Association between the implementation of standardised tobacco packaging legislation and illicit tobacco and cross-border purchasing in England: a time–series analysis between 2012 and 2020

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Abstract:

Background: In May 2016 the United Kingdom announced standardising packaging legislation for tobacco products. There was a 12 month transition period with both branded and standardised packs on the market until May 2017. The aim of this study was to investigate whether the implementation of standardised packaging in England was associated with changes in illicit tobacco and cross-border purchasing.

Methods: We used Smoking Toolkit Study data covering the time period from 2012 to 2020. We ran time-series analysis using ARIMAX models to investigate the monthly changes in illicit tobacco and cross-border purchasing in England. The model was adjusted for other tobacco control policies implemented during the relevant time period and tobacco pricing. We used May 2017 as an implementation point and run sensitivity analysis using July 2016 and February 2017 as alternative implementation points given phased introduction of the policy.

Results: The average prevalence of illicit tobacco and cross-border purchasing in the past six months was 14.4%. The implementation of standardised tobacco packaging legislation was associated with a monthly decline in illicit tobacco and cross-border purchases after May 2017 by 0.16% per month (B=-0.158 , 95%CI -0.270 to -0.046). The results were robust to considering different implementation points for the policy (July 2016: B=-0.109, 95% -0.213 to -0.005; Feb 2017: B=-0.141, 95%CI -0.245 to -0.036).

Conclusions: In contrast to the tobacco industry's argument that the legislation would lead to an increase in the illicit tobacco and cross-border market, this study demonstrates that the implementation of the policy associated with a decline in illicit tobacco and cross-border purchases in England.

Key messages

1. What is already known on this topic

The existing evidence show that the implementation of standardised tobacco packaging in the UK has been associated with considerable changes in tobacco market and smoking behaviour.

2. What this study adds

This study shows that in contrast to what was predicted by the tobacco industry, the implementation of standardised tobacco packaging was associated with a decline in in illicit tobacco and cross-border purchases in England.

3. How this study might affect research, practice, or policy

This study provides evidence important to countries around the world to support implementation of standardised tobacco packaging

Introduction

In May 2016 the United Kingdom (UK) implemented Standardised Packaging legislation, involving a year-long transition period until May 2017 [1]. From this date onwards, tobacco products could only be sold legally in plain drab brown packs with just the brand name and a descriptor on the packaging [2]. At the same time, additional new rules from the European Tobacco Products Directive were also enforced, which required minimum pack size limits of 20 cigarettes per pack and 30 grams for roll-your-own (RYO) tobacco as well as larger pictorial health warnings placed on the front and on the back of the pack [3].

The standardised packaging legislation was associated with considerable changes in the tobacco market as the number of products on the market decreased [4, 5] and the prices of tobacco products significantly increased [4, 5]. Prior to implementation, the tobacco industry argued that implementation of standardised packaging would lead to a substantial increase in illicit tobacco sales [6, 7]. Their main argument was that it would be easier to counterfeit standardised packaging and therefore the illicit products will be cheaper and easier to access though no specific estimates of illicit market changes were provided [8]. Tobacco tax increases are intended to increases the cigarette prices and in turn encourage smoking cessation. Illicit trade in tobacco is a concern as it allows the circumvention of tobacco tax. As a result of this, availability of cheaper illicit tobacco products may reduce motivation to quit [9, 10], and cost the UK an estimated £2.5billion in lost revenue in 2021 alone [11, 12]. The tobacco industry's view that standardised packaging would increase illicit tobacco was not supported by the HM Revenue and Customs assessment of potential impacts [13], nor an independent review by Sir Cyril Chantler [14]. The implementation in England but not globally may also have induced more people to legally purchase supplies of tobacco not in standard packs while travelling abroad. Cross-border purchases are important because these can be also much cheaper than tobacco purchased in England. As with illicit tobacco, availability of these cheaper tobacco products may reduce motivation to quit and tax revenue for the government. There is limited evidence of the impacts of the legislation using data collected post-implementation. One study compared European countries with standardised packaging legislation to countries without such legislation, and found no evidence of an increase in exposure to, but did not

assess purchases of illicit tobacco post-legislation, and relied only on data from 2015 and 2018 [15]. Similarly, there was no evidence of an increase in illicit tobacco purchasing in relation to standardised packaging in Australia which was the first country to implement such legislation in 2012 [16]. Therefore, this study advances previous research by examining the impact of standardised packaging legislation on illicit tobacco and cross-border purchases up to 2020.

Methods

Study Design

We used interrupted time-series analysis to investigate the association between implementation of standardised packaging legislation and reported purchasing of illicit tobacco and cross-border products in England. We ran Autoregressive Integrated Moving Average with Exogenous variables (ARIMAX) time series model using data from the Smoking Toolkit Study (STS). The STS collects data on smoking behaviours in monthly cross-sectional surveys using household computer-assisted interviews [17]. With approximately 1,800 participants each month, the sample is representative of England's population aged 16 and over and the socio-demographic composition of the sample is similar to those of existing large scale national surveys [17]. Random location sampling design was applied to the 165,665 Output Areas of England, each comprising of roughly 300 households and having been stratified by both geographic region and sociodemographic characteristics. Houses within the output areas were then chosen by the interviewers, depending on which would be most likely to satisfy their quotas, to conduct the interviews. In addition, the data collected were weighted on age, region, social grade, ethnicity, tenure and working status within sex to match England's population profile [17].

Data for the study sample was used from May 2012 until February 2020. We excluded STS data from March 2020 onwards due to the Covid-19 pandemic and a change in the methods of data collection procedure and changes in estimated smoking behaviour associated with the Covid-19 pandemic [18, 19]. We therefore used 94 data points obtained by collecting monthly data between May 2012 – February 2020.

Outcome Variables

Our outcome measure was self-reported prevalence of illicit and cross-border tobacco purchasing in the past six months among past year smokers, based on reported sources of tobacco.

Past year smokers within the STS were identified as those who answered the question of 'Which of the following best applies to you?' with one of the following statements:

- I smoke cigarettes (including hand-rolled) every day
- I smoke cigarettes (including hand-rolled), but not every day
- I do not smoke cigarettes at all, but I do smoke tobacco often
- I have stopped smoking completely in the last year

All past year smokers then responded to the following question:

'In the last 6 months, have you bought any cigarettes or hand-rolled tobacco from any of the following?'

1. Newsagent\Off license\Corner shop
2. Petrol garage shop
3. Supermarket
4. Cash and Carry
5. Internet
6. Pub (behind the bar)
7. Pub (vending machine)
8. Pub (somebody who comes round selling cigarettes cheap)
9. People who sell cheap cigarettes on the street
10. People in the local area who are a ready supply of cheap cigarettes
11. Buy them cheap from friends
12. Buy them from abroad and bring them back with me
13. Newsagent\Off license\Corner shop- "under the counter"
14. Other (please specify)
15. Have not bought any in the last 6 months
16. Don't know

This prevalence of illicit tobacco and cross-border tobacco purchasing each month was estimated by counting the number of participants who responded with any of the above sources between options 8, 9, 10, 11 and 13 (for illicit tobacco) and option 12 (for cross-border tobacco) divided by the total number of past year smokers.

We used weighted data for the analysis to represent the population of England. To prevent underestimation, past-year smokers without any data on their sources of cigarettes or tobacco were also excluded from the analysis (n=87).

Explanatory Variable

As the foremost independent variable of interest, the introduction of standardised tobacco packaging was modelled within the analysis as a dummy-coded intervention variable. This was performed in three alternative ways to account for the different possible effects: as an abrupt step level change, an abrupt temporary pulse effect and as a ramp effect.

May 2017, the time in which the standardised packaging was fully in place, was selected as the primary analysis intervention point. However, since the policy consisted of a gradual implementation process, sensitivity analysis was performed using both July 2016, when it was first introduced, and February 2017, when approximately 50% of cigarettes were sold in plain packaging, as additional intervention points [5] .

Subsequently, the modelling of standardised packaging observed the following coding structure:

Primary Ramp effect: ‘0’ before May 2017, ‘1’ in May 2017 and increasing by 1 for each consecutive month after

Secondary Ramp effect 1: ‘0’ before July 2016, ‘1’ in July 2016 and increasing by 1 for each consecutive month after

Secondary Ramp effect 2: ‘0’ before February 2017, ‘1’ in February 2017 and increasing by 1 for each consecutive month after

Primary Step level change: ‘0’ before May 2017, ‘1’ in May 2017 and after

Secondary Step level change 1: ‘0’ before July 2016, ‘1’ in July 2016 and after

Secondary Step level change 2: ‘0’ before February 2017, ‘1’ in February 2017 and after

Primary Pulse effect: ‘1’ in May 2017 and ‘0’ otherwise

Secondary Pulse effect 1: ‘1’ in July 2016 and ‘0’ otherwise

Secondary Pulse effect 2: ‘1’ in February 2017 and ‘0’ otherwise

Additional Covariates

The possible influence of a further tobacco control policy, the small-shop point-of-sale display ban, in April 2015 was accounted for through its inclusion as a covariate within the models. Modelled as a step level change, this dummy variable was coded as ‘0’ before the point of implementation in April 2015 then as ‘1’ during and afterwards. As we only included data from May 2012 onwards, we did not adjust for the point-of-sale display ban in large shops implemented in April 2012.

Additional covariates were changes in tobacco tax, modelled as pulse effects, and the UK’s monthly Consumer price index (CPI) of tobacco, a time series included within the model as an input variable. The implementation of the Stoptober campaign and any other annual co-variates were accounted for through seasonality adjustment in the models.

Statistical Analysis

For the interrupted time series analysis study design, Autoregressive Integrated Moving Average with Exogeneous Input (ARIMAX) models were applied to account for any potential autocorrelation among the monthly observations [20]. By allowing for the inclusion of exogenous variables in the modelling, ARIMAX extends autoregressive integrated moving average analysis (ARIMA), which uses previous values in the time series analysis (AR terms) and the errors of prior predictions (MA terms) to produce forecasts [21]. An advantage of fitting ARIMAX models was the ability to predict the different possible policy effects whilst still accounting for any seasonality and autocorrelation in the series [20].

Through applying the Box Jenkins method, the ARIMAX models fitted to the data for each possible policy effect were selected using standard recommended procedures. [22] Firstly, outlier detection

function in R (tsoutlier) and a box plot was produced to assess the time series for outlying values that could bias results. No outliers were identified.

A fundamental requirement of ARIMAX models is that the data must be stationary, i.e. mean and variance does not vary over time [23]. The assumption of stationarity was therefore assessed using a combination of visual assessments after plotting the time series graphically, the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests and the augmented Dickey–Fuller test (ADF) [24]. Given that neither the tests nor the plot of the data indicated issues with stationarity, it was concluded that no differencing was required.

In addition to these assessments, the possibility of any non-stationarity caused by the presence of seasonality was also investigated using a seasonal unit root test and an overall seasonality test developed by Webel and Ollech (the WO-test) [25]. It was determined that seasonal differences were also unnecessary.

Next in the analysis, both the autocorrelation function (ACF) and partial autocorrelation function (PACF) were evaluated to choose the baseline models' AR and MA values. Once these values had been selected, the baseline models were then compared to a variety of additional models containing differing fitted AR and MA terms using the Akaike Information Criterion (AIC). Within the Box-Jenkins method it is recommended that to maintain parsimony within the model selection process, either the value of p and q should be 2 or less or the total number of parameters should be less than 3 [22]. This was consequently used as a guide for which ARIMAX models would be included in the comparisons.

Finally, once the optimal adjusted and unadjusted models had been chosen, their diagnostics and assumptions were examined to ensure their suitability. This process involved an assessment of the final models' residuals, using Ljung-Box tests and plots of their ACFs, to determine if there was evidence they deviated from white noise. [26] Furthermore, in addition to their randomness and independence, the model residuals were also assessed for normality. All statistical analysis was performed in R Studio [27].

Results

Participants

Data were collected on the current smoking status of 169,215 people (weighted) aged 16 years and over across the total 94-month study sample period. Of these participants, 19.8% [95% confidence interval (CI) weighted = 19.6–20.0; *n* = 32,010] were classified as past-year smokers who had been asked about where they had purchased tobacco. Furthermore, within these 32,010 past-year smokers, 14.5% weighted [95% confidence interval (CI) = 14.1–14.9; *n* = 4634] reported purchasing illicit tobacco.

Descriptive Statistics

In May 2012 at the beginning of the study sample data, the prevalence of illicit tobacco and cross-border purchasing amongst past-year smokers was 11.4%. It reached its peak in June 2017 (21.3%) and was the lowest at the end of the study period in February 2020 (6.8%) (Figure 1). Overall, across the analysis period the average prevalence of illicit tobacco and cross-border purchasing was 14.4% [Standard Deviation (SD) = 2.8], and cross-border purchasing accounted for about 40% of the purchases.

Figure 1 here

Primary Analysis

Our primary analysis of the impacts of implementing standardised packaging in May 2017 on illicit tobacco and cross-border purchasing showed a negative ramp effect with a decrease in purchases by 0.16% per month after May 2017 (Beta = -0.158 , 95%CI -0.270 to -0.046). The model was inconclusive as to whether there was a step level change in the adjusted model (Beta = 0.812, 95%CI -1.746 to 3.370) (Table 1) . It did, however, indicate a statistically significant negative pulse change in May 2017 (Beta = -7.039, 95%CI -13.121 to -0.958). No statistically significant effects of any form were present in the unadjusted models.

Table 1: Primary analysis assessing the association between the introduction of plain packaging and prevalence of illicit tobacco and cross-border purchasing among past-year smokers using May 2017 as the point of implementation.

	Unadjusted Models			Adjusted Models		
	B	95%CI	p	B	95%CI	p
Step level change (abrupt sustained)	1.148	-1.241 to 3.537	0.346	0.812	-1.746 to 3.370	0.534
Temporary pulse (abrupt decay)	-2.955	-7.783 to 1.872	0.230	-7.039	-13.121 to -0.958	0.023
Ramp Effect	-0.066	-0.187 to 0.055	0.285	-0.158	-0.270 to -0.046	0.006

Secondary Analysis

Results from our secondary analyses of different implementation points were similar. The beginning of the standardised packaging implementation period in July 2016 was associated with a monthly decrease in illicit tobacco and cross-border purchases of about 0.11% per month (Beta = -0.109, 95% -0.213 to -0.005). There was no statistically significant step level change (Beta = -0.226, 95%CI -2.860 to 2.409) (Table 2) but a temporary decrease in illicit tobacco and cross-border purchases in the month of July 2016 (Beta = -4.782, 95%CI -9.249 to -0.316).

Table 2: Secondary analysis assessing the association between the introduction of plain packaging and prevalence of illicit tobacco and cross-border purchasing among past-year smokers using July 2016 as the point of implementation.

	Unadjusted Models			Adjusted Models		
	B	95%CI	p	B	95%CI	p
Step level change (abrupt sustained)	-0.509	-3.488 to 2.470	0.738	-0.226	-2.860 to 2.409	0.867
Temporary pulse (abrupt decay)	-4.948	-9.650 to -0.247	0.039	-4.782	-9.249 to -0.316	0.036
Ramp Effect	-0.029	-0.119 to 0.060	0.518	-0.109	-0.213 to -0.005	0.039

Adjusted analyses using February 2017 as the implementation point, showed there was evidence of a monthly decline in illicit tobacco and cross-border purchases by about 0.14% per month after February 2017 (Beta = -0.141, 95%CI -0.245 to -0.036). There were not statistically significant step level changes (Beta = 0.762, 95%CI -1.727 to 3.521) or pulse effects (Beta = 0.016, 95%CI -4.656 to 4.688) (Table 3).

Table 3: Secondary analysis assessing the association between the introduction of plain packaging and prevalence of illicit tobacco and cross-border purchasing among past-year smokers using February 2017 as the point of implementation.

	Unadjusted Models			Adjusted Models		
	B	95%CI	p	B	95%CI	p
Step level change (abrupt sustained)	0.534	-1.569 to 2.637	0.619	0.762	-1.727 to 3.251	0.548
Temporary pulse (abrupt decay)	-0.492	-5.408 to 4.424	0.844	0.016	-4.656 to 4.688	0.995
Ramp Effect	-0.048	-0.155 to 0.059	0.375	-0.141	-0.245 to -0.036	0.008

Discussion

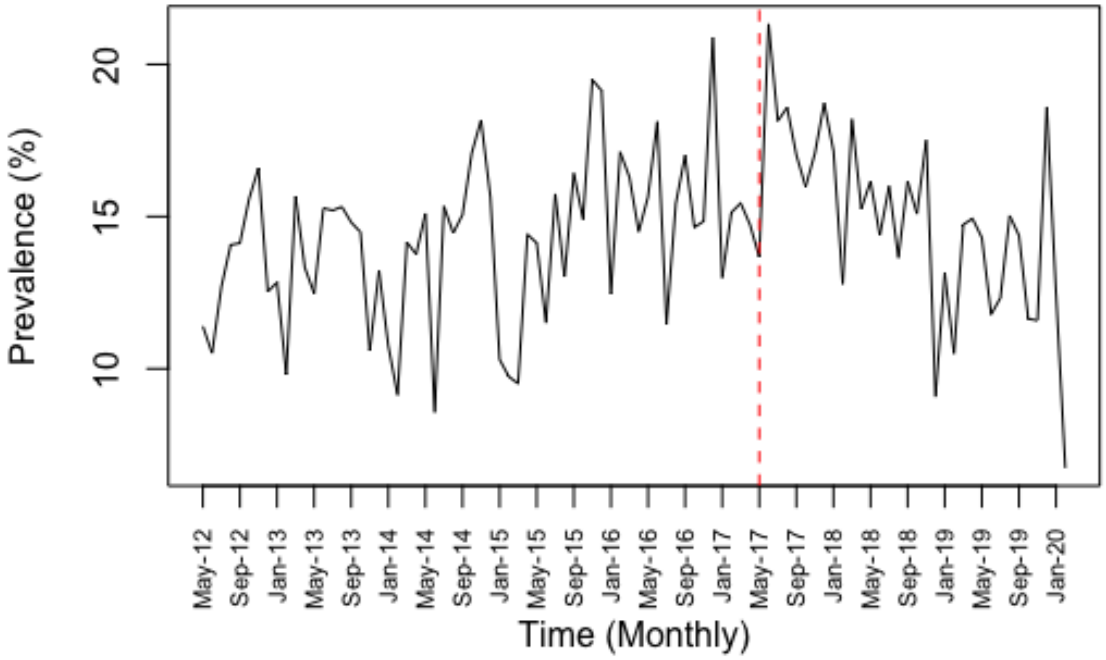
This is the first analysis of the impacts of standardised packaging legislation on illicit tobacco and cross border purchases in England looking at long term impact. It found that the standardised tobacco packaging legislation was associated with a decline in illicit tobacco and cross-border purchases, and results were robust to considering the phased implementation of the policy.

We used an interrupted time series analysis to assess the long-term impacts of standardised packaging and adjusted our analyses for other tobacco control policies during this period as well as seasonal effects. We used an ARIMAX approach that enabled different possible policy effects to be modelled whilst still accounting for any seasonality and autocorrelation in the series. Nonetheless there are limitations to this study. Although we ran a test to check stationarity of the time series and concluded that no transformation of the data was required, the time series still appeared quite volatile. Our estimate of illicit tobacco purchasing was based on self- reported purchasing of tobacco in certain places or in certain ways and must therefore be considered a proxy measure of illicit tobacco and cross-border purchasing. Cross-border purchasing accounted for about 40% of purchasing. We used a long term repeated cross sectional study with a well-established methodology and consistent questions over time. Also, although in this study we refer to standardised packaging legislation we acknowledge that this legislation was a combination of measures including changes in pack size, look of the pack, health warnings and potentially price we are unable to determine which specific element of all these contributed to the changes observed. Finally, we restricted our analyses from 2012 to February 2020 and have not assessed more recent changes due to uncertainty produced by Covid-19 pandemic and its effects on smoking behaviour and data collection methods.

This study is in contrast to tobacco industry claims that standardised packaging would increase the use of illicit tobacco. A systematic review in 2017 found no evidence that standardised packaging was linked to increased illicit trade in ten included studies [8]. There was no evidence of an increase in illicit tobacco purchasing in relation to standardised packaging in Australia which was the first country to implement such legislation in 2012 [16] though this study used different methodology where illicit products were based on brands and product details rather than place of purchase. The finding here of standardised packaging being linked to a reduction in the trend of illicit tobacco and cross border

purchases is in contrast with much of the independent research that found limited evidence of changes post-implementation [16, 28]. This is potentially as this study included almost three years worth of data post-implementation while other research focused on shorter-term impacts. Although our results are not fully alligned with those previously reported, none of the currently available studies supports the claims made by the tobacco industry that the implementation of the policy will lead to an increase in illicit tobacco purchasing. The decreasing trend observed in this study is in line with the overall decreases in illicit tobacco market as reported by HM Revenue and Customs [29]. We know from previous studies that implementation of standardised tobacco packaging was associated with tobacco users switching to cheaper tobacco products [30]. This might reflect a decrease in brand loyalty. Whilst we cannot fully explain the reasons for the observed decrease in illicit tobacco and cross-border purchasing, it is possible that as people switched to cheaper brands they were less motivated to seek illicit or cross-border sources. Whilst there have not been any major changes in tackling illicit tobacco over the study period, we were unable to account for activities aimed at tackling illicit tobacco at local or regional level. It is also possible that implementation of the legislation made it easier to identify illicit products and therefore led to a decrease in purchasing and possibly sales of illicit tobacco products, particularly in locations where licit products are available alongside illicit supply.

This study found that purchases of illicit tobacco and cross border purchases fell after the implementation of standardised packaging legislation in England. These findings should increase confidence in the ability of other jurisdictions to use standardised packaging legislation to control tobacco without increasing illicit trade or cross border purchases.


Prevalence (%)
10
15
20
May-12
Sep-12
Jan-13
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Sep-13
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May-15
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Sep-19
Jan-20
Time (Monthly)

Contributors:
HV- formal analysis & write-up; IB- conceptualization, analysis and write-up; EB- conceptualization; JB- conceptualization; AAL- conceptualization and write-up

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Competing interests:
JB and EB have received unrestricted research grants from Pfizer. HV, IB and AAL have no competing interests to declare. All authors declare there are no other relationships or activities that could appear to have influenced the submitted work.

Figure 1: Prevalence of illicit tobacco purchasing amongst past-year smokers.

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