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Intergenerational continuity in oral health: a review

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Abstract

Life course research considers not only the influences on health which act during the lifespan but it is also concerned with factors that act across generations. Rarely are genetics or environment solely responsible for producing individual variation; virtually all characteristics are the result of gene–environment interaction. An increasing interest in life course research and gene–environment interactions is reflected in greater awareness of the role of family history and intergenerational continuity in oral health as a practical, inexpensive approach to categorizing genetic risk for many common, preventable disorders of adulthood (including oral disease). Does the health status of one generation have an effect on that of the next? While researchers in recent years have begun to investigate the inter-generational associations between exposures and disease, little research has been carried out (to date) on the long-term biological, behavioural, psychological, social and environmental mechanisms that link oral health and oral disease risk to exposures acting across generations. This narrative review identifies studies which have contributed to highlighting some of the intergenerational factors influencing oral health. However, there is a need for a wider perspective on intergenerational continuity in oral health, along with a careful evaluation of the factors which contribute to the effect. A comprehensive investigation into the nature and extent of intergenerational transmission of oral health is required.

Keywords

gene-environment interaction; intergenerational; life course; oral health

Life course research relates chronic disease risk in adults to a variety of biological, behavioural and psychosocial exposures which accumulate during gestation, childhood, adolescence, young adulthood and later adult life, or across generations (1). It could be argued that intergenerational influences (whereby the health status of one generation has an effect on that of the next) should not be considered within a life course framework; after all, they are operative even before life begins. Nonetheless, some authors maintain that they should be included within such a paradigm (1,2). The accumulating evidence certainly supports this viewpoint. For example, studies have found inter-generational and familial associations for cardiovascular disease (3–13), non-insulin-dependent diabetes mellitus (14–21), metabolic syndrome (22–24), cancer (25–30), asthma (31,32), obesity (33–35) and health-related behaviours, including smoking, drug and alcohol use (36–42), and diet and exercise (43–45). In addition, there exists a considerable body of evidence which demonstrates associations between parents' socioeconomic status (SES) and that of their offspring (46,47). From what is known of the links between SES and health outcomes, it follows that the intergenerational transmission of poverty is likely to result in the intergenerational transmission of poor health.

While the mechanisms underlying intergenerational continuity in health remain unclear and are undoubtedly complex, there are a number of potential pathways whereby disease risk can

be transmitted through generations. Genetically determined traits may present in a similar way in each generation. Environmental risk factors (such as SES, smoking) may continue across generations. Poor maternal health before and during pregnancy (and/or during the early postnatal period) can have an unfavourable impact on intrauterine foetal growth and neonatal development, in turn leading to adverse outcomes for the offspring later in the life course (48–52). This intergenerational impact of maternal health on her adult offspring is consistent with the life course model, and further supports the contention that intergenerational influences should be considered within the life course paradigm. Another mechanism involving a genetic predisposition coupled with exposure to environmental risk factors forms the basis for the gene–environment interaction model; that is, the situation where both genetic and environmental factors interact to produce health outcomes in individuals and populations (53). An increasing interest in gene–environment interactions is reflected in a growing awareness of the utility of family history (and the role of the intergenerational continuity of health) as a practical, inexpensive approach to categorizing genetic risk for many common, preventable disorders of adulthood (54).

Little research has been carried out to date on the long-term biological, behavioural, psychological, social and environmental mechanisms which link oral health and oral disease risk to exposures acting across generations. Why do we need to understand how an individual's oral health and oral disease risk is influenced by his or her parent's oral health status and their oral health behaviours, attitudes and beliefs? Severe oral disease is concentrated in relatively few individuals. If targeted preventive treatment is to be offered before severe disease manifests, it is necessary to identify the most at-risk individuals as early as possible. Often, basic information on family history of oral disease can be accessed during an inexpensive screening; this is particularly so for children who usually would have a parent in attendance during screening. Taking such a history can be regarded as a preliminary step towards identifying high-risk individuals and families. The purpose of this paper is to provide an overview of the findings of studies which has provided important information on intergenerational effects in oral health. It should be emphasized that it is not a systematic review; rather, the paucity of such dental studies precluded the use of formal inclusion–exclusion criteria, and we chose to take a more inclusive approach than might be used in a formal meta-analysis.

Empirical research on the intergenerational continuity of oral health

Over the last three decades or so, a number of studies have investigated intergenerational associations in oral health. These can be grouped according to three main lines of investigation. First, some studies have examined associations between children's oral health and clinically or self-assessed parental oral health. Others have investigated the association of parental behaviours, attitudes, knowledge and beliefs with the oral health of children. Third, twin study models have allowed the examination of the relative contribution of genes and environment to particular characteristics.

Influence of parental oral health on child oral health

Several studies have found associations between maternal oral health (as assessed by the mother's number of missing teeth or DMFT score) and young or preadolescent children's caries experience (55–57). All found poorer maternal oral health to be associated with greater caries experience in the child. Other researchers found that mothers' caries status had an independent effect on how early her infant acquired *Streptococcus mutans*, and consequently, an influence on that child's later caries experience (58). While few investigators have considered the role of fathers' oral health or past caries experience as a predictor of children's oral health, a large prospective Finnish study did find that a father's past caries experience (measured by self-

reported annual occurrence of more than two carious teeth) to be associated with his child's caries experience (59).

Whereas a parent's number of missing teeth or DMFT score essentially represents past caries experience, the condition of the gingiva is a more current measure of oral health and oral health behaviour (such as brushing and flossing). A Japanese study found an association between a mother's gingival condition and her child's caries prevalence and severity at age 3 (60). The poorer the mother's gingival condition, the less likely it was that her child was caries free; the mean dmft was three times higher in children whose mothers had the poorest gingival health than in the children of mothers with excellent gingival health.

Influence of parental behaviours and attitudes on child oral health

Other researchers have focused on the associations between parents' oral health-related behaviours, knowledge and anxieties, attitudes towards oral hygiene and diet, and beliefs about their own oral health and the inevitability of tooth loss and their children's oral health, and oral health behaviours. These are described as follows.

Parental preventive dental behaviours and self-assessment of oral health—In particular, mothers' own oral hygiene habits and preventive dental behaviour have been observed to have an influence on children's oral health-related behaviours (59,61). Children behave according to what their mothers do. Poor oral health care habits may be transferred from a mother to her child; a longitudinal Swedish study found that the mother's self-assessment of her own oral health care as being 'less good to poor' when her child was aged one to 3 years was associated with greater caries experience in the child by age 15 (62).

Associations between children's oral health status and their parents' oral health status and oral health-related attitudes and behaviour can differ by gender. A study of 11- and 12-year-old Finnish children and their parents found many parent-related factors were associated with the presence of one or more active initial carious lesions in girls; however, for boys, the only parent-related factor was parents' poor self-assessed oral health (63).

Parental attitudes, knowledge and beliefs—Parents' dental attitudes may have an early effect on their child. Recently, Norwegian parents' negative attitude to diet was found to have an adverse effect on their child's caries increment between ages 3 and 5, with children whose parents had a negative attitude at both ages experiencing the most severe effect (64). Among poor African-American families in Detroit, parental dental fatalism (measured by asking parents to rate their agreement with the item 'Most children eventually develop dental cavities') to be a significant predictor of (i) early childhood caries and (ii) a higher 2-year caries increment in young children (65,66). This suggests that parental expectation of poor child oral health may become a self-fulfilling prophecy.

Iranian children whose mothers possessed both oral health-related knowledge and good oral health-related attitudes had better odds of having good oral health than children whose mothers possessed oral health-related knowledge only (67). It was found that while mothers' oral health-related knowledge *per se* had no effect on a child's oral health, it had a powerful additive effect with her favourable oral health-related attitudes.

Parental smoking—Other parental habits which influence oral health may have an effect on their offspring's caries risk. A number of recent studies have suggested that children exposed to environmental tobacco smoke (ETS) have a greater risk of caries (68–71). Measurement of children's ETS exposure ranged from parental self-report of smoking status (using a simple two- or three-category response format) to accurately measuring children's exposure level using serum cotinine. The NHANES III study used the latter measurement and observed a

biological gradient in children's primary teeth caries experience across categories of their serum cotinine levels (68).

Parental anxiety—Dental anxiety can impact on oral health. There is a positive association between dental anxiety and episodic use of dental health services (72). Episodic users of dental services have poorer self-reported oral health, and greater tooth loss and caries experience (73). While direct conditioning through an unpleasant dental experience is very important in the development of dental anxiety, indirect conditioning (vicarious experience) can also be a factor. Rantavuori et al. demonstrated intergenerational transmission of dental anxiety in a sample of Finnish children (74): those with a dentally anxious parent were more likely to report dental anxiety than those whose parents were not dentally anxious.

Twin studies

While twin studies are not intergenerational studies as such, they should be included in a discussion of intergenerational research because they allow examination of the relative contribution of genes and environment to a particular characteristic. Monozygous (identical) twins share all of their genes, whereas dizygous (fraternal) twins have about half of their genes in common. If a particular characteristic has a substantial genetic contribution, it will be more highly correlated between monozygous twins and less so between dizygous twins. The converse will be true of a characteristic with a strong environmental contribution. Therefore, twin studies may strongly suggest (but not prove) genetic inheritance. The findings from studies of twins raised apart are particularly compelling, as their separation has the effect of controlling for the influence of environmental factors.

The Minnesota Study of Twins Reared Apart (MSTRA) found that monozygotic twin pairs showed much greater similarity than dizygotic twin pairs for the variables studied (75). The mean age of the twins was 42.2 (SD 13.9); this was important as it allowed the effect of cumulative dental caries experience to be examined. The findings suggested a substantial genetic component (of between 45% and 67% of variance) for the number of teeth present, number of teeth and surfaces restored, and caries present.

A cross-sectional study of young twin pairs (mean age 5.2, SD 2.2) found a heritability estimate of 76% for surface-based caries prevalence rates, indicating a strong genetic component of dental caries in this age group (76). A longitudinal analysis of a subset of the cross-sectional sample over 12 months found heritability estimates for overall surface-based caries prevalence rates net increments to suggest a strong genetic contribution (77). These estimates differed for the different age groups. Genetic contributions were greatest for the youngest age group (18–47 months) and for the older group (over 6 years). This may indicate that caries onset in emerging dentitions may be particularly influenced by genetic factors.

Oral health data from 10 578 participants were used to examine the heritable and environmental factors in the aetiology of periodontal disease in a large population-based Swedish twin pairs study (78). The authors found that, while the greatest variation in risk for periodontal disease came from environmental factors (such as smoking), one-third of the risk could be attributed to genetic factors.

Methodological challenges

Each of the abovementioned studies has contributed to highlighting some of the factors acting across generations to influence oral health. Unfortunately, the practical difficulties of conducting intergenerational research mean that many studies have suffered from methodological shortcomings. Some studies are cross-sectional in design, and so do not offer a high level of evidence (55,60–63,66–69,71,72,74–76,78). A birth cohort study, with repeat

measures of exposures over a long period, is the ideal method of examining life course and intergenerational associations; however, few researchers are fortunate enough to have access to such data (1). Several researchers have focused on only a narrow aspect of oral health (58, 74). Some longitudinal studies have tended to examine the effects of exposures at one point in time only; for example, the Iowa Fluoride Study measured children's exposure to ETS during the first year of life only (70). The majority have concentrated on oral health outcomes in young children (55,56,58–61,64–71,76,77). There has been no research on intergenerational associations in oral health between adults and their parents; clearly, this requires long-term investment of effort and resources in cohort studies. Other studies have suffered from selection bias, self-report bias, social desirability bias, recall bias, response bias, attrition, a lack of generalizability, or insufficient power to find associations (55,57,60,61,⁶⁴–66,69–71,78). Some studies have not attempted to control for confounding factors (57,60). While other studies have controlled for some confounders, important ones (such as children's diet, oral hygiene habits, fluoride exposure, SES and ethnicity) have been not been controlled (55,64,68). In addition, there is a shortage of studies of intergenerational continuity in periodontal disease; this is a particular deficiency because genetic factors are thought to play a greater role in the aetiology of periodontal disease (79).

Discussion

Research into intergenerational continuity in oral health has been sparse and of variable quality. For the most part, it has found associations between the oral health of mothers and the oral health of their young children. Mothers' oral health has been assessed in a variety of ways: by clinically assessed caries status, DMF scores, number of missing teeth and gingival status; and by self-reported dental health status, oral health-related habits, behaviours, knowledge and attitudes. Children's oral health has typically been assessed clinically, with caries prevalence and/or severity being the main outcome measures. Generally, poorer maternal oral health (and poorer oral health-related factors) predicted poorer oral health outcomes in young children. Few studies have examined the role of fathers' oral health in predicting oral health outcomes in their children. While twin pair studies offer some clues as to the relative contribution of genes and environment to oral health traits, it remains likely that most are a result of gene–environment interactions.

The growing interest in gene–environment interactions corresponds with a greater understanding of the role of family history as a bridge from genetics (the study of genes) to genomics (the study of the whole genome) (80). 'Family medical history is the simplest applied "genomic tool" available in practice today... Family history reflects the consequences of shared genetic variations at multiple loci, shared exposures and responses to environmental factors, and shared behaviours' (54). Scheuner et al. have demonstrated that family history review 'is a feasible method of identifying and stratifying genetic risk for many common, preventable disorders of adulthood' (81).

While targeting those at highest risk of severe disease for intensive preventive measures is desirable, current methods used to detect those at high risk are generally limited and ineffective. In particular, public health screening for oral disease entails inexpensive measures which do not require an intra-oral examination. Obtaining basic information on family history of oral disease during such a screening can be considered to be the first step towards identifying those high-risk individuals and families who may benefit from more intensive (earlier, more frequent and more costly) preventive and therapeutic efforts.

The point of much intergenerational research is to elucidate the family-related risk factors which place some children at higher risk of dental disease than their peers. From a practical point of view, parents' oral health status cannot be changed without substantial effort, time and

resources. It may be more feasible to attempt to change oral health–related factors, such as attitudes, knowledge, oral hygiene behaviours, parental smoking and children’s exposure to ETS, and attitudes to attendance for routine dental care.

A brief discussion of the methodological challenges of such research is appropriate. To investigate intergenerational continuity in oral health, information is required from at least two consecutive generations where parents and their offspring are able to be linked. Thus, the methodological repertoire for investigating intergenerational continuity in oral health consists of prospective cohort studies and cross-sectional surveys. Ideally, the data should be prospectively obtained, as in the former, but there are clear challenges in doing so: the chronic, progressive and cumulative nature of the common oral conditions means that such research would take an inordinately long time, most likely exhausting the patience of researchers and funding bodies alike. It is likely that the two most common chronic oral conditions (dental caries and periodontitis) would differ markedly in the follow-up time which was required to allow the determination of the nature and extent of any intergenerational continuity. Obtaining such information must therefore be an opportunistic undertaking which involves identifying and using existing cohort studies with the potential to provide it, and investigators working in those studies should seriously consider ways of collecting the relevant data from the parents and/or children of their study participants. The information should preferably be collected directly from the individuals concerned, rather than through proxy informants or other sources. Of course, so little is known about the issue that, for now, the more pragmatic approach of using a cross-sectional study design would be useful despite the usual reservations about recall bias (such as in asking a parent about the age when he or she was first diagnosed with periodontal disease, or when and why teeth were extracted).

There is a need for a wider perspective of intergenerational continuity in oral health, along with a careful evaluation of the factors that contribute to the effect. A comprehensive investigation into the effects of intergenerational transmission of oral health – coupled with the effects of cumulative exposures throughout the life course on the oral health status of adults – is required. The difficulties of conducting such investigations demand an opportunistic approach be taken by investigators, and it is likely that wider understanding of the phenomenon will come from methodologically, geographically and culturally diverse sets of findings. It is also worth pointing out that an important principle in scientific investigation is the replication of findings (82). It is possible that an intergenerational association observed in one study may not be found in any another (local environmental effects notwithstanding). If it is found in other settings, on the other hand, then the case for the association being a substantive one is strengthened, particularly if the samples and settings differ in important ways.

In conclusion, further research into intergenerational transmission of oral health will enhance our ability to identify those individuals and families at greatest risk of developing oral disease. This should increase the likelihood of those in greatest need of preventive services actually receiving them, and possibly receiving them earlier than they otherwise would do. A more efficient use of scarce public health resources would be the ultimate outcome.

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