The relationship between income and oral health – A critical review

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Abstract

In this critical review, we summarized the evidence on associations between individual/household income and oral health, between income inequality and oral health, and on income-related inequalities in oral health. Meta-analyses of mainly cross-sectional studies confirm that low individual/household income is associated with oral cancer (odds ratio: 2.41 (95%CI: 1.59, 3.65)), dental caries prevalence (prevalence ratio: 1.29 (95% CI: 1.18, 1.41)), any caries experience (odds ratio: 1.40 (95% CI: 1.19, 1.65)), tooth loss (odds ratio: 1.66 (95% CI: 1.48-1.86) and traumatic dental injuries (odds ratio: 0.76 (95% CI: 0.65–0.89)). Reviews also confirm qualitatively that low income is associated with periodontal disease and poor oral health related quality of life. Limited evidence from the U.S. shows that psychosocial and behavioural explanations only partially explain associations between low individual/household income and oral health. Few country-level studies and a handful of sub-national studies from the U.S, Japan and Brazil show associations between area-level income inequality and poor oral health. However, this evidence is conflicting given that the association between area-level income inequality and oral health outcomes varies considerably by contexts and by oral health outcomes. Evidence also shows cross-national variations in income-related inequalities in oral health outcomes of self-rated oral health, dental care, oral health related quality of life, outcomes of dental caries and outcomes of tooth loss. There is a lack of discussion in oral health literature about limitations of using income as a measure of social position. Future studies on the relationship between income and oral health can benefit substantially from recent theoretical and methodological advancements in social epidemiology that include application of an intersectionality framework, improvements in reporting of inequality and causal modelling approaches. Theoretically well-informed studies, that apply robust epidemiological methods, are required to address knowledge gaps for designing relevant policy interventions to reduce income-related inequalities in oral health.

Keywords: Social determinants, Health inequalities, Epidemiology, Review, Dental, Theory

Introduction

Oral conditions affect nearly half of the global population, and unfairly more so among socially disadvantaged individuals and populations (Kassebaum et al. 2017; Watt et al. 2016). Understanding the drivers of population-levels of poor oral health and oral health inequalities is fundamental for formulating an adequate policy response. Social determinants of health are conditions in which people are born, grow, live, work and age ((CSDH) 2007). Among them, income has received ample attention and is noted as the best single indicator of material living standards in health research (Galobardes et al. 2006). Income is indicative of the standard of living and of life chances that individuals and households experience through sharing goods and services (Daly et al. 2002). The aetiology of commonly prevalent oral conditions include behavioural risk factors such as inadequate diet, tobacco use and high levels of stress, all of which are known to vary by income (Laaksonen et al. 2003; Lynch 1997). Income is also recognized as an enabling factor for access to healthcare (van Doorslaer et al. 2006). Therefore, it is vital to understand income's role as a societal driver of oral health.

Despite their interdependence, the individual/household income, the average income of the population, the income below a certain threshold (poverty line), and the distribution of income within an area (area-level income inequality) are all treated as separate exposures in relation to health. Although area-level measures of income are applied as proxies of income when the data at individual/household level is not available; treating them identically is inappropriate (Subramanian et al. 2009) and inconsistent with multiple hypotheses proposed to explain how income across levels of social organization impact health outcomes (see (Wagstaff 2000) for description of absolute income hypothesis, relative income hypothesis, deprivation hypothesis, relative position hypothesis and income inequality hypothesis). We show multiple hypotheses between different measures of income and across many oral health outcomes in Figure 1. Income is a preferred measure among studies comparing social inequalities in health (Galobardes et al. 2006). In this critical review, we summarize the evidence on the relationship between income and oral health, therefore, from three different perspectives:

Is low individual/ household-level income related to worse oral health outcomes?

Is area-level income inequality related to worse oral health outcomes?

What is the extent of income-related oral health inequalities within and between countries?

In the final section (Conclusion and Perspectives) we highlight theoretical and methodological advancements in social epidemiology that offer opportunities to fill current knowledge gaps on the relationship between income and oral health.

Is low individual/ household-level income related to worse oral health outcomes?

Theoretical pathways and explanations

Materialist explanations and behavioral/cultural explanations are widely adopted explanations for the relationship between low income and worse oral health outcomes (Sisson 2007; Townsend et al. 1982). The material explanation emphasizes the role of material disadvantage due to lack of income such as inability to afford preventive and regular dental care due to treatment costs and accessing healthy diets. Alternatively, behavioral/cultural explanations stress on the role of poor health

behaviors (tobacco use, high sugar consumption, infrequent and symptomatic dental visits, and poor oral hygiene practices) that may arise due to low income. The underlying reasons for such behavior include lack of education, knowledge, and attitudes towards healthy behavior. Another explanation for poor behaviour is the 'culture of poverty thesis'. At lower levels of income, a structure of norms, ideas, and behaviors can get established over as a process of biological and social adaptation over time leading to persistent poor health behaviors (Townsend et al. 1982).

Sabbah et al. (2009a) examined whether oral health behaviors (smoking, dental visits, frequency of eating fresh fruits and vegetables, and oral hygiene) explained the observed associations between income and multiple oral health outcomes (gingival bleeding, loss of periodontal attachment, tooth loss and perceived oral health) among adults in the U.S. population. Despite adjusting for the oral health behaviors, income related inequalities in all the outcomes remained (higher income vs lower income: gingival bleeding (regression coefficient) -0.6(95% CI: -0.9, -0.4); loss of periodontal attachment (regression coefficient) -0.3 (95%CI: -0.6, -0.1) poor/fair perceived oral health (odds ratio) 0.9 (95%CI: 0.8, 0.9); number of missing tooth surfaces (count rate ratio) 0.9 (95%CI: 0.9, 0.9)).

A psychosocial theory emphasizing the role of stress in leading to worse oral health outcomes due to relative disadvantage among individuals is also proposed (Sisson 2007). Sabbah et al. (2009b) examined the role of cognitive ability in income related oral health inequalities measured and found that income inequality persisted after accounting for cognitive ability (gingival bleeding (regression coefficient) -0.9(95% CI: -1.3, -0.6); loss of periodontal attachment (regression coefficient) -1.1 (95%CI: -1.5, -0.6); number of missing tooth surfaces (count rate ratio: 0.9 (95%CI: 0.8, 0.9)).

A life-course framework theorizes how exposures throughout life, especially during biologically or socially vulnerable periods, influence health at later ages (Ben-Shlomo and Kuh 2002). Using data from the Pelotas birth cohort study in Brazil, several studies showed later on impact on oral health of income earlier in life. Upwardly mobile income between childhood and adolescence improved dental care (Peres et al. 2007). Later on, when 31 years old, Schuch et al. (2018b) showed that adults belonging to low- and fluctuating-income trajectories from childhood to adulthood had twice as much the prevalence of periodontitis than in participants from stable high-income trajectories. The direct effect of early-life poverty on periodontitis in adulthood was also confirmed (Schuch et al. 2018a). Another study showed that participants with stable-low and upward income group trajectories had more unsound teeth than those in the stable high-income group (Peres et al. 2018).

Theoretical explanations on the relationship between area-level mean income and oral health are not well developed as they are mostly used as proxies for individual/household income.

Brief summary of evidence

Numerous studies have examined associations between low individual- and household-level income and oral health outcomes. Using a systematic search strategy on PubMed (Box 1, Appendix 1), we identified at least 16 reviews on this subject that adopted a systematic search strategy (three on periodontal disease, three on dental caries, two on oral cancer, one each on oral health related quality of life (OHRQoL), dental trauma, and tooth loss, and one generally on oral health) (See Appendix 1). The evidence reviewed is largely contributed from cross-sectional and case control studies, and only a few include cohort studies. Qualitatively, all reviews confirmed that low income is associated with poor oral health outcomes examined. Meta-analyses do not exist on the associations between low income and the outcomes of periodontal disease and OHRQoL. But, reviews concluded that low income is associated with higher periodontal disease (Bastos et al. 2011; Borrell and Crawford 2012; Schuch et al. 2017) in adults and low parental income is associated with worse

OHRQoL among children(Kumar et al. 2014). Few reviews applied meta-analysis to quantitively summarise evidence on low income and specific oral health outcomes.

Oral cancer

A meta-analysis (collective sample size: 905 cases and 1388 controls) of odds ratio estimates of low to high monthly household income associated with increased risk of oral cancer was found to be 2.41 (95%CI: 1.59, 3.65) (Conway et al. 2008). Authors also found higher odds among high income than low income countries in a fixed-effects model (p=0.04). No significant differences between studies by variations in income categories among selected studies or by adjustment of confounding factors were reported.

Dental caries

For dental caries, meta-analysis for the association between low income and dental caries prevalence from 31 studies found a pooled prevalence ratio of 1.29 (95% CI: 1.18, 1.41). Separately, pooled odds ratio of 1.40 (95% CI: 1.19, 1.65) was found for the association between low income and any caries experience (DMFT/dmft >0) from 15 studies (Schwendicke et al. 2015). No significant variations were reported by adjustment for confounding factors (Schwendicke et al. 2015).

Tooth loss

A meta-analysis of 11 studies examined the association between low income and tooth loss (Seerig et al. 2015) and found that low income was associated with 2.52 times (95% CI: 2.11, 3.01) higher odds of tooth loss. However, when only adjusted results were pooled, the odds ratio attenuated to 1.66 (95% CI: 1.48-1.86) (Seerig et al. 2015).

Traumatic dental injuries

Pooled odds ratio from eight cross-sectional studies on the association between income and traumatic dental injuries in primary dentition showed that children from households with income twice of average salary, and thrice of average salary, had 0.77 and 0.76 lower odds of traumatic dental injuries, (95% CI: 0.66–0.90) and (95% CI: 0.65–0.89) respectively (Correa-Faria et al. 2015).

Is area-level income inequality related to worse oral health outcomes?

Theoretical pathways and explanations

Theoretical explanations for the relationship between area-level income inequality and oral health are grounded in social relations and systematic distribution and misallocation of social resources relevant to health arising due to inequality. The relevance of these pathways is discussed extensively in social epidemiology. However, disagreement persists among their proponents.

Materialist explanation: the materialist explanations stress the role of environmental factors on health which tend to vary according to the degree of income inequality of an area. Macroeconomic factors such as unemployment and levels of economic development lead to hazardous work and living environments that lead to poorer health on an average (MacIntyre 1997).

Behavioral: the behavioral explanations state that compared to more egalitarian, unequal social environments produce more unhealthy behaviors. This is either due to individual choices or presence of social gradients in health behaviors (MacIntyre 1997).

Psychosocial: When there is high area-level income inequality, there is a greater degree of social-evaluative threats (comparisons between people) added with the lack of control and coping

strategies leading to higher levels of persistent stress. Therefore, a greater decrement in power and control across the social hierarchy in presence of more inequality leads to poorer health on average (Bartley 2004).

Social Capital: social capital explanations branch out from the psychosocial explanation as this theory posits that a more unequal distribution in income undermines trust and damages social relationships at a population level (Kawachi and Kennedy 1999). The lack of trust and social support are the key reasons for poorer population health in places with high inequality.

Neo-material: in contrast to the psychosocial and the social capital theories, the neo-material theory emphasizes the role of the neo-material cluster through which income inequality leads to worse oral health at the population level. The neo-material cluster consists of both lack of material resources by individuals and populations as well as a systematic underinvestment in social infrastructure such as public policies on health care, transportation, housing and welfare (Lynch et al. 2004).

Operationalization of these theories in oral epidemiological literature has been reviewed in the referred scoping review (Singh et al. 2016). The review found dominant use of psychosocial theory, more post-hoc use of theories than their explicit modeling within studies, and a need to acknowledge heterogeneity of aetiologies of oral health conditions and its impact on presumed theories (Singh et al. 2016).

Brief summary of evidence

To our knowledge, no systematic review exists on the relationship between area-level income inequality and oral health outcomes. Studies on income inequality and oral health are relatively recent and exist at both country level (Bernabe and Hobdell 2010; Bernabe et al. 2009a; Bhandari et al. 2015a; 2015b; Sabbah et al. 2010b) and at sub-national levels from Japan (Aida et al. 2011), USA (Bernabe and Marcenes 2011; Moeller et al. 2017), Brazil (Celeste et al. 2011a; Celeste and Nadanovsky 2010; Celeste et al. 2009; Chalub et al. 2014; Goulart Mde and Vettore 2016; Pattussi et al. 2001; Peres et al. 2003; Vettore and Aqeeli 2016; Vettore et al. 2013) and Australia (Singh et al. 2018).

Outcomes of dental caries

Five studies have examined the associations between area-level income inequality and outcomes of dental caries (Bernabe and Hobdell 2010; Bernabe et al. 2009; Celeste et al. 2009; Pattussi et al. 2001; Peres et al. 2003). Of these, three were ecological in study design (Bernabe and Hobdell 2010; Bernabe et al. 2009; Peres et al. 2003), and two applied multilevel modelling (Celeste et al. 2009; Pattussi et al. 2001). Two studies were conducted at the country level and the remaining three studies were conducted at the sub-national level in Brazil. Except for the study by Peres et al. (2003), all studies confirmed a positive association between area-level income inequality and at-least one component of DMFT. Bernabe and Hobdell (2010) found a correlation coefficient of 0.44 ($p=0.038$) for the association between Gini coefficient (a widely used measure of income inequality) and DMFT among 5-6 year children among rich nations, but found no association when low and middle income nations were included in the analysis. Bernabe et al. (2009) found a correlation coefficient of -0.82 ($p<0.001$) for the association between Gini coefficient and filled teeth, while a correlation of -0.66 ($p<0.01$) with DMFT scores. Pattussi et al. (2001) found higher administrative-level Gini coefficient to be associated with higher DMFT scores (beta coefficient: 3.1 (95% CI: 0.77, 5.55) in Brazil.

Periodontal disease

One country-level ecological study (Sabbah et al. 2010b) and two sub-national multilevel studies (Celeste et al. 2011a; Vettore et al. 2013) from Brazil have tested associations between income

inequality and periodontal disease. Except Celeste et al. (2011a), both confirmed a positive association between income inequality and periodontal disease. Sabbah et al. (2010a) found a correlation coefficient of 0.50 (p=0.013) for ≥4 mm periodontal pockets and 0.62 (p=0.008) for ≥6 mm periodontal pockets, respectively. Vettore et al. (2013) found that individuals living in Brazilian state capitals and federal districts within the highest tertile of income inequality had 3.0 times (95% CI: 1.5, 5.9) times higher odds of severe periodontal disease.

Outcomes of tooth loss

Only sub-national studies from Brazil, USA, Japan and Australia exist on the associations between income inequality and tooth loss (Aida et al. 2011; Bernabe and Marcenes 2011; Celeste et al. 2011a; Celeste and Nadanovsky 2010; Celeste et al. 2009; Chalub et al. 2016; Goulart Mde and Vettore 2016; Singh et al. 2018). Out of the eight studies, five studies reported a positive association between area-level income inequality and tooth loss (Aida et al. 2011; Bernabe and Marcenes 2011; Celeste and Nadanovsky 2010; Celeste et al. 2009; Goulart Mde and Vettore 2016), with effect estimates ranging from odds ratio of 1.17 (95% CI: 1.05, 1.30) associated with 5% change in income inequality to 1.67 (95% CI: 1.26, 2.29; having 19 or less teeth vs having 20 or more teeth as reference). Two reported no associations (Celeste et al. 2011a; Chalub et al. 2016), and one found high-income inequality to be associated with lower inadequate dentition among Australian adults (odds ratio of 0.64; 95% CI: 0.48, 0.87 for having less than 21 teeth) (Singh et al. 2018).

Subjective oral health outcomes

One study each from the U.S.A, Australia, and Brazil have tested associations between income inequality and subjective oral health outcomes (Moeller et al. 2017; Singh et al. 2018; Vettore and Aqeeli 2016). No association was reported in one study (Singh et al. 2018), while the other two studies found high-income inequality to be associated with worse subjective oral health.

Dental care utilization

Three country-level studies have investigated the associations between income inequality and dental care utilization (Bernabe et al. 2009; Bhandari et al. 2015a; 2015b). All confirmed an inverse association between income inequality and dental care utilization.

Other oral disorders

One sub-national study reported no association between income inequality and malocclusion (Celeste and Nadanovsky 2010).

What is the extent of income-related oral health inequalities within and between countries?

Theoretical pathways and explanation

Based on the reviewed theoretical pathways and the evidence for the relationship between income, poverty and income inequality and oral health above; one can speculate that income-related oral health inequalities between countries will differ depending on the underlying historical, political, economic and social environment that shape income inequality within countries. Proposing a conceptual model that can capture the influence of income across different levels of social organization, at different life stages, through multiple theorized pathways and that is relevant to all oral health outcomes can be ambitious. However, mapping the key aspects that connect income and income inequality to oral health outcomes is important to understand and address the societal drivers of income-related oral health inequalities. Conceptual models elucidate specific intervention points for reducing income-related oral health inequalities within and between countries. We

propose a theoretical framework in Figure 2, adapted from a previous model proposed for explaining population-level causation of dental caries (Holst et al. 2001), and existing models to explain social inequalities in health ((CSDH) 2007) and oral health (Watt and Sheiham 2012).

Brief summary of evidence

No systematic reviews exist on the extent of variations in income-related oral health inequalities. Social gradients and differences in oral health status according to income are confirmed by numerous studies. Few and relatively recent studies quantified income-related oral health inequalities using composite inequality measures and compared between populations by time or geography and/or oral health outcomes (Borrell and Talih 2012; Celeste et al. 2011b; Do et al. 2010; Farmer et al. 2017; Guarnizo-Herreno et al. 2015; Kramer et al. 2015; Manski et al. 2016; Mejia et al. 2014; Peres et al. 2015; Ravaghi et al. 2013a; 2013b; Roncalli et al. 2015; Sanders et al. 2009; Shen et al. 2013; Slade et al. 2014; Tchicaya and Lorentz 2014). Cross-national variations in income-related inequalities are confirmed from cross-sectional studies on self-rated oral health (Guarnizo-Herreno et al. 2015), oral health-related quality of life (Sanders et al. 2009) and dental care (Manski et al. 2016; Tchicaya and Lorentz 2014). Cross-national variations in trends in income-related inequalities are also confirmed in outcomes of dental caries, edentulousness, number of filled teeth (Farmer et al. 2016) and inadequate dentition (Peres et al. 2015). Within-countries variations in income-related oral health inequalities by time are also confirmed (Borrell and Talih 2012; Do et al. 2010; Kramer et al. 2015; Roncalli et al. 2015; Slade et al. 2014). Finally, some studies have confirmed variations in income-related oral health inequalities according to oral health outcomes within the same population (Farmer et al. 2017; Mejia et al. 2014; Ravaghi et al. 2013b). Only two studies have compared income-related inequalities between oral and general health outcomes in the same population and found higher in oral health outcomes rather than general health (Ravaghi et al. 2013a; Sabbah et al. 2007).

Conclusions and perspectives

Summary of evidence

The evidence on the relationship between income and oral health is multifaceted, and unclear on certain specific aspects. For example, while the evidence on the relationship between individual/household income and oral health outcomes is more developed (tested across large number of oral health outcomes and many nations), the evidence is limited and inconclusive on the relationship between area-level income inequality as an exposure and oral health outcomes. Variations of temporal and geographic nature in income-related inequalities in oral health within and between countries is also less evidenced.

Gaps in evidence

Some knowledge gaps persist on the relationship between income, income inequality and oral health outcomes. For instance, it is less likely that low income affects all oral health outcomes with the same intensity or through identical pathways. Oral diseases differ in their aetiology and low income, or high-income inequality, may lead to different material stressors relevant to each of them (for example: accessing preventive dental healthcare for dental caries and accessing tobacco cessation services and nicotine replacement therapies for the periodontal disease). There is limited discussion on the use of income as a measure of social position despite its known limitations related to misreporting and its reliability for young and older adults and its relevance as measure of social disadvantage among population sub-groups such as among those with disabilities, ethnic minorities, indigenous people and diverse gender or sexual identities. There is lack of clarity and consensus on causal pathways through which income, or income inequality, impacts oral health outcomes.

Increased knowledge of causal pathways is tantamount to better understand and address issues around confounding by other measures of social position such as occupation, employment and education. Finally, evidence on the relationship between income and oral health is derived mainly from cross-sectional studies where the temporal sequence between low income and poor oral health cannot be established. We do not summarize evidence on poverty and oral health in this critical review as poverty cannot be solely defined and measured by income and must include aspects of low wealth and low consumption (Headey 2008) and should be examined in future reviews.

Way forward for research

Despite knowing that social exposures such as gender, ethnicity, age, education as well as income are shaped by societal systems of oppression and privilege (Kapilashrami and Hankivsky 2018; Merlo 2018), studies treat these measures as independent to each other in relation to health. Such an exercise risks considering these exposures as measures of individual risk and ignores intersection between different forms of social identities (Evans et al. 2018). An intersectionality approach, that can examine interactions between income and multiple social exposures when studying determinants of oral health and oral health inequalities will be valuable (Kapilashrami and Hankivsky 2018; Merlo 2018).

Often studies on income-related oral health inequalities selectively choose scales (absolute or relative) to report inequality. The choice between the scales are value-laden and sometimes driven by either preferred conclusions or selective exclusion of measures (Kjellsson et al. 2015). To avoid such suspicions, inequalities should be presented on both scales (Mackenbach et al. 2016). Choosing a reference group when estimating inequalities is an additional issue of concern. Particularly, when inequalities are measured on a relative scale for oral health outcomes that have an upper and lower bound when outcomes can be expressed as either health attainments or shortfalls (example: presence or absence of periodontitis). It is advised that income-related oral health inequalities are presented using all three measures: attainment-relative, absolute, and shortfall-relative, to avoid risks of suspecting preferential reporting of shortfall or attainment perspective (Kjellsson et al. 2015).Inequality plots are now developed that can simultaneously present changes in income-related oral health inequalities over time on both relative and absolute scales (Blakely et al. 2017).

Causal approaches based on the 'potential outcome approach' framework are gaining momentum in epidemiology to address pertinent research questions related to health inequalities but lags in oral health literature. Examples include the estimation of causal effects of social disadvantage on health (Nandi et al. 2012) or modeling utility of interventions in reducing existing socioeconomic inequalities in health (Blakely et al. 2018). These techniques offer substantial opportunities to improve the current understanding of income and oral health relationship (VanderWeele 2015). Rich observational data can be utilized using these methods that mimic randomized controlled trials to examine causal relationships between income and health. By employing mediation analysis, the total causal effects of income on oral health outcome can be decomposed into a portion of the total effect that is not transmitted through measured pathways (natural direct effect), and a portion transmitted through measured mediators (natural indirect effect). It must be noted that causal modeling approaches have strong assumptions of no confounding among others. Therefore, the selection of confounding factors must be carefully thought through and theoretically informed (Fleischer and Diez Roux 2008). Well-designed longitudinal studies with sufficiently large representative sample sizes, long-term follow up, and rich baseline covariate data can help in minimizing bias. Long-term follow-up studies, for instance birth cohorts, also offer unique opportunities to examine the oral health impact of early life exposures to low parental income

across the life-course. Furthermore, longitudinal studies have the capacity to inform lagged and period effects of low income on oral health, of which cross-sectional and intervention studies with short-term follow-up may not.

Conclusion

The studies on oral health effects of individual/household income and of societal income inequality need to enhance their theoretical and methodological rigor. Well-designed epidemiological studies that exploit ongoing methodological advances in epidemiology and statistics, as well as theoretical developments in social epidemiology, are likely to address current knowledge gaps on income-related inequalities in oral health. Robust evidence generated from studies that capitalize on these advancements can help design policy interventions to reduce the pervasive oral health effects of low income and income inequality. Meta-analyses confirm that low individual/household income is associated with several adverse oral health outcomes. Limited evidence shows that psychosocial and behavioural explanations only partially explain associations between low individual/household income and oral health. The evidence on area-level income inequality and poor oral health is conflicting given that the associations varies considerably by contexts and by oral health outcomes.

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Conflicts of Interest

None to declare

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Figure 1 Relationship between income and oral health outcomes at different levels of social organisation

Figure 2 Conceptual framework for income and oral health relationship