Inequalities in oral health: Understanding the contributions of education and income

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ABSTRACT

OBJECTIVE: To quantify the extent to which income and education explain gradients in oral health outcomes.

METHODS: Using data from the Canadian Community Health Survey (CCHS 2003), binary logistic regression models were constructed to examine the relationship between income and education on self-reported oral health (SROH) and chewing difficulties (CD) while controlling for age, sex, ethnicity, employment status and dental insurance coverage. The relative index of inequality (RII) was utilized to quantify the extent to which income and education explain gradients in poor SROH and CD.

RESULTS: Income and education gradients were present for SROH and CD. From fully adjusted models, income inequalities were greater for CD ($RII_{inc} = 2.85$) than for SROH ($RII_{inc} = 2.75$), with no substantial difference in education inequalities between the two. Income explained 37.4% and 42.4% of the education gradient in SROH and CD respectively, whereas education explained 45.2% and 6.1% of income gradients in SROH and CD respectively. Education appears to play a larger role than income when explaining inequalities in SROH; however, it is the opposite for CD.

CONCLUSION: In this sample of the Canadian adult population, income explained over one third of the education gradient in SROH and CDs, whereas the contribution of education to income gradients varied by choice of self-reported outcome. Results call for stakeholders to improve affordability of dental care in order to reduce inequalities in the Canadian population.

KEY WORDS: Oral health; socio-economic factors; educational status; income; population health

La traduction du résumé se trouve à la fin de l'article.

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Socio-economic inequalities in oral health are recognized globally, exist both in developed and developing countries, and have gained substantial attention.^{1–3} For example, 2013 marked the inception of the International Centre for Oral Health Inequalities Research and Policy (ICOHIRP) and the subsequent release of the London Charter on Oral Health Inequalities in 2015.³ Systematic monitoring and research on the mechanisms behind oral health gradients is also part of the International Association of Dental Research Global Oral Health Inequalities Research Agenda (IADR-GOHIRA).⁴

Socio-economic gradients in oral health are often attributed to factors such as occupation, social class, income and education; among which, income and education are most commonly utilized.⁵ The potential contribution of income to oral health inequalities can be explained by increased acquisition of material resources with increased income (financial access to care),⁶ whereas education allows for the acquisition of non-material resources (such as knowledge) that promote healthy behaviours and better navigation of health resources.⁶ However, the relative contribution of education to the income gradient in oral health outcomes, and that of income to the education gradient in oral health outcomes, remains unclear. This is a fundamental consideration given that this knowledge can help determine what policy approaches may best narrow gaps and/or reduce oral health inequalities between social groups. For example, if income is dominant in explaining

education gradients, then policies that impact income inequality are more germane to the goal of reducing inequalities in oral health; while if education is dominant in explaining income gradients, then policies based in knowledge acquisition may be best in achieving the same.

In this context, the use of complex measures of socio-economic inequalities, such as the concentration index and its decomposition approach, has permitted an understanding of contributors to socio-economic inequalities in oral health.^{7–9} However, for public policy advocacy, simple approaches, such as regression-based methods are utilized more due to their easier interpretation. As demonstrated in the health literature, such methods have been used to parse out interdependencies between income and education on inequalities in health.^{10,11} Using the regression-based relative index of inequality (RII) method, Lahelma et al. (2004) found that income and education mediated the effects of respective health inequalities.¹⁰ To date, only a few studies have applied these methods to understanding the relative effects on social inequalities in oral health.²

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Thus, the primary objective of this research is to determine how much of the income gradient in oral health is explained by education, and how much of the education gradient in oral health is explained by income.

METHODS

Data sources

Data from the nationally representative cross-sectional 2003 Canadian Community Health Survey (CCHS) were utilized for analysis. The 2003 CCHS collected demographic, socio-economic, and self-reported information on health care utilization and health status (including oral health) of privately dwelling Canadians, age 12 years and older, through 45-minute computer-assisted personal and telephone interviews. The CCHS comprises questions asked to all respondents (common content) and questions only asked to respondents within select regions (optional content), where topics that make up common and optional content vary by survey year. Although more recent CCHS surveys exist, the 2003 CCHS was deemed most appropriate for analyses due to its completeness in reporting oral health-related variables at the national level (e.g., oral health outcomes, dental insurance). The CCHS used three sampling frames to select the sample of households: 49% of the sample of households came from an area frame, 50% came from a list frame of telephone numbers and the remaining 1% came from a Random Digit Dialing (RDD) sampling frame. It statistically represents approximately 98% of the Canadian population aged 12 or older. Full-time Canadian Forces members, people living on Indian Reserves or Crown land, and those in institutions or certain remote areas were not part of this survey.¹²

Variables

Two outcome variables were used for analyses. The first was self-reported oral health (SROH), which was reported using a 5-point scale (1 = excellent, 2 = very good, 3 = good, 4 = fair, and 5 = poor). In order to examine inequalities among individuals who had a negative perception of their oral health, the five categories were collapsed into a binary poor SROH variable (good = excellent + very good + good, and poor = fair + poor). The second was the presence of chewing difficulties (CD), which was grouped as yes and no.

Variables used to explain SROH and CD were age, sex, ethnicity, dental insurance coverage, employment status, income and education. Dental insurance coverage was dichotomized to yes and no; employment status over the past year was categorized as employed and unemployed; sex was male and female; and ethnicity was grouped as white and visible minority. Further classification of employment status, such as part-/full-time status, was not possible due to limitations in survey reporting in the 2003 CCHS. For age, we chose to analyze data for respondents who were 25 years and older, as participants of younger age groups might not have completed their education and not be earning. Five 10-year age groups were created: 25–34 years, 35–44 years, 45–54 years, 55–64 years, and 65 years and older.

Education was collected on a 4-point scale. Respondents were asked, “What is the highest certificate, diploma, or degree, that you (or person in home) have completed?” Respondents’ highest level of education was then collapsed into <high school, high school graduation, and more than high school. For income, the CCHS

collected household income and number of people in household to derive a ranked 5-point income adequacy variable.

Analysis

Our analysis consisted of individuals 25 years and older. Respondents with missing data were excluded and survey weights were applied to all analyses in order to account for complex survey design. First, using bivariate analysis, unadjusted proportions for poor SROH and CD were computed for income and education gradients. Second, to assess the effect of socio-economic factors, two sets of logistic regression models were constructed for each outcome (Models 1a and 1b). Models 1a and 1b were compared to the fully adjusted Model 2 respectively, to qualitatively examine the effect of income on education, and vice versa.

Model 1a: adjusted for age + sex + ethnicity + dental insurance coverage + employment status + education

Model 1b: adjusted for age + sex + ethnicity + dental insurance coverage + employment status + income

Model 2: adjusted for age + sex + ethnicity + dental insurance coverage + employment status + education + income

To determine the extent to which education gradients in these oral health outcomes can be explained by income and vice versa, *ridit* scores for education and income were calculated. *Ridit* scores take into account the distribution of income (or education) within a population. To derive *ridit* scores, income (or education) categories are first organized by least deprived (highest income) to most deprived (lowest income). Then, scores between 0 and 1 are assigned to each category based on the midpoint range of the cumulative distribution of individuals within each category. For example, if the first category comprises 30% of the population, the assigned value is 0.15 (0.3/2), and if the second category comprises 20% of the population, this category is assigned a value of 0.40 (0.3 + [0.2/2]), and so forth. These *ridit* scores were then incorporated into the regression models stated previously to determine the Relative Index of Inequality (RII).⁹ The exponential of the regression coefficient is taken as the RII, which allows interpretation of the risk of poor/fair oral health at the lowest level in the hierarchy compared to those at the highest level, where values greater than 1 indicate a higher prevalence of the outcome in lower socio-economic groups.⁹ Using the RII, we then calculate the percent difference explained by introducing other explanatory variables (income or education) into each model using the equation:^{10,13,14}

$$\text{Percent (\%) RII difference} = \frac{(\text{RII model 1} - \text{RII model 2})}{(\text{RII base model 1})} \times 100$$

RESULTS

Characteristics of the sample population are outlined in Table 1. The majority of the sample were less than 65 years of age, with equal proportions of men and women, had middle to highest income adequacy, and greater than high school educational attainment. Nearly two thirds had some form of dental insurance coverage, and over half reported working in a job within the past 12 months (Table 1). Approximately 15.1% and 7.2% of respondents had poor SROH and CD respectively.

Table 1. Baseline characteristics of population (weighted proportions)

Variables	Proportion (%) <i>n</i> = 15 852 672
Age groups (years)	
25–34	22.0 (21.97–22.02)
35–44	28.2 (28.17–28.22)
45–54	23.7 (23.68–23.72)
55–64	16.1 (16.08–16.18)
65+	9.9 (9.88–9.91)
Sex	
Male	50.1 (50.07–50.12)
Female	49.9 (49.89–49.92)
Job status in the past 12 months	
Employed	77.9 (77.98–78.02)
Unemployed	22.1 (22.08–22.12)
Dental coverage	
No	36.1 (36.07–36.12)
Yes	63.9 (63.87–63.92)
Ethnicity	
White	85.9 (85.88–85.92)
Visible minority	14.1 (14.08–14.11)
Educational attainment	
Less than high school	15.9 (15.88–15.92)
High school	18.3 (18.28–18.32)
More than high school	65.8 (65.77–65.82)
Income adequacy	
Lowest	7.7 (7.68–7.71)
Lower middle	17.7 (17.68–17.71)
Upper middle	35.4 (45.47–45.42)
Highest	39.2 (39.18–39.22)
Self-reported oral health (SROH)	
Excellent/very good/good	84.9 (84.88–84.91)
Fair/poor	15.1 (15.08–15.11)
Chewing difficulties (CD)	
No	92.8 (92.78–92.81)
Yes	7.2 (7.18–7.21)

An inverse relationship was exhibited between the proportion of individuals with poor SROH or CD and increasing income and education (Figure 1). Table 2 shows that even after adjusting for age, sex, ethnicity, dental insurance coverage and employment status, education and income remained significant determinants of

both outcomes ($p < 0.05$). This is illustrated in the fully adjusted models, where respondents in the lowest income category were 2.92 times more likely to have poor SROH than those in the highest income category (CI = 2.90–2.94), and respondents with less than high school education were 1.43 times more likely to have poor SROH than those with higher educational attainment (CI = 1.42–1.44). Similarly, for CD, respondents in the lowest income category were 2.58 times more likely to report CD than those in the highest income category (CI = 2.56–2.59), and respondents with less than high school education were 1.57 times more likely to report CD than those with higher educational attainment (CI = 1.56–1.57) (Table 3).

From the fully adjusted models, inequalities were greater in magnitude for income than for education (Table 4). For both gradients, inequalities were greater for CD ($RII_{inc} = 2.85$, $RII_{ed} = 1.42$) than for poor SROH ($RII_{inc} = 2.75$, $RII_{ed} = 1.44$). Table 4 shows that 45.2% of the income gradient in poor SROH is explained by education, whereas 37.4% of the education gradient is explained by income. For CD, these values were 6.1% for the effect of education on the income gradient and 42.4% for the effect of income on the education gradient.

DISCUSSION

Using data from a nationally representative Canadian survey, this study examined the effects of income and education on gradients in two important oral health outcomes: poor self-reported oral health and chewing difficulties. Our results suggest an inverse relationship between increasing socio-economic status, represented by income and education, and poor SROH and chewing difficulties. They also suggest that income exhibits a dominant effect on socio-economic inequalities in oral health, but the effect of education on income-related inequalities in oral health may vary by type of outcome. As has been shown here, with the case of chewing difficulties, education explained only 6.1% of the income gradient, but 45.2% of the income gradient in poor SROH.

Our analysis revealed that income and education had nearly equal contributions to gradients in poor SROH. Self-reports have been described as a way for individuals to report on the complex nature of

Figure 1. Unadjusted weighted proportion reporting poor self-reported oral health (SROH) and chewing difficulties (CD) within past year by income adequacy and educational attainment

Table 2. Adjusted effects of income and education on poor SROH (odds ratios and 95% CI)[†]

	Model 1a*	Model 1b*	Model 2*
Age groups (years)			
25–34	1.000	1.00	1.000
35–44	1.253 (1.247–1.258)	1.217 (1.211–1.222)	1.232 (1.226–1.237)
45–54	1.543 (1.536–1.549)	1.390 (1.384–1.396)	1.486 (1.480–1.493)
55–64	1.313 (1.307–1.319)	1.138 (1.133–1.144)	1.239 (1.233–1.245)
65+	1.077 (1.071–1.084)	0.900 (0.896–0.906)	0.987 (0.981–0.993)
Sex			
Male	1.000	1.000	1.000
Female	1.362 (1.358–1.366)	1.295 (1.291–1.299)	1.354 (1.350–1.358)
Ethnicity			
White	1.000	1.000	1.000
Visible minority	1.402 (1.397–1.407)	1.621 (1.615–1.627)	1.425 (1.420–1.431)
Job status in the past 12 months			
Employed	1.000	1.000	1.000
Unemployed	1.089 (1.084–1.093)	1.301 (1.296–1.306)	1.054 (1.050–1.058)
Dental coverage			
Dentally insured	1.000	1.000	1.000
Non-insured	1.478 (1.474–1.483)	1.774 (1.769–1.779)	1.464 (1.459–1.468)
Income adequacy			
Lowest income	3.186 (3.169–3.202)		2.919 (2.903–2.935)
Lower middle income	2.360 (2.350–2.370)		2.204 (2.195–2.214)
Upper middle income	1.639 (1.633–1.645)		1.582 (1.576–1.587)
Highest income	1.000		1.000
Educational attainment			
<High school (HS)		1.704 (1.698–1.710)	1.431 (1.425–1.436)
HS only		1.243 (1.239–1.248)	1.160 (1.156–1.164)
>HS		1.000	1.000

* All values significant at $p < 0.001$.[†] Model 1a – adjusted for age, sex, insurance, employment status and income; Model 1b – adjusted for age, sex, insurance, employment status and education; Model 2 – adjusted for age, sex, insurance, employment status and education. Reference group – Males, 25–34, more than high school education, highest income group, insurance, employed.**Table 3.** Adjusted effects of income and education on CD (odds ratios and 95% CI)[†]

	Model 1a*	Model 1b*	Model 2*
Age groups (years)			
25–34 (ref)	1.000	1.000	1.000
35–44	1.340 (1.331–1.349)	1.297 (1.288–1.306)	1.312 (1.303–1.321)
45–54	1.802 (1.790–1.814)	1.627 (1.616–1.638)	1.715 (1.704–1.727)
55–64	2.486 (2.469–2.504)	2.129 (2.114–2.144)	2.302 (2.286–2.318)
65+	3.114 (3.090–3.139)	2.532 (2.512–2.552)	2.787 (2.765–2.809)
Sex			
Male (ref)	1.000		1.000
Female	0.906 (0.903–0.910)	0.867 (0.864–0.871)	0.898 (0.895–0.902)
Ethnicity			
White (ref)	1.000	1.000	1.000
Visible minority	1.053 (1.047–1.058)	1.199 (1.192–1.206)	1.074 (1.068–1.080)
Job status in the past 12 months			
Employed (ref)	1.000	1.000	1.000
Unemployed	1.300 (1.294–1.307)	1.498 (1.491–1.506)	1.251 (1.244–1.258)
Dental coverage			
Dentally insured (ref)	1.000	1.000	1.000
Non-insured	1.188 (1.183–1.193)	1.364 (1.359–1.370)	1.165 (1.160–1.170)
Income adequacy			
Lowest income	2.926 (2.906–2.946)		2.580 (2.562–2.599)
Lower middle income	1.958 (1.946–1.970)		1.777 (1.766–1.788)
Upper middle income	1.381 (1.374–1.389)		1.322 (1.315–1.329)
Highest income (ref)	1.000		1.000
Educational attainment			
<High school (HS)		1.828 (1.819–1.837)	1.568 (1.560–1.575)
HS only		1.185 (1.178–1.191)	1.131 (1.125–1.137)
>HS (ref)		1.000	1.000

* All values significant at $p < 0.001$.[†] Model 1a – adjusted for age, sex, insurance, employment status and income; Model 1b – adjusted for age, sex, insurance, employment status and education; Model 2 – adjusted for age, sex, insurance, employment status and education. Reference group – Males, 25–34, more than high school education, highest income group, insurance, employed.

Table 4. Contributions of income and education to gradients in poor SROH and CD*

	Model 1a (income)	Model 1b (education)	Model 2 (income + education)	% RII difference [†]
Poor SROH				
Income	4.200 (4.175–4.225)	–	2.752 (2.728–2.776)	45.25
Education	–	1.708 (1.690–1.727)	1.443 (1.427–1.459)	37.43
Chewing difficulty				
Income	2.974 (2.939–3.009)	–	2.853 (2.819–2.887)	6.13
Education	–	1.733 (1.707–1.759)	1.422 (1.401–1.444)	42.38

* Model 1a – adjusted for age, sex, insurance, employment status and income; Model 1b – adjusted for age, sex, insurance, employment status and education; Model 2 – adjusted for age, sex, insurance, employment status and education. Reference group – Males, 25–34, more than high school education, highest income group, insurance, employed.

[†] The % RII difference indicates the percent that income (or education) contributed to socio-economic inequalities (e.g., 45.2% of the income gradient for poor SROH was explained by education and 37.4% of the education gradient for poor SROH was explained by income).

their current health (or oral health) status, while providing a representation of their social history and prediction of potential later life health problems.^{15,16} As oral health encompasses many dimensions, such as the ability to speak, eat and socialize unhindered by pain, discomfort or embarrassment,^{17,18} individual ratings for poor SROH are subject to personal beliefs, cultural background, as well as social, educational and environmental factors; all of which makes it difficult to discern how education and income mediate oral health gradients in SROH in the absence of other contextual variables.

Interestingly, the odds of reporting poor oral health did not increase linearly with age. One reason to explain why adults aged 65 years and older had lower odds of reporting poor oral health than younger age groups is that factors influencing self-perceived oral health status may differ along the life course.^{19–22} In addition, comparisons to age, peers and social norms, such as the social ideal of straight white teeth in North American culture,²³ may also influence perceptions of oral health.¹⁹ The extent to which various social and clinical factors influence these self-reports are beyond the scope of this analysis but have been explored elsewhere in the literature.^{20–22,24}

Utilizing chewing difficulties as an additional measure arguably enables an understanding of how respondents describe their oral health in terms of symptoms and function. This measure can be considered as a proxy indicator of oral disease burden, as chewing difficulties likely inhibit normal functioning and may be the result of oral disease (periodontal disease, caries); this may ultimately be the consequence of an inability to receive timely preventive or curative care. Income exhibited a greater contribution to the educational gradient for chewing difficulties than for poor SROH. This is similar to findings by Sanders et al., who reported that although there was a significant socio-economic gradient in dental visits, those individuals of low socio-economic status were not different in their oral self-care compared to the affluent, and concluded that the root of poor oral health was more likely financial limitations than neglect of self-care.²⁵

The contribution of income to education gradients in health is supported by Cutler and Lleras-Muney (2010); their analyses on health surveys in the United States revealed that material resources, such as income and insurance, accounted for 30% of the effect of education on health behaviours.²⁶ They suggest that the combination of knowledge and availability of financial resources enables healthier lifestyle choices, especially for behaviours that involve the medical care system.²⁶ In addition, results from a population of females in Finland found that one third of education

effects on health were due to income and one fifth of income effects on health were due to education, which further support the claim that material resources are required to maintain good health.¹⁰ As dental care is predominantly privately financed and thus remains a personal responsibility for the majority of Canadians, this corroborates our findings of the large and consistent contribution of income toward educational inequalities in obtaining care that prevents poor SROH and CD.^{27,28}

Conversely, using the Fourth German Oral Health Study data, Geyer et al. examined the effects of income and education on clinical oral health outcomes (DMFT) and determined that education may be a more important factor in oral health.⁶ Differences may be due to the use of a conflated measure of oral health and disease in their analysis, as DMFT encompasses both treated and untreated dental disease.²⁹ These discrepancies may also be attributed to differences in oral health care systems, as preventive dental coverage exists for individuals up to the age of 18 in Germany, whereas public coverage only exists for targeted populations in Canada.^{6,28} This further suggests that social, political and economic contexts of jurisdictions might play a role in how socio-economic factors contribute to inequalities.

Our results identified the contribution of income and education to socio-economic inequalities in two self-reported oral health outcomes. Income and education represent different domains of socio-economic position, where both play a role in the distribution of oral health in society.³⁰ In our study, the influence of material resources (income) consistently contributed to education inequalities in oral health. This suggests that access to material resources and social standing associated with income may be required in order to enable healthy lifestyle choices. The contribution of education to income-related inequalities suggests that educational attainment does not explain differences in chewing difficulties by income levels, but may have some social and historical influence on how individuals of different income levels perceive their oral health. Unfortunately, due to the cross-sectional nature of the survey, causality, timing of educational attainment, and mechanisms behind these contributions could not be explored in this study.

Given this variability in research findings, a shortcoming of our study is the reliance on self-reported rather than clinically derived measures of oral health, which may not always indicate actual dental need or burden of disease. However, as stated, measuring chewing difficulties provides an opportunity to uncover inequalities in impaired function related to dental/oral problems. Also, we were limited by the number of explanatory variables, and

would have ideally included measures of oral health literacy and oral health-related behaviours, among others.

Despite our limitations, our results provide a nationally representative picture of the effects of income and education on self-reported oral health outcomes. They reveal that the effect of education on income inequalities varied by oral health outcome, but income consistently explained over one third of the education effect on inequalities for the oral health outcomes used in this study. This suggests that future social and economic policy aimed at improving financial and material resources for individuals would better reduce socio-economic inequalities in oral health than those solely targeted toward changing oral health behaviour or knowledge acquisition of healthy behaviour.

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RÉSUMÉ

OBJECTIF : Chiffrer la mesure dans laquelle le revenu et l'instruction expliquent les gradients dans les résultats de santé buccodentaire.

MÉTHODE : À l'aide des données de l'Enquête sur la santé dans les collectivités canadiennes (ESCC, 2003), nous avons construit des modèles de régression logistique pour examiner la relation entre le revenu, d'une part, et l'instruction, d'autre part, sur la santé buccodentaire autodéclarée (SBA) et sur les difficultés de mastication (DM), en tenant compte des effets de l'âge, du sexe, de l'ethnicité, de la situation d'emploi et de l'assurance-soins dentaires. Nous avons utilisé l'indice relatif d'inégalité (IRI) pour chiffrer la mesure dans laquelle le revenu et l'instruction expliquent les gradients des problèmes de SBA et des DM.

RÉSULTATS : Les gradients du revenu et de l'instruction étaient présents tant pour la SBA que pour les DM. Selon les modèles pleinement ajustés, les inégalités de revenu étaient plus prononcées pour les DM ($IRI_{rev} = 2,85$) que pour la SBA ($IRI_{rev} = 2,75$), mais il n'y avait pas de différence marquée dans les inégalités en matière d'instruction. Le revenu expliquait 37,4 % et 42,4 % du gradient de l'instruction pour la SBA et les DM, respectivement, tandis que l'instruction expliquait 45,2 % et 6,1 % du gradient du revenu pour la SBA et les DM, respectivement. L'instruction semble jouer un plus grand rôle que le revenu lorsqu'il s'agit d'expliquer les inégalités de SBA; c'est toutefois le contraire pour les DM.

CONCLUSION : Dans cet échantillon de la population adulte canadienne, le revenu a expliqué plus du tiers du gradient de l'instruction pour la santé buccodentaire autodéclarée et pour les difficultés de mastication, tandis que l'apport de l'instruction dans les gradients du revenu variait selon le choix du résultat autodéclaré. Ces résultats appellent les acteurs du milieu à améliorer l'abordabilité des soins dentaires pour réduire les inégalités dans la population canadienne.

MOTS CLÉS : santé buccodentaire; facteurs socioéconomiques; niveau d'instruction; revenu; santé des populations