

Research Proposal for the High School Academic Research Competition 2026

Name:

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Research Topic:

To what extent does the implementation of a sugar-sweetened beverage tax causally reduce the prevalence and severity of dental caries in children aged 5, and how does this effect vary across socioeconomic groups?

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Abstract

Dental caries is the most common chronic disease in children globally, with sugar-sweetened beverage (SSB) consumption representing a key modifiable risk factor. While SSB taxes have been shown to reduce consumption, their downstream impact on childhood dental caries remains underexplored. The only published paper using a Difference-in-Difference approach was conducted in Philadelphia (Petimar et al., 2023), found no significant general-population effect on DMFT (decayed, missing and filled teeth) but found meaningful reductions among low-income Medicaid patients. Critically, the Philadelphia tax operated through price increase in a single city which allowed cross-border purchasing. The UK Soft Drinks Industry Levy (SDIL, 2018) operates instead through nationwide product reformulation. This study proposes a DiD analysis estimating the causal effect of the SDIL on dmft, with effects examined across socioeconomic deprivation quintiles.

Introduction

520 million children globally carry untreated deciduous caries (Wen et al, 2021). In England, tooth decay is the leading cause of hospital admission in children aged 5-9. (OHID, 2023). The underlying mechanism is well established: dietary sugars are metabolised by oral bacteria, producing organic acids that reduce plaque pH below the 5.5 demineralisation threshold of enamel hydroxyapatite (Pitts et al, 2017). Repeated exposure to these acidic conditions shifts the plaque microbiome towards cariogenic species, driving progressive mineral loss (Marsh, 2006).

The UK SDIL, implemented in April 2018, imposed tiered levies of 18-24/litre based on sugar content, which led to widespread manufacturer reformulation. Post-SDIL evaluations confirm a 4.8g/day reduction in children's free sugar intake and significant reductions in sugar purchased from high-levy beverages (Rogers et al., 2023, 2024). What hasn't been studied yet is whether this translated into fewer dmft cases, and that's the gap this proposal addresses.

Literature Review

There's a well-established dose-response relationship between free sugar intake and caries: each additional 10 g/day of free sugar is associated with a 0.09-unit DMFT increment (Bernabé et al., 2015), and restricting free sugars below 10% of total energy intake reduces caries incidence (Moynihan & Kelly, 2013). SSBs are particularly harmful, generating repeated acid-pH troughs and promoting biofilm ecological shift toward aciduric species (Marsh, 2006). SSB tax consumption evidence is robust. In Mexico, Colchero et al. (2016) reported a 6% reduction in SSB purchases post-tax, rising to 9.7% by year two, with the largest impact recorded in the lowest-income tertile (Colchero et al., 2017). Teng et al. (2019) meta-analysed 17 studies, estimating a 10% reduction in consumption per 10% tax. Modelling studies predict large caries reductions: Briggs et al. (2017) estimated 269,000 fewer dmft cases annually in the UK; Cobiac et al. (2024) projected 3,600 fewer caries cases in the first post-SDIL decade.

However, empirical caries-outcome evidence is sparse and methodologically limited. Rogers et al. (2023) found a 12.1% reduction in carious tooth extractions post-SDIL using interrupted time series, but extractions capture only severe end-stage caries. Hernández-F et al. (2021) found reduced dmft in Mexican children post-tax but used single-jurisdiction time series without a control group. Petimar et al. (2023) conducted the only published DiD study, comparing 83,260 patients in Philadelphia against control areas: no significant overall dmft change was observed ($DD = -0.02$, 95% CI: -0.08 to 0.03), but significant reductions emerged among Medicaid patients. The Philadelphia tax operated through price increase in a single city which allowed cross-border avoidance, and product sugar content was unchanged. The SDIL's

reformulation mechanism is structurally distinct: it reduces sugar in products available across the entire UK, with no avoidance pathway. This difference motivates a UK-specific DiD study.

Methodology

This study uses a Difference-in-Difference quasi-experimental method exploiting the SDIL's implementation as a natural experiment.

- Estimator: $DiD = (England_post - England_pre) - (Ireland_post - Ireland_pre)$.
- Treatment: England post-SDIL (April 2018).
- Control: Republic of Ireland, which implemented no comparable levy until 2023 and shares broadly similar dietary culture, caries burden, and dental infrastructure. Ireland's national water fluoridation coverage (~73%) compared to England (~10%) represents a structural difference between the two populations; fluoridation coverage will therefore be included as a covariate, and sensitivity analyses will be conducted, excluding highly fluoridated Irish regions to test the robustness of the main estimate.
- Outcome: Prevalence of dentinal caries experience ($dmft > 0$) in five-year-olds, drawn from England's National Dental Epidemiology Programme (NDEP) biennial surveys (2012–2024) and Irish national oral health survey data (Sharma et al., 2023; Whelton et al., 2006).

The regression model is:

$$dmft_prev(i,t) = \beta_0 + \beta_1(England) + \beta_2(Post) + \beta_3(England \times Post) + \gamma X(i,t) + \varepsilon$$

where the interaction term β_3 is the causal estimator of interest. Covariates $X(i,t)$ include fluoridation coverage, dentist-to-population ratio, deprivation index, and baseline SSB consumption. Given the biennial NDEP survey cycle, the pre-SDIL period yields only three observations (2012, 2015, 2017). Parallel trends will be assessed visually across these years and supplemented by a formal placebo test designating 2015 as a false treatment year, though the limited number of pre-period observations constrains the statistical power of this test, results should be interpreted bearing this in mind.

A secondary analysis stratifies β_3 by English Index of Multiple Deprivation (IMD) quintile, testing whether the SDIL effect is concentrated in the most deprived communities (consistent with Petimar et al. (2023) and Colchero et al. (2017)), whose children bear a 3.5-fold greater caries burden (OHID, 2023).

Conclusion

This study proposes the first DiD evaluation of a reformulation-driven SSB tax on childhood dental caries prevalence. A confirmed causal reduction in $dmft$ would broaden the public health justification for SSB taxation beyond metabolic outcomes and provide direct evidence for policymakers. The socioeconomic stratification analysis would address whether fiscal sugar policy disproportionately benefits deprived communities, contributing to ongoing debates around equity in consumption taxes. A null result would itself be significant, challenging whether consumption reductions within a five-year window are sufficient to shift population-level caries rates and redirecting attention to complementary clinical interventions.

Limitations include the biennial NDEP data cycle, Ireland's substantially higher structural fluoridation difference requiring careful covariate control, the slowly progressive nature of caries limiting short-run detection, and potential concurrent policy confounders. These are acknowledged and will be addressed through sensitivity analyses.

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