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Review Article

Theoretical basis and explanation for the relationship between area-level social inequalities and population oral health outcomes – A scoping review

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ABSTRACT

This study was conducted to review the evidence on the association between area-level social inequalities and population oral health according to type and extent of social theories. A scoping review was conducted of studies, which assessed the association between area-level social inequality measures, and population oral health outcomes including self-rated oral health, number of teeth, dental caries, periodontal disease, tooth loss, oral health-related quality of life (OHRQoL) and dental pain. A search strategy was applied to identify evidence on PubMed, MEDLINE (Ovid), EMBASE, Web of Science, ERIC, Sociological Abstracts, Social Services Abstracts, references of selected studies, and further grey literature. A qualitative content analysis of the selected studies was conducted to identify theories and categorize studies according to their theoretical basis. A total of 2892 studies were identified with 16 included in the review. Seven types of social theories were used on 48 occasions within the selected studies including: psychosocial ($n=13$), behavioural ($n=10$), neo-material ($n=10$), social capital ($n=6$), social cohesion ($n=4$), material ($n=3$) and social support ($n=2$). Of the selected studies, four explicitly tested social theories as pathways from inequalities to population oral health outcomes, three used a theoretical construct, seven used theories for post-hoc explanation and two did not have any use of theory. In conclusion, psychosocial theories were used most frequently. Although theories were often mentioned, majority of these studies did not test a social theory.

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1. Introduction

'He who loves practice without theory is like the sailor who boards ship without a rudder and compass and never knows where he may cast' – (Leonardo da Vinci 1452–1519).

Theory is essential to understanding patterns in ideas and observations, and to develop causal explanations (Krieger, 2011, 2014). It has a paramount role in the field of social epidemiology (Bartley, 2004; Krieger, 2014) as the discipline is not only limited to study effects of socio-structural factors on health (Honjo, 2004; Kawachi & Berkman, 2000) but also to understand the causal explanations and to intervene in order to effect change. Oral diseases affect 3.9 billion people and untreated dental caries (tooth decay) is the most prevalent condition globally (Marcenes et al., 2013). Oral diseases significantly affect quality of life (Marcenes et al., 2013) and are associated with significant health care costs (Listl, Galloway, Mossey & Marcenes, 2015). Baker and Gibson (2014) have argued that routine testing of theoretical pathways is not generally evident in the field of social oral epidemiology. This scoping review assesses the extent to which theory is used in any capacity in studies of social inequality and oral health.

1.1. Theory, social ecology and health

A curvilinear association between average national income and overall health has been observed since the late 1970s (Rodgers, 1979). These observations gave rise to the 'income inequality hypothesis' (IIH), which states that beyond a certain threshold of average income within a society, the distribution of income has a greater effect on average population health than average income (Wagstaff & Doorslaer, 2000). This hypothesis has given rise to studies of 'social ecology' to test the association between inequality and overall health. At least 300 studies of social ecology with various health outcomes have been published (Pickett & Wilkinson, 2015a), and, the importance of income inequality as a 'social pollutant' (Subramanian & Kawachi, 2006) has been widely debated over the past three decades (Pickett & Wilkinson, 2015b). While earlier reviews expressed scepticism with regards to the evidence on this relationship (Lynch et al., 2004; Wagstaff & Doorslaer, 2000), more recent reviews have supported this association. These later reviews concluded that detrimental effects of area-level social inequality, primarily income inequality, are universally evident (Kondo et al., 2009; Wilkinson & Pickett, 2006), causally related and affect the majority of the population (Pickett & Wilkinson, 2015a). They are not simply the result of higher rates of poverty in more unequal societies (Pickett & Wilkinson, 2015b).

Several theories/theoretical models have been proposed to explain how area inequalities may influence societal levels of health and disease (Bartley, 2004; Coburn, 2000; Kawachi & Kennedy, 1999; Lynch et al., 2004; Lynch, Smith, Kaplan & House, 2000; Marmot & Wilkinson, 2000; Navarro, 2002; Wilkinson & Pickett, 2006). Six distinct theories are identified that can be tested in studies of the association between social inequality and oral health (Bartley, 2004). The first two represents ecological counterparts to explanations for the association between individual socioeconomic position and health within the Black Report (Townsend, Davidson & Black, 1982), while the remainder were developed specifically to explain differences between populations:

i) **Materialist:** materialist explanations emphasize the role of the external environment on health; these vary with the level of inequality. Exposure to risks to health, and to protective factors varies with social position. Macroeconomic variables such as levels of production and unemployment affect health. Attention is paid to the roles of stress associated with material

factors and with the hazardous nature of work. At an ecological level, more unequal societies have more people exposed to these risks (Townsend et al., 1982; Macintyre, 1997).

- ii) **Behavioural:** behavioural explanations state that unequal societies generate higher levels of unhealthy behaviours. There are two versions of this explanation (Macintyre, 1997). One (hard) version of behavioural explanations identifies individual inadequacy as the main source of this behaviour. A second (soft) version is that behaviours have social gradients and contribute to observed gradients in health status.
- iii) **Psychosocial:** psychosocial was developed to explain individual-level inequalities. At an individual level, psychosocial explanations claim that social position affects health in one of two ways. First, people's perception of their social position affects health. Second, there is an inverse association between levels of control, and resulting chronic stress and social position that affects health. Whether through perception or control/stress, the subsequent effect on health is either through direct physiological changes or through health damaging behaviours (Bartley, 2004). Within unequal societies, due to constant social evaluative threats, it is likely that people who are less well-off tend to compare themselves to those who are relatively better. Such comparisons lead to a constant perception of belonging to a low status group, along with lack of control and coping strategies consequently leads to chronic stress. This stress through either health compromising behaviours or through directly affecting physiological health, may lead to higher levels of disease (Wilkinson, 1997). The more unequal a society, the greater the decrement in power and control and the more damaging the perception and lack of psychosocial assets, thus the greater the impact on health. Because the social gradient is steeper within unequal societies, these effects may be more evident higher up the social gradient compared to more equal societies (Marmot & Wilkinson, 2000).
- iv) **Social capital:** social capital explanations are often described as a subset of psychosocial explanations. These explanations state that unequal distribution of income undermines trust and damages social relationships. This can manifest in low levels of social support or civic participation, or in high levels of antisocial behaviour, particularly crime. This has been accepted as a potential pathway since Kawachi, Kennedy, Lochner, and Prothrow-Stith (1997) demonstrated that the association between inequality and mortality in the United States was mediated by social capital (Kawachi & Kennedy, 1999; Subramanian & Kawachi, 2004).
- v) **Neo-material:** neo-material explanations arise from criticism that the psychosocial and social capital explanations ignore upstream factors that affect health and may be associated with greater inequality. Specifically, they ignore the role of uneven distribution of power and class relations, and labour market dynamics in sustaining and driving inequalities (Muntaner, Lynch & Oates, 1999; Navarro, 2002; Coburn, 2000). This results from a systematic underinvestment in human, physical, health, and social infrastructure that support health (Lynch et al., 2000, 2004).
- vi) **Structural:** the structural explanation states that it is likely that the income inequality results in greater residential segregation leading to spatial concentrations of race and poverty, which in turn influences individual health. This may consequently lead to worse population health (Subramanian & Kawachi, 2004).

Many of these pathways are linked (Lynch & Kaplan, 1997) and some are treated as a subset of others in the literature. These pathways are unlikely to be mutually exclusive with more than

one operating at any time or place, but the role of each may vary according to context and health outcome. But, depending on the different sociological origins of each theory, the policy implications of each theory will be accordingly different. Muntaner and Lynch (1999) argue that 'IHH' and psychosocial interpretation treat income as a resource for purchasing social goods rather than as a product of production relations. At an area level this argument relates to whether inequality is conceptualized on a stratificational (gradational) scale or as a relational product (Muntaner & Lynch, 1999), as also shown at an individual level (Muntaner et al., 2010). Ignoring the relational property of inequality ignores underlying class relations, power dynamics and consequent exploitation that may affect health separately to income. So, a more psychosocial and social capital emphasis may deviate the attention of policy-makers from addressing more relevant structural factors related to social inequalities which impact population health (Muntaner & Lynch, 1999). On the contrary, the psychosocial theorists argue that ignoring the psychosocial mechanisms may ignore the negative impacts of relative deprivation and social comparisons on the physiological and psychological health and social fabric (Marmot and Wilkinson, 2000).

The need to test theoretical pathways between social inequalities and overall health is well established (Bartley, 2004; Campbell et al., 2014; Krieger, 2011, 2014). But, the evidence regarding the use of theory in explaining area level social inequalities and population oral health has not been reviewed. Evidence on the role of pathways between area-level social inequalities and population oral health outcomes clarifies the basis for specific policies in order to reduce the health effects of social inequalities. In order to address the significant gap regarding the use of theory in studies of social ecology in oral health, this scoping review was performed with four objectives: (i) to assess the availability of evidence on the association between area-level social inequality and population oral health according to type of social theories, (ii) to assess the extent to which the literature on this association is theoretically based, (iii) to identify and categorize conceptual and measurement alternatives used in the evidence to measure social class or socioeconomic inequalities according to either stratification or relational approach, and (iv) to identify and highlight any gaps in the literature.

2. Methods

A scoping review determines the extent, range and nature of any research activity, making it a more suitable approach than a systematic review for this research question (Arksey & O'Malley, 2005; Levac, Colquhoun, & O'Brien, 2010). Given the complexity of the review design, a detailed protocol for this scoping review was published which also elaborates this justification (Singh, Harford, Watt, & Peres, 2015). A methodological framework for this review is based on the existing literature and has five steps (Arksey & O'Malley, 2005):

- (1) *Identifying the research question*: the research question framed was, 'What is the nature and extent of social theories/theoretical models being used as a basis to explain the associations between area-level social inequalities and population oral health in the existing literature?'
- (2) *Identifying relevant studies*: a search strategy was formulated to identify both published studies and grey literature. A three-step search strategy was developed for this review. An initial limited search of MEDLINE was undertaken followed by analysis of the text contained in the title and abstract, and of the index terms used to describe the articles. Following this the next step involved using all identified keywords and index

terms to search across all selected databases: PubMed, MEDLINE (Ovid), EMBASE, Web of Science, ERIC (Education Resources Information Center), Sociological Abstracts, Social Services Abstracts. A detailed search strategy including the relevant keywords and MeSH terms was constructed specifically for each selected database. Each data source was individually checked for availability and usage of controlled vocabulary for indexation through the use of hierarchically defined and periodically updated thesauruses (Appendix 1). The search was first conducted on 14th January, 2015 and further updated to identify recent studies on 7th March, 2016. The reference list of all identified reports and articles was searched to identify any additional studies. Finally, the search for unpublished studies included reference lists, book chapters, Thesis (Proquest) and conference abstracts. Furthermore, eight experts were identified and contacted for relevant grey literature based on the criterion that within the literature search they should have published at least twice on this research topic.

- (3) *Study selection*: pre-defined inclusion and exclusion criteria were developed to identify relevant studies (Arksey & O'Malley, 2005). Studies were excluded if they were published in a language other than English, or did not include a measure of inequality, or focussed on individual-level inequalities in health outcomes, or had outcomes of interest other than dental caries, periodontal disease, self-rated oral health, number of teeth, tooth loss, oral health-related quality of life (OHRQoL) and dental pain. The detailed inclusion and exclusion criteria are reported elsewhere (Singh et al., 2015).
- (4) *Charting the data*: a data charting guide and recording proforma were developed by the reviewers and piloted independently by two investigators (AS and HSS) on five studies who cross-checked extracted information and revised the guide and proforma to address discrepancies. The information charted included study details (author, publication type, study design, locations, population focus, sample size, statistical modelling, geographical unit of aggregation and population oral health outcomes), details on theory (mention of theory, number of use and type of theories) and measure of social inequality (type of inequality and area based quantitative measure of inequality). Based on emerging information from studies this form was constantly updated in consultation with the reviewers. Two (AS and HSS) reviewers independently charted all the extracted information and crosschecked the information to reduce individual bias (Riva, Gauvin, & Barnett, 2007). Any disagreements were resolved firstly by discussion then by intervention of a third reviewer (JH).
- (5) *Collating, summarizing and reporting the results*: Extracted data was summarised using narrative synthesis (Arksey & O'Malley, 2005). The proposed *a-priori* approach to data mapping was to categorize included studies both by the type of social theory used and the extent to which social theory as drawn upon by the authors. Selected papers were entered into NVivo v10 software, which was used to identify theories and categorise studies according to extent of their theoretical use. A deductive content analysis using pre-defined categories was performed by analysing extracts on theories from the primary studies (Fig. 1). This process involved analysing elements such as naming the theory, context in which theories are introduced, and, application of theory based on their emphasis within objectives and use as variables within the analysis strategy. Information reflecting these aspects was extracted from the papers under following categories, 'comment on theoretical pathways', 'direct mention of theory', 'inferred theory', 'variables for theory', and 'objectives' (Fig. 1). Based on the analysis of extracted information under these

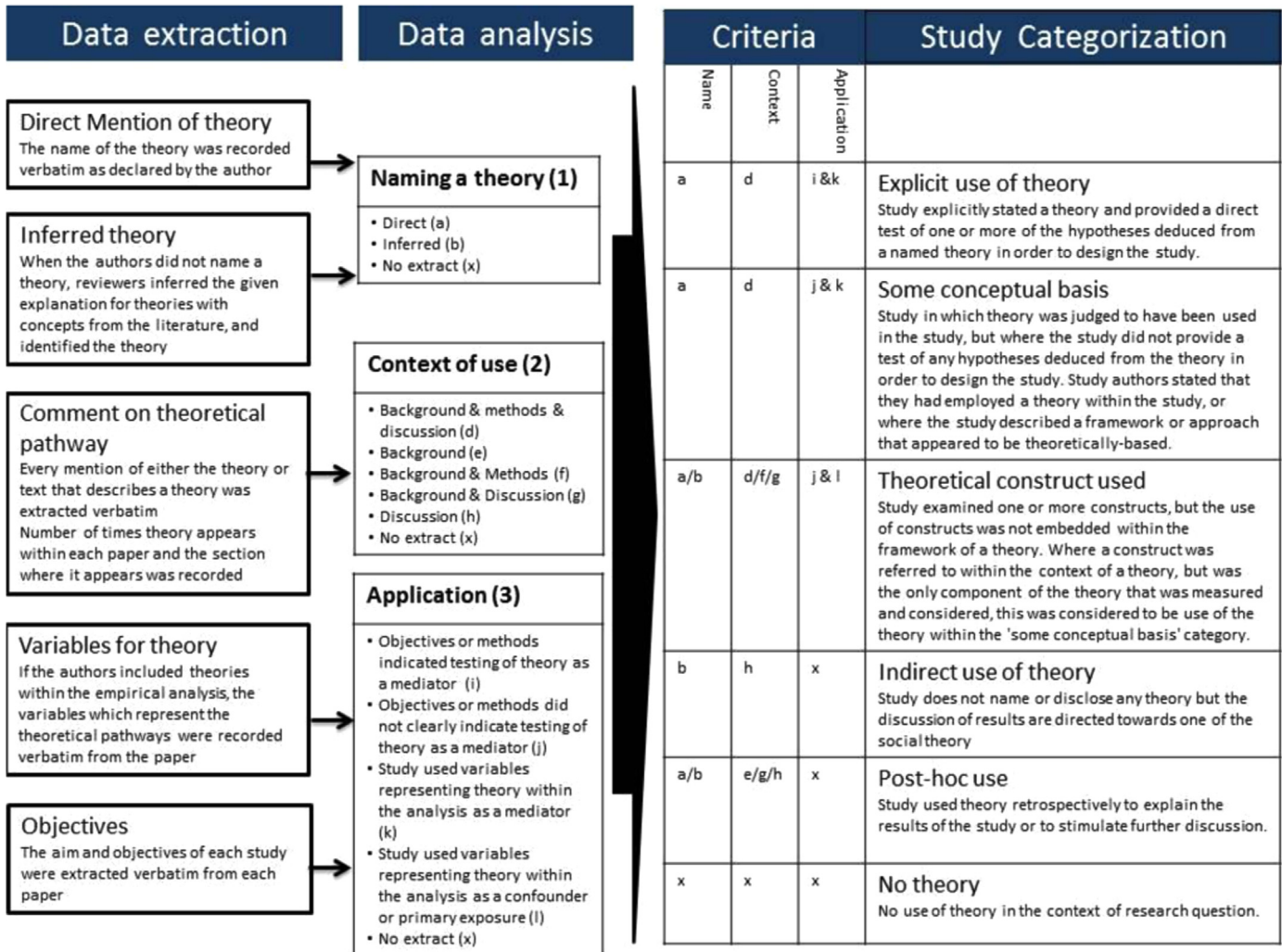


Fig. 1. Deductive content analysis to categorize studies according to their extent of use of theory.

categories, each study was then categorized exclusively into one of the following pre-defined categories for use of theory: 'explicit use of theory', 'some conceptual basis', 'theoretical construct used', 'post-hoc use', 'indirect use of theory' and 'no theory' (Singh et al., 2015). For instance, the study by Aida et al. (2011) had 6 unique mentions of theories, within the introduction, methods and discussion section. The study's objectives clearly mentioned that it aimed to test whether social capital explained the associations between income inequality and dental status. The study explicitly named the 'social capital' theory and used the variables representing theory within the analytical strategy (Appendix 1). Based on this information, the study was categorized under the 'explicit use of theory'. The unit of analysis for this activity was a study rather than a theory, therefore any study with multiple theories was classified according to the highest level use of theory as indicated by this ordering of categories. Additionally, a narrative synthesis was added to highlight the between study differences identified within categories.

The criteria for each of these categories were derived from a systematic review for a similar research question, but applied in a different field (Davies, Walker, & Grimshaw, 2010). Furthermore, the extracted information under 'direct mention of theory' and 'inferred theory' assisted in identifying all types of social theories and the frequency of their use within the studies selected. In order

to be inclusive of depletion of social capital pathway as an independent theoretical pathway (Kawachi & Kennedy, 1999), apart from those theories summarized by Bartley (2004); material, neo-material, behavioural/cultural and psychosocial; all extracts (implicit and inferred) that made reference to any dimension of social capital were also identified.

To ensure a reliable process and to reduce individual bias, two reviewers participated in both the data extraction exercise and data categorization exercises. The initial data extraction exercise was performed by AS with HSS crosschecking the decisions regarding number and relevance of extracts. A pilot exercise on two selected studies compared the consistency in data extraction. Both AS and JH conducted the study categorization exercise independently with disagreements resolved through discussion.

A sub-analysis focussed on the choice of measurement variables for area-level social inequality. Studies were categorized according to the measure of inequality used and how it was quantified. A quality assessment of the selected studies was not conducted, as a scoping review does not aim to synthesize evidence according to methodological quality (Arksey & O'Malley, 2005).

3. Results

Overall, 2892 studies were identified by a systematic search on all selected databases, and 1188 duplicates were removed. Some

1600 records were excluded where it was clear from title and abstract they were out of scope based on the inclusion/exclusion criteria leaving 105 relevant titles. Upon full text review another 89 studies were excluded leaving 16 relevant studies for data charting. A flowchart of this process is shown in Fig. 2.

3.1. Summary characteristics of the identified studies

The majority of studies examined the impact on health of inequalities within countries (IDs B,D,F,H,J,K,L,M,N,O&P in Table 1). Five studies examined multiple high income countries (IDs A,C,E,

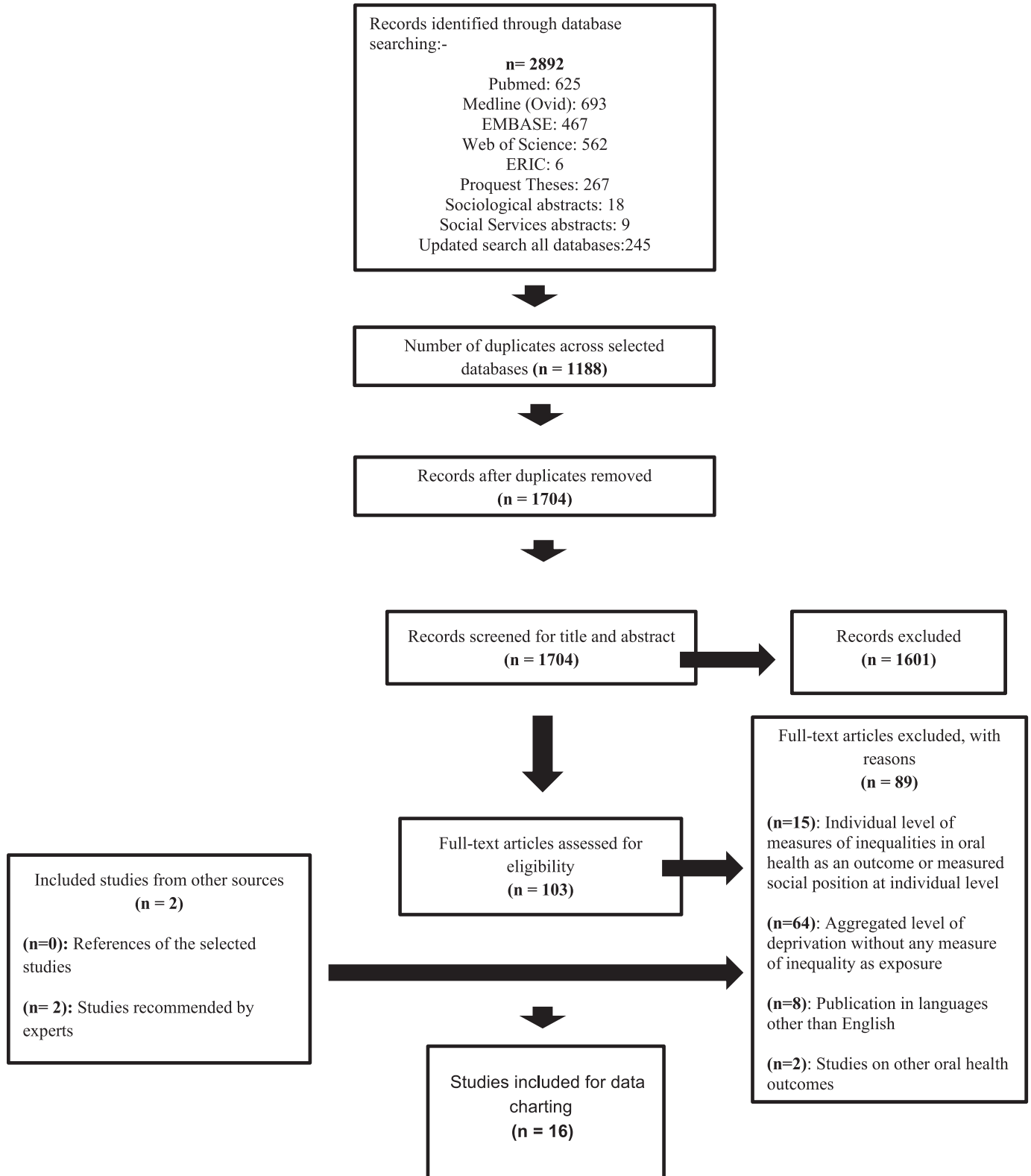


Fig. 2. Flow chart for the process of literature search to study selection.

Table 1
Descriptive summary of the selected studies.

Code	Study	Study design/ analysis	Location	Population focus	Aggregate level	Oral health outcomes	Main Results (inequality – oral health)	Main Results (Theories)
A	Nadanovsky and Sheiham (1995)	Ecological/ correlations	18 industrialized countries	12-year-old children	Country	12-year-old DMFT Compound Annual Rate (%)	The higher the concentration of income in the top 20% income households in 1970–75, the lower the rate of DMFT reduction.	NA
B	Pattussi, Marcenes, Croucher, and Sheiham (2001)	Cross sectional/ correlations	Brazil	6–12-year-old school children	Intra-urban areas of Brasilia (Federal District)	Dental caries levels: the percent of children free of caries, mean DMF-T scores	GINI coefficient was negatively statistically significantly associated with both measures of dental caries experience, percent of caries free ($P=0.003$) and mean DMF-T scores ($P=0.01$).	NA
C	Hobdell et al. (2003)	Ecological/ correlations	99 countries (Dental caries) 44 countries (CPITN)	12 year olds (caries) and 35–44 year old adults (CPITN)	Country	Dental caries (DMFT) and destructive periodontal disease (CPITN)	Gini Index was positively and significantly correlated with dental caries and CPITN scores	NA
D	Peres et al. (2003)	Ecological/ correlations	São Paulo, Brazil	5–6 year old children	Cities and Town	Dental caries: mean DMFT	DMFT not associated with income inequality	NA
E	Bernabe, Sheiham, and Sabbah (2009)	Ecological, cross-sectional study/ correlations	High income countries	35–44 year old adults from rich countries	Country	Dental caries experience: untreated caries, missing teeth, filled teeth and DMFT; dental care index: restorative index, treatment index	Income inequality was significantly and inversely related to the number of filled teeth, DMFT score and provision of restorative treatment, but not to the number of decayed or missing teeth.	NA
F	Celeste, Nadanovsky, Ponce de Leon and Fritzell (2009)	Cross sectional/ multi-level	Brazil	15–19 and 35–44 year olds	Municipal level	Tooth loss: all natural teeth (yes/no); untreated dental caries: number of teeth with untreated dental caries	Income inequality showed an effect after controlling for known confounders and mediators based on a priori postulated pathways with missing teeth and number of teeth with untreated decay. (VPC for at least one missing tooth=9.36%; Number of teeth with untreated caries=5.28%; Edentulism=9.08%; Number of teeth with untreated caries=4.37%)	Models representing social capital and health services did not change the Gini effect considerably
G	Bernabe and Hobdell (2010)	Cross sectional/ correlations	48 countries	5- to 6-year old children	Country	Dental Caries (DMFT Index)	The dmft index was significantly correlated with the Gini index in rich countries but not all countries	NA
H	Celeste and Nadanovsky (2010)	Cross sectional/ multi-level	Brazil	15–19 year olds	Municipal level	Number of missing teeth and number of decayed teeth	Municipal level public policies were the main explanation for the income inequality effects on oral health	Most of the Gini effect was explained by the number of years of water fluoridation and Scale of Municipal Public Policies (SMPP)
I	Sabbah, Sheiham and Bernabe (2010)	Ecological/ correlations	17 rich countries	Adults aged 35–44 years	Country	Periodontal disease: percentage of adults with periodontal pockets > 4 mm 'Community Periodontal Index (CPI) 3 or 4' and with periodontal pockets > 6 mm (CPI 4)	Higher levels of income inequality in rich countries were associated with higher levels of periodontal disease in adults, even after adjusting for measures of absolute national income	NA
J	Aida et al. (2011)	Cross sectional/ multi-level	Aichi, Japan	Older adults (65 and above)	District	Number of remaining natural teeth (having 20 or more teeth vs having 19 or less teeth)	Income inequality in communities was significantly associated with poor dental status. Income inequality was a major contributor to the variation in dental status between communities (Dental	Individual- and community-level non-volunteering and mistrust did not substantially reduce the odds for poorer dental status

K	Bernabe and Marcenes (2011)	Cross sectional/ multi-level	USA	18 years and above	State	Self-reported tooth loss: (none, 1–5, 6 or more but not all, and all teeth)	status, Variance=0.011, SE=0.012) State Gini coefficient was associated with higher odds of reporting greater tooth loss. (Between state Variance=0.025; SE=0.005)	The state Gini coefficient remained significantly associated with tooth loss after adjustment for state dentist-to population ratio and percent receiving fluoridated water (neo-material) and individuals' marital status (social capital).
L	Celeste, Fritzell and Nadanovsky (2011)	Cross sectional/ multi-level	Brazil	35–44 year-olds adults	Municipal level	Untreated dental caries, edentulism, at least one site with CAL > 8 mm, bleeding or dental calculus	Lagged Gini showed no association with any outcome; current Gini was associated with untreated dental caries but not with edentulism and periodontal disease. (VPC for untreated dental caries=3.6%)	NA
M	Vettore, Marques and Peres (2013)	Cross sectional/ multi-level	Brazil	Adults aged 35–44	State Capitals and Federal Districts	Periodontal disease: "Moderate to severe" periodontal disease; "Severe" periodontal disease	Income inequality was independently associated with "severe" periodontal disease (OR=3.0, 95%CI 1.5;5.9); Variance=0.101, SE=0.044	NA
N	Vettore and Aqeeli (2015)	Cross sectional/ multi-level	Brazil	Adults aged 35–44	City	Oral Health Related Quality of Life (ORHQoL) measured by Oral Impacts on Daily Performance (OIDP)	Income inequality associated with emotional status, work and social contact. (Gini 1991; Variance=0.070, SE=0.021; Gini 2000; Variance= 0.072, SE=0.021)	NA
O	Goulart and Vettore (2016)	Cross sectional/ Multi-level	Brazil	Adults aged 35 to 44	City	Tooth loss (Measured by M component of DMFT): Severe tooth loss (< 9 teeth) and lack of functional dentition (< 21 teeth)	Moderate and high increase in income inequality associated with both outcomes (Severe Tooth Loss – Variance=0.104, SE=0.055; Functional dentition, Variance=0.189; SE=0.061)	Income inequality was not associated with any definition of functional dentition
P	Chalub, Martins, Ferreira and Vargas (2016)	Cross sectional/ multi-level	Brazil	Adults aged 35–44	Municipal level	Functional dentition (4 Definitions:- WHO functional dentition, Well distributed teeth, Functional dentition classified by aesthetics and occlusion, Functional dentition classified by esthetics, occlusion and periodontal status)		

G&I). Nine studies pertained to Brazil (IDs B,D,H,L,M,N,O&P), with three of these (IDs F,G&L) reporting overlapping outcomes for two identical population groups from the same survey. The selected studies included ages five years and upwards. All 16 studies were cross-sectional with seven assessing the association by correlations while nine conducted a multi-level analysis. Random parameters were reported in six out of nine multi-level studies. The geographic unit of analysis ranged from municipal level to country level. Among the selected studies, nine were designed specifically to test associations between inequality and oral health while seven were exploratory studies which tested inequality as one of the contextual factors. Oral health outcomes tested included dental caries ($n=9$), tooth loss ($n=8$), periodontal disease/outcomes ($n=4$) and oral health related quality of life ($n=1$) (Table 1).

3.2. Theories – type and extent in the selected studies

Overall, there were 48 uses of seven types of social theories in the selected studies including psychosocial (13-IDs C,E,F,G,H,I,J,K,L,M&N), behavioural (10-IDs A,C,D,E,G,K,L,M,N&P), neo-material (10-IDs D,F,G,H,I,K,L,N,O&P), social capital (6-IDs B,E,F,I,J&N), social cohesion (4-IDs B,E,K&O), material (3-ID D,F&N) and social support (2-IDs K&M) (Table 2). This includes all theories that were either directly mentioned by authors in the text or in which the text appeared to describe one of these theories. Six of theories were directly mentioned; psychosocial (11-IDs C,E,F,G,H,I,K,L,M&N,P), behavioural (7-IDs C,E,G,L,M,N&P), social capital (5-IDs E,F,I,J&N), social cohesion (4-IDs B,E,K&O), material (3-IDs F,N,P) and neo-material (2-IDs F&H) (Table 2).

Four studies (IDs F,H,J&K) explicitly tested the theories as mediators or pathways between social inequalities and population oral health outcomes (Table 2, Appendix 2). Three studies (IDs B, M&P) discussed at least one construct that was consistent with a theory in the introduction and discussion, but did not test it. Seven studies (IDs C,E,G,I,L,N&O) used theories for post-hoc explanations to either discuss their findings or to stimulate further discussion. Three studies had no theoretical basis at all (ID A&D) (Table 2).

3.3. Within category differences between studies

Despite testing theories as mediators, differences according to the explicitness and comprehensibility regarding the theories were observed among the four explicitly theory based studies (IDs F,H,J&K). While (IDs F,H&J) explicitly stated that they intended to test the potential of one or alternate theoretical models, in explaining the associations between income inequality and health outcomes, (ID K) only incorporated theories within the modelling strategy and stated that it accounted for diverse set of individual and state level factors. In terms of comprehensibility, while (IDs F, H,K) included multiple theoretical models, (ID J) only tested the potential of social capital to explain the relationship. The studies categorized under 'post-hoc' group differed in the way that while studies (IDs E&O) only introduced theories in the introduction to justify testing for inequality – oral health association, studies (IDs I&L) used theories in both introduction and discussion to justify the objective and potential explanations for their findings. Finally, studies (IDs C,G&N) only discussed theories in the discussion as potential explanations for their findings. Such between study differences were not observed under those identified with 'no theory' and 'theoretical construct used'.

3.4. Measurement of social inequality in the selected studies

All the selected studies used income inequality as the measure of area-level social inequality. 15 out of the 16 selected studies used the Gini Index as a measure of income inequality, while one

study (ID E) used both the Gini index and the 20:20% (ratio of total annual household income received by the richest 20% of the population to that received by the poorest 20%). Only one study (ID A) used the percentage of national income earned by the top 20% as the measure of area-level social income inequality (Table 3).

4. Discussion

All but one of the selected studies mentioned at least one theoretical pathway between social inequality and population oral health; however, theories were seldom explicitly stated and tested. Psychosocial theory was most frequently used. Income inequality was the only measure of inequality reported and always measured on a stratificational scale.

Although social theories are often mentioned in studies of social ecology in social (oral) epidemiology and have drawn interest over time, the lack of explicit theoretical basis among selected studies substantiates the findings from the study by Baker and Gibson (2014). Using a qualitative methodology the current study observed that theories were mostly used for a post-hoc explanation of results rather than being explicitly stated or incorporated in analytical models. Furthermore, differences were also observed in the context in which theories were used in a post-hoc manner. When theories were tested for mediation, the studies differed according to their comprehensibility and explicitness. The differences in descriptive and explanatory objectives of the selected studies may be a potential explanation for such differences. Most of the selected studies were designed to test the empirical association between inequality and oral health, rather than to explain them. On the other hand, some studies were exploratory and included inequality as one of the exposures. A very small proportion of studies aimed to test any theoretical pathways. As a scoping review, the current study did not draw conclusions on the associations between inequality and population oral health. However, summary of findings (Table 1) suggests an association between income inequality and multiple oral health outcomes. Considering that theories form a strong basis for choosing appropriate strategies to reduce ill effects of inequalities on population oral health, findings from the current review highlights the lack of theory and underscores the necessity for explicit theoretical basis in future studies.

The different theoretical pathways have key implications for the pathogenesis of different oral health outcomes. For example, fluoride intake affects the risk of experiencing caries, but is not considered to be causative for periodontal disease. Even within one oral disease, caries, intermediate and proximal factors that affect the risk of having disease in the first place (e.g. sugar, fluoride) are not the same as the risk of losing a tooth due to caries (add access to timely dental care to sugar and fluoride). This highlights the need for outcome-specific theoretical models to explain the associations and for robust data collection based on outcome specific theoretical models. This would make research recognize the heterogeneity of etiologies and these may be important for which pathways matter for different conditions. Furthermore, inequality is a true ecological variable (Diez-Roux, Link, & Northridge, 2000), and the intervening mechanisms or resources may differentially impact individual and population health status (Rose, 1992). Therefore, the theoretical models demand more clarifications when differentiating between ecological relationship between inequality and population health, and contextual effects of inequality on individual health. Use of direct acyclic graphs (DAGs) (Fleischer & Diez-Roux, 2008) to identify *a-priori* confounders and mediators can also help in this process.

The predominance of psychosocial theory including depletion of psychosocial assets such as social capital and social support theory in oral health literature is mirrored in its use in research in general

Table 2
Analysis of the theoretical basis of selected studies assessing the association between area level social inequality and population health outcomes.

Study	Type of theory/theories: Direct (*) and Inferred (#)	Explicitly theory-based	Some conceptual basis	Theoretical construct used	Post-hoc	No Theory
A	No extract					+
B	Social cohesion* and social capital [#]			+		
C	Behavioural* and psychosocial*				+	
D	Behavioural [#] , material [#] and neo-material [#]					+
E	Social capital*, social cohesion*, psychosocial* and behavioural*				+	
F	Social capital*, material*, psychosocial*, neo-material [#]	+				
G	Behavioural*, psychosocial* and neo-material [#]				+	
H	Psychosocial*, neo-material [#]	+				
I	Psychosocial*, social capital* and neo-material [#]				+	
J	Social capital* and psychosocial [#]	+				
K	Social cohesion*, psychosocial* and behavioural*, neo-material [#] and social support [#]	+				
L	Psychosocial*, behavioural* and neo-material [#]				+	
M	Psychosocial*, behavioural* and social support [#]			+		
N	Material*, social capital*, behavioural*, psychosocial* and neo-material [#]				+	
O	Social cohesion*, neo-material [#] and psychosocial [#]				+	
P	Behavioural* and psychosocial*			+		

health literature (Islam, Gerdtham, Gullberg, Lindstrom & Merlo, 2008; Murayama, Fujiwara & Kawachi, 2012; Oksanen et al., 2008; Robert, 2001). The use of social capital, social cohesion, social network and social support along with the levels at which they are conceptualized needs more clarification. First, social capital is a broader concept which includes both social cohesion and social network (Mackenbach et al., 2016). Second, these inter-personal constructs and resources may mean different things at the individual and contextual level. Finally, their potential explanatory power may differ for different outcomes. This is substantiated by the evidence showing community-level structural social capital to attenuate the odds of inequality for poorer self-rated health but having no substantial impact on the odds for worse dental status (Aida et al., 2011). The limited explicit attention to the neo-material pathway within the selected studies could be due to the lack of clarity on its conceptualisation and measurement. The definition of neo-material theory contains two important elements: 'structural factors differentiating equal and unequal societies' and 'systematic underinvestment in public policies and health care' (Lynch et al., 2000). In terms of public health policies and health care, some of the key determinants of oral diseases in the population may include infrastructures such as access to dental health care, water fluoridation, food supply and population-level tobacco control measures (Watt, 2012). Under the neo-material interpretations of the inequality – health relationship, it is argued that the historical,

cultural, political and economic processes, which lead to inequality, may also shape the nature and availability of health supportive infrastructure (Lynch et al., 2004). In eight out of the ten selected studies where neo-material explanations were inferred, policy determinants such as water fluoridation; social spending and public investment, and, dentist to population ratio were mentioned; but the pathway was not identified as neo-material. It should be noted that all selected studies conducted a secondary analysis which limits conceptualization of the theoretical pathways as the investigators are restricted to use the available variables and examine only a few constructs.

All the selected studies conceptualized social inequality as income inequality. Social inequality contains structured and recurrent patterns of unequal distributions of goods, wealth, opportunities, rewards, and punishments. It is argued in the literature that income inequality may not capture all dimensions in which social inequality can occur such as those canvassed widely in the health inequalities literature including gender, ethnicity, indigenous status, education and economic position/wealth (Costa-Font & Hernández-Quevedo, 2012; Krieger, 1999; Bartley, 2004). Economic inequality is one dimension in which social inequality may occur. In addition, using income inequality does not capture all aspects of economic inequality (Sen, 1992, 1997, 1999). The value of income is entirely as a means to realizing individual achievements and freedoms. Income is not the only means by which this is achieved. The other means

Table 3
Conceptual and measurement alternatives used to measure social inequality in the selected studies.

Study ^a	Type of social inequality	Area based quantitative measure of inequality	Categorization of inequality variable
A	National distribution of income	Percentage of national income	Percentage of national income earned by the top 20%
B	Income inequality	Gini Index	Continuous measure of Gini
C	Income Inequality	Gini Index	Continuous measure of Gini
D	Income Inequality	Gini Index	Continuous measure of Gini
E	Income inequality	(1) Gini Index (2) 20:20: Ratio of the total annual household income received by the richest 20% of the population to that received by the poorest 20%	Continuous measure of Gini
F	Income inequality	Gini Index	A change of 10 points in the Gini scale
G	Income inequality	Gini Index	Continuous measure of Gini
H	Income inequality	Gini Index	A change of 0.46 points in Gini: difference between the Gini value of the lowest and the highest Brazilian municipalities
I	Income inequality	Gini coefficient and the ratio between annual income of richest and poorest 20% of the population (20:20 ratio)	Continuous measure of Gini
J	Income inequality	Gini Index	0.1 point difference in Gini coefficient
K	Income inequality	Gini Index	Per 0.05 unit increase (or 5%) in the Gini coefficient
L	Income inequality	Gini Index	A change of 10 points in the Gini scale
M	Income inequality	Gini Index	Tertiles of distribution into low, moderate and high
N	Income inequality	Gini Index	Tertiles of distribution into low, moderate and high
O	Income Inequality	Gini Index	Tertiles of distribution into low, moderate and high and then change in Gini over time by categorizing into (Stable, reduction, moderate increase and high increase)
P	Income Inequality	Gini Index	Tertiles of distribution

^a All studies assessed social status rather than social class, and examined inequalities on a stratificational or gradational scale.

include rights, liberties and opportunities and wealth, and the social bases of self-respect (Sen, 1997). Whether or not a particular level of income provides economic equality depends on a range of factors, including personal characteristics, environmental conditions, variations in social climate, differences in local commodity requirement and the distribution of income within a family. Further, while many studies of individual social position explore the impact of belonging to one group or another within these dimensions, ecological studies have examined social inequalities and population health primarily using the dimension of income inequality (Navarro, 2009). The use of income inequality to measure social inequality only captures one dimension of social inequality. As such it risks ignoring the underlying class relations, power dynamics and exploitation (Muntaner & Lynch, 1999), which are responsible for generating these income inequalities. Muntaner and Lynch (1999) further stated that a measure of class exploitation can be measured at any aggregate level and is more informative due to its explicit social mechanism.

The current review had several strengths and some limitations. This study scoped the area-level inequality oral health literature using a novel and robust methodology. The use of deductive content analysis using qualitative software for critical evaluation of the theoretical basis of empirical studies has not been published elsewhere. The search strategy of the current scoping review included a wide range of electronic databases as well as grey literature. A limitation includes that potentially relevant studies ($n=8$) (Appendix 1) could not be included in the review as they were not published in English. Furthermore, the scoping review assessed the use of theory in a specific research question which is the association between area level social inequalities and population oral health, and some of the evaluated social theories (behavioural, material and psychosocial) are also used to explain health inequalities within societies (Bartley, 2004). The individual level oral health inequalities literature was not assessed in our review for the use of theory and future studies may use the current methodology to address this question. Finally, the evaluated social epidemiological theories included those which were generalizable across societies which may lead to the lack of inclusion of context specific explanations.

4.1. Research implications and conclusions

The need for more robust empirical testing of pathways in the association between area-level social inequality and population oral health has emerged as one of the main research implications from this review. With the importance placed on the conceptualization and measurement of social inequality, an understanding of how other societal measures of inequality such as labour market inequality (Muntaner, Chung, Benach & Ng, 2012) and rate of exploitation (Muntaner et al., 2002) affect population oral health would complement the research on the income inequality hypothesis. Systematic reviews and meta-analysis should be conducted to summarize evidence on the inequality – oral health relationship. However, it is conceivable that meta-analysis may not be appropriate as different pathways operate to different extents in different contexts. Finally, outcome specific theoretical models would provide insight to potential interventions to reduce the public health burden of oral diseases associated with inequality. With growing income and social inequalities globally, this research is an important line of investigation to reduce the overall public health burden of oral diseases.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.ssmph.2016.06.001>.

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