Area-level differences in the prices of tobacco and electronic nicotine delivery systems — A systematic review

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ABSTRACT

Objective: To examine associations between area-level characteristics (socioeconomic status, racial or ethnic characteristics, age, and any other characteristics that may be associated with vulnerability) and the prices of tobacco products and electronic nicotine delivery systems (ENDS).

Data sources: We searched MEDLINE, EconLit and Scopus, unpublished and grey literature, hand-searched four specialty journals, examined references of relevant studies, and contacted key informants.

Study selection: We considered all studies that quantitatively examined area-level variations in the prices of tobacco products and ENDS. We included all studies that examined any area-level measures regardless of the geographic location, language or time of publication. At least two reviewers independently screened the articles. We identified 20 studies.

Data extraction: At least two reviewers independently extracted the characteristics, methods, and main results and assessed the quality of each included study.

Data synthesis: Overall, cigarette prices were found to be lower in lower socioeconomic status neighbourhoods, and in neighbourhoods with a higher percentage of youth, and Blacks or African Americans. We identified too few studies that examined price differences for cigarillos, chewing tobacco, roll-your-own, and ENDS to reach any conclusions.

Conclusions: Our findings are in keeping with tobacco industry documents that detailed how manufacturers used race, class, and geography to target vulnerable populations and suggest that regulations that can limit industry price manipulation such as minimum, maximum, and uniform prices, and high specific excise taxes should be considered. More frequent and systematic monitoring of tobacco prices and ENDS is warranted.

1. Introduction

There is overwhelming evidence that higher tobacco prices reduce tobacco use and that young people and those from more socioeconomically disadvantaged groups tend to be more sensitive to price changes (International Agency for Research on Cancer, 2011; US National Cancer Institute and World Health Organization, 2016). Consequently, vulnerable groups such as the young and the poor may be more susceptible to strategies that make tobacco products more affordable. Associations between individual socioeconomic status (SES) and smoking are well documented (Hiscock et al., 2012). There is also ample research that suggests area-level characteristics, such as household income, have an independent effect on individual smoking even after taking into account individual-level characteristics such as SES (Duncan et al., 1998; Reijneveld, 1998, 2002; Ross, 2000; Chuang et al., 2005; Cohen et al., 2011; Corsi et al., 2012; Karriker-Jaffe, 2013). While overall smoking prevalence has fallen over time in high-income countries, SES differences in smoking uptake, smoking prevalence and cessation have remained the same or even increased (Bosdriesz et al., 2015; Green et al., 2016; Drope et al., 2018; Tabuchi et al., 2018).

A comprehensive review of smoking and SES concluded that increasing the price of tobacco products was likely the tobacco control intervention with the greatest potential to reduce health inequalities from tobacco use (Hiscock et al., 2012). As a response to more
comprehensive marketing restrictions (e.g., prohibition of all tobacco advertising, promotion, and sponsorship, including point-of-sale and plain/standardized packaging), the tobacco industry has increasingly focused its attention on the use of price as a marketing tool (Henriksen, 2012). Surprisingly, little seems to be known about area-level (i.e., neighbourhood) variation in the price of tobacco products. A broader 2015 systematic review of neighbourhood disparities in point-of-sale tobacco marketing identified eight studies (Toomey et al., 2009; Seidenberg et al., 2010; McCarthy et al., 2011; Henriksen et al., 2012; Cantrell et al., 2013; Dalglish et al., 2013; Burton et al., 2014; Lipperman-Kreda et al., 2014) that specifically studied area-level differences in the prices of tobacco; results specific to prices, however, were not disaggregated from the other types of marketing (outside of the appendix evidence table) (Lee et al., 2015a).

To fill this research gap, we systematically searched for and critically reviewed studies that examined associations between area-level characteristics and the prices of tobacco products. Additionally, given the rapid increase in the use of electronic nicotine delivery systems (ENDS) which can provide a pathway to the cessation of tobacco use, but can also increase the risk of young non-smokers becoming addicted to nicotine, we also searched for and critically reviewed studies that examined associations between area-level characteristics and the prices of ENDS (McNeill et al., 2018; Yoong et al., 2018; Livingston et al., 2019).

2. Methods

We used an ‘a priori’ design but were unable to register our review to PROSPERO (an international database of prospectively registered systematic reviews) because our review does not have any health-related outcomes. Key information about our ‘a priori’ design which closely follows PROSPERO’s template is presented in the appendix.

Search. We searched MEDLINE, EconLit and Scopus (see appendix for more details). We searched unpublished and grey literature via the New York Academy of Medicine Grey Literature Report, Open Grey, Google, and Google Scholar, and hand-searched four specialty journals (Addiction, Health & Place, Nicotine & Tobacco Research and Tobacco Control). We examined reference lists of relevant reviews and individual studies that we identified and examined studies that cited key papers using Thomson Reuters Web of Science and Google Scholar. Finally, we contacted four key informants to ensure that our search strategy captured all relevant studies. The database search was last updated on 12 May 2020. At least two reviewers, using distillerSR, screened titles and abstract of the search, yielding 16 studies that met all inclusion criteria. An additional study was identified after contacting key informants and one after searching reference lists of included studies (Fig. 1). Out of the 20 studies, three were from Australia (McCarthy et al., 2011; Dalglish et al., 2013; Burton et al., 2014), one from Scotland (Shortt et al., 2020) and 16 were from the United States (Toomey et al., 2009; Seidenberg et al., 2010; Henriksen et al., 2012, 2016, 2017; Cantrell et al., 2013, 2015; Lipperman-Kreda et al., 2014; Resnick et al., 2012; Lee et al., 2015b; Schleicher et al., 2015; Laestadius et al., 2018; Mills et al., 2018, 2019; Epperson et al., 2019; Kephart et al., 2019), of which four were conducted nationally, (Resnick et al., 2012; Lee et al., 2015b; Mills et al., 2018, 2019), one both nationally and in California (Henriksen et al., 2016), five in California (Henriksen et al., 2012, 2017; Lipperman-Kreda et al., 2014; Schleicher et al., 2015; Epperson et al., 2019), two in Washington DC (Cantrell et al., 2013, 2015), one in Wisconsin (Laestadius et al., 2018), one in Minnesota (Toomey et al., 2009) and two in Massachusetts (Seidenberg et al., 2010; Kephart et al., 2019). The first study was published in 2009 and presented data from the Minneapolis-St. Paul metropolitan area collected in 2002 (Toomey et al., 2009). The most recent study was published in 2020 and presented Scottish data from April 2018 (Shortt et al., 2020). A list of excluded studies and reasons for exclusion is provided in the appendix.

Among the 20 studies, six assessed area-level variation at the neighbourhood level, four in census blocks, four in census tracts, two using postcodes, and the remaining using suburbs (n = 1), city (n = 1), communities (n = 1), or geopolitics units (n = 1) as the area unit. We

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1 Main results were synthesized graphically and presented by neighbourhood characteristics for all four components (grouped together) of point-of-sale tobacco marketing: price (advertised price, price discounts, or price promotions), promotion, product, and placement.

2 ENDS are battery-powered portable electronic devices that heat liquid (known as e-liquid or e-juice) containing nicotine or heat real tobacco leaves (heat-not-burn products) and generates vapour that is inhaled by the user (vaping). The experience simulates smoking a cigarette and the ENDS may or may not look like a cigarette (e-cigarette) (Glasser et al., 2017; National Academies of Sciences et al., 2018).
identified 19 studies that reported area-level differences in cigarette prices. Most studies (18 of 19) reported on cigarette pack price (single and/or multipack, premium and/or menthol, and/or cheapest pack). We also identified five studies that examined area-level differences in the prices of other tobacco products (little cigars/cigarillos [n = 3], chewing tobacco [n = 1], and roll-your-own [n = 1]), and two studies that examined electronic nicotine delivery systems (ENDS). Table 1 presents a summary of study characteristics and limitations (last column). eTables 1-3 presents a synthesis of main findings organized by area-level characteristics: SES, race/ethnicity, and youth. Detailed data extracted for each study are presented in the appendix.

Most studies did not examine area-level SES, racial/ethnic, and youth compositions in isolation. Consequently, correlation between area-level variables such as SES and racial/ethnic composition can affect both the magnitude and statistical significance of estimated associations (i.e., when explanatory variables are highly correlated, most of their variation is common to both variables, leaving little variation unique to each variable) (Kennedy, 2003). Fig. 2 presents results that, when applicable, included multiple area-level measures such as SES, racial/ethnic, and youth compositions while adjusting for other variables such as type of stores and retailer density.

Fig. 2 shows the count of results that showed a negative, unclear, and positive association between neighbourhood characteristics (SES, racial/ethnic composition, youth composition) and cigarette prices. The top panel uses an individual study as the unit of analysis while the bottom panel uses an association between one area-level characteristic and one product as the unit of analysis. In Fig. 2, and in the discussion below, we treat a study that both explored US (2012) and California (2014) as two independent studies (Henriksen et al., 2016). We first discuss associations between cigarette prices and SES characteristics and, racial/ethnic and youth composition of the area unit. We then discuss area-level differences in the prices of little cigars/cigarillos, chewing tobacco, roll-your-own, and ENDS.

3.1. Cigarettes

**Socioeconomic status.** 17 studies reported on the association between cigarette prices and SES characteristics of the area unit (Seidenberg et al., 2010; McCarthy et al., 2011; Henriksen et al., 2012, 2016, 2017; Dalglish et al., 2013; Burton et al., 2014; Lipperman-Kreda et al., 2014; SHORTT et al., 2020; Cantrell et al., 2015; Lee et al., 2015b; Schleicher et al., 2015; Mills et al., 2018, 2019; Epperson et al., 2019; Kephart et al., 2019). SES was primarily measured using median household income; one study utilized the proportion of students eligible to receive free or reduced priced lunches as a measure of school SES (Henriksen et al., 2012), and four studies used indices for socioeconomic advantages and/or disadvantages (McCarthy et al., 2011; Dalglish et al., 2013; Burton et al., 2014; SHORTT et al., 2020). Amongst the 17 studies, 15 found that prices were generally lower in lower-SES areas (11 of which were statistically significantly different at the 5% level). Two studies found unclear associations between tobacco prices and SES, while no study concluded that prices were higher in lower-SES areas.

identified a study that both explored US (2012) and California (2014) as two independent studies (Henriksen et al., 2016). We first discuss associations between cigarette prices and SES characteristics and, racial/ethnic and youth composition of the area unit. We then discuss area-level differences in the prices of little cigars/cigarillos, chewing tobacco, roll-your-own, and ENDS.
<table>
<thead>
<tr>
<th>Study/location/period</th>
<th>Area units/sampling approach</th>
<th>Neighbourhood characteristics</th>
<th>Tobacco/ENDS products</th>
<th>Statistical approach, covariates</th>
<th>Limitations/risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Australia</strong></td>
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<tr>
<td>Burton, Williams et al., 2013</td>
<td>- New South Wales, Australia</td>
<td>SES, youth composition, racial/ethnic composition, remoteness</td>
<td>Winfield, pack and twin-pack</td>
<td>Generalized estimating equation (GEE) with a linear link, and exchangeable working correlation structure; Additional covariates: outlet type, legislation breach and listing with Ministry of Health.</td>
<td>1. # of area units: 95  2. # of stores: 1579  3. addressed spatial dependence: yes  4. used probability-based sampling of: area units: yes; of stores: n/a, 1579 of 1739 retailers were audited  5. inter-rater reliability: not reported  6. collected relative prices: no  7. provided interpretation and discussed effect sizes: yes</td>
</tr>
<tr>
<td>McCarthy et al., 2011</td>
<td>- Australia</td>
<td>Neighbourhoods (in 1 km radius of selected milk bars); Closest two milk bars per school.</td>
<td>Peter Jackson, pack Winfield, pack Longbeach, pack Benson &amp; Hedges, pack Horizon, pack</td>
<td>Exact logistic regressions; Additional covariates: presence of a supermarket within 500 m of the school.</td>
<td>1. # of area units: 36  2. # of stores: 62  3. addressed spatial dependence: no  4. used probability-based sampling of area units: unclear; of stores: no  5. inter-rater reliability: not reported  6. collected relative prices: no  7. provided interpretation and discussed effect sizes: no</td>
</tr>
<tr>
<td>Dalglish et al., 2013</td>
<td>- South-East Queensland, Australia</td>
<td>Suburbs from the lowest and highest SES deciles were selected if the suburb contained a moderate-sized shopping centre (&lt;100 retail outlets) and a 1 km radius from the main shopping centre did not include the Brisbane river; all retail outlets within a 1 km radius of a shopping centre were surveyed.</td>
<td>SES, racial/ethnic composition</td>
<td>Two sample t-test; 2 factor-ANOVA; Additional covariates: none.</td>
<td>1. # of area units: 4  2. # of stores: unclear  3. addressed spatial dependence: no  4. used probability-based sampling of area units: no; of stores: all stores were sampled  5. inter-rater reliability: no  6. collected relative prices: no  7. provided interpretation and discussed effect sizes: no</td>
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<tr>
<td>United Kingdom</td>
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<tr>
<td>Shortt et al., 2020</td>
<td>- Scotland</td>
<td>Unclear; electronic point-of-sale data were obtained from convenience stores.</td>
<td>SES</td>
<td>Linear regression models; Additional covariates: tobacco outlet density, urban/rural status.</td>
<td>1. # of area units: unclear  2. # of stores: 274  3. addressed spatial dependence: yes  4. used probability-based sampling of area units: unclear; of stores: no  5. inter-rater reliability: n/a  6. collected relative prices: no  7. provided interpretation and discussed effect sizes: yes</td>
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<tr>
<td>United States, national</td>
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</tr>
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<tbody>
<tr>
<td>Mills et al., 2019</td>
<td>Area unit: census tract; 97 unique counties were randomly selected from all 3109 US counties.</td>
<td>SES, racial/ethnic composition, youth composition</td>
<td>Cheapest cigarette, pack</td>
<td>Linear mixed-effects/multilevel models; Additional covariates: store type, US region.</td>
<td>1. % of area units: 97 2. % of stores: 2069 3. addressed spatial dependence: yes 4. used probability-based sampling of area units: yes; of stores: yes 5. inter-rater reliability: yes 6. collected relative prices: no 7. provided interpretation and discussed effect sizes: yes</td>
</tr>
<tr>
<td>Mills et al., 2018</td>
<td>Area units: census tracts; 97 unique counties selected from all 3109 counties. In the majority of counties, 24 tobacco retailers were randomly selected.</td>
<td>SES, racial/ethnic composition, youth composition</td>
<td>Marlboro Red, pack Newport, pack</td>
<td>Linear mixed-effects/multilevel models; Additional covariates: store type, US region.</td>
<td>1. % of area units: 97 2. % of stores: 2124 3. addressed spatial dependence: yes 4. used probability-based sampling of area units: yes; of stores: yes 5. inter-rater reliability: yes 6. collected relative prices: no 7. provided interpretation and discussed effect sizes: yes</td>
</tr>
<tr>
<td>Lee, Goldstein, et al., 2015</td>
<td>Area units: census tracts; Census tracts in 97 counties across the US. 100 counties were randomly selected with minimal replacement and with probability proportionate to population size; For each selection of a county, up to 24 phone-verified stores were selected.</td>
<td>SES, racial/ethnic composition, youth composition, concentration of same-sex couples, rurality</td>
<td>Marlboro, pack Newport, pack</td>
<td>Linear mixed-effects/multilevel models; Additional covariates: store type.</td>
<td>1. % of area units: 1696 2. % of stores: 2231 3. addressed spatial dependence: yes 4. used probability-based sampling of area units: yes; of stores: yes 5. inter-rater reliability: yes 6. collected relative prices: no 7. provided interpretation and discussed effect sizes: to some extent</td>
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### Table 1 (continued)

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</tr>
</thead>
<tbody>
<tr>
<td>Resnick et al., 2012</td>
<td>Area units: census block groups; Sampling strategy not reported.</td>
<td>Racial/ethnic composition</td>
<td>Marlboro Red, pack Newport, pack Cheapest cigarette, pack</td>
<td>Not reported; Additional covariates: none.</td>
<td>1. # of area units: 1373 2. # of stores: 2387 3. addressed spatial dependence: no 4. used probability-based sampling of area units: not reported; of stores: not reported 5. inter-rater reliability: not reported 6. collected relative prices: no 7. provided interpretation and discussed effect sizes: no</td>
</tr>
<tr>
<td>United States, states, cities</td>
<td>Area units: census tracts; All retail outlets designated as licensed to sell tobacco.</td>
<td>SES, racial/ethnic composition, youth composition, population density</td>
<td>Cheapest cigarette, pack Swisher Sweets cigarillo, single</td>
<td>Linear mixed-effects/multilevel models, spatial regressions; Additional covariates: store type, distance to nearest competitor.</td>
<td>1. # of area units: 616 2. # of stores: 7393 3. addressed spatial dependence: yes 4. used probability-based sampling of area units: yes; of stores: yes 5. inter-rater reliability: no 6. collected relative prices: no 7. provided interpretation and discussed effect sizes: yes</td>
</tr>
<tr>
<td>Schleicher et al., 2015</td>
<td>0.5 mile service areas around each store 2014: random sample; 2014: all 2011 stores still operating and selling tobacco were sampled; replacement stores randomly selected from the 2013 retailer licensing list.</td>
<td>SES, racial/ethnic composition, youth composition</td>
<td>Marlboro Red, pack Newport, pack Pall Mall, pack Cheapest cigarettes, pack Disposable e-cigarette: Blu NJoy Chewing tobacco: Grizzly Copenhagen</td>
<td>Least squares regression models for cross-sectional analysis; linear mixed-effects/multilevel models for longitudinal analysis; Additional covariates: store type.</td>
<td>1. # of area units: same as # of stores; 2. # of stores: n = 691 for longitudinal and n = 579 for cross-sectional 3. addressed spatial dependence: yes 4. used probability-based sampling of area units: yes; of stores: yes 5. inter-rater reliability: yes 6. collected relative prices: yes 7. provided interpretation and discussed effect sizes: to very little extent</td>
</tr>
<tr>
<td>Henriksen et al., 2012</td>
<td>School neighbourhoods; All school neighbourhoods with six or fewer tobacco retailers were selected; in 31 neighbourhoods with more than 6 retailers, 6 or 50%, whichever yielded the larger number, were selected.</td>
<td>SES, racial/ethnic composition, youth composition, population density</td>
<td>Marlboro Red, pack Newport, pack Camel, pack Pall Mall, pack Cheapest cigarettes, pack</td>
<td>Linear mixed-effects/multilevel models; Additional covariates: store type, retailer density, discounted prices.</td>
<td>1. # of area units: 91 2. # of stores: 407 3. addressed spatial dependence: yes 4. used probability-based sampling of area units: yes; of stores: partially 5. inter-rater reliability: not reported 6. collected relative prices: no 7. provided interpretation and discussed effect sizes: yes</td>
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</thead>
<tbody>
<tr>
<td>Lipperman-Kreda, Grube, Friend, 2012 - California - time of data collection not reported.</td>
<td>City;Outlets were randomly sampled from lists created specifically for the study.</td>
<td>SES, racial/ethnic composition, youth composition, population density</td>
<td>Marlboro Red, pack Newport, pack</td>
<td>Linear mixed-effects/multilevel models; Additional covariates: store type, prevalence of adult smokers, retailer density, local tobacco retailer licensing, cigarette tax.</td>
<td>1. # of area units: 50 2. # of stores: 997 3. addressed spatial dependence: yes 4. used probability-based sampling of area units: yes; of stores: yes 5. inter-rater reliability: yes 6. collected relative prices: no 7. provided interpretation and discussed effect sizes: no</td>
</tr>
<tr>
<td>Epperson et al., 2019 - California; - Jan to Mar 2017</td>
<td>0.5 mile service areas around each store; Random sample.</td>
<td>SES, racial/ethnic composition, youth composition</td>
<td>American Spirit, pack Pall Mall, pack Newport, pack Marlboro, pack Cheapest cigarettes, pack</td>
<td>Least squares regression models; Additional covariates: store type.</td>
<td>1. # of area units: 1182 2. # of stores: 1182 3. addressed spatial dependence: n/a 4. used probability-based sampling of area units: n/a; of stores: yes 5. inter-rater reliability: yes 6. collected relative prices: no 7. provided interpretation and discussed effect sizes: no</td>
</tr>
<tr>
<td>Cantrell et al., 2015 - Washington, DC - Sep 2011 to Mar 2012</td>
<td>Census block groups;All licensed tobacco retail outlets were surveyed.</td>
<td>SES, racial/ethnic composition, youth composition</td>
<td>Newport, pack Cheapest cigarettes, pack Black &amp; Mild cigarillo, single</td>
<td>Linear mixed-effects/multilevel models; Additional covariates: store type, closest school type, schools within 1 mile buffer, lowest price on exterior, brand category, special price status, menthol status, lowest Newport menthol price, # registers, zoning, retailer density.</td>
<td>1. # of area units: 265 2. # of stores: 750 3. addressed spatial dependence: yes 4. used probability-based sampling of area units: no; of stores: no 5. inter-rater reliability: yes 6. collected relative prices: no 7. provided interpretation and discussed effect sizes: yes</td>
</tr>
<tr>
<td>Kephart et al., 2019 - Boston, Massachusetts - Jul 2015 to Jun 2016</td>
<td>Census block groups;All tobacco retailers were surveyed.</td>
<td>SES, racial/ethnic composition, youth composition, retail density</td>
<td>Marlboro Red, pack Camel, pack Pall Mall Red, pack</td>
<td>Generalized linear mixed models (GLMM) with a normal distribution; Additional covariates: retailer density, % of independent retailers.</td>
<td>1. # of area units: 325 2. # of stores: 689 3. addressed spatial dependence: yes 4. used probability-based sampling of area units: no; of stores: no 5. inter-rater reliability: not reported 6. collected relative prices: no 7. provided interpretation and discussed effect sizes: to some extent</td>
</tr>
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<tr>
<td>Seidenberg et al., 2010</td>
<td>Each community (Dorchester and Brookline) was treated as an area unit; All identified tobacco retailers were visited.</td>
<td>SES, racial/ethnic composition, youth composition</td>
<td>Advertised cigarette pack price</td>
<td>t-tests; Additional covariates: none.</td>
<td>1. # of area units: 2; 2. # of stores: 56 Dorchester and 42 Brookline; 3. addressed spatial dependence: n/a; 4. used probability-based sampling of area units: no; of stores: no; 5. inter-rater reliability: yes; 6. collected relative prices: no; 7. provided interpretation and discussed effect sizes: to some extent; The statistical analysis performed did not examine associations between prices and community characteristics.</td>
</tr>
<tr>
<td>Laestadius et al., 2018</td>
<td>Zip codes; A random sample of retailers.</td>
<td>Racial/ethnic composition</td>
<td>Newport, pack Cheapest cigarettes, pack Blu disposable e-cigarette</td>
<td>Anova F-test (p-values adjusted to correct for multiple comparisons using the Bonferroni procedure); Additional covariates: none.</td>
<td>1. # of area units: 9; 2. # of stores: 195; 3. addressed spatial dependence: unclear; 4. used probability-based sampling of area units: no; of stores: yes; 5. inter-rater reliability: no; 6. collected relative prices: no; 7. provided interpretation and discussed effect sizes: no</td>
</tr>
<tr>
<td>Toomey et al., 2009</td>
<td>Geopolitical units (GPU); Max of 8 stores randomly selected from each of the GPUs.</td>
<td>Racial/ethnic composition, youth composition</td>
<td>Light premium brand that youth often buy, pack Menthol brand often smoked by minority racial/ethnic groups, pack Discount brand, pack Brand names not reported</td>
<td>Generalized linear model (link function not reported); Additional covariates: store type, # of schools, # of stores.</td>
<td>1. # of area units: 29; 2. # of stores: 214; 3. addressed spatial dependence: yes; 4. used probability-based sampling of area units: yes; of stores: yes; 5. inter-rater reliability: not reported; 6. collected relative prices: no; 7. provided interpretation and discussed effect sizes: no</td>
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A. Number of studies

Fig. 2. Count of results for cigarette price differences by direction of association and neighbourhood characteristics of socioeconomic status, ethnic/racial composition and youth composition.

B. Number of associations
of which found that price differences were statistically significantly different at the 5% level).

In Australia, price differences between high and low-SES areas ranged between 0.35 to AU$0.75, or a 2–5% difference (McCarthy et al., 2011; Dalglish et al., 2013; Burton et al., 2014). In Scotland, prices of all sales of packs of 20 cigarettes were £0.20, ±0.40, £0.56, and ±0.50 cheaper in quintiles 2–5, compared to quintile 1 (lowest income deprivation). There were, however, negligible differences in the prices of specific brands between SES categories. In the US, at the national level, price differences were either negligible or ranged from about $0.10 to $0.15 a pack between lower- and higher-SES areas, or about $0.20 less with each standard deviation decrease in median area-level income. In California, price differences were similar: either negligible or about $0.10 to $0.20 less with each standard deviation decrease in median area-level income. Lastly, comparable price differences were also observed in Boston and Washington, DC.

Racial or ethnic composition. 18 studies investigated the association between cigarette pricing and the racial or ethnic compositions of the area (Toomey et al., 2009; Seidenberg et al., 2010; Henriksen et al., 2012, 2016, 2017; Burton et al., 2014; Lipperman-Kreda et al., 2014; Resnick et al., 2012; Cantrill et al., 2015; Lee et al., 2015b; Schleicher et al., 2015; Laestadius et al., 2018; Mills et al., 2018, 2019; Epperson et al., 2019; Kephart et al., 2019). 14 studies examined associations between cigarette prices and the proportion of Blacks or African Americans. 14 studies examined associations between cigarette prices and the proportion of Blacks or African American smokers (Gardiner, 2004; Giovino et al., 2004, 2015; Lipperman-Kreda et al., 2014; Resnick et al., 2012; Cantrill et al., 2015; Mills et al., 2018; Epperson et al., 2019; Kephart et al., 2019) found that prices were generally lower in areas with a higher % of youth (nine of which found that price differences were, on the whole, statistically significantly different at the 5% level), while one study found unclear associations between cigarette prices and neighbourhoods’ youth composition and one study found that cigarette prices were higher (although not statistically significantly) in areas with a higher proportion of youth (Cantrill et al., 2015; Henriksen et al., 2016).

In Australia, relative to areas with a youth composition (≤18 years old) of less than 16%, prices were lower by AU$0.24, AU$0.45, and AU $0.62 in areas with 16–22%, 22–25%, and 25–% of youth (Lipperman-Kreda et al., 2014). In the US in 2015, Newport cigarettes cost $0.12 and $0.09 less in the third and highest quartiles of youth (5–17 years) as compared to the lowest quartile while Marlboro cigarettes cost $0.11 less in neighbourhoods with the highest quartiles of youth as compared to the lowest quartiles of youth. (Mills et al., 2018). For each 5% points increase in the % of youth, the cheapest pack cost $0.04 less (Mills et al., 2019).

Temporal changes in the difference in area-level cigarette prices. One study collected prices of Marlboro and Newport cigarettes in 2011 and 2014 in California. Although cigarette prices only changed marginally between 2011 and 2014, significant changes were observed by neighbourhood demography (Schleicher et al., 2015). In areas with higher proportions of school-age youth, the price of Marlboro decreased significantly and in areas with higher proportions of African American and Asian/Pacific Islander residents, the price of Newport cigarettes significantly decreased by more than in areas with fewer of these residents (Schleicher et al., 2015).

Proportion of same-sex couples. One study examined the association between the rate of same-sex couples per 1000 coupled households and Newport and Marlboro prices in 1696 census tracts in 97 US counties in 2012 and found that prices were generally higher in areas that had a higher proportion of same-sex couples. Three of the four associations examined were statistically significantly different at the 5% level but differences were fairly small (Lee et al., 2015b).

3.2. Cigarillos, chewing tobacco, roll-your-own tobacco and ENDS

In addition to cigarettes, area-level differences in the prices of little cigars, cigarillos, chewing tobacco, roll-your-own, and e-cigarettes were studied. Two studies examined the association between the prices of little cigars and cigarillos and area-level SES and youth and found that prices were generally lower in lower-SES areas and in areas with a higher proportion of youth (Schleicher et al., 2015; Henriksen et al., 2017). There was conflicting evidence among the three studies that examined the associations between the prices of little cigars and cigarillos and the racial/ethnic composition of neighbourhoods (Cantrill et al., 2013; Schleicher et al., 2015; Henriksen et al., 2017). Two studies did not find any substantial associations between little cigar/cigarillo prices and the racial/ethnic compositions of neighbourhoods (Schleicher et al., 2015; Henriksen et al., 2017), while the other found strong negative associations, with prices decreasing with increasing quartiles of African American residents (Cantrill et al., 2013). One study examined the association between chewing tobacco prices and area-level measures of income, and racial/ethnic and youth compositions and found no clear associations between prices of chewing tobacco.
and any area-level characteristics (Schleicher et al., 2015). One study examined roll-your-own tobacco in Scotland and found that prices were prices were generally lower in more deprived areas (Shortt et al., 2020).

Lastly, we identified two studies that examined the association between e-cigarette prices and neighbourhoods’ racial/ethnic composi-
tions. In the summer of 2016 in Milwaukee, Wisconsin, Blu e-cigarettes cost less (about $2) in neighbourhoods with a greater percentage of African Americans relative to neighbourhoods with a greater proportion of Hispanics or whites (Laestadius et al., 2018). One study collected e-cigarette prices in California and found that unlike cigarette prices, there was little variation in the prices of e-cigarettes: prices of Blu and NJOY e-cigarettes were the same in 79% and 84% of stores, respectively (Schleicher et al., 2015).

4. Discussion

Main findings. On the whole, we found consistent evidence that cigarette prices were lower in lower SES neighbourhoods, and in
neighbourhoods with a higher percentage of youth, and of Blacks or African Americans. These findings are in keeping with tobacco industry
documents that detailed how manufacturers used race, class, and ge-
ography to target vulnerable populations (Yerger et al., 2007). Although
we are confident about the direction of price differences between
neighbourhoods, the heterogeneity between studies made it difficult to
assess the overall magnitude of price differences. Some studies docu-
mented statistically significant but modest price differences between
neighbourhoods, while others documented fairly large statistically sig-
nificant differences. One study assessed temporal changes in the dif-
ference in area-level cigarette prices and found that modest changes in
average prices overtime concealed significant changes in prices between
neighbourhood characteristics (Schleicher et al., 2015). We identified
too few studies that examined price differences between neighbour-
hoods for cigarillos, chewing tobacco, roll-your-own, and ENDS to reach
any conclusions.

We assessed the quality of each included study using seven criteria
(Table 1, last column). First, area unit sample sizes were adequate in all
studies with, perhaps, three exceptions that compared two, four, and
nine area units (Seidenberg et al., 2010; Dalglish et al., 2013; Laestadius
et al., 2018). Second, the total number of retailers and the number of
retailers per area unit varied considerably between studies. For example,
some studies collected data from one or two stores per area (McCarthy
et al., 2011; Schleicher et al., 2015; Mills et al., 2018) while others
collected data from about 20 stores per area (Lipperman-Kreda et al.,
2014; Lee et al., 2015b; Laestadius et al., 2018). Additionally, one study
did not clearly report the number of retailers3 (Dalglish et al., 2013).
Third, because prices collected in stores from the same area may be
correlated, it is preferable not to assume that observations/areas are
independent of one another (LeSage, 2008). Spatial dependency was not
clearly addressed in five studies. Fourth, only eight studies reported
having used probability-based sampling for both area units and retailers
(Toomey et al., 2009; Lipperman-Kreda et al., 2014; Lee et al., 2015b;
Schleicher et al., 2015; Henriksen et al., 2017; Mills et al., 2018, 2019);
one study sampled all retailers in all areas (Kephart et al., 2019). Fifth,
only two studies collected prices for products other than tobacco or
ENDS (Schleicher et al., 2015; Henriksen et al., 2016). One study found
that bottled water generally cost more in pharmacies where cigarettes
cost less; on the whole, however, the price of bottled water did not vary
by area-level characteristics (Henriksen et al., 2016). Another study also
collected prices of bottled water but did not report any results. Col-
lecting prices for products other than tobacco or ENDS can allow re-
searchers to more insightfully comment on industry pricing strategies

3 An adequate number of area units and adequate number of stores inherently
depends on context. Table 1 presents the number of areas and the number stores
for each study to facilitate assessment.

and affordability of tobacco and ENDS products (Schleicher et al., 2015).
Sixth, only eight studies provided an intuitive interpretation and clear
discussion of the magnitude of price differences between areas (Hen-
rksen et al., 2012, 2016, 2017; Burton et al., 2014; Lee et al., 2015b;
Mills et al., 2018, 2019; Epperson et al., 2019). Additionally, we examined whether each study discussed their scientific quality and/or
limitations. A common limitation that was self-reported by many au-
authors was that the cross-sectional nature of most studies impeded any
sort of temporal inferences from being made.

Strengths and limitations. We extracted detailed characteristics for all
studies that investigated price variations across SES, racial or ethnic
characteristics, age and other characteristics that may be associated with
vulnerability and used seven components to assess the quality of
included studies. Nonetheless, our paper has some inherent limitations.
First we were unable to conduct a meta-analysis due to the heteroge-
neity in the methods and measures used in different studies, hence
impeding us from providing adequate summary measures. Second, as all
the studies were conducted in the US, Scotland or Australia, the gener-
alizability of our findings is limited. Moreover, the studies conducted in
the US were predominately focused on states that already had relatively
strict tobacco control policies in place (e.g., California, Massachusetts,
Minnesota), thus further limiting their applicability to other regions
with less comprehensive tobacco control measures. Third, it was, on
occasion, unclear how price data were collected and what they repre-
ented (e.g., indoor/outdoor advertised prices, prices obtained from
retailers in face-to-face interactions or actual purchase prices). Adver-
tised prices may not represent actual retail prices but nevertheless
represent an important promotion channel, especially for youth in ju-
risdictions with point-of-sale restrictions. One study found good
concordance between advertised cigarette prices with purchase receipts
in the US. (Schleicher et al., 2018) We found that the most popular brand
of menthol cigarettes in the US, Newport cigarettes, consistently cost
less in areas with a greater proportion of Blacks or African Americans.
This finding, however, does not necessarily extend to other brands of
menthol cigarettes. Lastly, our review suffers from limitations identified
by Lee, Henriksen et al. (Lee et al., 2015a) in their review of neigh-
bourhood disparities in point-of-sale tobacco marketing: 1) the rela-
tionship between area-level characteristics and prices may be nonlinear
(e.g., there might be household income thresholds that are more rele-
ant to the pricing strategy of manufacturers); and, 2) area-level char-
acteristics such as SES and racial/ethnic or youth compositions may be
 correlated which can make it difficult to disentangle independent
effects.

Implications for policy and research. Our findings suggest that regu-
lations that can limit industry price manipulation such as minimum,
maximum, and uniform prices, and high specific excise taxes should be
considered. There is emerging evidence that price-promotion re-
strictions and minimum-price laws can be useful approaches to reduce
price disparities and lower tobacco consumption (Golden et al., 2016).
Additionally, there is fairly robust evidence that price-based alcohol
policy interventions such as minimum pricing of alcohol can reduce
alcohol consumption (Boniface et al., 2017).

Given the importance of prices in increasing cessation and reducing
tobacco use onset and disparities in tobacco use (International Agency
for Research on Cancer, 2011; US National Cancer Institute and World
Health Organization, 2016), it is surprising that so little research in so
few jurisdictions has examined area-level differences in prices. More
frequent and systematic monitoring of tobacco prices is warranted. In
particular, additional research in geographic locations with high to-
bacco use prevalence and in low- and middle-income countries has the
potential to make important contributions to tobacco control research.
Given the rapid increase in the use of ENDS in many jurisdictions
(Kmietowicz, 2014; Filippidis et al., 2017; Cantrell et al., 2018; Ham-
mond et al., 2019), close price monitoring is also warranted. Because
area-level characteristics such as SES and racial/ethnic or youth com-
positions may be correlated, we recommend that key neighbourhood
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Declaration of competing interest

None.

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References

Supplementary data

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