

LONDON  
SCHOOL of  
HYGIENE  
& TROPICAL  
MEDICINE



LSHTM Research Online

Chen, J; McGhee, SM; Townsend, J; Lam, TH; Hedley, AJ; (2015) Did the tobacco industry inflate estimates of illicit cigarette consumption in Asia? An empirical analysis. *Tobacco control*, 24 (e2). e161-7. ISSN 0964-4563 DOI: <https://doi.org/10.1136/tobaccocontrol-2014-051937>

Downloaded from: <http://researchonline.lshtm.ac.uk/2031032/>

DOI: <https://doi.org/10.1136/tobaccocontrol-2014-051937>

**Usage Guidelines:**

Please refer to usage guidelines at <http://researchonline.lshtm.ac.uk/policies.html> or alternatively contact [researchonline@lshtm.ac.uk](mailto:researchonline@lshtm.ac.uk).

Available under license: <http://creativecommons.org/licenses/by/2.5/>

<https://researchonline.lshtm.ac.uk>



OPEN ACCESS

# Did the tobacco industry inflate estimates of illicit cigarette consumption in Asia? An empirical analysis

Jing Chen,<sup>1</sup> Sarah M McGhee,<sup>1</sup> Joy Townsend,<sup>2</sup> Tai Hing Lam,<sup>1</sup> Anthony J Hedley<sup>1</sup>

<sup>1</sup>School of Public Health, The University of Hong Kong, Hong Kong SAR, China

<sup>2</sup>Department of Social and Environmental Health Research, London School of Hygiene & Tropical Medicine, London, UK

## Correspondence to

Professor Tai Hing Lam, School of Public Health, The University of Hong Kong, Hong Kong SAR, China; hmrhth@hku.hk

Received 30 July 2014

Accepted 25 November 2014

Published Online First

7 January 2015

## ABSTRACT

**Objective** Estimates of illicit cigarette consumption are limited and the data obtained from studies funded by the tobacco industry have a tendency to inflate them.

This study aimed to validate an industry-funded estimate of 35.9% for Hong Kong using a framework taken from an industry-funded report, but with more transparent data sources.

**Methods** Illicit cigarette consumption was estimated as the difference between total cigarette consumption and the sum of legal domestic sales and legal personal imports (duty-free consumption). Reliable data from government reports and scientifically valid routine sources were used to estimate the total cigarette consumption by Hong Kong smokers and legal domestic sales in Hong Kong. Consumption by visitors and legal duty-free consumption by Hong Kong passengers were estimated under three scenarios for the assumptions to examine the uncertainty around the estimate. A two-way sensitivity analysis was conducted using different levels of possible undeclared smoking and under-reporting of self-reported daily consumption.

**Results** Illicit cigarette consumption was estimated to be about 8.2–15.4% of the total cigarette consumption in Hong Kong in 2012 with a midpoint estimate of 11.9%, as compared with the industry-funded estimate of 35.9% of cigarette consumption. The industry-funded estimate was inflated by 133–337% of the probable true value. Only with significant levels of under-reporting of daily cigarette consumption and undeclared smoking could we approximate the value reported in the industry-funded study.

**Conclusions** The industry-funded estimate inflates the likely levels of illicit cigarette consumption.

have an incentive to inflate the extent of illicit cigarette consumption to oppose tobacco tax increases. Joossens *et al*<sup>6</sup> showed that estimates from Project Star, which was commissioned by Philip Morris International (PMI) and compiled by Klynveld Peat Marwick Goerdeler (KPMG), were higher than the estimates based on a study among a sample of representative smokers in 11 of 18 European countries. Stoklosa and Ross<sup>7</sup> showed that the industry estimate in Poland (22.9%) was higher than their estimates based on survey data (14.6%) or based on representative-discarded pack data (15.6%). van Walbeek<sup>8</sup> compared the estimates presented by the Tobacco Institute of Southern Africa (30%), a body representing the interests of large cigarette companies, with estimates based on rigorous econometric methods (6.1%) and showed again that the industry-funded data were not reliable.

Another more recent example is the report, “Asia-Illicit Tobacco Indicator 2012”.<sup>9</sup> This study was funded by PMI and compiled by Oxford Economics (OE) and the International Tax and Investment Center (ITIC). The ITIC itself is funded by major transnational tobacco companies. In the report, illicit cigarette consumption in 11 Asian markets was estimated and claims were made that in 2012, illicit consumption comprised 35.9% of total cigarette consumption in Hong Kong. This estimate lacked rigorous validation, and the methods by which it had been obtained were not clearly described. The Southeast Asia Tobacco Control Alliance raised many questions about the sources of data, analytic methods and conclusions of this report.<sup>10</sup> Nonetheless, the OE estimates for Hong Kong have been used to oppose tax increases.

In Hong Kong, stopping the illicit trade of tobacco, especially cigarette smuggling, has always been a priority of the Customs and Excise Department (CED). The drop in the number of seized cigarettes in the past decade, from 153 million sticks in 2003 to 39 million sticks in 2012, indicates that more stringent enforcement by the CED along with better cooperation with counterparts in bordering countries, primarily Mainland China and other local enforcement agencies, has deterred smuggling activities.<sup>11</sup> In the meantime, in February 2009 and February 2011, the Hong Kong Government increased tobacco tax by 50% and 41.5%, respectively. Tobacco tax revenue increased from HK\$2.8 billion in 2007 to HK\$5.0 billion in 2012,<sup>11</sup> while the prevalence of smoking declined from 11.8% in 2007 to 10.7% in 2012.<sup>12 13</sup> The number of seized cigarettes in 2009 (29 million sticks) and 2011 (57 million sticks) did not increase as compared to the previous years of 2008

## INTRODUCTION

Article 6 of the WHO Framework Convention on Tobacco Control (FCTC) recommends the use of taxation and pricing policies on tobacco products to decrease tobacco use.<sup>1</sup> Increasing tax that results in an increase in cigarette prices is considered to be an effective policy to reduce tobacco consumption, induce smokers to quit and, in particular, reduce the initiation of smoking among young people<sup>2</sup> without reducing the revenue of the government.<sup>3</sup> The argument that illicit trade will increase as a result of price rise is often raised by tobacco companies, sometimes successfully, to oppose tobacco tax increases.<sup>4</sup> The tobacco companies themselves, on the other hand, are the major beneficiaries of illicit trade and have been found to facilitate smuggling so that cigarettes penetrate youth markets.<sup>4</sup>

Data on illicit cigarette consumption are limited and not available in many countries.<sup>5</sup> The available data, often provided by industry-funded studies,



Open Access  
Scan to access more  
free content



CrossMark

**To cite:** Chen J, McGhee SM, Townsend J, *et al.* *Tob Control* 2015;**24**: e161–e167.

(81.6 million sticks) and 2010 (57 million sticks).<sup>11</sup> However, when tobacco control and public health professionals in Hong Kong pressed the government to increase tobacco tax by 100% in 2013 and when the Bill to increase tax on tobacco was introduced in the Legislative Council in 2014, the OE estimate of 35.9% of cigarette consumption being illicit, which had been presented to the mass media in Hong Kong in 2013, was repeatedly used by opponents of tobacco taxation to lobby the government not to increase tobacco tax. Finally, in 2014, the Hong Kong Government increased the tax by only 11.7%.

Therefore, the current study aimed to estimate illicit cigarette consumption in Hong Kong in 2012 and to validate the estimate published by OE. To do this, we used a comparable estimation framework, including consumption by Hong Kong residents and visitors, but our data came from more reliable and transparent sources.

**METHODS**

**Estimation framework**

Approach adopted by ITIC and OE

The report by ITIC and OE (OE Report) describes their estimation framework as:

$$\begin{aligned} \text{Total cigarette consumption} &= \text{legal domestic consumption} \\ &+ \text{legal non-domestic consumption} \\ &+ \text{illicit domestic consumption} \\ &+ \text{illicit non-domestic consumption}^9 \end{aligned}$$

The OE Report used a bottom-up approach to estimate total cigarette consumption. The report estimated the legal domestic consumption from the legal domestic sales data from the Hong Kong CED minus the outflows of duty-paid cigarettes to other countries based on the ‘empty pack surveys’ (EPS) in other countries, legal non-domestic consumption from EPS plus ‘OE estimates’, and illicit non-domestic consumption based on EPS plus ‘OE estimates’ (Annexe A, Page 94).<sup>9</sup> The total consumption was then the sum total of the above three components and the EPS plus OE estimates (Annexe A, page 94).<sup>9</sup>

OE estimates for Hong Kong were mostly based on the EPS for which previous studies have raised serious concerns<sup>7 10 14 15</sup> and no details were disclosed anywhere as to how the survey had been carried out. There are many questions about this approach in the case of Hong Kong, the answers to which could greatly affect the results of the survey and interpretation of those data. For example: (1) How did they identify any empty pack that was duty-paid, smuggled or duty-free, since this information is usually not available on the pack in Hong Kong? (2) Could the sampled sites and timings yield a representative sample of all packs discarded in Hong Kong? (3) What was the final sample size with regard to the number of packs picked up from different bins and locations at different times? For example, how many packs were picked up on weekdays or weekends or holidays (such as ‘Golden Week’ holidays)? How replicable were the data? (4) How can we interpret these data in terms of consumers (local residents or visitors) who had smoked the cigarettes from the empty packs? The answers to these questions are the minimum information we would need to determine the validity and reliability of the survey methods used; and hence, the likely accuracy and representativeness of the results presented.

In our estimate, we used the same overall framework described above, but included only data from known sources and methods that are reproducible. We used a top-down approach where we

first estimated the total cigarette consumption and then, legal domestic and non-domestic consumption. The difference between the total consumption and the legal domestic and non-domestic consumption were the illicit cigarette consumption. Our methods are described below.

**Estimation of illicit cigarette consumption**

Hong Kong, as an international metropolis, attracts tourists and business personnel from all over the world. In 2012, visitor-arrivals amounted to 48.6 million.<sup>16</sup> Using the same framework as in the OE Report, we summarised and labelled the different types and sources of cigarette consumption in Hong Kong (table 1).

We estimated illicit cigarette consumption by Hong Kong smokers and visiting smokers, using the following formulae:

$$\begin{aligned} \text{Illicit consumption by Hong Kong smokers (I}_h\text{)} \\ &= \text{annual cigarette consumption by Hong Kong smokers (A}_h\text{)} \\ &\quad - \text{annual legal consumption by Hong Kong smokers (B}_h\text{)} \\ &\quad - \text{annual legal personal imports by Hong Kong smokers (C}_h\text{)} \end{aligned} \tag{1}$$

$$\begin{aligned} \text{Illicit consumption by visitors (I}_v\text{)} \\ &= \text{total cigarette consumption by smoking visitors (A}_v\text{)} \\ &\quad - \text{total legal consumption by visiting smokers (B}_v\text{)} \\ &\quad - \text{total legal personal imports by smoking visitors (C}_v\text{)} \end{aligned} \tag{2}$$

We calculated the total annual cigarette consumption (legal plus illicit) by summing the annual cigarette consumption by Hong Kong smokers (A<sub>h</sub>) and by visiting smokers (A<sub>v</sub>). The illicit consumption was estimated as this total minus the legal domestic consumption (B<sub>h</sub>), legal personal imports (C<sub>h</sub>), legal non-domestic consumption (B<sub>v</sub>) and legal personal imports by visitors (C<sub>v</sub>). The illicit consumption could be summarised thus:

$$I = I_h + I_v = (A_h + A_v) - (B_h + B_v) - (C_h + C_v). \tag{3}$$

Our data sources are detailed below.

**Parameters and data sources**

Annual cigarette consumption by Hong Kong smokers (A<sub>h</sub>) This was estimated from the Hong Kong Thematic Household Survey 2012 (THS No. 53).<sup>13</sup> THS is a population-based household survey conducted regularly by the Census and Statistics Department. THS No. 53 provided the smoking prevalence by age group and sex, and the average daily consumption of current smokers in each group in 2012. A<sub>h</sub> was calculated by multiplying the average daily consumption of each smoker by age group and the number of smokers in each group, and then grossing up to a year (366 days in 2012). The estimated A<sub>h</sub> was 3227 million sticks, which included legal and illicit

**Table 1** Composition of cigarette consumption in Hong Kong, 2012

Type of consumption	Origins of smokers	
	Local smokers	Visiting smokers
Legal consumption	B <sub>h</sub>	B <sub>v</sub>
Legal personal imports	C <sub>h</sub>	C <sub>v</sub>
Illicit consumption	I <sub>h</sub>	I <sub>v</sub>
Total consumption	A <sub>h</sub>	A <sub>v</sub>

**Table 2** Estimated number of smokers among visitors in Hong Kong, 2012

Country of residence	Number of overnight visitors <sup>17</sup>	Proportion of people aged 15+ <sup>23</sup>	Smoking prevalence of those aged 15+	Number of visiting smokers
Mainland China	15 110 372			
Male (40.0% <sup>24</sup> )	6 044 149	82.0%	52.9% <sup>19*</sup>	2 621 831
Female (60.0% <sup>24</sup> )	9 066 223	82.0%	2.4% <sup>19*</sup>	178 423
Other places	8 659 823			
Male (44.0% <sup>24</sup> )	3 810 322	73.6%	36.0% <sup>18†</sup>	1 009 583
Female (56.0% <sup>24</sup> )	4 849 501	73.6%	8.0% <sup>18†</sup>	285 539
Total number of smokers among visitors				4 095 376

\*Smoking prevalence in 2010.

†Prevalence of smoking any tobacco product among adults aged ≥15 years in 2009.

consumption. Consumption by occasional smokers (prevalence was 1% in 2012) was not counted in this calculation because the smoking intensity by occasional smokers had not been captured in THS No. 53 and their contribution to the estimated annual cigarette consumption was not likely to be significant.

#### Annual cigarette consumption by visiting smokers ( $A_v$ )

This was estimated from the product of the number of overnight visitors,<sup>17</sup> the smoking prevalence in the visitors' original countries,<sup>18–19</sup> the average length of stay in Hong Kong of overnight visitors<sup>16</sup> and the average daily consumption of visiting smokers.<sup>20–22</sup> Among the 48.6 million visitors in 2012, 23.7 million stayed overnight and the other 24.8 million were 1-day visitors.<sup>17</sup> The 1-day visitors were assumed to bring cigarettes within the duty-free allowance (19 sticks) for a day visit, given the fact that smokers usually carry cigarettes with them when they are going out. So consumption by 1-day visiting smokers was removed from this calculation. An estimated 4.1 million overnight visiting smokers arrived in Hong Kong in 2012 (table 2). We estimated  $A_v$  from these 4.1 million overnight visiting smokers under several scenarios, which have been described in Alternative Scenarios.

#### Annual legal consumption by Hong Kong smokers and visiting smokers ( $B_h+B_v$ )

This is equal to the annual legal domestic sales of cigarettes in Hong Kong estimated by dividing the total cigarette tax revenue by the tax rate per stick. In 2012, the tax revenue was HK\$5024 million.<sup>11</sup> According to THS No. 53, 99.4% of current smokers consumed cigarettes and only 0.8% consumed other forms of tobacco.<sup>13</sup> We assumed that 99% (HK\$4974 million) of the tobacco tax revenue was from cigarettes. Hong Kong had a single specific excise tax rate of HK\$1706 for 1000 cigarettes (equivalent to HK\$34 per pack of 20), so the annual legal domestic sales were 2925 million sticks (HK \$4974 million×20 sticks/HK\$34) in 2012. These legal duty-paid sales of cigarettes would be consumed by Hong Kong or visiting smokers ( $B_h+B_v$ ).

#### Legal personal imports for Hong Kong smokers and visiting smokers ( $C_h+C_v$ )

These were estimated based on the number of incoming smokers to Hong Kong using data on the number of incoming passengers into Hong Kong and the smoking prevalence of Hong Kong residents aged 15 or above, and the number of incoming visitors, their countries of origin and smoking prevalence in their home countries for those aged 15 or above. Several assumptions were made regarding the total number of duty-free cigarettes brought by the incoming smokers and these are described below.

#### Alternative scenarios for estimating $A_v$ and $C_h+C_v$

There is uncertainty around the average daily consumption of visiting smokers since passengers may temporarily change their smoking habits during a trip, and also around the amount of legal personal imports (duty-free consumption) by Hong Kong smokers and visiting smokers, since they may or may not bring cigarettes with them. Thus, three scenarios were examined to show how the different possible magnitudes of these parameters would influence illicit cigarette consumption estimates (I) (table 3).

#### Midpoint estimate

Among the overnight visitors, 15.1 million (63.6%) were from Mainland China and the rest were mainly from other Asian countries (22.1%), Europe (6.7%), the Americas (5.2%) and Australia (2.4%).<sup>17</sup> The average daily consumption reported by smokers in China was 17 sticks,<sup>20</sup> in the US 16 sticks,<sup>21</sup> in Australia 14 sticks and in the UK 12 sticks.<sup>22</sup> The mean (15 sticks) reported daily consumption was used in the calculation for this scenario, assuming that visitors would not change their smoking habits during a trip. During a typical 4-day visit (average length of stay of overnight visitors was 3.5 nights<sup>16</sup>) to Hong Kong, one visiting smoker would smoke 60 cigarettes.

The total cigarette consumption of smoking visitors ( $A_v$ ) was estimated to be 245.7 million sticks (4.1 million visiting smokers×15 sticks per day×4 days). There were 133.9 million passengers who arrived in Hong Kong in 2012 including Hong

**Table 3** Scenarios for the estimation of illicit cigarette consumption in Hong Kong

Scenarios	Average daily consumption by visiting smokers	Number of smokers (million) among Hong Kong passengers who bring duty-free cigarettes (%)	Number of visiting smokers (million) who bring duty-free cigarettes (%)
Upper bound	17	0 (0)	2.05 (50)
Midpoint bound	15	4.04 (50)	3.07 (75)
Lower bound	13	8.09 (100)	4.1 (100)

Kong passengers and visitors.<sup>25</sup> The total visitor arrivals was 48.6 million so there were 85.3 million (133.9–48.6) incoming Hong Kong passengers. Scaling by smoking prevalence (10.7% in those aged 15 or above) and the proportion of people aged 15 or above (88.6%<sup>26</sup>), there were 8.09 million Hong Kong smokers among the incoming passengers. In this scenario, 75% of visiting smokers and 50% of Hong Kong smokers, among the incoming passengers, were assumed to bring cigarettes with them when entering Hong Kong. Thus, the legal personal import (duty-free consumption) ( $C_h + C_v$ ) was estimated to be 135.2 million sticks (50% $\times$ 8.09 million incoming HK smokers $\times$ 19 sticks per smoker+75% $\times$ 4.1 million visiting smokers $\times$ 19 sticks per smoker).

#### Upper bound estimate

The average daily consumption by Chinese smokers (which was the highest reported) was used in this scenario.  $A_v$  was estimated to be 278.5 million sticks (4.1 million visiting smokers $\times$ 17 sticks per day $\times$ 4 days). Conservatively, it was assumed that none of the smokers among the incoming Hong Kong passengers and 50% of all visiting smokers would bring duty-free cigarettes (19 sticks) when entering Hong Kong. Thus, in this scenario,  $C_h + C_v$  was 38.9 million sticks (4.1 million visiting smokers $\times$ 50% $\times$ 19 sticks per smoker).

#### Lower bound estimate

The average daily consumption by Hong Kong smokers (13 sticks<sup>13</sup>) was used in this scenario. Since Hong Kong has comprehensive smoking bans in almost all public places, it was assumed that visiting smokers during the trip in Hong Kong would reduce their daily consumption to the level of Hong Kong smokers.  $A_v$  was estimated to be 212.9 million sticks (4.1 million visiting smokers $\times$ 13 sticks per day $\times$ 4 days). It was assumed that all smokers among Hong Kong incoming passengers and all visiting smokers would bring cigarettes with them.  $C_h + C_v$  was estimated to be 231.5 million sticks (8.09 million incoming HK smokers $\times$ 19+4.1 million visiting smokers $\times$ 19).

#### Sensitivity analysis

The estimation of total cigarette consumption was based on self-reported smoking status and self-reported daily consumption by smokers. Some previous studies claimed that smokers may under-report their daily consumption.<sup>27–29</sup> We have no estimate of what this proportion might be in Hong Kong but we tested the impact on the results of under-reporting of consumption by 10%, 15% and 20%. It is also claimed that some smokers might not admit to smoking at all. However, Yeager and Krosnick carefully assessed the reasons for apparent differences between self-reported and biochemically-validated prevalence and concluded that there was little evidence of deliberate misreporting of smoking habits.<sup>30</sup> They were investigating face-to-face self-reports but commented that this result may apply also to other methods of data collection such as telephone surveys. Therefore, as a conservative approach, we have tested their maximum estimate of up to 0.94% of smokers denying that they smoked. We used a two-way sensitivity analysis, testing how levels of under-reporting of consumption, that is, 10%, 15% and 20%, and values of undeclared smoking prevalence, that is, 0.3%, 0.6% and 0.94%, would influence our estimates.

#### RESULTS

Illicit cigarette consumption was estimated to be 411.8 million sticks in 2012 in Hong Kong, ranging from 282.7 to 540.8 million sticks (table 4). The estimated illicit cigarette

consumption as a percentage of total consumption ranged from 8.2% to 15.4% with a midpoint estimate of 11.9%. This implies that the tobacco-industry-funded OE Report estimate of 35.9% inflated the illicit cigarette consumption in 2012 in Hong Kong, relative to our estimate, by 133% to 377% (35.9/15.4-1, 35.9/8.2-1). Sensitivity analysis showed that only with 20% under-reporting of daily consumption and 0.94% undeclared smoking prevalence (for which we would have to underestimate consumption by 976.2 million cigarettes per year), could our estimate approach that from the industry-funded report.

#### DISCUSSION

Our study, using a framework comparable to the one used in a recent industry-funded report but based on data in the public domain from verifiable sources, showed that illicit consumption in 2012 in Hong Kong ranged from 8.2% to 15.4% with a midpoint estimate of 11.9%. The estimate in the OE Report (35.9%), funded by Philip Morris, inflated the illicit cigarette consumption estimate by 203% (range 133–337%). Only if there had been a significant under-reporting of daily cigarette consumption and undeclared smoking prevalence, could our estimate approach the values reported in the industry-funded study.

Research on the global illicit cigarette trade has estimated that illicit cigarettes account for 11.6% of the total market: 16.8% in low-income and 9.8% in high-income countries.<sup>5</sup> Our estimate for Hong Kong (midpoint 11.9%) is comparable to this global estimate. Our findings are consistent with a growing body of other overseas academic studies, which report that industry-funded studies tend to exaggerate illicit consumption. Such exaggeration has been found in tobacco industry backed reports on the West European,<sup>6</sup> East European<sup>7</sup> and African markets<sup>8</sup> and now Asian markets as well. A recent empirical analysis in Vietnam used two methods: the difference between legal sales and domestic tobacco consumption from surveys, and the trade difference between Vietnam and trade partners; both were based on publicly available data and showed that illicit consumption in Vietnam ranged from 0.7% to 6%.<sup>31</sup> This was much lower than the estimate for Vietnam (19.4%<sup>9</sup>) in the same OE Report that we have described in this paper. The similarly-generated estimates for the other markets covered in the OE Report may also be substantially inflated. Scientific studies for other markets are needed to refute the dubious industry-funded estimates.

The tobacco industry has also manipulated the historical data to create an impression that illicit trade has been increasing dramatically. Blecher *et al*<sup>32</sup> identified inconsistencies between estimates of illicit trade for the same years released in successive editions of the Euromonitor reports for countries such as South Africa, Mexico and Bulgaria. Rowell *et al*<sup>15</sup>, after closely examining the media coverage of illicit trade in the UK, showed that the claim of the tobacco industry on the rapidly increased illicit trade in the UK was inconsistent with historical trends and the industry data on illicit trade were unreliable.

Apart from exaggerating levels of illicit trade and manipulating the historical data to lobby against tobacco tax increases, the tobacco industry has been complicit in smuggling all over the world, a practice that has been exposed and sometimes brought to trial.<sup>33</sup> For example, in July 2008, in Canada, two tobacco companies pleaded guilty and admitted to having aided people to sell or keep tobacco products manufactured in Canada, but not packaged or stamped in conformity with the Excise Act, between 1989 and 1994.<sup>34</sup> In Vietnam, even after British American Tobacco (BAT) signed a licensing agreement with Vinataba, the

**Table 4** Estimated illicit cigarette consumption (million sticks) in Hong Kong, 2012

	Upper	Midpoint	Lower
Total cigarette consumption	3505.5	3472.7	3439.9
Total legal consumption (sales)	2925.7	2925.7	2925.7
Total legal duty-free consumption	38.9	135.2	231.5
Estimated number of illicit cigarettes	540.8	411.8	282.7
Estimated illicit cigarettes as % of total consumption (%)	15.4	11.9	8.2
Inflation by tobacco industry-funded report (%)	132.7	202.8	336.9
0% undeclared smoker			
Illicit consumption as % of total consumption (10% under-reporting, %)	22.6	19.4	16.1
Illicit consumption as % of total consumption (15% under-reporting, %)	25.7	22.6	19.5
Illicit consumption as % of total consumption (20% under-reporting, %)	28.6	25.7	22.7
0.3% undeclared smoker			
Illicit consumption as % of total consumption (0% under-reporting, %)	17.5	14.0	10.4
Illicit consumption as % of total consumption (10% under-reporting, %)	24.5	21.3	18.1
Illicit consumption as % of total consumption (15% under-reporting, %)	27.5	24.5	21.5
Illicit consumption as % of total consumption (20% under-reporting, %)	30.3	27.5	24.6
0.6% undeclared smoker			
Illicit consumption as % of total consumption (0% under-reporting, %)	19.5	16.0	12.4
Illicit consumption as % of total consumption (10% under-reporting, %)	26.3	23.2	20.0
Illicit consumption as % of total consumption (15% under-reporting, %)	29.3	26.3	23.3
Illicit consumption as % of total consumption (20% under-reporting, %)	32.0	29.2	26.3
0.94% undeclared smoker			
Illicit consumption as % of total consumption (0% under-reporting, %)	21.6	18.2	14.7
Illicit consumption as % of total consumption (10% under-reporting, %)	28.2	25.2	22.0
Illicit consumption as % of total consumption (15% under-reporting, %)	31.2	28.2	25.2
Illicit consumption as % of total consumption (20% under-reporting, %)	33.8	31.0	28.2

Upper: visiting smokers will smoke 17 cigarettes a day during a typical 4-day stay in Hong Kong. Fifty per cent of visiting smokers and one of smokers among Hong Kong passengers will bring as many duty-free cigarettes as allowed (19 sticks).

Midpoint: visiting smokers will smoke 15 cigarettes a day during a typical 4-day stay in Hong Kong. Seventy-five per cent of visiting smokers and 50% of smokers among Hong Kong passengers will bring as many duty-free cigarettes as allowed (19 sticks).

Lower: visiting smokers will smoke 13 cigarettes a day during a typical 4-day stay in Hong Kong. All visiting smokers and all smokers among Hong Kong passengers will bring as many duty-free cigarettes as allowed (19 sticks).

state tobacco monopoly, to produce and sell its State Express (SE) 555 cigarettes locally, BAT continued to supply traders smuggling UK made SE 555 into the country, apparently well aware of the illicit trade.<sup>35</sup>

The available evidence shows that illicit trade in the form of smuggling between jurisdictions with different levels of tobacco duty is linked, not primarily to the levels of tax but to the extent of corruption and criminality in individual jurisdictions.<sup>36</sup> The solution to this would be to deal firmly with the illegal activities, corruption and criminality associated with them, and to raise tobacco tax to provide more revenue for disciplined services to combat illicit trade.

Our estimate was validated using survey data in Hong Kong. In a recent population-based telephone survey in Hong Kong, among all randomly sampled current smokers (n=800) aged 15–65, 8.8% claimed that they had often bought cigarettes far cheaper than the regular prices in the past 6 months.<sup>37</sup> Of those who had bought the low-cost cigarettes, 28.5% believed that the cigarettes had been smuggled from other places. The survey did not record the number of illicit cigarettes consumed. The daily consumption of smokers who often bought low-cost cigarettes was 16.3 sticks as compared to 14.1 of the average daily consumption from the above survey. If the smokers who often bought low-cost cigarettes only smoked low-cost cigarettes and if all of the low-cost cigarettes had been smuggled, then the proportion of illicit consumption from this survey would be 10.2% (8.8%×16.3/14.1), which is within the range of our current estimates of 8.2–15.4%.

Our estimate was based on different assumptions but we always used the more conservative ones. We assumed the visiting smokers smoked the same amount of cigarettes as they did in their home countries (average daily consumption of 13, 15 and 17 in lower, midpoint and upper bound estimates, respectively). Hong Kong has a very comprehensive smoke-free law where almost all public places are smoke-free. Visitors during a trip may involuntarily reduce their cigarette consumption. One study in Thailand showed that the average daily consumption of a visiting smoker was 7.8.<sup>38</sup> If we applied this value, the illicit consumption as the percentage of total consumption would be 5.9–11.6%. We assumed at least 50% of visiting smokers would bring cigarettes with them when entering Hong Kong. Almost 70% of the visiting smokers were from Mainland China in 2012. Smokers from Mainland China predominantly smoke China-made cigarettes of Chinese brands, which are quite different from those smoked by Hong Kong smokers. There are over 200 domestic cigarette brands in the Chinese market.<sup>39</sup> It seems unlikely that most of these smokers would purchase cigarettes in Hong Kong, not only because prices are much more expensive<sup>40</sup> but primarily because Chinese smokers are not used to the taste of foreign brands of cigarettes such as Marlboro and Mild Seven, which are widely sold in Hong Kong.

There are smokers who do not admit their smoking status (undeclared smokers) and under-report their cigarette consumptions for whatever reasons. One study in the UK used an uplift factor correcting for this bias to estimate the illicit market for tobacco.<sup>41</sup> It calculated the uplift factor in a year in which the

illicit market was estimated by other sources and believed to be small by comparing total consumption based on self-reported data with total consumption based on actual clearance and estimate of legal cigarettes brought from abroad. We are unable to do the same because such data were not available, but overseas studies showed that self-reports of smoking were accurate with minimal response bias, especially in nationally representative surveys in adult populations.<sup>30 42 43</sup>

This study is subject to several limitations that should be addressed in future work. The study provides a point estimate of illicit cigarette consumption in 2012 with a plausible range but cannot demonstrate that tax increases will not increase illicit cigarette consumption. For this, along with longitudinal survey data that can validly and directly monitor the changes of illicit consumption over time, we also need multiple methods to cross-validate different estimates, which should be considered in future work. Different methods of assessment may provide different estimates of illicit consumption.<sup>44</sup> The method used in our estimate (difference between total consumption and legal consumption) was a gap method that was used in studies in South Africa,<sup>8</sup> Vietnam<sup>31</sup> and the UK.<sup>41</sup> We cannot be certain whether our report overestimates or underestimates the true magnitude of illicit consumption. However, we have cross-validated our estimates using a different method and an entirely different data source. We also sought to use conservative assumptions as explained above in order to avoid underestimation. Our study provides a replicable model for estimating illicit cigarette consumption using scientifically valid data sources along with transparent and testable assumptions.

All the industry effort is to lobby decision-makers not to increase tax, undermine the effects of tobacco control policies and to eventually significantly benefit from it. The industry-funded estimate of 35.9% of consumption in Hong Kong being illicit, for example, was repeatedly used by opponents to argue against a tobacco tax increase in 2014 and the HK Government, instead of increasing the tax 100% as advocated by tobacco control professionals, finally only increased it 11.7%. By the time this paper was under revision, the ITIC and OE had already held two press conferences in Hong Kong to report their estimates of illicit cigarettes, which drew substantial attention from the public. Given the need for reliable data in order to inform local policies and to counter false arguments against the essential public health need to raise tobacco taxes, territories such as Hong Kong and the neighbouring regions need regular monitoring and continuous data collection on illicit consumption. Hong Kong should also ensure active co-operation from all its neighbours to reduce illicit trade while maintaining and increasing tobacco tax.

### What this paper adds

- ▶ This is the first study to directly validate an industry-funded estimate of illicit cigarette consumption, using a comparable estimation framework employed by the industry but with reliable and transparent data sources.
- ▶ This estimate is based on the tobacco usage of residents and visitors who are smokers, to include all possible sources of illicit trade.
- ▶ Compared with our estimate, the industry-funded estimate of illicit cigarette consumption for Hong Kong had been inflated by at least 133%.

**Acknowledgements** The authors thank Mr So Ching from the School of Public Health, HKU and Dr Cheung Yee Tak Derek from the School of Nursing, HKU, for their suggestions on research methods. The authors thank Dr David Simpson, former Director of Action on Smoking and Health (ASH) for his suggestions on the manuscript. The authors thank three reviewers of the journal.

**Contributors** JC, SMM and THL designed the study. JC and SMM analysed the data and drafted the manuscript. All authors revised the manuscript.

**Funding** The Hong Kong Council on Smoking and Health (COSH) provided funding for this study.

**Competing interests** AJH and THL are former chairs of COSH.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Open Access** This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

### REFERENCES

- 1 World Health Organization. *WHO framework convention on Tobacco Control*. Geneva: World Health Organization, 2003. <http://whqlibdoc.who.int/publications/2003/9241591013.pdf> (accessed 15 Sep 2014).
- 2 Chaloupka FJ, Straif K, Leon ME. Effectiveness of tax and price policies in tobacco control. *Tob Control* 2011;20:235–8.
- 3 ITC Project. *Tobacco price and taxation: ITC cross-country comparison report*. Waterloo, Ontario, Canada: University of Waterloo, 2012. [http://www.itcproject.org/files/ITC\\_CrossCountry-Price-Tax\\_Apr20-v11-web.pdf](http://www.itcproject.org/files/ITC_CrossCountry-Price-Tax_Apr20-v11-web.pdf) (accessed 17 Sep 2014).
- 4 Joossens L. Tobacco smuggling: an optimal policy approach. In: Abedian I, van der Merwe R, Wilkins N, et al., eds. *The economics of tobacco control: towards an optimal policy mix*. Private Bag, Rondebosch, South Africa: Applied Fiscal Research Centre, University of Cape Town, 1998:146–54.
- 5 Joossens L, Merriman D, Ross H, et al. The impact of eliminating the global illicit cigarette trade on health and revenue. *Addiction* 2010;105:1640–9.
- 6 Joossens L, Lugo A, La Vecchia C, et al. Illicit cigarettes and hand-rolled tobacco in 18 European countries: a cross-sectional survey. *Tob Control* 2014;23:e17–23.
- 7 Stoklosa M, Ross H. Contrasting academic and tobacco industry estimates of illicit cigarette trade: evidence from Warsaw, Poland. *Tob Control* 2014;23:e30–4.
- 8 van Walbeek C. Measuring changes in the illicit cigarette market using government revenue data: the example of South Africa. *Tob Control* 2014;23:e69–74.
- 9 ITIC. Oxford Economics. Asia-11 Illicit Tobacco Indicator 2012. 2013. <http://www.iticnet.org/file/document/watch/3953> (accessed 20 Dec 2013).
- 10 Southeast Asia Tobacco Control Alliance. ITIC's Asia -11 Illicit Tobacco Indicator 2012: More Myth than Fact A Critique by SEATCA 2014. [http://seatca.org/dmdocuments/ITIC%20report\\_More%20Myth%20than%20Fact\\_2%20July%202014.pdf](http://seatca.org/dmdocuments/ITIC%20report_More%20Myth%20than%20Fact_2%20July%202014.pdf) (accessed 22 Sep 2014).
- 11 Custom and Excise Department, Hong Kong SAR. Departmental reviews, 2003-04 to 2012. Hong Kong, 2014. [http://www.customs.gov.hk/tc/publication\\_press/publication\\_departmental\\_reviews/index.html](http://www.customs.gov.hk/tc/publication_press/publication_departmental_reviews/index.html) (accessed 14 Oct 2014).
- 12 Census and Statistics Department, Hong Kong SAR. *Thematic Household Survey Report, No.36*. Hong Kong, 2008. <http://www.statistics.gov.hk/pub/B11302362008XXXXB0100.pdf> (accessed 20 Dec 2013).
- 13 Census and Statistics Department, Hong Kong SAR. *Thematic Household Survey Report, No.53*. Hong Kong, 2013. <http://www.censtatd.gov.hk/hkstat/sub/sp140.jsp?productCode=B1130201> (accessed 17 Sep 2014).
- 14 Gilmore AB, Rowell A, Gallus S, et al. Towards a greater understanding of the illicit tobacco trade in Europe: a review of the PMI funded 'Project Star' report. *Tob Control* 2014;23:e51–61.
- 15 Rowell A, Evans-Reeves K, Gilmore AB. Tobacco industry manipulation of data on and press coverage of the illicit tobacco trade in the UK. *Tob Control* 2014;23:e35–43.
- 16 Census and Statistics Department, Hong Kong SAR. Hong Kong: The Facts—Tourism Hong Kong: Tourism Commission & Hong Kong Tourism Board, Hong Kong SAR. 2013. <http://www.gov.hk/en/about/aboutthk/factsheets/docs/tourism.pdf> (accessed 15 Apr 2014).
- 17 Hong Kong Tourism Board, Hong Kong SAR. *Monthly Report—Visitors arrivals statistics*. Hong Kong, 2013. <http://partnernet.hktb.com/filemanager/pressrelease/Tourism%20Stat%2012%202012.pdf> (accessed 20 Dec 2013).
- 18 World Health Organization. *World Health Statistics 2012*. Geneva: World Health Organization, 2012. [http://whqlibdoc.who.int/publications/2012/9789241564441\\_eng.pdf](http://whqlibdoc.who.int/publications/2012/9789241564441_eng.pdf) (accessed 15 Apr 2014).
- 19 Li Q, Hsia J, Yang G. Prevalence of smoking in China in 2010. *N Engl J Med* 2011;364:2469–70.
- 20 Huang J, Zheng R, Chaloupka FJ, et al. Chinese smokers' cigarette purchase behaviours, cigarette prices and consumption: findings from the ITC China Survey. *Tob Control* 2014;23(Suppl 1):i67–72.

- 21 Australian Institute of Health and Welfare. *Drugs in Australia 2010: tobacco, alcohol and other drugs*. Canberra, 2011. <http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=10737420455>.
- 22 Acting on Smoking and Health. Smoking statistics: who smokes and how much? 2013. [http://ash.org.uk/files/documents/ASH\\_106.pdf](http://ash.org.uk/files/documents/ASH_106.pdf) (accessed 27 May 2014).
- 23 World Bank Open Data. [database on the Internet]. The World Bank, 2013. <http://data.worldbank.org/> (accessed 15 Apr 2014).
- 24 Hong Kong Tourism Board, HKSAR. *Visitor Profile Report—2013*. 2014. [http://securepartnernet.hktb.com/filemanager/intranet/dept\\_info/private\\_20/paper/Visitor-Pro/Visitor\\_Profile2013/Profile\\_2013\\_1.pdf](http://securepartnernet.hktb.com/filemanager/intranet/dept_info/private_20/paper/Visitor-Pro/Visitor_Profile2013/Profile_2013_1.pdf) (accessed 14 Oct 2014).
- 25 Census and Statistics Department, HKSAR. Hong Kong: The Facts. 2014. <http://www.gov.hk/en/about/abouthk/factsheets/docs/statistics.pdf> (accessed 2 Oct 2014).
- 26 Census and Statistics Department, Hong Kong SAR. Hong Kong Population Projections, 2012–2041. 2012. <http://www.statistics.gov.hk/pub/B1120015052012XXXXB0100.pdf> (accessed 17 Sep 2014).
- 27 Hatziandreu EJ, Pierce JP, Fiore MC, *et al*. The reliability of self-reported cigarette consumption in the United States. *Am J Public Health* 1989;79:1020–3.
- 28 Gallus S, Tramacere I, Boffetta P, *et al*. Temporal changes of under-reporting of cigarette consumption in population-based studies. *Tob Control* 2011;20:34–9.
- 29 Perez-Stable EJ, Marin BV, Marin G, *et al*. Apparent underreporting of cigarette consumption among Mexican American smokers. *Am J Public Health* 1990;80:1057–61.
- 30 Yeager DS, Krosnick JA. The validity of self-reported nicotine product use in the 2001–2008 National Health and Nutrition Examination Survey. *Med Care* 2010;48:1128–32.
- 31 Nguyen MT, Denniston R, Nguyen HT, *et al*. The empirical analysis of cigarette tax avoidance and illicit trade in Vietnam, 1998–2010. *PLoS ONE* 2014;9:e87272.
- 32 Blecher E, Liber A, Ross H, *et al*. Euromonitor data on the illicit trade in cigarettes. *Tob Control* 2015;24:100–1.
- 33 Joossens L, Raw M. Progress in combating cigarette smuggling: controlling the supply chain. *Tob Control* 2008;17:399–404.
- 34 *Federal and provincial governments reach landmark settlement with tobacco companies*. Quebec: Canada Revenue Agency, Press release, 2008. <http://www.cra-arc.gc.ca/nwsrm/rlss/2008/m07/nr080731-eng.pdf> (accessed 9 Jul 2014).
- 35 Joossens L. Vietnam: smuggling adds value. *Tob Control* 2003;12:119–20.
- 36 Jha P, Chaloupka FJ, World Bank. *Curbing the epidemic: governments and the economics of tobacco control*. Washington DC: World Bank, 1999. [http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2000/08/02/000094946\\_99092312090116/Rendered/PDF/multi\\_page.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2000/08/02/000094946_99092312090116/Rendered/PDF/multi_page.pdf) (accessed 20 Apr 2014).
- 37 McGhee MS, Chen J, Lam TH. Tobacco control policy-related survey report. 2013.
- 38 Termsirikulchai L, Kengganpanich M, Benjakul S, *et al*. Cigarette consumption among foreign tourists in Thailand. *J Med Assoc Thai* 2012;95(Suppl 6):S71–7.
- 39 Li Q, Hyland A, Fong GT, *et al*. Use of less expensive cigarettes in six cities in China: findings from the International Tobacco Control (ITC) China Survey. *Tob Control* 2010;19(Suppl 2):i63–8.
- 40 Mackay J, Eriksen MP, Ross H. *The tobacco atlas*. 4th edn. Atlanta, GA: American Cancer Society, 2012.
- 41 HM Revenue and Customs. Measuring tax gaps 2013 edition. Tax gap estimates for 2011–12. 2013. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/249537/131010\\_Measuring\\_Tax\\_Gaps\\_ACCESS\\_2013.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/249537/131010_Measuring_Tax_Gaps_ACCESS_2013.pdf) (accessed 4 Oct 2014).
- 42 Caraballo RS, Giovino GA, Pechacek TF, *et al*. Factors associated with discrepancies between self-reports on cigarette smoking and measured serum cotinine levels among persons aged 17 years or older: Third National Health and Nutrition Examination Survey, 1988–1994. *Am J Epidemiol* 2001;153:807–14.
- 43 Wong SL, Shields M, Leatherdale S, *et al*. Assessment of validity of self-reported smoking status. *Health Rep* 2012;23:47–53.
- 44 IARC Working Group on the Effectiveness of Tax and Price Policies for Tobacco Control., International Agency for Research on Cancer. *Effectiveness of tax and price policies for tobacco control*. Lyon Cedex: International Agency for Research on Cancer, 2011. <http://www.iarc.fr/en/publications/pdfs-online/prev/handbook14/handbook14-0.pdf> (accessed 15 Apr 2014).