



Determinants of smoking intensity in South Africa: Evidence from township communities

Micheal Kofi Boachie*, Hana Ross

Research Unit on the Economics of Excisable Products (REEP), School of Economics, University of Cape Town, Cape Town 7700, South Africa

ARTICLE INFO

Keywords:

Smoking intensity
Cigarettes
Prices
South Africa
Low-income communities
Negative binomial

ABSTRACT

In order to analyze the smoking patterns in economically disadvantaged communities in South Africa, this paper examines the determinants of smoking intensity, using pooled data on price and non-price determinants of smoking from two cross-sectional surveys conducted in 2017 and 2018 to investigate the drivers of conditional cigarette demand among daily smokers. The analysis was done using a negative binomial regression. The results show that smokers reduce the number of cigarettes smoked daily when cigarette prices increase. The conditional price elasticity of cigarette demand of -0.295 for the overall sample shows that a 10% increase in cigarette price leads to a 2.95% decline in cigarette consumption among smokers. For young smokers, a 10% increase in cigarette price causes their smoking intensity to fall by 5%. Similar to other studies, the response of female smokers to cigarette price changes is statistically insignificant. Other factors affecting the conditional demand for cigarettes are education, race, single stick sales, gender, wealth, and age. We conclude that cigarette prices play a significant role in reducing smoking intensity among the South African poor. Since the magnitude of the price effect varies across age groups, races, and genders, the policy of higher tobacco excise taxes should be accompanied by interventions targeted at those less responsive to price-related measures.

1. Introduction

Tobacco is a unique product, killing half of its long-term users. Globally, statistics show that tobacco kills more than eight million people annually (World Health Organization, 2019). Despite the overwhelming evidence on the harmful health effects of tobacco use, there are many people around the world who still smoke. The devastating financial and health implications of tobacco use cannot be over-emphasized, both for individuals and governments (Goodchild et al., 2018; John et al., 2009; Ross et al., 2007).

In South Africa, the cost of tobacco use is between about 31–60 billion Rand annually (Boachie et al., 2019; Goodchild et al., 2018), as smoking accounts for about 9% of the country's mortality burden (Groenewald et al., 2007). In 2016, Ischaemic Heart Diseases (IHD) and Chronic Lower Respiratory Diseases (CLRD/COPD), usually caused by smoking, accounted for nearly 26,000 deaths (Statistics South Africa, 2018). For these reasons, implementing tobacco control policies is important for reducing smoking-related morbidity and mortality.

Taxation is one of the most effective tobacco control measures. Taxes that lead to higher retail prices for cigarettes reduce the number of cigarettes consumed daily, motivate people to quit smoking, and prevent young people from beginning smoking (IARC, 2011). Although

different data and methodologies have produced varying price elasticities of cigarette demand, they confirm an inverse relationship between cigarette consumption and cigarette prices (Rodríguez-Iglesias et al., 2017; Ross and Al-Sadat, 2007; Vellios and van Walbeek, 2016).

Many countries have used excise taxes to lower tobacco use (IARC, 2011; NCI, WHO, 2016), including South Africa during the 1994–2012 period. Consequently, real cigarette prices rose during that time. This resulted in large public health gains as consumption fell by 38% (Vellios and van Walbeek, 2016). Although considerable progress has been made, tobacco use, especially of cigarettes, is ubiquitous in South Africa (Drope et al., 2018).

A number of studies has investigated the determinants of cigarette demand and smoking patterns in South Africa (Strebel et al., 1989; Teare et al., 2018; van Walbeek, 2002; Vellios and van Walbeek, 2016; Mukong and Tingum, 2018), yet few of these focused specifically on low-income and deprived communities such as townships (Strebel et al., 1989; Teare et al., 2018). Given that Teare et al. (2018) and Strebel et al. (1989) do not assess the impact of cigarette prices (and by implication taxation) on consumption, we attempt to fill this gap in the literature. A recent study that looked at smoking in townships focused on illicit trade (van der Zee et al., 2020). This study seeks to uncover the effect of price and non-price factors on smoking intensity in selected

* Corresponding author.

E-mail addresses: micheal.boachie@uct.ac.za (M.K. Boachie), hana.ross@uct.ac.za (H. Ross).

low-income communities in South Africa. Given the gender and racial differences in smoking patterns (Reddy et al., 2015), we conduct our analysis by gender and race as well as age. The study focuses on townships because smoking prevalence in many of these communities is higher than the national average, with some communities reporting smoking prevalence as high as 77% (Teare et al., 2018). Secondly, townships are underdeveloped and often economically weak. With low incomes, the responsiveness to price changes in such areas can be expected to be greater than in the more affluent areas, *ceteris paribus*.

2. Methods

2.1. Data and sample

The study uses pooled data from two cross-sectional surveys of adult (≥18 years) smokers living in selected South African townships. A township or location is an apartheid-created segregated urban settlement for specific population groups: Africans, Coloreds and Asians (see Bond, 2008). These areas are usually underdeveloped. The Economics of Tobacco Control Project (ETCP), now the Research Unit on the Economics of Excisable Products (REEP), at the University of Cape Town, collected data on adult smokers in townships as one of several measures tracking the consumption of cigarettes and other tobacco products since 2017. The first survey was conducted in 2017 (October – November) and the second in 2018 (July – August) (van der Zee et al., 2020). The third round of the survey is expected around the same time in 2020. Even though the survey does not follow individuals over time, it provides valuable information about smoking patterns in the selected townships (Eldorado Park, Ivory Park, Khayelitsha, Mitchell's Plain, Thabong, and Umlazi) located in four provinces (Gauteng, Free State, Western Cape, and KwaZulu Natal). The data from these surveys have been used to contribute to the understanding of the illicit cigarette

Table 1
Characteristics of the Sample.

Variable	n	%	Mean Cigarettes per day	P-value **
Gender				
- Male	1,665	72.23	10.06	0.239
- Female	640	27.77	9.67	
Race				
- African	1562	67.77	8.92	<0.001
- Colored	743	32.23	12.10	
Education				
- None to Primary level	266	11.55	11.65	<0.001
- Some secondary	1036	44.98	10.33	
- Secondary	884	38.38	8.99	
- Tertiary	117	5.08	10.02	
Employment Status				
- Employed	849	36.98	10.59	<0.001
- Unemployed	1032	44.95	9.75	
- Not Economically Active	415	18.07	9.14	
Wealth Quintile				
- Poorest	533	23.22	10.10	0.069
- 2	395	17.21	9.19	
- 3	478	20.83	10.00	
- 4	461	20.09	9.85	
- Richest	428	18.65	10.55	
Purchase type				
- Carton/Packs of 20 #	878	38.09	12.99	<0.001
- Single cigarette †	1427	61.91	8.08	
Share Cigarettes with friends/others				
- No	1580	68.67	9.51	<0.001
- Yes	721	31.33	10.91	

Notes: # cartons make up 0.87% of this purchase; numbers may not tally due to missing data. ** Tests the null hypothesis of no difference in mean smoking intensity among various groups. † Single stick is also used to refer to single cigarette in this study.

market in South Africa (van der Zee et al., 2020).

Data collection involved random walks through the targeted townships by enumerators who selected households to interview. The random walk approach to sampling involved two steps. First, the enumerators chose a starting point in each of the communities. Afterwards, they determined in which direction they should move. Following the roads, they identified the households to visit since almost all houses were connected to a road. If the household had a smoker, the eligibility criteria was satisfied; a list of all smokers in the household was compiled and one smoker was randomly selected to be interviewed. If the household had no smokers, the enumerators proceeded to the next house. The process continued until the target of 200 smokers per township was achieved. It is important to note that the sample is not representative of all residents in townships and low-income communities, since the selection of household and townships was not probabilistic. Notwithstanding this, the study provides useful information on factors influencing smoking intensity in low-income communities.

Participation in the study was voluntary; formal consent was obtained from participants after the purpose of the survey and its intended use were explained. Respondents were asked to report the number of cigarettes they smoked daily (smoking intensity), in addition to answering other questions related to their smoking history, such as how long they had smoked (smoking duration). Smoking duration also serves as a proxy for addiction stock, which is the depreciated sum of all past cigarette consumption at the time of the survey; it captures the dependence of current consumption on past consumption (Chaloupka, 1990). Smokers were also asked about the amount they spent on each cigarette purchase and where such purchases were made, as well as the usual demographic variables (e.g., age, sex, residence, and education). Based on previously defined official population groups in South Africa, respondents reported race or group they belong to. 'African' refers to black people originating from the African continent, 'Colored' includes people of mixed Khoi, San, Malay, European and black African ancestry, 'Asian' as descendants of individuals from East Asia and the Indian subcontinent, and 'White' refers to Caucasians of European ancestry (Parry et al., 2005; Vellios and van Walbeek, 2018). Each of these population groups has its own cultural identity and its own history. They also reported whether or not they share cigarettes with friends or peers. The Ethics in Research Committee at the Faculty of Commerce, University of Cape Town, granted approval for the study, and respondents were free to withdraw from the study at any time.

A total of 2489 cigarette smokers were interviewed over the course of the two surveys. Of these, 2316 (93.05%) were daily smokers. The analysis sample in this study is restricted to daily smokers. As there is missing data on some of the variables, the sample size used in the analyses varies.

3. Descriptive statistics

Among the daily smokers interviewed, 67.77% were Africans, while Coloreds represented 32.23% of the sample. Their mean daily consumption was 8.92 and 12.10 cigarettes, respectively (see Table 1). As they provided fewer observations in the sample, Whites, Asians, and Grant holders were excluded.¹ 72.23% of the respondents were males. Half of the sample smoked more than 8 cigarettes a day, and the mean number of cigarettes smoked is 10 per day, which is slightly above the national average of ~8 (Southern Africa Labour and Development Research Unit (SALDRU), 2018)). The median duration of smoking is 15 years. The sample's characteristics are summarized in Tables 1 and 2.

Table 1 shows that the majority of smokers (56.53%) have an educational level of either 'some secondary' or lower, and that these smokers consume more cigarettes. The mean intensity for men is

¹ Grant holders are people who receive social grants from the government.

Table 2
Other Characteristics.

Township	Mean Age	Mean Smoking Duration (years)	Mean Cigarettes per day	Mean Price per cigarette
Eldorado Park	36.33 (13.76)	19.73 (12.94)	10.78 (7.52)	1.65 (0.83)
Ivory Park	33.08 (11.69)	15.02 (10.98)	9.30 (6.71)	1.85 (0.83)
Khayelitsha	33.58 (11.77)	16.25 (10.66)	9.20 (5.73)	1.65 (0.63)
Mitchell's Plain	41.00 (15.36)	24.60 (14.48)	12.94 (7.84)	1.29 (0.54)
Thabong	34.14 (13.72)	16.01 (11.62)	9.56 (7.00)	1.36 (0.79)
Umlazi	30.74 (10.83)	13.95 (10.57)	7.69 (5.80)	1.91 (0.79)
Overall	34.87 (13.35)	17.65 (12.53)	9.95 (7.01)	1.60 (0.77)

Standard deviation in parenthesis.

slightly higher (10.06) than for women (9.67). Disaggregation of the data by township indicates that the number of cigarettes smoked daily is highest in Mitchell's Plain (12.94) and lowest in Umlazi (7.69). Smoking duration and average age of smokers are also highest in Mitchell's Plain (Table 2).

The average price per single cigarette was R1.62 for the overall sample. Cigarette prices were highest in Umlazi township (R1.91 per stick), whereas Mitchell's Plain recorded the lowest average price (R1.29 per stick) (Table 2). In 2017, there was a slight (R1.18 per pack of 20 cigarettes, or R 0.059 per stick) increase in the tobacco excise tax. This consequently led to an increase in the average retail price in 2018 from R31.25 to R33.13 per pack, or from R1.56 to R1.67 per stick, inclusive of VAT (van Walbeek, 2019). However, the self-reported price data show that the average retail price per stick in the townships rose by only R0.01 during the period – an amount substantially lower than the tax increase.

4. Method of analysis

We estimate the conditional demand for cigarettes, in which the dependent variable is the number of cigarettes smoked daily, defined as smoking intensity. The independent variables include the determinants of smoking intensity — cigarette price and non-price factors. The non-price factors include gender, age, education, smoking duration (i.e., number of years smoked), whether a smoker shares cigarette with friends or not, employment status, race, and the packaging type of the purchase (single stick, carton/pack). Information on the ownership of household assets from the survey (e.g., cars and washing machines) and living conditions (e.g., access to electricity and toilets) are used to construct a household wealth index (a proxy for income). The wealth index is created using Principal Component Analysis, a method commonly used for this purpose (Dauchy and Ross, 2019; Palipudi et al., 2012).

The study employs a negative binomial regression model that estimates the log of the expected count of the dependent variable (i.e., the expected number of cigarettes smoked per day) as a function of its predictors. The model for the expected number of cigarettes consumed daily is given by equation (1):

$$E(C_i|P_i, X_i) = \exp(\varphi P_i + \beta X_i)$$

In equation (1), C_i is the number of cigarettes smoked daily, P_i is the price per cigarette and X_i represents the non-price factors affecting cigarette consumption (i.e., socioeconomic characteristics of the respondents, product features, etc.). The negative binomial regression model corrects for unobserved heterogeneity and handles overdispersion (Agresti, 2013; Jones, 2007). An exponentiated coefficient

from this regression shows the consumption rate associated with a unit change in a covariate. The Doornik-Hansen test for normality showed that cigarette consumption and price variables were not distributed normally. Price enters the regression in logarithmic form so that its coefficient is interpreted as elasticity.

One problem in demand analysis is related to endogeneity; it creates an identification problem in disentangling the consumption effect of price changes. Following the example of previous studies (Bishop et al., 2007; Nargis et al., 2014; Ross, 2004; Stoklosa et al., 2019), we dealt with the issue of price endogeneity by generating an average price per stick for each township, obtained from the self-reported prices, and used this in the regression. All smokers in a particular township would then pay the same price. For this reason, variations across townships rather than within explain smoking intensity.

Concerns with this method are that using area-specific average prices removes the variations that exist between individuals in the same geographic area, and that price changes observed across regions as a result of the averaging method may be due to differences in smokers' purchasing behavior, which is influenced by socio-economic characteristics, rather than to actual price changes (Stoklosa et al., 2019). To address these concerns, we used the exponential mean model with a control function approach (Papies et al., 2017; Petrin and Train, 2010; Wooldridge, 2015). The control function approach corrects for endogeneity of self-reported prices by using the fitted values from a first stage regression for price as an additional regressor in the demand equation (Papies et al., 2017; Petrin and Train, 2010; Wooldridge, 2015). Thus, the self-reported price is regressed on township, survey year, product characteristics, and respondent characteristics; the residual from this regression is used as an additional regressor. Stoklosa et al. (2019) also used a similar approach to address the concerns with the averaging method. Like the averaging method, the results from this approach show an inverse relationship between prices and smoking intensity; young people are more responsive to price changes than older adults. The price elasticities are, however, lower using the control function approach (see Tables 7 and 8). All coefficients are interpreted using a *ceteris paribus* assumption.

5. Results

5.1. Determinants of daily cigarette consumption

Table 3 presents the estimates of the factors influencing smoking intensity in townships. The goodness of fit of the model is satisfactory, given the significant Wald χ^2 . The likelihood ratio test indicates the presence of overdispersion of the data (Table 3). Hence, the use of negative binomial regression is appropriate. As expected, higher prices are associated with lower intensity. The coefficient of the log price, which can be interpreted as the price elasticity of cigarette demand, is negative and significant, reaching -0.295 . This elasticity, however, varies by age as it reaches -0.504 for persons aged 30 or less. The price elasticity for smokers above 30 is lower and not statistically significantly.

The effect of the wealth index on cigarette demand also varies by age group, though it is significantly negative only for young people. For the full sample, the coefficient is -0.017 , whereas it is -0.033 for youth. The coefficient of smoking duration is positive and statistically significant ($\beta = 0.015, p < 0.01$). Other significant factors influencing smoking intensity include sharing cigarettes with friends/peers, race, gender, and type of purchase. The coefficients of cigarette sharing and gender (male dummy) are positive. Also, smokers who buy cigarettes in sticks smoke less ($\beta = -0.425, p < 0.01$).

To understand how cigarette prices affect smoking intensity for different genders and races, we conduct the analysis separately for 4 groups (Table 4). The effect of price is still negative, but the results are only significant for Males and Africans.

The effect of household wealth is also negative for both groups, but

Table 3
Determinants of Smoking Intensity.

VARIABLES	All Ages	18–30 years	30 + years
Log of price	−0.295*** (0.111)	−0.504*** (0.165)	−0.039 (0.154)
Wealth Index	−0.017** (0.008)	−0.033*** (0.012)	0.002 (0.012)
Smoke duration	0.015*** (0.004)	0.015*** (0.005)	0.002 (0.002)
Age	−0.011*** (0.003)		
Gender Ref = Female			
Male	0.240*** (0.032)	0.310*** (0.049)	0.224*** (0.044)
Education Ref = None to Prim.			
Some secondary	−0.044 (0.052)	−0.090 (0.077)	−0.058 (0.065)
Secondary	−0.114** (0.056)	−0.178** (0.080)	−0.099 (0.073)
Tertiary	−0.069 (0.079)	−0.209* (0.118)	−0.016 (0.105)
Race Ref = African			
Colored	0.160*** (0.036)	0.113* (0.059)	0.245*** (0.046)
Employment Status Ref = Employed			
Unemployed	0.002 (0.030)	−0.026 (0.050)	0.051 (0.039)
Not Economically Active	−0.146*** (0.040)	−0.098 (0.061)	−0.115* (0.064)
Purchase type Ref = Carton/pack			
Single stick	−0.425*** (0.031)	−0.423*** (0.052)	−0.392*** (0.039)
Share cigarettes with others Ref = No			
Yes	0.125*** (0.030)	0.138*** (0.043)	0.115*** (0.041)
Constant	2.607*** (0.103)	2.433*** (0.147)	2.306*** (0.119)
Observations	2,249	1,053	1,196
Pseudo R ²	0.0371	0.0357	0.0299
Wald χ^2	637.7***	249.6***	282.4***
Alpha #	0.236 (0.011)	0.237 (0.015)	0.232 (0.015)
Lalpha	−1.444*** (0.046)	−1.441*** (0.064)	−1.463*** (0.065)

Standard errors in parentheses. # p < 0.01 for LR test of alpha equals zero.
*** p < 0.01, ** p < 0.05, * p < 0.1

marginally significant at conventional levels only for the categories Male, Female, and Colored. The coefficients of smoking duration, and the Colored dummy in the gender-specific regressions, are positive and statistically significant at 1%.

To test the sensitivity of the results presented in Table 3, we included the interaction between gender and race to measure the simultaneous effect of gender and race (e.g., being a Colored Male) on smoking intensity. The coefficient of this interaction term is significantly negative ($\beta = -0.168, p < 0.01$) for the full sample and for smokers above 30 years ($\beta = -0.230, p < 0.01$). Thus, the effect of gender on smoking intensity differs by race (Tables 5 and 6). For instance, compared to African males, average smoking intensity is ~12% higher among Colored males. The overall price elasticity in Table 3 decreases by 0.004, but it is still significant; the inverse relationship between consumption and price is maintained. The effect of education is significantly negative for those with a secondary level education. By age disaggregation, unemployed smokers appear to smoke a greater number of cigarettes than the employed, but this result is insignificant. The regression results for this model specification are presented in Table 5.

Table 4
Determinants of Smoking Intensity by Gender and Race.

VARIABLES	Male	Female	African	Colored
Log of price	−0.344*** (0.127)	−0.217 (0.231)	−0.274** (0.131)	−0.290 (0.216)
Wealth Index	−0.016* (0.009)	−0.028* (0.017)	−0.015 (0.009)	−0.027* (0.016)
Smoke duration	0.012*** (0.004)	0.020*** (0.007)	0.010** (0.004)	0.024*** (0.007)
Age	−0.010*** (0.004)	−0.011* (0.007)	−0.008** (0.004)	−0.017** (0.007)
Gender Ref = female				
Male			0.338*** (0.046)	0.157*** (0.046)
Education Ref = None to Prim.				
Some secondary	−0.070 (0.060)	0.034 (0.099)	−0.077 (0.065)	0.022 (0.083)
Secondary	−0.180*** (0.065)	0.070 (0.107)	−0.187*** (0.068)	0.036 (0.091)
Tertiary	−0.106 (0.088)	0.067 (0.168)	−0.067 (0.095)	−0.082 (0.140)
Race Ref = African				
Colored	0.113*** (0.043)	0.242*** (0.072)		
Employment status Ref = employed				
Unemployed	−0.016 (0.035)	0.040 (0.059)	0.008 (0.038)	−0.032 (0.051)
Not economically active	−0.169*** (0.048)	−0.120* (0.072)	−0.142*** (0.050)	−0.173** (0.068)
Purchase type Ref = Carton/pack				
Single stick	−0.400*** (0.036)	−0.481*** (0.062)	−0.396*** (0.039)	−0.464*** (0.054)
Shares cigarette with others Ref = No				
Yes	0.149*** (0.036)	0.061 (0.051)	0.180*** (0.039)	0.043 (0.043)
Constant	2.931*** (0.109)	2.351*** (0.198)	2.491*** (0.131)	2.842*** (0.152)
Observations	1,625	624	1,515	734
Pseudo R ²	0.0316	0.0570	0.0303	0.0332
Wald χ^2	380.1***	286.8***	328.9***	183.7***
Alpha	0.234 (0.013)	0.226 (0.020)	0.234 (0.013)	0.226 (0.018)
Lalpha	−1.450*** (0.054)	−1.487 (0.088)	−1.451 (0.054)	−1.489*** (0.081)

Standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1

6. Discussion

Many studies have examined price and nonprice factors linked to cigarette demand or tobacco use in South Africa. However, few studies have focused on specific vulnerable communities. This study contributes to the literature on the determinants of cigarette demand using data on smokers in economically vulnerable communities in South Africa.

Largely, the results show that price is a significant determinant of the number of cigarettes smoked daily even after controlling for other factors affecting demand. We find that cigarette demand and prices are inversely related, but that the degree of responsiveness to price changes varies according to factors such as age, gender, and race.

Specifically, the results show that a 10% increase in cigarette prices induces ~3% fall in smoking intensity for the entire sample, *ceteris paribus*. Young people reduce their consumption by 5%, while older adults are less responsive to price changes. This result is consistent with the literature on cigarette demand (Bishop et al., 2007; Vellios and van

Table 5
Determinants of Smoking Intensity.

VARIABLES	All ages	18–30 years	30 + years
Log of price	−0.291*** (0.111)	−0.500*** (0.165)	−0.056 (0.152)
Wealth index	−0.018** (0.008)	−0.033*** (0.012)	0.003 (0.012)
Smoke duration	0.015*** (0.004)	0.015*** (0.005)	0.002 (0.002)
Age	−0.011*** (0.003)		
Gender Ref = Female			
Male	0.328*** (0.046)	0.322*** (0.062)	0.362*** (0.067)
Education Ref = None to Prim.			
Some secondary	−0.044 (0.052)	−0.090 (0.077)	−0.058 (0.064)
Secondary	−0.116** (0.056)	−0.178** (0.080)	−0.103 (0.073)
Tertiary	−0.071 (0.079)	−0.211* (0.117)	−0.016 (0.105)
Employment Ref = Employed			
unemployed	0.002 (0.030)	−0.026 (0.050)	0.052 (0.038)
Not economically active	−0.149*** (0.040)	−0.098 (0.061)	−0.119* (0.064)
Purchase type Ref = carton/pack			
Single stick	−0.418*** (0.031)	−0.422*** (0.052)	−0.382*** (0.039)
Share cigarettes with others Ref = No			
Yes	0.123*** (0.029)	0.138*** (0.044)	0.113*** (0.040)
Racial Group Ref = African			
Colored	0.278*** (0.059)	0.134 (0.089)	0.404*** (0.080)
Gender*Race			
Male*Colored	−0.168*** (0.065)	−0.030 (0.102)	−0.230*** (0.087)
Constant	2.526*** (0.106)	2.420*** (0.153)	2.191*** (0.127)
Observations	2,249	1,053	1,196
Pseudo R ²	0.0376	0.0357	0.0310
Wald χ^2	645.5***	251.8***	294.1
Alpha	0.235 (0.011)	0.237 (0.015)	0.230 (0.015)
Lalpha	−1.448*** (0.046)	−1.441*** (0.064)	−1.471*** (0.065)

Standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.

Table 6
Predicted number of cigarettes smoked daily based on gender and race.

Group	Margin	Std. Err.	Z	95% CI
Gender				
Female	8.202	0.224	36.61	7.763 8.641
Male	10.607	0.181	58.53	10.252 10.962
Race				
African	9.308	0.179	52.09	8.958 9.658
Colored	10.817	0.300	36.02	10.228 11.406
Gender*Race				
Female, African	7.312	0.319	22.91	6.686 7.937
Female, Colored	9.652	0.340	28.41	8.986 10.317
Male, African	10.169	0.206	49.37	9.765 10.573
Male, Colored	11.320	0.384	29.45	10.567 12.073

Based on the full sample in Table 5.

Table 7
Determinants of Smoking Intensity.

VARIABLES	All ages	18–30 years	31 + years
Log of price	−0.122*** (0.028)	−0.156*** (0.044)	−0.097*** (0.036)
Wealth Index	−0.010 (0.008)	−0.025** (0.011)	0.009 (0.012)
Smoke duration	0.014*** (0.004)	0.017*** (0.005)	0.000 (0.002)
Age	−0.011*** (0.003)		
Gender Ref = Female			
Male	0.234*** (0.032)	0.302*** (0.049)	0.220*** (0.043)
Education Ref = None to Prim.			
Some secondary	−0.035 (0.054)	−0.058 (0.082)	−0.049 (0.066)
Secondary	−0.108* (0.057)	−0.146* (0.085)	−0.099 (0.072)
Tertiary	−0.049 (0.082)	−0.164 (0.122)	−0.002 (0.109)
Race Ref = African			
Colored	0.180*** (0.034)	0.173*** (0.052)	0.226*** (0.044)
Employment Status Ref = Employed			
Unemployed	−0.018 (0.031)	−0.028 (0.050)	0.033 (0.040)
Not Economically Active	−0.148*** (0.040)	−0.067 (0.062)	−0.120* (0.063)
Purchase type Ref = Carton/pack			
Single stick	−0.426*** (0.032)	−0.428*** (0.053)	−0.390*** (0.040)
Share cigarette with others Ref = No			
Yes	0.130*** (0.030)	0.138*** (0.045)	0.126*** (0.041)
Constant	2.527*** (0.093)	2.196*** (0.116)	2.355*** (0.098)
c_inprice	0.104* (0.054)	0.067 (0.081)	0.168** (0.074)
Observations	2,207	1,029	1,178

residual term to correct for price endogeneity. Standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1

Walbeek, 2016; Ross, 2004). Since older people are often economically stronger, cigarette expenditure is likely to be a smaller proportion of their disposable incomes and therefore may not be as responsive to changes in price. A higher degree of addiction as a result of a longer smoking history may also make price increases less effective in fighting cigarette use among older people (NCI, WHO, 2016).

Further, a 10% increase in price reduces the number of cigarettes smoked among men by 3.4%, while the negative effect of price is insignificant for women. This is analogous to findings from an initiation study in South Africa (Vellios and van Walbeek, 2016). Earlier studies such as Chaloupka (1990) also found that changes in prices did not influence cigarette use among women in the US. In Italy and Russia, on the other hand, women were found to be more responsive to price than men (Aristei and Pieroni, 2009; Ogloblin and Brock, 2003). Ross et al. (2008) attributed this to men smoking cheaper brands of cigarettes. This may not be the case in this study, as the average price paid by males is higher. Plausibly, men provide women with cigarettes, especially in pubs and bars where the norm is for men to pay the bills. The results also show that price is not a significant predictor of smoking intensity among Coloreds. Cigarettes may be more affordable to Coloreds who are relatively better off than Africans. Among Africans, a 1% increase in cigarette price reduces consumption by 0.27%, *ceteris*

Table 8
Determinants of Smoking Intensity by Gender and Race (CF Approach).

VARIABLES	Male	Female	African	Colored
Log of price	-0.124*** (0.033)	-0.135*** (0.051)	-0.102*** (0.034)	-0.186*** (0.047)
Wealth Index	-0.008 (0.010)	-0.020 (0.017)	-0.009 (0.009)	-0.014 (0.017)
Smoke duration	0.010*** (0.004)	0.020*** (0.007)	0.009** (0.004)	0.022*** (0.007)
Age	-0.010*** (0.004)	-0.012** (0.006)	-0.007* (0.004)	-0.018*** (0.006)
Gender				
Ref = Female				
Male			0.338*** (0.045)	0.128*** (0.046)
Education				
Ref = None to Prim.				
Some secondary	-0.070 (0.061)	0.063 (0.098)	-0.065 (0.065)	0.033 (0.085)
Secondary	-0.182*** (0.066)	0.087 (0.105)	-0.171** (0.069)	0.041 (0.093)
Tertiary	-0.095 (0.092)	0.115 (0.170)	-0.039 (0.097)	-0.075 (0.148)
Race				
Ref = African				
Colored	0.128*** (0.040)	0.257*** (0.065)		
Employment Status				
Ref = Employed				
Unemployed	-0.037 (0.036)	0.030 (0.059)	0.000 (0.038)	-0.080 (0.051)
Not Economically Active	-0.172*** (0.048)	-0.108 (0.074)	-0.135*** (0.050)	-0.186*** (0.067)
Purchase type				
Ref = Carton/pack				
Single stick	-0.397*** (0.037)	-0.480*** (0.062)	-0.392*** (0.040)	-0.469*** (0.053)
Share cigarette with others				
Ref = No				
Yes	0.155*** (0.036)	0.063 (0.052)	0.186*** (0.039)	0.036 (0.044)
Constant	2.823*** (0.097)	2.315*** (0.176)	2.380*** (0.115)	2.876*** (0.149)
c_Inprice #	0.124* (0.068)	0.043 (0.098)	0.121** (0.061)	-0.003 (0.104)
Observations	1595	612	1484	723

residual term to correct for price endogeneity. Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

paribus.

The study also finds that an improvement in household wealth significantly reduces smoking intensity in the overall sample and among young adults. This implies that a unit increase in the wealth index reduces the expected number of cigarettes smoked daily by 1.69% for all ages, while consumption declines by 3.2% among young people. This suggests that a cigarette is an inferior good among smokers in the townships studied.

Consistent with the literature, conditional cigarette consumption is influenced by addiction stock. People who have smoked for longer period smoke more; this is true for all groups. The results indicate that each additional year of smoking increases smoking intensity by 1.5% (see Table 3). Aristei and Pieroni (2009) found addiction to be a key driver of smoking intensity. Overall, males smoke between 27% and 36% more than females (Table 3). In many African settings, cultural norms favor men. This may be one of the reasons why males smoke more than females.

It is expected that educated people would have more access to information about the health hazards of smoking. This exposure to information is expected to reduce smoking among the educated, and this is the case in the townships. From Table 3, we find that smokers with a

secondary-level education smoke between 11% and 16% fewer cigarettes than those with a primary-level or no education, while higher levels of education, i.e., tertiary education, are insignificantly associated with smoking intensity. Since educated people are less likely to initiate smoking (Vellios and van Walbeek, 2016), once they decide to smoke the effect of education on intensity may be smaller. This could be the reason for the insignificant negative effect of tertiary education on smoking intensity. The small number of smokers with tertiary education in the sample may also explain the results.

There are racial differences in smoking intensity in townships. Results from the full sample suggest that Coloreds smoke 17% more than Africans (see Table 3). The percentage is even higher among older adults. When the sample is restricted to only Coloreds, we find that Colored males smoke 17% more than their female counterparts (Table 4). For the African group, the regression results show that males smoke 40% more than females. The African culture makes it less acceptable for females to smoke, which may explain gender differences in smoking. In Nigeria, for instance, cigarettes, cured tobacco leaves, and snuff are provided to men alone during traditional ceremonies. Smoking is more acceptable among men, while some communities believe that a woman is not supposed to smoke (Egbe et al., 2014; Egbe et al., 2013). Further, the results in Table 4 indicate that smoking intensity is ~12% higher among Colored males than among African males, whereas Colored females smoke 27% more than African females. The number of cigarettes smoked daily predicted by the regression with gender and race interacted showed similar patterns (see Table 6). Smoking intensity is higher among Coloreds and this may explain why they are less responsive to price changes. In addition, Coloreds are economically relatively stronger than Africans. In fact, our wealth index by population group (not reported) shows that only 11% of Coloreds were in the poorest group, compared to 24% of Africans. Within the South African population, approximately 64% and 41% of Africans and Coloreds, respectively, are living in poverty (Statistics South Africa, 2017).

Single cigarette sales are associated with lower smoking intensity. This is true for all categories: age, race, and gender. The results for the full sample suggest that smokers who buy single sticks smoke 35% less relative to smokers who buy cigarettes in cartons and/or packs. Heavy smokers often purchase cigarettes in bulk, pay a lower price, and as a result smoke more. On the other hand, smokers who would like to quit may want to control the number of cigarettes consumed, and therefore purchase single sticks (Stillman et al., 2007; Thrasher et al., 2009). At the same time, many smokers in our sample were too poor to be able to afford to buy cigarettes by packs/cartons. This may explain the results. Notwithstanding its negative effect on smoking intensity, allowing single-stick sales may inhibit tobacco control, since such sales give young people and low-income individuals an opportunity to initiate or continue smoking (Thrasher et al., 2011).

The results on the sharing of cigarettes with peers/friends suggest that smoking intensity increases with cigarette sharing, and the effect is statistically significant for the entire sample. Individuals who share cigarettes may do so within their social networks and may expect such gestures from other smokers. These smokers would still be able to smoke even if they cannot afford to buy cigarettes as they can rely on the generosity of other smokers.

7. Conclusions

Understanding the factors that drive tobacco use is essential for an effective tobacco-control policy. In this regard, we examined the factors determining smoking intensity among smokers in South African townships. The results corroborate the existing literature on cigarette demand. Smokers are sensitive to price changes. The effect is, however, confined to young people, particularly males. Older people, females, and Coloreds are less responsive to changes in cigarette prices. Single stick sales, cigarette sharing, and addiction are some of the factors

influencing smoking intensity.

The results have important policy implications for tobacco control. First, a tax policy that significantly raises cigarette prices is still an effective tobacco-control measure in South Africa. Higher tobacco taxes that result in higher prices motivate many poorer smokers to reduce their smoking intensity. As the literature on cigarette demand shows, this would enhance their likelihood of quitting while also dissuading others from initiating. It is acknowledged that smoking fewer cigarettes has limited health benefits (Oelsner et al., 2019). However, smoking fewer cigarettes may increase the likelihood of quitting. Recognizing that the magnitude of the price effect varies across age groups, races, and genders, the policy of higher tobacco excise taxes should be accompanied by interventions targeted at those less responsive to price-related measures.

Smokers with a secondary-level education smoke less than those with educational levels below secondary level. Although there is an inverse relationship between single-stick purchases and smoking intensity, such sales must be controlled as they undermine tobacco control measures; single-stick sales offer young people an opportunity to experiment and they may then find it difficult to quit.

Some limitations must be noted when interpreting the results. First, selecting townships and households in a non-probabilistic manner may produce a sample that is not representative of all township communities and residents; this makes the sample less representative, which could bias the results. Additionally, the quality of survey data partly depends on the respondent's ability to recall past information accurately. The inability to recall past information correctly may lead to missing data and measurement errors in some of the variables, for instance consumption and price. Unlike measurement errors in cigarette consumption (dependent variable), errors in cigarette prices (regressor) may bias the consumption effect of price changes. Though township-specific average prices reduce the endogeneity problem, they remove much of the variation in the prices paid by individuals in the same township. Some of the analyses are also limited by a smaller sample size (e.g., the number of Coloreds and females). While these issues may affect the results, this study provides a general picture of how price and non-price factors influence smoking intensity in low-income South African communities.

CRedit authorship contribution statement

Micheal Kofi Boachie: Conceptualization, Methodology, Formal analysis, Writing - original draft, Project administration. **Hana Ross:** Conceptualization, Methodology, Writing - review & editing, Supervision, Funding acquisition, Project administration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This research was supported by the International Development Research Centre under the Global Alliance for Chronic Diseases research programme (grant ID number: 108442-002 and IRMA 25761) and Cancer Research UK (grant ID number: C62640/A24723 and IRMA 25171). We are thankful to Corné van Walbeek and other members of the REEP team for valuable comments.

References

Agresti, A., 2013. *Categorical Data Analysis Third Edition* ed. John Wiley & Sons, Inc, Hoboken, New Jersey.

Aristei, D., Pieroni, L., 2009. *Addiction, social interactions and gender differences in*

- cigarette consumption. *Empirica* 36, 245–272.
- Bishop, J.A., Haiyong, L., Qi, M., 2007. Are Chinese smokers sensitive to price? *China Econ. Rev.* 18, 113–121.
- Boachie, M.K., Rossouw, L., Ross, H., 2019. The Economic Cost of Smoking in South Africa, 2016. Biennial Conference of the Economic Society of South Africa, 2019, Johannesburg.
- Bond, P., 2008. Townships. *International Encyclopedia of the Social Sciences*, 2nd ed. Macmillan Reference USA, pp. 405–407.
- Chaloupka, F.J., 1990. Men, women, and addiction: the case of cigarette smoking. National Bureau of Economic Research.
- Dauchy, E., Ross, H., 2019. The Effect of Price and Tax Policies on the Decision to Smoke among Men in Kenya. *Addiction* 114, 1249–1263.
- Drope, J., Schluger, N., Cahn, Z., Drope, J., Hamil, S., Islami, F., Liber, A., Nargis, N., Stoklosa, M., 2018. The Tobacco Atlas, in: *Strategies*, A.C.S.a.V. (Ed.), 6 ed. American Cancer Society, Inc, Atlanta.
- Egbe, C.O., Meyer-Weitz, A., Asante, K.O., Petersen, I., 2014. “A woman is not supposed to smoke”: exploring gendered stereotypes in smoking patterns in a Nigerian setting. *J. Psychol.* 5, 1–7.
- Egbe, C.O., Petersen, I., Meyer-Weitz, A., 2013. Community participation in tobacco control in a Nigerian setting. *J. Psychol. Afr.* 23, 311–315.
- Goodchild, M., Nargis, N., d'Espaignet, E.T., 2018. Global economic cost of smoking-attributable diseases. *Tobacco Control* 27, 58–64.
- Groenewald, P., Vos, T., Norman, R., Laubscher, R., Van Walbeek, C., Saloojee, U., Sitas, F., Bradshaw, D., Collaboration, S.A.C.R.A., 2007. Estimating the burden of disease attributable to smoking in South Africa in 2000. *S. Afr. Med. J.* 97, 674–681.
- IARC, 2011. In: *IARC Handbooks of Cancer Prevention, Tobacco Control*, vol. 14. Effectiveness of tax and price policies for tobacco control. International Agency for Research on Cancer, Lyon, France.
- John, R., Sung, H., Max, W., 2009. Economic cost of tobacco use in India, 2004. *Tobacco Control* 18, 138–143.
- Jones, A., 2007. *Applied econometrics for health economists: A practical guide*, 2 ed. Radcliffe Publishing Ltd.
- Mukong, A., Tingum, E., 2018. The demand for cigarettes: new evidence from South Africa. Cape Town: SALDRU UCT. (SALDRU Working Paper No. 227).
- Nargis, N., Ruthbah, U.H., Hussain, A.G., Fong, G.T., Huq, I., Ashiquzzaman, S., 2014. The price sensitivity of cigarette consumption in Bangladesh: evidence from the International Tobacco Control (ITC) Bangladesh Wave 1 (2009) and Wave 2 (2010) Surveys. *Tobacco Control* 23, i39–i47.
- NCI/WHO, 2016. *The Economics of Tobacco and Tobacco Control*. National Cancer Institute Tobacco Control Monograph 21. NIH Publication No. 16-CA-8029A.
- Oelsner, E.C., Balte, P.P., Bhatt, S.P., Cassano, P.A., Couper, D., Folsom, A.R., Freedman, N.D., Jacobs Jr, D.R., Kalhan, R., et al., 2019. Lung function decline in former smokers and low-intensity current smokers: a secondary data analysis of the NHLBI Pooled Cohorts Study. *The Lancet. Respir. Med.*
- Ogloblin, C., Brock, G., 2003. Smoking in Russia: the ‘Marlboro Man’ rides but without ‘Virginia Slims’ for now. *Comparati. Econ. Stud.* 45, 87–103.
- Palipudi, K.M., Gupta, P.C., Sinha, D.N., Andes, L.J., Asma, S., McAfee, T., Group, G.C., 2012. Social determinants of health and tobacco use in thirteen low and middle income countries: evidence from Global Adult Tobacco Survey. *PLoS ONE* 7, e33466.
- Papies, D., Ebbes, P., Van Heerde, H.J., 2017. Addressing endogeneity in marketing models. *Advanced methods for modeling markets*. Springer, pp. 581–627.
- Parry, C.D., Plüddemann, A., Steyn, K., Bradshaw, D., Norman, R., Laubscher, R., 2005. Alcohol use in South Africa: findings from the first Demographic and Health Survey (1998). *J. Stud. Alcohol* 66, 91–97.
- Petrin, A., Train, K., 2010. A control function approach to endogeneity in consumer choice models. *J. Market. Res.* 47, 3–13.
- Reddy, P., Zuma, K., Shisana, O., Jonas, K., Sewpaul, R., 2015. Prevalence of tobacco use among adults in South Africa: results from the first South African National Health and Nutrition Examination Survey. *S. Afr. Med. J.* 105, 648–655.
- Rodríguez-Iglesias, G., Schoj, V., Chaloupka, F., Champagne, B., González-Rozada, M., 2017. Analysis of cigarette demand in Argentina: the impact of price changes on consumption and government revenues. *salud pública de méxico* 59, 95–101.
- Ross, H., 2004. The Ukraine (Kiev) 1999 global youth tobacco survey: economic issues. HNP DISCUSSION PAPER: Economics of Tobacco Control Paper No. 20.
- Ross, H., Al-Sadat, N.A., 2007. Demand analysis of tobacco consumption in Malaysia. *Nicot. Tobacco Res.* 9, 1163–1169.
- Ross, H., Shariff, S., Gilmore, A., 2008. Economics of tobacco taxation in Russia. Paris: International Union Against Tuberculosis and Lung Disease 4-5.
- Ross, H., Trung, D.V., Phu, V.X., 2007. The costs of smoking in Vietnam: the case of inpatient care. *Tobacco Control* 16, 405–409.
- Southern Africa Labour and Development Research Unit (SALDRU), 2018. *National Income Dynamics Study 2017, Wave 5*. Version 1.0.0. Southern Africa Labour and Development Research Unit, Cape Town.
- Statistics South Africa, 2017. *Poverty trends in South Africa: An examination of absolute poverty between 2006 and 2015*. Statistics South Africa, Pretoria.
- Statistics South Africa, 2018. *Mortality and causes of death in South Africa, 2016: Findings from death notification*. Statistics South Africa Pretoria, South Africa.
- Stillman, F.A., Bone, L., Avila-Tang, E., Smith, K., Yancey, N., Street, C., Owings, K., 2007. Barriers to smoking cessation in inner-city African American young adults. *Am. J. Public Health* 97, 1405–1408.
- Stoklosa, M., Goma, F., Nargis, N., Drope, J., Chelwa, G., Chisha, Z., Fong, G.T., 2019. Price, tax and tobacco product substitution in Zambia. *Tobacco control:tobaccocontrol-2017-054037*.
- Strebel, P., Kuhn, L., Yach, D., 1989. Determinants of cigarette smoking in the black township population of Cape Town. *J. Epidemiol. Community Health* 43, 209–213.
- Teare, J., Naicker, N., Albers, P., Mathee, A., 2018. Prevalence of tobacco use in selected

- Johannesburg suburbs. *S. Afr. Med. J.* 108, 40–44.
- Thrasher, J.F., Villalobos, V., Barnoya, J., Sansores, R., O'Connor, R., 2011. Consumption of single cigarettes and quitting behavior: A longitudinal analysis of Mexican smokers. *BMC Public Health* 11, 134.
- Thrasher, J.F., Villalobos, V., Dorantes-Alonso, A., Arillo-Santillán, E., Cummings, K.M., O'Connor, R., Fong, G.T., 2009. Does the availability of single cigarettes promote or inhibit cigarette consumption? Perceptions, prevalence and correlates of single cigarette use among adult Mexican smokers. *Tobacco Control* 18, 431–437.
- van der Zee, K., Vellios, N., van Walbeek, C., Ross, H., 2020. The illicit cigarette market in six South African townships. *Tobacco Control* 1–8. <https://doi.org/10.1136/tobaccocontrol-2019-055136>.
- van Walbeek, C., 2002. Tobacco epidemic can be reversed: tobacco control in South Africa during the 1990s. Applied Fiscal Research Centre, University of Cape Town, Cape Town, ZA.
- van Walbeek, C., 2019. South Africa time series data for cigarettes [Dataset]. Research Unit on Economics of Excisable Products (REEP), [producer], 2019. Cape Town.
- Vellios, N., van Walbeek, C., 2016. Determinants of regular smoking onset in South Africa using duration analysis. *BMJ Open* 6, e011076.
- Vellios, N., van Walbeek, C., 2018. Self-reported alcohol use and binge drinking in South Africa: Evidence from the National Income Dynamics Study, 2014–2015. *S. Afr. Med. J.* 108, 33–39.
- Wooldridge, J.M., 2015. Control function methods in applied econometrics. *J. Human Resour.* 50, 420–445.
- World Health Organization, 2019. Tobacco. World Health Organization <https://www.who.int/news-room/fact-sheets/detail/tobacco> (Accessed: 18 Oct 2019).