoked tobacco as a major contributor to the TB burden in Asia. Taken together with meta-analyses from small samples from 19 nations [5–7], and recent global estimates from mathematical modeling [2], these data support that the global reduction of tuberculosis infection is heavily dependent on successful tobacco control being achieved in Asia [17].

Pathophysiology of smoking intensity and tuberculosis infection

Our findings identify a more than 3-fold increase in odds of TB among adults who were smoking one pack a day or more or those who had smoked greater than 30 pack-years (Figures 1, 2). These data on heavy smokers are concordant with much of what is known of the mechanism of increased susceptibility to TB infection in smokers [3,18]. Such smoking-induced mechanisms include: 1) an impairment of mucociliary function [19,20] lower airway epithelial damage and inflammation [19,21] 3) a constriction of the alveolar air sac [17,19,22] 4) an increase in the number of circulating alveolar macrophages (the cells targeted by tuberculosis) [17,23], 5) a collapse of the bronchioles [1,24–26]. Beyond physical changes, the immune suppression from heavy smoking could also contribute to TB infection of the lung [17,19,27,28].

Cigarette smoking as a component of a Bio-behavioral framework linking TB infection with respiratory disease risk factors in rural adults of the western pacific region

The association between TB and smoking among the primarily rural adults of Cambodia that we studied, needs to be considered in the context of the many other environmental factors in this region that can contribute to TB infection. Specifically, much of the smoking-related lung damage described above that potentially increases

Table 2 Univariate odds ratios relating smoked tobacco, manufactured cigarette smoking, and demographics to tuberculosis among 15,615 subjects of the 2011 National Adult Tobacco Survey of Cambodia

| Age-adjusted Multivariable* | OR [95% CI] | OR [95% CI] |
|----------------------------|------------|------------|
| All smoked Tobacco         |            |            |
| Current Smoker             | 1.30[0.89, 1.89] | 1.42[0.90, 2.24] |
| Non-smoker                 | 1.00 [referent] | 1.00 [referent] |
| Manufactured Cigarette     |            |            |
| Current Smoker             | 1.31[0.84, 2.05] | 1.58[0.97, 2.58] |
| Non-smoker                 | 1.00 [referent] | 1.00 [referent] |
| Demographics               |            |            |
| Age (per 1 year)           | 1.02[1.01, 1.03] | 1.02[1.01, 1.03] |
| Gender                     |            |            |
| Female                     | 1.01[0.75, 1.34] | -          |
| Male                       | 1.00 [referent] |            |
| Residence                  |            |            |
| Rural                      | 3.51[1.63, 7.58] | 2.55[1.03, 6.27] |
| Urban                      | 1.00 [referent] | 1.00 [referent] |
| Daily exposure to Environmental Tobacco Smoke | | |
| Yes                        | 1.11[0.71, 1.76] | 0.98[0.56, 1.73] |
| No                         | 1.00 [referent] | 1.00 [referent] |
| Education                  |            |            |
| 0 years                    | 1.00 [referent] | 1.00 [referent] |
| 0-6 years                  | 0.61[0.43, 0.86] | 0.89[0.55, 1.46] |
| 7-9 years                  | 0.24[0.13, 0.44] | 0.30[0.14, 0.65] |
| 10-12 years                | 0.33[0.16, 0.68] | 0.50[0.23, 1.11] |
| >12 years                  | 0.17[0.05, 0.59] | 0.16[0.02, 1.17] |
| Daily Income               |            |            |
| <1 USD                     | 1.00 [referent] | 1.00 [referent] |
| 1-2 USD                    | 0.85[0.54, 1.34] | 0.84[0.47, 1.50] |
| >2-3 USD                   | 1.01[0.53, 1.91] | 1.02[0.48, 2.19] |
| >3 USD                     | 0.82[0.52, 1.30] | 0.89[0.50, 1.59] |

*adjustment for age, rural dwelling, weekly consumption of beer, wine, spirits (excluding homemade palm liquor), homemade palm liquor.
risk of TB infection, can also be caused by the high rates of exposure to Second hand smoke [29,30], indoor cooking fires [31,32], crop-burning [32], and occupational dust and dirt that is highly prevalent in the region. Also noteworthy are pathogen transmission pathways present in the rural lifestyle such as crowding in household environments and health and hygiene practices.

In our analysis, it is noteworthy that the two of the strongest demographic risk factors included rural residence and less years of education (Table 2). Among women and ethnic minorities of Cambodia and the region there is also a possible link between non-cigarette forms of tobacco (i.e. betel quid, waterpipe) and TB and/or lung damage [10,33,34].

Implications for tobacco and tuberculosis control programs in Cambodia and the western pacific region

Our findings estimate that there is an excess of 58 TB cases per 10,000 Cambodian men due to the smoking of manufactured cigarettes (a baseline rate in non-smokers of 102 cases per 10,000 men). It is noteworthy that our 2011 findings indicate that manufactured cigarette smoking is the predominant form of smoked tobacco sold in Cambodia (18 out of 21 cigarettes sold are manufactured cigarettes) – a recent trend that is likely due to the lower price per pack (0.20 USD per pack) [11]. The current survey also indicated that 95% of the manufactured packs had a tax stamp [11] that can be used to set the price. Taken together, these findings indicate that implementation of WHO Framework Convention on Tobacco Control initiatives to increase the tax on these packs can be effective in not only controlling tobacco use but also in tuberculosis control initiatives. Since Cambodia has a very high prevalence of both tuberculosis (21st in the world) and smoked tobacco habits, future efforts to coordinate tobacco and tuberculosis control programs should be considered. For example,
the timing of national tuberculosis screening with FCTC implementation efforts (i.e. effective increases in the price of manufactured cigarettes) can measure the efficacy of a coordinated control effort.

Limitations
Limitations of our analysis of this 2011 national sample of Cambodia need description. We have examined the relation between smoked tobacco and self-reported TB in a cross-sectional analysis and thus we cannot directly infer causation. The report of TB to our trained health interviewers was by an item that measured ever having been diagnosed with TB during a subject’s lifetime. Such a measure does not discriminate between active primary TB infection, active secondary TB infection, or Latent TB infection [35]. Also, despite controlling for a number of indicators of poverty, unmeasured confounders such as number of rooms per house and number of household members were not accounted for in the analysis. Lastly, findings of this study do not apply to institutionalized individuals and the tobacco-TB association would need further investigation in studies of these subgroups.

Conclusion
Our findings from a large national sample of adults in Cambodia identify that a history of TB infection was more common among men who smoked manufactured cigarettes and the heaviest smokers (> 1 pack per day, > 30 pack years). The high prevalence of smoking and TB in Cambodia and the region, identifies a need for coordinating control measures for smoking and TB.

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

Authors’ contribution
PNs and DY conceived the study, obtained the funding, analyzed the data, and, and drafted the report; TK directed the data collection and sampling; GS assisted in data analysis and editing of the report; JSJ obtained funding and, and drafted the report; PNS and DY conceived the study, obtained the funding, analyzed the data, and, and drafted the report; and the Southeast Asia Tobacco Control Alliance (SITT project).

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