Longitudinal evaluation of the impact of standardised packaging and minimum excise tax on tobacco sales and industry revenue in the UK

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ABSTRACT
Background Standardised packaging for factory-made cigarettes (FM) and roll-your-own tobacco (RYO), and a minimum excise tax (MET) were fully implemented in the UK in May 2017 following a 12-month transition period. This paper is the first to examine effects on tobacco sales volumes and company revenues.

Methods Analysis of UK commercial supermarket and convenience store electronic point of sale data on tobacco sales. FM and RYO products’ data (May 2015–April 2018) yielded 107 572 monthly observations. Expected values from additive mixed modelling were used to calculate trends in: (1) volumes of tobacco sold overall; by cigarette type (FM and RYO) and by seven market segments; and (2) company net revenues. A 10-month period (June 2015–March 2016) before the transition to standardised packs was compared with a 10-month period after the introduction of the MET and full implementation of standardised packs (June 2017–March 2018).

Results Postimplementation, the average monthly decline in stick sales was 6.4 million (95% CI 0.1 million to 12.7 million) sticks faster than prelegislation, almost doubling the speed of decline. Sales of cheap FM brands, previously increasing, plateaued after implementation. Company monthly net revenues declined from a stable £231 million (95% CI £228 million to £234 million), prelegislation, to £198 million (95% CI £191 million to £206 million) in April 2018.

Conclusions The concurrent introduction of standardised packaging and MET in the UK was associated with significant decline in sales and in tobacco industry revenues, and the end of the previous growth in cheap cigarette brands that appeal to young and price conscious smokers.

INTRODUCTION

The tobacco industry has been able to keep low priced tobacco available for price-conscious smokers in many countries in order to encourage uptake and discourage quitting yet has continued to grow profits, even where there are rising taxes and declining sales.1–13 A growing price gap between cheap and expensive cigarettes driven by the tobacco industry’s pricing strategies is likely to have led to these outcomes.1 2 7 The tobacco industry overshifts taxes on the most expensive cigarettes to maximise profits while undershifting taxes on the cheapest to reduce the impact of tax increases on their retail price.

By mid-2017, the UK government had fully implemented two policies that may address these pricing strategies: standardised packaging14–16 for factory-made cigarettes (FM) and roll-your-own tobacco (RYO) and a minimum excise tax (MET) on FM products.17 The industry’s ability to create a price gap depends on signalling the premium connotations of its more expensive brands, and conversely indicating that other products are cheap. Standardised packaging threatens its ability to do this by reducing exposure to prosmoking imagery and branding and also increases the salience of health warnings.18 This therefore threatens the industry’s profitability model, and likely underpins the tobacco industry’s well-documented intense opposition to the policy.19 20

The MET is an addition to existing tobacco taxes: ad valorem tax on FM brands (a tax levied as a percentage of the sales value) and specific tax (tax on volume sold). The MET is an alternative method of calculating the tobacco duty payable on the cheapest FM brands where ad valorem duty might otherwise mean that total duty was lower than a specified minimum (further information on existing tobacco taxes is available elsewhere).21 Thus if a product’s price point does not ordinarily incur the level of tax required by the MET, the tobacco company has to pay the higher MET level to the government. In short, the MET effectively creates a de facto minimum price and discourages the selling of cheaper FM products.22

A previous descriptive study of linear-only trends in UK sales volumes suggested that FM sales have been falling but RYO sales have been rising in recent years, both pre-standardised packaging implementation and during standardised packaging implementation (2013–2018).23 The paper’s authors called for a more detailed analysis of the impact of standardised packaging on different market segments to understand the impact on the tobacco industry and its pricing strategies.23 This paper’s objective is to examine market segment sales volumes and company revenues surrounding the implementation of standardisation and a MET in the UK. The results of this study will be globally important as other jurisdictions consider implementing these policies.

METHODOLOGY

Data

Nielsen, a global information company, collates electronic point of sales (EPOS) data on tobacco
product sales from nearly 90% of UK supermarkets (including a
census of sales from stores owned by the largest four UK super-
market chains) and a stratified sample of 15% of convenience
stores. Nielsen then scale up collated data to develop sales and
pricing estimates for the UK overall and split into 11 geographi-
cal areas. Strata for the scaling up are based on Nett Barb TV
geography, shop/group type, and fascia (ie, chain affiliation).

Using a hierarchical structure, Nielsen records for each product
(or stock keeping unit (SKU)): the tobacco brand, brand family,
brand variant, and specific features of the pack (eg, number of
sticks (FM) or weight of contents (RYO), whether packaging is
price-marked or (for FM only) standardised, and whether sold
as a single or multipack).

For each SKU, 3 years (May 2015–April 2018) of monthly
data on volume of sales, sales prices, and extent of distribution
of sales within the 11 UK geographical areas were available.
For sample design reasons, Nielsen recommend only analysing
observations of widely distributed SKU (sold via 10% or more
retailers). We therefore excluded monthly observations that
did not reach this threshold either in the UK overall or within
a given geographical area if sales did not reach the threshold
in that area. This left 107 572 monthly observations of widely
distributed SKUs, which included 91% of total volume (further
sample details are available).21

Variables
Market segment
The tobacco industry splits its products into market segments
and has different pricing strategies for each market segment.2 7
We allocated brand variants to market segments based on our
2018 comprehensive review of the commercial literature and
analysis of Nielsen data. This identified four market segments
for FM products (premium, midprice, value, and subvalue) and
three for RYO products (premium, midprice, and value). Graphi-
cal representation of SKU prices in the prelegislative period
(May 2015–April 2016) and an updated review of the commer-
cial literature (January 2015–December 2017) were used to
revalidate this allocation. On this basis, three of 348 brand vari-
ants were moved into different market segments based on the
majority time spent in each market segment.

A few SKUs (5% of RYO and 0.1% of FM by volume) could
not be classified by market segment. The majority of these were
RYO ‘combi packs’ that included papers and filters within the
pack. Unclassified FM products were not present in all months
of the data series.

Time
Standardised packaging came into force on 20 May 2016 in
concert with the EU Tobacco Products Directive.14 15 From this
date, new packaging was required to be printed in standardised
designs but a year-long sell through period was allowed where
old branded stock could continue to be sold; thus only from
20 May 2017 were all FM and RYO products required to be
sold in standardised packages.14 The MET for FM products was
introduced on the same day (20 May 2017).17 Our dataset, a
36-month period (May 2015–April 2018), provided 1 year of
prelegislative data, 1 year of sell through data and 1 year of post
full implementation data.

Season
Tobacco sales are known to vary by season.24 Exploratory anal-
ysis of this dataset revealed low sales in January in all 3 years.

Volume
We measured volume in terms of the number of sticks of FM and
stick-equivalents of RYO sold. RYO stick equivalents were set to
a weight of 0.5 g tobacco per stick based on the latest evidence
on RYO cigarette size in the UK.9 To take into account differing
numbers of days per month and so varying opportunities to sell
tobacco, we calculated the number of sticks sold per day and
then adjusted to a monthly volume (the original scale) by multi-
plying by the average days per month (365/12).

Tobacco industry revenue
Tobacco industry revenues refer to net revenues after tobacco
taxes have been paid (ie, net price multiplied by sales), and hence
cover the manufacturing, packaging, retailing, and distribution
costs with the remainder accruing as industry profit. Revenue
was calculated in three stages. First, to allow for the variation in
pack size over time,7 we calculated price per stick (FM) or stick
equivalents (RYO) as our measure of price. To calculate stick
equivalent prices for RYO, we again used a weight of 0.5 g per
stick.9 Real prices were calculated via adjusting nominal prices
for inflation to May 2015 prices using the official UK measure of
inflation.25 Second, we calculated net revenue per stick as the
price per stick minus the taxes due on each stick. The taxes were
the tobacco taxes (specific, ad valorem, and MET) and VAT.21
Third, for each SKU, we multiplied the net price per stick by the
volume of sticks sold.

Statistical analysis
To take account of tobacco industry market segments and non-
linear effects of predictor variables including time, and to create
confidence intervals in order to understand whether patterns in
the data are noise or evidence of a significant change in outcome
variables, we estimated additive mixed models (AMM), which is
a special case of Generalised Additive Mixed Models. We used R
version 3.6.1 with the Mixed GAM Computation Vehicle with
Automatic Smoothness (mgcv) package.26 Parameter estimation
used penalised least squares. We created two models. The depen-
dent variable for the first model was volume and for the second,
tobacco industry revenue.

Point of sale data are difficult to model due to a large number
of zero sales as products come on and off the market.27 We
overcame this issue by aggregating the UK sales by market
segment and type, that is, summing over SKU for each segment
combination. Thus, in our dataset for modelling volume,
rather than each case representing a product/SKU (in a particu-
lar month and geographical area), each case represented a market
segment (in a month). In our model of tobacco industry revenue,
we were interested in the overall impact (rather than by market
segment), so in the dataset for modelling, each case represented
a month. As with volumes, revenues of the original cases were
summed to create the revenue for each month in the dataset used
for modelling.

Our dataset for analysis of volume consisted of 292 observa-
tions with each observation representing a market segment
in a particular month. The sales volume for each case was the
summed sales of all SKU sold in all geographies for that market
segment and in that month. The independent variables were
market segment $m$ and two variables related to the observation
month (detailed below): time $t$ and season $s$. The dependent
variable was volume:

$$\text{vol}_{mt} = \alpha + \text{marketsegment}_m + f_m(t) + f(s) + e_{mt}$$

We modelled:

$$\text{vol}_{mt} = \alpha + \text{marketsegment}_m + f_m(t) + f(s) + e_{mt}$$


Original research
assuming a normal distribution for errors $\varepsilon_\text{nu}$. 

Exploratory analysis showed that the trends of volume in time were non-linear. Hence, we used an AMM, as this is a flexible model, allowing the data to estimate the form of the time trend.28

Exploratory assessment of the autocorrelation function (ACF) and partial ACF showed some temporal correlation with volume—the volume sold in 1 month was similar to the volume sold in the previous month. Hence, we assumed an autoregressive process of order 1 (AR1) for the residuals of the model. Ignoring the temporal correlation may lead to a negative bias in the variance estimates and consequently too narrow confidence intervals (CIs).

Model selection (using the Akaike information criterion) showed that the best model (presented in table S1 in the online supplementary file) included smooth functions of time varying by market segment (in other words an interaction between time and segment). The function $f_m(t)$ was represented with thin plate regression spline basis.

The function $f_m(t)$ represents any effect of time on volume. Time has 36 months where month 1 is May 2015 and Month 36 is April 2018. Time is therefore a proxy for the different tax events, the introduction of standardised packaging, pricing strategies of the tobacco industry, and any other events that might have impacted volumes (eg, public health campaigns on smoking). Tax events and implementation of standardised packaging happened in the same time period so it is not possible to distinguish between these effects.

The function $f(s)$ represents a seasonal effect for time of year. Season represents a categorisation of the month of the year where month 1 is May (the first month of the data series) and month 12 is April (the last month of the data series). The effect is represented by a cyclic cubic regression spline, that is, a penalised cubic regression spline whose ends match up to second derivative.

We conducted three sensitivity tests on the effects: first including geography as a dependent variable, second including population size in the model, and third using Nielsen’s UK wide estimates rather than separate estimates for regions/devolved nations (see supplementary file for more details). Model conclusions did not change substantially.

Trend estimation using model results

Quantity of sticks sold

Estimated mean monthly sales volumes with 95% CIs (overall, by tobacco type and by market segment), across the data series, are presented in plots. CIs were calculated using the model matrix (also called the prediction matrix), estimated model coefficients, and the estimated variance covariance matrix using standard linear model theory.29

Prelegislation and postlegislation growth or decline

To provide further clarity, we explored whether month-to-month fluctuations in sales volumes (illustrated in figure 1) were on average showing rises or declines in sales prelegislation and postlegislation (overall and by tobacco type). We compared mean monthly change in sales volumes (monthly change was calculated by subtracting modelled previous month monthly sales (in sticks) from modelled sales) over two time periods.

The first time period was 10 months before the sell through period, and the second time period was the same 10 calendar months after the introduction of standardised packaging and MET. The same months (June–March) were used to reduce the impact of seasonal variations. These 10 months did not include the month immediately before the implementation or the month of implementation because changes might already have been underway.

The 95% CIs were also estimated using the model matrix, the estimated model coefficients and the estimated variance covariance matrix. The estimated model coefficients vector was multiplied with a linear combination of the model matrix for the point estimates, and their standard errors were obtained by premultiplying and postmultiplying the covariance matrix with this linear combination of the model matrix.

We also calculated the difference between mean stick sales within the two periods. If CIs did not cross zero, then a significant change had occurred.

Tobacco industry revenue model

Our dataset for revenue consisted of 36 observations with each observation representing a month. We modelled monthly revenue $r_{\text{rev}}$ for each month time $t$:

$$r_{\text{rev}} = \alpha + f(t) + \varepsilon,$$

where the function $f(t)$ is a non-linear effect for month (see online supplementary table 2). This model (table S2 in the online supplementary file) assumes normal errors.

Patient and public involvement

We led a session on standardised packaging policy with the UK Centre for Tobacco and Alcohol Studies University of Nottingham panel of smokers and former smokers (now the Tobacco & Nicotine Discussion Group) in October 2017. The group were asked to discuss their thoughts on and experiences of standardised packaging and whether they had noticed any changes to tobacco products and packs both in the sell-off period and thereafter. These discussions helped inform our research questions but were not formally part of our data analysis.

RESULTS

Sales volumes overall declined over the study period (figure 1a) from 3.29 billion sticks (95% CI 3.24 billion to 3.33 billion) in May 2015 to 3.16 billion (95% CI 3.11 billion to 3.20 billion) in April 2018. FM sales fell from 2.33 billion (95% CI 2.30 billion to 2.36 billion) to 2.04 billion (95% CI 2.01 billion to 2.07 billion), whereas RYO sales grew from 0.95 billion (95% CI 0.93 billion to 0.98 billion) to 1.12 billion (95% CI 1.09 billion to 1.15 billion).

To understand any impact of the legislation, we compare the monthly change in stick sales preimplementation and postimplementation (table 1). Overall, average monthly stick sales were lower than the previous month in both periods. The rate of decline almost doubled postlegislation. On average, the monthly decline was an extra 6.4 million (95% CI 0.1 million to 12.7 million) sticks postlegislation compared with prelegislation. FM sticks were also declining significantly faster postlegislation (extra monthly decline 9.0 million sticks (95% CI 4.3 million to
13.6 million). RYO sales were rising in both periods, and there was not significant change in the rate of growth.

Monthly sales volumes of FM premium, midprice, and value products fell significantly through the study period (figure 1b). FM premium monthly sales declined from 383 million (95% CI 373 million to 393 million) sticks in May 2015 to 224 million (95% CI 213 million to 234 million) in April 2018, FM midprice sales fell from 637 million (95% CI 624 million to 651 million)
to 324 million (95% CI 310 million to 337 million), and FM value sales fell from 902 million (95% CI 885 million to 918 million) to 692 million (95% CI 676 million to 709 million).

FM subvalue sales, however, increased significantly from 409 million (95% CI 391 million to 427 million) to 780 million (95% CI 767 million to 793 million) in July 2017 (just after full implementation of legislation), and did not increase significantly afterwards. Sales were 799 million (780 million to 817 million) in April 2018.

There was no significant change in sales of RYO premium and midprice products during the study period (figure 1c). RYO value sales grew significantly from 174 million (95% CI 161 million to 186 million) to 355 million (95% CI 343 million to 368 million).

Tobacco industry revenue
Tobacco industry monthly revenue was stable until the beginning of the sell through period (figure 2 and table S3 in the online supplementary file). Thenceforth, revenue declined steadily throughout the sell through period and post full implementation of standardised packaging.

Prelegislation, tobacco industry mean monthly net revenue was estimated to be £231 million (95% CI £228 million to £234 million) and did not vary significantly. During the sell through period, revenue declined from £233 million (£229 million to £236 million) in May 2016 to £212 million (95% CI £208 million to £216 million) in May 2017. By April 2018 (the final month of the data series), revenue had declined to £198 million (£191 million to £206 million). Thus, monthly net revenue was estimated to have declined by 13% (or £31 million) over the study period.

DISCUSSION
Standardised packaging was fully introduced concurrently with a MET in May 2017. After implementation, overall tobacco sales declined faster as did sales of FM products. There was no significant change in the growth of RYO products.

The cheapest FM cigarettes (FM subvalue brands) stopped growing post MET/standardised packaging. Our previous pricing analysis suggests that FM subvalue prices rose around the introduction of the MET such that they were then similar to FM value product prices. Although sales of the cheapest RYO products

Table 1 Change in stick sales (millions) pre and post standardised packs and MET implementation

<table>
<thead>
<tr>
<th></th>
<th>Period 1: preimplementation</th>
<th>Period 2: post full implementation</th>
<th>Difference between post and pre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>−7.0</td>
<td>−13.3</td>
<td>−6.4</td>
</tr>
<tr>
<td>FM</td>
<td>−11.5</td>
<td>−20.4</td>
<td>−9.0</td>
</tr>
<tr>
<td>RYO</td>
<td>4.5</td>
<td>7.1</td>
<td>2.6</td>
</tr>
</tbody>
</table>

FM, factory made; RYO, roll your own.
rose, the overall decline in sales implies that downtrading to the cheapest RYO did not (entirely) substitute for the disappearance of cheap FM brands. Thus, options for price conscious smokers to continue to smoke via purchasing cheap products have been limited, which has implications for improving public health and reducing health inequalities.\(^{31,32}\) There is no evidence that such smokers have turned to illicit tobacco as UK government (Her Majesty’s Revenue and Customs (HMRC)) estimates for illicit tobacco have changed little over this period.\(^{33}\)

The tobacco industry claimed that sales in Australia, the first country to introduce standardised packaging, may have risen in the short term.\(^{34}\) Our research concurs with Australian peer-reviewed research suggesting that post standardised packaging and a tax rise consumption overall fell.\(^{35}\)

An evaluation of the introduction of a MET on Spanish cigarettes found no decline in male prevalence and a small long-term, but no short term, decline in female prevalence.\(^{36}\) The lack of effect was thought to be due to switching to cheaper RYO tobacco, on which no MET had been applied. In the UK, the simultaneous introduction of standardised packaging with the MET, which mandates a RYO minimum pack size of 30 g\(^2\), may have made switching from FM to RYO less attractive in the UK. Furthermore, there were concurrent tax changes during this period that markedly increased taxes on RYO products.\(^{37}\) However, these changes have not yet been sufficient to lead to sales decline of RYO, and hence, there remains considerable scope to increase RYO taxes further.

The introduction of standardised packaging in May 2016 coincided with a decline in tobacco industry revenues. This would imply that standardised packaging has reduced revenue from the sale of an addictive deadly substance\(^{37}\) and signals why the industry has been so opposed to plain packaging.

**Strengths and limitations**

The strengths of this paper are that we were able to evaluate a policy, standardised packaging, which was brought in gradually because our GAM modelling meant we were not restricted to a simple before-and-after comparison of volume trends. We were simultaneously able to monitor impacts of tax changes, including the introduction of a MET, on volumes.

Given the late appearance of standardised packs in the implementation period,\(^{21}\) it is not possible to distinguish statistically between effects of standardised packaging, minimum pack sizes, and the four taxation changes in 2016 and 2017. Thus, our analysis generally focused on differences at the beginning and end of the analysis period rather than before and after each policy change.

Nielsen uses EPOS data to provide estimates of the UK tobacco market. The advantage of Nielsen data is that it is based on a census of sales at stores owned by the big four UK supermarkets. Nielsen estimates that 70%–80% tobacco sales are from convenience stores where Nielsen estimates are based on a sample. However, Nielsen estimates of the UK entire grocery market lie within estimates from other sources\(^{38,39}\) suggesting they are reasonable. It should, however, be noted that our dataset did not cover all tobacco-related sales. For example, it did not include sales of: RYO rolling papers and filters (unless sold within tobacco pouches); pipe tobacco; cigars and cigarillos; and sales from specialist tobacconists. Tobacconists revenue is only £454 million per year (under 2% of total FM plus RYO sales) and has declined by 9% (2013–2018), pipe tobacco is now about 0.6% of total tobacco sales, and sales of cigars and cigarillos (barely covered by standardised packaging legislation and representing 0.8% of total tobacco sales)\(^{40}\) were thought not to be growing in response to standardised packaging during the study period.\(^{41}\)

Nielsen has not provided details of how they scale up the sample data to the population level, and hence, for example, whether they use modelling. They do, however, suggest excluding low distributed products for sampling reasons. This has meant our analysis covers only about 90% of the UK cigarette market and hence that our estimates of volume and revenue are likely to be conservative. Nevertheless, they should offer reasonable insights into the changing nature of sales trends since our market coverage does not materially change during the period of analysis.

Tobacco sales volumes may also have been affected by other changes in this period. For example, Euromonitor data suggest that the value of sales of vaping products (eg, e-cigarettes) grew,\(^{42}\) although official sources suggest that prevalence of vaping in Great Britain was stable and under 6%.\(^{43}\) UK population growth during the study period (1.3 million people (2%)\(^{44}\)) may have had an impact on tobacco sales so small reductions in sales volumes translate to slightly larger reductions in terms of per capita consumption. Furthermore, some disadvantaged smokers (smokers are more disadvantaged than the general population) were having incomes squeezed by benefit freezes, benefit payment delays with the introduction of universal credit (a new income benefit), and growth in housing private rental costs.\(^{45,46}\)

Sales data provide information on products rather than smokers who purchase the product. Thus, we are unable to assess the extent to which reduced volumes were the result of...
smokers quitting as opposed to reducing consumption. Moreover, although we have described trends, and changes in trends, we cannot prove any changes were the direct result of the tobacco control legislation introduced.

Conclusions

Introducing standardised packaging and a MET was associated with a decline in tobacco sales and tobacco industry revenue. The introduction of the MET coincided with the end of sales growth in FM brands that had previously been cheapest. We therefore recommend other countries consider implementing both policies for the improvement of public health.

Correction notice This paper has been updated since first published to update authors’ order.

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Contributors All authors contributed to the research proposal, had input into the analysis and contributed substantially to redrafting. RH led the literature review, first draft of the paper, data curation, and study administration. RH contributed to the statistical analysis, data validation, and redrafting. NHA designed the statistical analysis and contributed to the first draft of the study. JRB contributed to the data validation. ABG was the principal investigator for the study and led the study design. ABG and RH are responsible for the overall content as guarantors. The corresponding author attests that all listed authors meet authorship criteria and no others meeting the criteria have been omitted.

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Competing interests JRB owns 10 shares in Imperial Tobacco for research purposes. The shares were a gift from a public health campaigner and are not held for financial gain or benefit. All dividends received are donated to tobacco/health-related charities, and proceeds from any future share sale or takeover will be similarly donated.

Patient consent for publication Not required.

Ethics approval Ethical approval was granted by the head of department of the University of Bath Department for Health, in line with University of Bath guidelines for studies which do not include human participants.

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Original research

REFERENCES


3 Branstorn JR, Gilmore AB. The case for Ofsmoke: the potential for price cap regulation of tobacco to raise £500 million per year in the UK. *Tob Control* 2014;23:45–50.


5 Gilmore AB, Reed H. The truth about cigarette price increases in Britain. *Tob Control* 2014;23:e15–16.


Original research


32 Hirono KT, Smith KE. Australia’s $40 per pack cigarette tax plans: the need to consider equity. *Tob Control* 2018;27:229–33.


