Oral Health, Oral Pain, and Visits to the Dentist: Neighborhood Influences among a Large Diverse Urban Sample of Adults

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ABSTRACT *The objective of this study was to assess the association between oral health and individual-level characteristics as well as both socioeconomic position (SEP) and service provision characteristics at the neighborhood level. Multilevel logistic analysis was undertaken of data from the Neighbourhood Effects on Health and Well-being Study in Toronto comprising 2,412 participants living in 47 neighborhoods and 87 census tracts. Three oral health outcomes were investigated: last dental visit, self-rated oral health, and self-rated oral pain. Results indicated that SEP was significantly associated with no dental visits in the last year, poor self-rated oral health, and experiencing oral pain after adjusting for age, gender, and immigrant status. Lack of dental insurance was associated with no visits to the dentist in the last year and poor self-rated oral health; however, no association was observed with oral pain. In adjusted regression models, few neighborhood level variables were significantly associated with dental visits and self-rated oral health and no neighborhood variables were associated with oral pain. Based on these results, SEP appears to be important in evaluating oral health outcomes. While insignificant in this study, neighborhood factors are important when considering the impact of service provision on oral health.*

KEYWORDS *Socioeconomic position, Oral health, Neighborhoods, Multilevel modeling*

INTRODUCTION

Socioeconomic position (SEP) has long been studied as a predictor of oral health, and evidence suggests that there is a strong social gradient to the inequalities seen in oral health outcomes.[1–3] For example, the recent Canadian Health Measures Survey found that, compared to others, vulnerable and disadvantaged groups are less likely to have dental insurance, more likely to avoid dental visits due to cost, more likely to consult dentists only in case of emergencies, and more likely to experience untreated dental decay, gum diseases, missing teeth, dental pain, and avoid eating healthy foods such as fruits and vegetables due to oral health problems.[4] Importantly, researchers have investigated these inequalities from a broader perspective than just the individual-level determinants of health. While still not fully understood,[5] contextual factors appear to be highly associated with oral health outcomes and

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the study of these factors is undoubtedly important in service planning and health inequalities research.[1,6]

However, findings from current literature on neighborhood impacts on oral health are mixed: some studies have found neighborhood characteristics to be significant in predicting oral health, even after controlling for individual-level factors,[5,7–10] while others have not found significant associations with oral health outcomes.[11–13] For example, Turrell et al. found that, after adjusting for individual characteristics in a sample of 2,915 individuals aged 43–57 years, residents of disadvantaged neighborhoods in Adelaide, South Australia were more likely to rate their oral health as fair or poor, have fewer teeth, and suffer from oral health conditions that negatively affected their quality of life.[10] Yet Locker and Ford, in a sample of 1,846 Ontario citizens aged 50 years or older, found that household income was a better predictor of inequalities in oral health status than area-based measures (oral health was more strongly associated with household income, yet their neighborhood variable was significant as well).[13]

Explanations for these contradictory findings may first include the use of different subpopulations (children or adults) and statistical methods (some studies did not use multilevel modeling to take into account the clustered design of their data).[5,7,11,13–15] Second, different definitions for both outcome and neighborhood measures have been used.[1,2,5,7–14,16,17] Previous studies either looked at various clinical outcomes (e.g., number of teeth, number of decayed teeth, periodontitis) [7,9,10,12,14,16] or self-rated outcomes (e.g., self-rated number of teeth, self-rated oral health).[5,8,11,13,15,17] Moreover, most studies have looked at neighborhood in terms of an SEP proxy or deprivation score, rather than something that, in itself, contributes to or harms health.[10] Inherently problematic in the characterization of neighborhoods is the lack of a widely accepted definition of deprivation, as is the lack of a theoretical framework to assist with appropriate indicator selection.[1] Finally, only a few have considered structural aspects of neighborhoods and their effects on oral health. For instance, Tellez et al. found that the severity of dental caries among low-income African-American children and their caregivers in Detroit, Michigan increased with a higher number of grocery stores and decreased with a higher number of churches after adjustment for individual-level characteristics.[9]

For this reason, neighborhood effects on oral health merit further study by investigating the association between structural aspects of neighborhoods and oral health outcomes, such as resource and service allocation impacts on health, rather than simply using a socioeconomic or deprivation score. Thus, the aim of this study was to assess the association between oral health and individual-level characteristics as well as both SEP and service provision characteristics at the neighborhood level. This study adds to the literature by not only considering the socioeconomic aspect of neighborhoods, but also by considering structural aspects of neighborhoods and their influence on oral health outcomes. This data is drawn from a population-based sample, representing broad SEP levels, having high immigrant participation, a wide adult age range, and rich neighborhood data.

METHODS

Sample Design
This study draws its data from the Neighbourhood Effects on Health and Well-being (NEHW) Study in the Greater Toronto Area. Participants were sampled using a

three-stage sampling design, extensively described elsewhere.[18] In the first sampling stage, 50 of the 140 neighborhoods were selected using serpentine ordering. The second sampling stage consisted of simple random sampling selection of two census tracts (CTs) within each of the 50 neighborhoods. Because of financial constraints, the final number of CTs was 87. At the third sampling stage, about 25 households were randomly selected within each CT based on residential address. Individuals aged 25 to 64 years were selected using the closest birthday method. All individuals were required to have resided in their neighborhood for at least 6 months.

Data were collected from March 2009 to June 2011 using computer-assisted personal interviewing techniques. In total, 2,412 participants, representing 47 neighborhoods and 87 CTs, were included in the sample (response rate of 72 %). CTs were chosen to define our neighborhoods because of their extensive use in previous multilevel analyses of neighborhoods.[5,7,9,11,16]

Outcome Variables

This study looks at three different outcomes: dental visits in the last year, self-rated oral health, and self-rated oral pain. In the face to face questionnaire, participants were asked "how long has it been since your last visit to the dentist?" and given the choice of answering "less than 1 year ago," "1–2 years ago," "2–3 years ago," "3–4 years ago," "4–5 years ago," "5 years or more," and "never." Answers were recoded into a dichotomous variable indicating whether the dentist had been visited in the last year ("yes" versus "no" 0/1, respectively). Participants were also asked to rate the health of their teeth and mouth on a five-point Likert scale; a dichotomous indicator of poor self-rated oral health was created grouping "fair" and "poor" categories together as "poor oral health" and "excellent," "very good," and "good" were grouped into a "good oral health" category. Lastly, participants were asked "in the past month, how often have you had any pain or discomfort in your teeth and gums?" with four response items: "often," "sometimes," "rarely," or "never." The variable self-rated oral pain was either coded as having oral pain (consisting of "often," "sometimes," and "rarely," coded as 1) or not having oral pain (consisting of the response "never," coded as 0).

Individual Characteristics

Individual characteristics used in this study were yielded from the participant interviews. Individual-level predictor variables were yearly household income and dental insurance status. Additionally, demographic variables such as sex, age, and immigrant status were used to adjust our analysis.

Neighborhood Characteristics

Data characterizing NEHW neighborhoods at the CT level were obtained from a variety of sources.[18] Neighborhood data were geocoded using GeoPinpoint v.3.3 software (DMTI Spatial Inc., Markham, Ontario, Canada) and imported into ArcGIS Editor 9.3 (ESRI, Redlands, CA, USA) for combination to the CT level. These data were subsequently merged with the individual-level survey data based on CT.[18] We used median income from the 2006 census to characterize the socioeconomic level of each CT (creation of SEP variable described later). We also considered structural aspects of neighborhoods: number of fast-food institutions, number of supermarkets, number of social services, number of parks, and number of dental services per CT. Data on park space in Toronto was obtained from DMTI Spatial CanMap Route Logistics 2007. The number of social services in Toronto were collected based on information from FindHelp (Toronto 211) 2011. Data

involving food-vending establishments came from Toronto Dinesafe 2011 (all food establishments in Toronto).[18] Data concerning the number of dentists per CT were obtained from Canadian Business Points 2010.[19] All these structural neighborhood variables were recoded as categorical variables: service not available in the CT of residence; only one service available in the CT; two or more services available in the CT. Because of small cells, the last two categories were sometimes combined.

SEP Variable

A cross-classified SEP variable was created as a composite of individual-level household income and median census income. Four categories were created: a low-income household (<$75,000) in a low-income neighborhood (<$75,000) was coded as 0; a high-income household (≥$75,000) in a low-income neighborhood was coded as 1; a low-income household in a high-income neighborhood (≥$75,000) was coded as 2; and a high-income household in a high-income neighborhood was coded as 3.

Statistical Analysis

We used the Glimmix procedure (SAS v9.3) to estimate multilevel logistic models and take into account the sampling design where individuals (level 1) were nested within CTs (level 2). Sampling weights were created and used in order to ensure that the sample was representative of the study population. Many models were specified for each of our three outcomes. First, an unadjusted model was estimated to assess the existence a contextual effect (model 0). Second, all individual and neighborhood variables were estimated one at a time. Third, model 1 estimated all individual-level predictors adjusted for age, sex, and immigrant status, while model 2 estimated all neighborhood characteristics. Finally, model 3 included all individual and neighborhood variables adjusting for age, sex, and immigrant status. Variables were selected based on their p values (removing insignificant variables one at a time until only significant variables remained). The results are presented as odds ratios (OR) and their 95 % confidence intervals (95 % CI). For each model, we calculated the intra-class correlation (ICC) coefficient in order to quantify the variation between CTs.

RESULTS

Description of Sample

While the original sample was comprised of 2,412 adults between the ages of 25 and 65 years, we excluded those who had missing data on key variables. Thus, our analysis was performed on 2,244 persons as we excluded individuals with missing data on household income, dental insurance status, immigrant status, age, and gender. Within this sample, 53.3 % was identified as female. The distribution of age categories showed that 39.5 % were under the age of 40 years, while only 9.1 % were 60 years of age or older. Confirming the high proportion of immigrants in the Greater Toronto Area, only 41.3 % of the sample was Canadian-born, while 45.2 % and 13.6 % have moved to Canada less than 10 years ago (recent immigrants) and more than 10 years ago (non-recent immigrants), respectively. Half of the sample reported a yearly household income of <$75,000 and 67.8 % reported having dental insurance. Individual characteristics are further outlined in Table 1.

Tables 2, 3, and 4 present the crude and adjusted ORs and their 95 % CI for the three investigated outcomes: dental visits in the last year, self-rated oral health, and

TABLE 1 Weighted sample characteristics (in percent) by length of time since last dental visit, self-rated oral health, and self-rated oral pain

	Overall (n=2,244)	Dental visits in the last year (n=2,245)			Self-rated oral health (n=2,247)			Oral pain (n=2,247)		
		Yes (76.0 %)	No (24.0 %)	p value	Good (84.6 %)	Poor (15.4 %)	p value	No (64.3 %)	Yes (35.7 %)	p value
Age										
<40 years	887 (39.5)	617 (36.3)	270 (50.2)	<0.0001	778 (41.0)	109 (31.5)	0.001	580 (40.2)	307 (38.3)	0.080
40–49 years	636 (28.3)	517 (30.4)	118 (22.1)		533 (28.1)	103 (29.8)		390 (27.1)	246 (30.6)	
50–59 years	518 (23.1)	396 (23.3)	117 (21.8)		413 (21.8)	105 (30.2)		328 (22.7)	190 (23.7)	
≥60 years	203 (9.1)	171 (10.1)	32 (6.0)		173 (9.1)	29 (8.4)		144 (10.0)	59 (7.4)	
Sex at birth										
Male	1,049 (46.7)	779 (45.8)	266 (49.4)	0.145	878 (46.3)	169 (48.7)	0.412	693 (48.1)	355 (44.3)	0.086
Female	1,196 (53.3)	923 (54.2)	272 (50.6)		1,018 (53.7)	178 (51.3)		749 (51.9)	447 (55.7)	
Immigrant status										
Canadian-born	926 (41.3)	745 (43.8)	180 (33.5)	<0.0001	813 (42.9)	113 (32.5)	0.002	591 (41.0)	334 (41.7)	0.005
Nonrecent immigrant	304 (13.6)	189 (11.1)	115 (21.4)		249 (13.2)	55 (15.8)		220 (15.3)	84 (10.5)	
Recent immigrant	1,014 (45.2)	768 (45.1)	242 (45.1)		834 (44.0)	179 (51.7)		631 (43.7)	383 (47.8)	
Highest level of education										
Less than high school	438 (19.5)	298 (17.5)	140 (26.0)	<0.0001	335 (17.7)	101 (29.3)	<0.0001	266 (18.5)	171 (21.4)	0.095
High school completed	1,806 (80.5)	1,404 (82.5)	398 (74.0)		1,561 (82.3)	245 (70.7)		1,176 (81.5)	630 (78.6)	
SEP										
Low-income individual and neighborhood	1,048 (46.7)	682 (40.1)	364 (67.6)	<0.0001	835 (44.0)	212 (61.3)	<0.0001	641 (44.5)	406 (50.7)	<0.0001
High-income individual/low-income neighborhood	866 (38.6)	742 (43.6)	123 (22.8)		773 (40.8)	93 (27.0)		589 (40.9)	277 (34.6)	
Low-income individual/high-income neighborhood	76 (3.4)	57 (3.3)	19 (3.5)		61 (3.2)	15 (4.4)		32 (2.2)	44 (5.5)	
High-income individual and neighborhood	254 (11.3)	222 (13.0)	32 (6.0)		229 (12.1)	25 (7.3)		180 (12.5)	74 (9.2)	
Dental insurance status										
Has dental insurance	1,522 (67.8)	1,277 (75.0)	242 (44.9)	<0.0001	1,339 (70.6)	183 (52.8)	<0.0001	1,006 (69.8)	516 (64.4)	0.008
No dental insurance	722 (32.2)	425 (25.0)	296 (44.1)		557 (29.4)	163 (47.2)		436 (30.2)	286 (35.7)	

TABLE 2 Multilevel models for "dental visits in the last year" ($n = 2{,}245$)

	Model 0	Unadjusted models			Model 1[a]			Model 2			Model 3[a]		
		OR	95 % CI	p value	OR	95 % CI	p value	OR	95 % CI	p value	OR	95 % CI	p value
Individual-level characteristics													
SEP													
Low-income individual and neighborhood		3.63	2.26–5.82	<0.0001	2.35	1.41–3.92	0.001				2.35	1.42–3.90	0.001
High-income individual/low-income neighborhood		1.18	0.72–1.92	0.514	1.06	0.63–1.78	0.836				1.05	0.63–1.77	0.843
Low-income individual/high-income neighborhood		2.33	1.20–4.52	0.013	1.46	0.72–2.95	0.292				1.45	0.72–2.94	0.299
High-income individual and neighborhood		1	Ref.		1	Ref.					1	Ref.	
Dental insurance status													
Has dental insurance		1	Ref.		1	Ref.					1	Ref.	
Does not have dental insurance		3.75	3.02–4.65	<0.0001	3.06	2.42–3.86	<0.0001				3.09	2.44–3.90	<0.0001
Neighborhood-level characteristics													
Dental services per CT													
None		0.96	0.66–1.39	0.817				1.13	0.70–1.83	0.617			
One dental service		0.91	0.59–1.40	0.656				0.93	0.59–1.47	0.745			
More than one dental service		1	Ref.					1	Ref.				
Fast-food institutions per CT													
None		0.94	0.69–1.28	0.668				0.87	0.60–1.26	0.455			
One or more		1	Ref.					1	Ref.				
Supermarkets per CT													
None		0.99	0.66–1.49	0.974				1.02	0.64–1.63	0.929			
One supermarket		1.20	0.78–1.85	0.402				1.2	0.76–1.88	0.423			
More than one		1	Ref.					1	Ref.				
Social services per CT													
None		0.88	0.62–1.26	0.475				0.89	0.60–1.34	0.583	1.11	0.77–1.60	0.560

	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
One social service	1.54	1.04–2.26	0.030	1.37	0.90–2.09	0.138				1.30	0.88–1.91	0.182
More than one	1	Ref.		1	Ref.					1	Ref.	
Parks per CT												
0–3 parks				1.03	0.68–1.55	0.891				1.04	0.71–1.54	0.841
4–8 parks				1.02	0.68–1.53	0.927				1.00	0.69–1.45	0.985
9 or more parks				1	Ref.					1	Ref.	
Covariance[b]	0.233 (0.074)			0.302 (0.084)			0.249 (0.076)			0.272 (0.074)		
ICC	0.066			0.084			0.070			0.076		

[a]Adjusted for age, gender, and immigrant status
[b]Estimate (standard error)

TABLE 3 Multilevel models for "self-rated oral health" (n=2,247)

	Model 0	Unadjusted models			Model 1[a]			Model 2			Model 3[a]		
		OR	95 % CI	p value	OR	95 % CI	p value	OR	95 % CI	p value	OR	95 % CI	p value
Individual-level characteristics													
SEP													
Low-income individual and neighborhood		2.38	1.37–4.13	0.003	2.02	1.16–3.53	0.014				2.43	1.41–4.17	0.002
High-income individual/low-income neighborhood		1.13	0.64–2.00	0.673	1.12	0.64–1.98	0.689				1.31	0.76–2.27	0.331
Low-income individual/high-income neighborhood		2.11	1.02–4.38	0.045	1.90	0.90–4.02	0.091				1.94	0.92–4.09	0.083
High-income individual and neighborhood		1	Ref.		1	Ref.					1	Ref.	
Dental insurance status													
Has dental insurance		1	Ref.		1	Ref.					1	Ref.	
Does not have dental insurance		2.08	1.63–2.67	<0.0001	1.76	1.35–2.28	<0.0001				1.80	1.38–2.34	<0.0001
Neighborhood-level characteristics													
Dental Services per CT													
None		1.03	0.69–1.55	0.880				0.94	0.57–1.55	0.808			
One dental service		0.75	0.46–1.24	0.256				0.60	0.37–0.98	0.043			
More than one dental service		1	Ref.					1	Ref.				
Fast-food Institutions per CT													
None		0.83	0.58–1.17	0.272				0.77	0.53–1.12	0.171			
One or more		1	Ref.					1	Ref.				
Supermarkets per CT													
None		0.95	0.60–1.48	0.802				0.93	0.58–1.48	0.755			
One supermarket		0.74	0.45–1.21	0.225				0.74	0.47–1.18	0.207			
More than one		1	Ref.					1	Ref.				
Social services per CT													
None		1.21	0.81–1.81	0.351				1.33	0.87–2.02	0.181	1.33	0.91–1.93	0.135

	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
One social service	1.50	0.97–2.32	0.070				1.70	1.10–2.61	0.017	1.57	1.06–2.34	0.026
More than one	1	Ref.					1	Ref.		1.00	Ref.	
Parks per CT												
0–3 parks	0.71	0.47–1.05	0.087				0.72	0.48–1.08	0.111	0.67	0.45–0.99	0.043
4–8 parks	0.55	0.37–0.81	0.003				0.53	0.35–0.80	0.003	0.49	0.33–0.71	0.0003
9 or more parks	1	Ref.					1	Ref.		1	Ref.	
Covariance[b]	0.316 (0.097)			0.277 (0.094)			0.238 (0.090)			0.180 (0.081)		
ICC	0.088			0.078			0.067			0.052		

[a]Adjusted for age, gender, and immigrant status
[b]Estimate (standard error)

TABLE 4 Multilevel models for "self-rated oral pain" ($n = 2{,}247$)

	Model 0	Unadjusted models			Model 1[a]			Model 2			Model 3[a]		
		OR	95 % CI	p value	OR	95 % CI	p value	OR	95 % CI	p value	OR	95 % CI	p value
Individual-level characteristics													
SEP													
Low-income individual and neighborhood		1.51	1.04–2.18	0.032	1.48	1.01–2.17	0.044				1.54	1.06–2.24	0.024
High-income individual/low-income neighborhood		1.12	0.77–1.64	0.544	1.11	0.76–1.63	0.575				1.12	0.76–1.63	0.570
Low-income individual/high-income neighborhood		3.36	1.93–5.84	<0.0001	3.53	2.00–6.21	<0.0001				3.68	2.10–6.45	<0.0001
High-income individual and neighborhood		1	Ref.		1	Ref.					1	Ref.	
Dental insurance status													
Has dental insurance		1	Ref.		1	Ref.							
Does not have dental insurance		1.26	1.04–1.52	0.020	1.13	0.92–1.39	0.254						
Neighborhood-level characteristics													
Dental services per CT													
None		1.07	0.80–1.44	0.626				1.05	0.72–1.54	0.800			
One dental service		0.94	0.67–1.33	0.736				0.87	0.60–1.25	0.449			
More than one dental service		1	Ref.					1	Ref.				
Fast-food institutions per CT													
None		0.95	0.74–1.21	0.672				0.87	0.65–1.17	0.342			
One or more		1	Ref.					1	Ref.				
Supermarkets per CT													
None		1.00	0.72–1.38	0.999				0.95	0.66–1.37	0.771			
One supermarket		0.93	0.66–1.31	0.670				0.91	0.63–1.30	0.586			
More than one		1	Ref.					1	Ref.				
Social services per CT													
None		1.20	0.90–1.59	0.209				1.24	0.90–1.71	0.187			

	Model 1	Model 2	Model 3	Model 4
One social service	1.25, 0.91–1.70, 0.167		1.32, 0.94–1.85, 0.110	
More than one	1, Ref.		1, Ref.	
Parks per CT				
0–3 parks	0.97, 0.71–1.32, 0.838		0.96, 0.70–1.33, 0.824	
4–8 parks	0.86, 0.64–1.15, 0.293		0.86, 0.62–1.18, 0.342	
9 or more parks	1, Ref.		1, Ref.	
Covariance[b]	0.147 (0.048)	0.140 (0.048)	0.166 (0.053)	0.141 (0.048)
ICC	0.043	0.041	0.048	0.041

[a]Adjusted for age, gender, and immigrant status
[b]Estimate (standard error)

self-rated oral pain. All three unadjusted (model 0) indicated the need to use multilevel logistic models rather than a simple logistic regression (ICCs varying from 0.043 to 0.088). For instance, 8.8 % of individual variation in oral pain might be attributable to contextual factors or the area composition.

Model 3 (Table 2) shows that dental visits in the last year were associated with SEP, dental insurance, and social services within the CT. Individuals with a household income of <$75,000 living in a low-income neighborhood were more likely than those with household incomes ≥$75,000 living in a high-income neighborhood to have last visited the dentist over 1 year ago (OR, 2.35; 95 % CI, 1.42–3.90), and those without dental insurance were more likely to have not visited the dentist than those who are insured (OR, 3.07; 95 % CI, 2.44–3.90). These relationships were significant in both the unadjusted model and the adjusted individual model (model 1). In the unadjusted model, there were no significant neighborhood variables. In the final model, the only neighborhood variable to be significantly associated with dental visits was social services per CT, with those living in a CT with one social service more likely to not have gone to the dentist in the last year than those living in CTs with more than one social service. ICCs slightly decreased in models 1 and 3 but the final model indicated that 6.6 % of the variation between CTs was still not explained.

Self-rated oral health (Table 3) produced similar results with regards to SEP and dental insurance being highly significant in the unadjusted model, the adjusted individual model (model 1), and the final model (model 3); however, the magnitude of their significance declined slightly upon adjustment for age, gender, and immigrant status. Individuals with a household income <$75,000 living in a low-income neighborhood and with no dental insurance were likely to report poor self-rated oral health. In model 2, social services per CT, parks per CT, and dental services per CT were significantly associated with self-rated oral health; however, upon assessment in the final model (model 3), only social services per CT and parks per CT remained significant predictors. Those living in areas with four to eight parks were less likely to report poor self-rated oral health (OR, 0.49; 95 % CI, 0.33–0.71) compared to those living in areas with nine or more parks, and those in CTs with one or more social services were more likely to report poor self-rated oral health than those in CTs with more than one social service (OR, 1.57; 95 % CI, 1.06–2.34). Adding individual-level and neighborhood-level characteristics decreased the ICC value, but 5.2 % of the variation between CTs remained unexplained in the final model.

Unlike the previous results, all models showed that self-rated oral pain (Table 4) was not associated with any neighborhood variables. In the unadjusted model, both SEP and lack of dental insurance were significantly associated with reporting oral pain in the previous month; however, upon adjustment for all individual characteristics in model 1, dental insurance no longer showed any significant association. In the final model, only SEP remained a significant predictor of reporting oral pain, with those who reported a household income of <$75,000 living in a low-income neighborhood more likely to report experiencing oral pain (OR, 1.54; 95 % CI, 1.06–2.24) compared to those with household incomes ≥$75,000 in high-income neighborhoods. Unique to oral pain was the fact that, additionally, low-income individuals living in high-income neighborhoods were significantly more likely to report experiencing oral pain (OR, 3.86; 95 % CI, 2.10–6.45). ICCs did not improve when adding individual-level and neighborhood-level characteristics into the models.

DISCUSSION

Our results demonstrated that SEP was highly associated with oral health outcomes. Compared to their higher-income counterparts, those in the lower-income household category were more likely to report visiting the dentist over 1 year ago, rated their oral health as poor, and experienced oral pain. This is not surprising, as the literature is consistent in finding that income is a very strong predictor of adverse oral health outcomes, whether self-reported or clinically determined.[5,8,10–13,17,20] Similar to the existing literature, our results also demonstrated that dental insurance was a significant predictor of oral health outcomes.[2,3,21] Although no association was found between not having dental insurance and reporting the experience of oral pain, the insured group was significantly more likely to have visited the dentist over 1 year ago and reporting poorer oral health.

Importantly, consistent with previous studies which did not find that neighborhood characteristics were associated with oral health,[11–13] very few neighborhood variables in our study were significant predictors of a person's last dental visit, self-rated oral health, or self-rated oral pain. It is arguable that, since dental services are not publicly funded in Canada, individual income is likely the strongest predictor of utilization and access.

Interestingly though, the number of social services per CT was a significant factor in predicting both the length of time between dental visits and self-rated oral health; in both cases, those living in areas with one or more social services were more likely to report last visiting the dentist over 1 year ago and reporting poor oral health. Additionally, those who lived in areas with more parks were less likely to report poor oral health. These variables might be, in part, additional proxies for SEP, with social services representing lower-income neighborhoods and higher numbers of parks representing higher-income neighborhoods.

The strengths of our study include its contribution to the growing literature on the neighborhood effects on oral health, its large sample size, its representative data on the population of Toronto, its rich data on neighborhood factors, and the application of multilevel modeling to account for clustered data. Additionally, three oral health outcomes were explored, which produced relatively comparable results. Lastly, we looked at both individual and neighborhood SEP, as well as diverse structural aspects of neighborhoods in relation to the outcomes of interest. However, the lack of information on relevant individual characteristics such as dental hygiene practices and whether dental care was available through public programs may have had an impact on our findings. Further analysis on this topic could also be done to include social capital dimensions of neighborhoods in order to observe what role these aspects play in explaining oral health outcomes.

CONCLUSIONS

Although our results revealed few significant neighborhood variables in this sample, these factors are still important to consider in oral health research. Understanding health inequalities ultimately depends on understanding what underlying factors cause these inequalities, and addressing these factors. These underlying factors are reflected at the neighborhood level, such as the availability of dental services, nutritional food sources, or park space. Without addressing these "upstream" social determinants of health, the "downstream" efforts, which focus on individual behavioral factors, will be less effective.[6] Studying oral health using neighborhood

measures allows for underserved groups to be easily pinpointed, thus allowing for targeted interventions and more effective resource allocation.[1] Ultimately, oral health must arguably be treated as a complex phenomenon and, as such, must be studied from a broad perspective.

ACKNOWLEDGMENTS

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