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# The relationship between income and oral health among people with intellectual disabilities: a global perspective

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# The relationship between income and oral health among people with intellectual disabilities: a global perspective

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2012

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# Abstract

The relationship between income and oral health among people with intellectual disabilities: a global perspective

By Michael J. Hughes

BACKGROUND
The scientific literature cites wide health disparities for people with intellectual disabilities compared to the general population. The burden of disease is highest amongst poorer individuals in this population, but little is known about the global state of oral health across income groups. This study seeks to gain an understanding of the effects of income status on oral health in a global population of people with intellectual disabilities.

METHODS
Data were collected between 2007 and 2013 during Special Olympics health screening events. 82,570 participants were screened and eligible for inclusion in this study. Participants were examined by a volunteer health professional who completed a survey of oral health signs and symptoms. The main exposure (income status) and selected outcomes (missing teeth, untreated decay, injury, gingivitis and mouth pain) were used to conduct a cross-sectional analysis. Prevalence odds ratios were obtained through logistic regression.

RESULTS
Compared to high-income countries, there were higher odds of mouth pain among participants from upper middle- (OR 95% CI [1.5, 1.7]), lower middle- ([3.3, 3.7]), and low-income countries ([1.7, 2.1]). There were higher odds of untreated decay among participants from upper middle- (OR 95% CI [3.3, 3.5]), lower middle- ([4.6, 5.1]), and low-income countries ([1.3, 1.5]). There were lower odds of missing teeth among participants from upper middle- (OR 95% CI [0.7, 0.7]), lower middle- ([0.7, 0.8]), and low-income countries ([0.4, 0.5]). There were lower odds of injury among participants from upper middle- (OR 95% CI [0.8, 0.9]), lower middle- ([0.7, 0.8]), and low-income countries ([0.3, 0.5]). Finally, there were lower odds of gingivitis among participants from upper middle- (OR 95% CI [0.8, 0.9]), lower middle- ([0.9, 1.0]), and low-income countries ([0.5, 0.6]).

CONCLUSION
Oral health problems are not exclusive to low-income study participants. Unexpectedly high odds of missing teeth, injury, and gingivitis in high-income countries may be attributed to the high proportion of participants from the United States, which is considered a high-income country but has large income disparities. Health-determining circumstances in low-income countries provide some protection from the hypothesized gradient of oral health for all measured outcomes. These results signal a need for consistent oral health screenings and etiologic studies for people with intellectual disabilities in all economic settings.

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## BACKGROUND

Intellectual disability is the most common developmental disorder that inhibits full participation in society for hundreds of millions of people. Factors related to income increase the risk of comorbid conditions and thereby reduce the quality of life among people with intellectual disabilities, but the relationship between income and oral health in a global context is unclear. Individuals with intellectual disabilities have poorer overall health than the general population (1, 2). This study seeks to build a framework for identifying individuals with intellectual disabilities at high risk for poor oral health and to guide policy and programming for global health intervention.

In developing and developed countries, the burden of oral disease and need for care are highest amongst poorer population groups, although these data do not necessarily translate to the global population (3). Special Olympics is the world's largest sports and public health organization for children and adults with intellectual disabilities. It served 4,205,630 million athletes worldwide in 2012 and constitutes a global network of individuals with intellectual disabilities. From this unique cohort, we can gain an opportunity to learn about the effects of income on oral health.

### *Defining and classifying intellectual disability*

The definition of disability is socially constructed and relies on the interpretation of impairment, which may be physical or a mental state (4). Intellectual disability occurs when impairment impedes cognition and adaptive functioning. Given that the prevalence of associated mental disorders is three to four times greater in people with intellectual disabilities compared to the general population, recognizing co-occurring conditions,

both psychiatric and medical, is an important step to intervention (5).

Today there are multiple ways to define intellectual disability. The current diagnosis system accounts for intelligence and adaptive behavior. However, when used independently, these guidelines should not be followed rigidly because of the range of social norms, levels of functioning (*e.g.*, expressive language difficulties, physical disabilities, and hearing or visual problems that affect responses to interview questions), and interviewers' levels of familiarity with the individuals seeking diagnosis (6). Diagnosis and classification are often necessary for planning support and interventions, determining eligibility for educational programs, and obtaining legal assistance. In addition, comprehensive classifications are useful for evaluation preceding medical care and public health research (7).

Two medication classification systems, the International Classification of Diseases (ICD-10) (8) and the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (9), provide a framework for defining a disorder, indicating levels of severity, designating medication conditions and associated syndromes, and obtaining support from professionals and services. The advantage of these systems is that they accomplish medical profiles that reach beyond a simple, one-dimensional definition of intellectual disability.

The American Institute on Intellectual and Development Disabilities (AIIDD) Definition, Classification, and Systems of Supports, 11$^{th}$ Edition (10), provides best practices for multidimensional functional evaluations, which emphasize adaptive functioning and systems of support. The International Classification of Functioning, Disability, and Health (ICF) (11) evaluates disability by healthy years of life lost. These

four systems are supplemented by materials designed and distributed by the Royal College of Psychiatry and the National Association for the Dually Diagnosed.

*Prevalence of intellectual disability*

In developed countries, the prevalence of intellectual disability ranges from 1-3% based on measurement approach. A birth cohort study conducted in British Columbia conducted between 1952 and 1966 found that the overall prevalence of intellectual disability is fewer than 10 per 1,000 persons (or less than 1%) based on classification of IQ level (12). A meta-analysis of studies in various economic settings found that the overall prevalence of intellectual disability is about 10.4 per 1,000 persons, yet estimates are higher in low-income countries compared to high-income countries (16.4 versus 9.21 per 1,000 persons, respectively) (13). Prevalence estimates increase to 3% based on a statistical approach, which utilizes standardized tests to measure the extent of disability compared to a standardized norm. The 3% estimate includes individuals with an IQ less than two standard deviations below the mean (IQ of 70 or lower). These rates assume equal life expectancy for people with intellectual disabilities as the general population and that diagnosis does not change with age, therefore prevalence may be higher among people with milder forms of disability who are sometimes diagnosed during mid-adulthood (7).

In 1996, the Centers for Disease Control and Prevention (CDC) conducted a study based on 1993-1994 reports from the Department of Education and the Social Security Administration to estimate the prevalence of intellectual disability in the United States. Data were collected from children aged 6-17 enrolled in special education programs and

adults aged 18-64 who received Supplementary Social Security Income and/or Social Security Disability Insurance following the standard definition "significantly subaverage intellectual functioning with deficits in adaptive behavior" (14). Data indicated that the overall rate of intellectual disability was 7.6 cases per 1,000 persons, or approximately 1.5 million people ages 6-64.

Rates vary dramatically by state. For example, there was also a ninefold difference for the rate among children between New Jersey (3.2 cases per 1,000 persons) and Alabama (31.4 cases per 1,000 persons). For adults, the prevalence ranged sixfold between Alaska (2.5 cases per 1,000 persons) and West Virginia (15.7 cases per 1,000 persons). State-to-state variation was accounted for by median household income, percentage of births to teenaged mothers, and percentage of adults with less than a ninth-grade education (15).

Prevalence rates are affected by poverty, nutrition, timely intervention, and refined medical diagnoses. These factors may be further influenced by age, sex, race, socioeconomic level or variation between rural and urban settings (16). Detection may increase between preschool years to middle school years because performance expectations are greater upon entry into school and because of social and behavioral demands (17). Prevalence decreases among older individuals as a result of entry into less demanding vocational programs or early death from certain syndromes (18).

Regional and international studies also suggest that variations in poverty are associated with incidence of intellectual disability (19). The psychosocial nature of socioeconomic status, which includes factors like overcrowding and lack of educational opportunity, also plays a role in the rate of severe intellectual disability (16).

Environmental factors especially relevant to determining prevalence include nutrition, exposure to toxins, microorganisms, and radiation. Recognizing these factors geographically is an important step for anticipating and preventing future impairment.

*Socioeconomic determinants of health*

Poverty during childhood exerts biological stressors that are associated with well-being and people with intellectual disability are more likely to experience poverty than their non-disabled peers (20). Tangible aspects of low socioeconomic status (SES) like inadequate medical care, low education levels, and unsafe housing and jobs have historically been understood to be responsible for poor health. Research has increasingly pointed not only to income level but also to the SES gradient that results in inequitable health outcomes (21). Studies comparing countries with large and small gaps between rich and poor have found that populations in more egalitarian countries (*e.g.*, Japan and Sweden) are healthier and live longer (22). Lower status groups face social discrimination and fewer resources which are more problematic when inequalities are greater (e.g., United States) (23).

It is evident that a person's status in a socioeconomic hierarchy influences mediators to health. Michael Marmot demonstrated that for British civil servants enrolled in a follow-up study for coronary heart disease, the lowest income grade experienced a risk of coronary heart disease over three times greater than the highest income grade (24). Daily stressors, fewer psychosocial resources, dangerous environmental hazards, and detrimental patterns in health behaviors are among the hypothesized pathways that lead to variations in individual biology (25-28).

*Life expectancy and comorbidities*

Life expectancy for people with intellectual disabilities is shorter than that of the general population. A study conducted in 1999 found that people with intellectual disabilities on average live to 55.8 years compared 66.1 years for the general population (18). This difference is pronounced among populations of people with intellectual disabilities where individuals with impaired mobility or inability to self-feed live shorter lives than those with less severe forms of disability (29). Life expectancy for the population of people with intellectual disabilities is increasing over time in a similar fashion to the general population (30).

Improvements in care for aging populations of individuals with intellectual disabilities have resulted in the need to assess age-related disorders. Data from the 1993 National Health Interview Survey (NHIS) indicated that in a population of adults 45 to 74 years old with intellectual disabilities, respondents with intellectual disabilities showed higher prevalence of hypothyroidism, nonischemic heart disorders, and visual impairments compared with their peers. Additional analysis from the NHIS indicated that adults with Down syndrome were significantly more likely to have hypothyroidism, heart disease, and visual impairments, yet less likely to be hypertensive than adults with other types of intellectual disability (31).

In the Netherlands, cardiovascular and cerebrovascular disease prevalence among adults with intellectual disabilities from 60 to 90 years of age was equivalent to the aging Dutch population. Such is not true for esophageal adenocarcinoma for which people with intellectual disabilities experienced an increased risk. This may be attributed to increased

prevalence of gastroesophageal reflux in a population that has more neurological and postural problems (32).

Mobility problems occur at higher rates in both young and old individuals with intellectual disabilities. Factors that impair mobility may range from those related to intellectual disability like neurological disease or congenital blindness to factors related to aging like chronic diseases (32). Mobility-impairing factors combined with communication or behavioral problems raise concerns about medical barriers for patients who need specialized health care.

Several researchers have noted a deficit among individuals with intellectual disabilities in self-reporting diseases that are commonly reported at high rates. Deficiencies in reporting may arise because of difficulties with understanding and communication (33). This develops further concern that those who need care may not even know it (34). A study conducted in Australia found that adults with mild to severe intellectual disability had a comparatively higher risk of chronic diseases that were frequently not recognized or not treated appropriately. Despite a mean of 2.5 major health impairments per study subject (5.4 problems overall per patient), 65% reported no symptoms and 24% of the caregivers reported no problems (34). Another study in the Netherlands reported that an elderly population of adults with intellectual disabilities did not adequately report serious symptoms of disease despite objective observations during evaluations. It is clear that beyond inadequate access, people with intellectual disabilities are less likely to self-report disease symptoms and caregivers may not adequately detect symptoms. The first time many patients learn about major internal problems is during screenings (34).

*Oral health*

Periodontal and gum disease occur at dramatically higher rates in populations of people with intellectual disabilities (35). One study found that over two-thirds of subjects in their study of adults with intellectual disabilities had dental disease. This was the most common health problem present in 86% of the study population (34). Highly prevalent dental disease is compounded by poor dental hygiene. Only 22% of children with intellectual disabilities report daily brushing (36) and 25% have unmet dental needs. Many of the dental needs in this population are untreated and unmet (37).

The prevalence of dental caries (also known as cavities) among adults is nearly 100% of the population in most countries. Rates of dental caries are much lower in developing African and Asian countries but on the rise as a result of the consumption of sugars and inadequate exposure to fluorides. Dental caries are on the decline in industrialized countries due to a number of public health measures, such as fluoridation and improved self-care practices (3).

Gingivitis is inflammation of the gums caused by bacteria from plaque and tartar. It is a mild form of gum disease that does not include loss of bone or tissue. In cases of gingivitis, forgoing daily brushing and flossing can advance to periodontitis, which causes decay of bone and tissue that hold teeth in place (38). Signs of gingivitis and periodontal disease are found in most children and adults worldwide. Severe periodontitis, which may lead to tooth loss, is found in 5-20% of the adult population (3). Prevalence estimates of gingivitis among individuals with intellectual disabilities range from 1.2 to 1.9 times the estimate for the general population (39).

Orodental trauma leading to injury is increasing in industrialized countries, although there is little reliable data about incidence in developing countries and among individuals with intellectual disabilities. Orodental trauma is of special concern to athletes because many cases are caused by participation in sports, and others by unsafe play conditions, road accidents, or violence (40).

Treatment of oral disease is costly even in industrialized countries. In developing countries, little to no resources are allocated for preventive or restorative dental care. The capacity of such countries in Africa, Asia, and Latin America are limited to pain relief or emergency care (41). Effective prevention measures in low-income settings should therefore focus on reducing excessive consumption of sugars and use of tobacco products, which are major risks factors for dental disease, premature tooth loss, and oral cancer (42, 43).

# INTRODUCTION

Special Olympics athletes compose a convenient global sample of people with intellectual disabilities. The Special Olympics 2012 Reach Report states that, "15.4% of athletes reported mouth pain, 36.9% had obvious, untreated tooth decay, 19.5% reported never having had an eye exam, and 24.2% failed hearing tests." Sixty-eight percent of athletes from 35 to 44 years of age who participated in oral health screenings at the 1996 New Jersey Special Olympics Games had gingivitis compared to 42% of the general population, although it is unclear if the estimates differ significantly between populations (2). These studies and others conducted within cohorts of Special Olympics athletes signal a need for reliable information about oral health (44).

An inquiry about oral health with a global perspective could influence programming and health services for people who need it the most. Actions taken toward providing equitable care are encompassed in economic, social, and cultural change. Investment in the health care of Special Olympics athletes and individuals with intellectual disabilities could assist with reducing burden of disease for a vulnerable population (45, 46).

This study seeks to gain an understanding of the association between income and oral health, and to test the hypothesis that people with intellectual disability from lower income countries are more likely to experience tooth decay, missing teeth, mouth pain, injury, and gingivitis than those from higher income countries. It follows that we expect to observe an oral health gradient whereby individuals from lower income countries experience poorer outcomes than people from higher income countries.

# METHODS

## *Study background*

Many of the Special Olympics athletes who attend local, regional, or world competitions also participate in free health screenings through a program coordinated by Special Olympics called Healthy Athletes which consists of health examinations in seven disciplines: podiatry, physical therapy, healthy behaviors, audiology, sports physicals, optometry, and dentistry. In 2012 alone, 111 Special Olympics programs from 65 countries held a total of 741 Healthy Athletes events.

This is a cross-sectional study based on oral health and demographic data collected at dental examinations between March 10, 2007 and March 20, 2013 that aims to determine associations between national income status and oral health outcomes. The purpose of this study is to gain prevalence odds estimates of oral health outcomes in a convenient global sample of people with intellectual disabilities.

## *Study population*

Healthy Athletes participants were excluded from the study if they met any of the following criteria: missing or unknown data about name, age, sex, or country; unknown information about the presence of teeth; and less than 8 or greater than 80 years of age. Due to unreliable data prior to January 2007, only participants who were examined and had forms completed in 2007 and onward were included in the study. Duplicate participants were recognized if the following four criteria matched across observations: first name, last name, date of birth, and sex. Only the earliest observations for participants with multiple screenings were retained for analysis.

*Data collection*

During the dental examination, participants began a record by giving consent (or obtaining consent from their guardian) then answering questions about oral hygiene habits and pain inside the mouth. Participants indicated whether they cleaned their mouth once or more a day, once or multiple times a week, or less than once per week. Participants were then assessed for ability to screen and whether or not they have teeth. Participants who did not complete their dental examination because of refusal or lack of teeth were dismissed from further examination. Participants with teeth were examined by a volunteer dental professional who completed the remainder of the survey (**Appendix A**).

Dental professionals who completed the surveys used standardized guidance to complete a checklist of oral health signs that include decay, fillings, injury, fluorosis, and gingivitis. The survey concludes with an assessment of treatment urgency on a three-part scale: normal, maintenance needed, and urgent maintenance needed. Occasionally the dental professional will give the patient fluoride and a mouth guard.

*Exposure, outcome, and covariate variables*

The main exposure variable, income status, was estimated by aggregating participants by country of residence. The midpoint survey year among the analysis population is 2010; therefore, 2012 World Bank economic classifications (**Appendix B**) (47), which classify economies based on data from two years prior, were used to build a four-level indicator variable for national income level: low-income (gross national

income per capita $995 or less), lower middle-income ($996 to $3,945), upper middle-income ($3,946 to $12,196), and high-income ($12,196 or more).

Each outcome was dichotomized following responses to survey questions about missing teeth, untreated decay, injury, and gingivitis. An additional measurement for mouth pain was built using responses to a question about pain inside the mouth. Participants were dichotomized by those who reported to have any toothache or mouth pain and those who did not report any pain.

Covariates used for statistical analysis include sex, age, and oral hygiene. Participants were divided into five age groups to generate descriptive information. Age was also examined as a continuous variable for use in logistic regression. Participants were grouped by frequency of mouth cleaning (once or more per day, once or multiple times per week, or less than once per week), where cleaning once or more per day is the reference group for oral hygiene.

*Statistical analysis*

Participants were grouped by both geographic region and national income status to obtain descriptive statistics. Participants with teeth were evaluated for five oral health outcomes with positive or negative responses: missing teeth, untreated decay, mouth pain, injury, and gingivitis. An unconditional logistic regression model was used to obtain prevalence odds ratio estimates for the oral health outcomes based on income status. Confounding variables were selected based on biological significance and further assessed with Wald chi-square values upon inclusion in the model. The logit model used to obtain an estimate of effect between income status and oral health controlling for age,

sex, and frequency of mouth cleaning. Backward elimination was used to evaluate plausible interaction. Age and frequency of mouth cleaning were found to be significant effect modifiers and were included in the logistic regression as an interaction term. Analyses were performed using SAS 9.3 (SAS Institute, Cary, NC).

# RESULTS

## *Descriptive statistics*

Out of 99,877 available dental records, 82,570 met eligibility criteria and were further analyzed (**Figure 1**). About half of the participants (49%) are from North America and 64% are from high-income countries. Twenty-one percent of participants are from upper middle-income countries, 11% from lower middle-income countries, and 4% from low-income countries. The most underrepresented world region is North Africa and Middle East, which consists of 0.5% of the study population (**Table 1**).

Almost two-thirds (62%) of the study population is male and about half (45%) is between 20 to 39 years of age (**Table 2**). The mean age of participants from high-income and upper middle-countries is about six years greater than the mean from lower middle-income and low-income countries. The overall mean age of participants is 27 years (data not shown).

One percent of the total study population was edentulous (lacking teeth) and therefore did not yield dental examination results. Of the population having teeth and completing a dental examination, 29% had missing teeth, 36% had untreated decay, 15% had reported mouth pain, 8% had an injury, and 45% had signs of gingivitis. High-income countries had the highest proportion of participants with missing teeth, gingivitis, and injury. Lower middle-income countries had the highest proportion of participants with untreated decay and mouth pain. The majority of all participants in the study qualified for oral treatment, with 52% requiring maintenance and 15% requiring urgent care (**Table 3**).

*Bivariate analysis*

All five outcomes of interest (missing teeth, untreated decay, mouth pain, injury, and gingivitis) were statistically significantly associated with income status ($p < 0.0001$). Edentulousness and treatment urgency, which was divided between participants requiring oral treatment and those with normal status, were also significantly associated with world income region ($p < 0.0001$) (data not shown).

*Logistic regression*

Among participants having teeth and completing a dental examination, those from upper middle-income countries had higher odds of mouth pain (OR 95% CI [1.5, 1.7]) and untreated decay ([3.3, 3.5]) compared to those from high-income countries. Participants from lower middle-income countries had three-and-a-half times the odds of mouth pain (OR 95% CI [3.3, 3.7]) and five times the odds of untreated decay ([4.6, 5.1]). Participants from low-income countries had twice the odds of mouth pain (OR 95% CI [1.7, 2.1]) and one-and-a-half the odds of untreated decay ([1.3, 1.5]) compared to participants from high-income countries.

Participants from upper middle-income countries had lower odds of missing teeth (OR 95% CI [0.7, 0.7]), injury ([0.8, 0.9]), and gingivitis ([0.8, 0.9]) compared to those from high-income countries. Participants from lower middle-income countries also had lower odds of missing teeth (OR 95% CI [0.7, 0.8]) and injury ([0.7, 0.8]), but had approximately the same odds of gingivitis (OR 95% CI [0.9, 1.0]) compared to participants from high-income countries. Participants from low-income countries had

lower odds of missing teeth (OR 95% CI [0.4, 0.5]), injury ([0.3, 0.5]), and gingivitis ([0.5, 0.6]) compared to those from high-income countries (**Table 4**).

## DISCUSSION

This cohort of athletes represents a convenient sample of individuals that are potentially more physically active and socially supported than the entire population of people with intellectual disabilities. Many study participants are from North American, Latin American, or European countries, whereas fewer are from African, Asian, or Middle Eastern countries. Only 4% of athletes are from low-income countries. Despite these differences in athletes represented at health screenings, Special Olympics health programs are increasingly reaching poorer communities with people with intellectual disabilities.

Oral health problems are not exclusive to low-income athletes. A great number of individuals from every income group required maintenance or urgent care. However, residency in low-income countries had a protective effect against the hypothesized gradient of oral health. Overall, participants from low-income countries experienced oral health outcomes at a lower rate than expected. This is especially true for untreated decay and mouth pain, for which participants from low-income countries experienced halved odds compared to the next highest lower middle-income group.

To explain this unexpected difference in prevalence of untreated decay and mouth pain from middle-income to low-income countries, it is necessary to observe the remaining outcomes measures in this study. The likelihood of missing teeth was unexpectedly lower than the reference group at all income levels. A significant portion of the overall number of cases of missing teeth may be explained by therapeutic tooth extractions performed in dental care settings. Participants who can afford care may be more likely to undergo extractions to remedy dental problems than participants who do

not have the necessary resources. Thus, it could be expected that residents in high-income groups have greater odds of missing teeth.

Injured teeth were also less likely in all lower income countries compared to high-income countries. This unexpected difference may be attributed to the lifestyle of athletes who participate in Special Olympics in high-income countries. Well-established Special Olympic athletic programs in North America and Europe may give athletes more opportunities for participation in sport, yet also increase the likelihood for injury in practice or competition.

Gingivitis is another oral health outcome that was hypothesized to be higher in middle-to-low income countries yet the opposite trend was observed. There are marginally fewer cases of gingivitis in lower middle-income countries yet 50% fewer cases in low-income countries compared to high-income countries. If this result is considered along with the unexpectedly low odds of the remaining oral health outcomes (decay, pain, injury, and gingivitis), it is plausible to conclude that underlying environmental or social factors associated with income protect low-income individuals with intellectual disabilities from the hypothesized gradient of oral health.

In high and middle-income countries, sugary and convenient foods are widely consumed. These types of foods such as fast food and soft drinks are readily available to individuals of any economic background and are especially carious. Developing nations without such access to sugary foods may rely more on fruits and vegetables for daily consumption and therefore experience decreased odds of outcomes associated with sugary foods like dental caries, loss of teeth, or gingivitis, despite deficiencies in resources required for routine dental care.

Social factors that affect the health of individuals with intellectual disability should not be overlooked. In settings with abundant access to health care, practitioners may face challenges accommodating patients with intellectual disabilities. For instance, patients with intellectual disabilities may face problems communicating with their physicians or feeling discriminated against. Indirect discrimination may also occur from lack awareness or information suiting patients' needs (48). These issues have the potential to create inequitable access and complicate oral health problems for athletes. Finally, social marginalization and other such psychosocial factors are drivers for health status in any individual. Such cases of maltreatment and abuse of people with intellectual disabilities are well-documented and necessary considerations for observing and intervening for health outcomes (49).

This study has a number of strengths, including a large sample size (82,570 study participants from 206 countries), standardized screening methods, and data collection from multiple events. This study fulfills a need for statistically sound data in the current literature about oral health among people with intellectual disabilities. Additionally, this study allows for the evaluation of oral health beyond a single symptom or disease. For this reason, multiple conclusions can be drawn about the association between income and oral health. Finally, health screenings were free and accessible for all individuals at Healthy Athlete events, which means no athletes were turned away for economic reasons.

Despite the strengths of this study, there are several limitations. First, this study is limited to athletes participating in local, national, regional, and world sporting events. This cross-sectional analysis does not perfectly represent the entire population of people with intellectual disabilities. For example, Special Olympics athletes from low-income

countries who attend regional or world events may be better funded or socially supported than their countrymen with intellectual disabilities who do not or cannot participate in Special Olympics programs. Thus, efforts to sample athletes who are screened at local events may diminish selection bias in future studies. Second, athletes who participated in this study may have milder forms of intellectual disability than is actually prevalent among non-athletes. Despite this limitation, athletes who attend health screenings are not turned away for having a severe form of intellectual disability, which is a potential concern at clinics with fewer resources. Finally, this study also includes a very large percentage (47%) of athletes from the United States, which is considered a high-income country but has large income gaps (50). Aggregating income status for each individual from a given country is a necessary limitation given that very little demographic information is collected at the time of examination.

Future studies about income status and oral health of people with intellectual disability should carefully consider income and other socioeconomic factors that influence outcomes for each individual. This is especially important for individuals from the United States where socioeconomic status varies greatly. Understanding state-to-state variations in multiple health disciplines would benefit public health programs that serve people with intellectual disabilities in the United States. Future studies should also target populations that better represent the global population of people with intellectual disabilities by including individuals who are institutionalized and those with more severe forms of intellectual disability.

The oral health status of people with intellectual disabilities is an urgent and widespread problem. Findings from this study identify who among this population is

experiencing increased risks and symptoms of periodontal disease. Low-income countries do not necessarily have an increased number of cases of poor oral health, possibly due to over-consumption of highly carious foods and tobacco use in high and middle-income countries. Health-determining circumstances in low-income countries provide some protection from the hypothesized gradient of oral health for all measured outcomes. Following these findings, oral health screenings should be expanded for individuals with intellectual disabilities and future research should continue to identify risky and protective factors in all economic settings.

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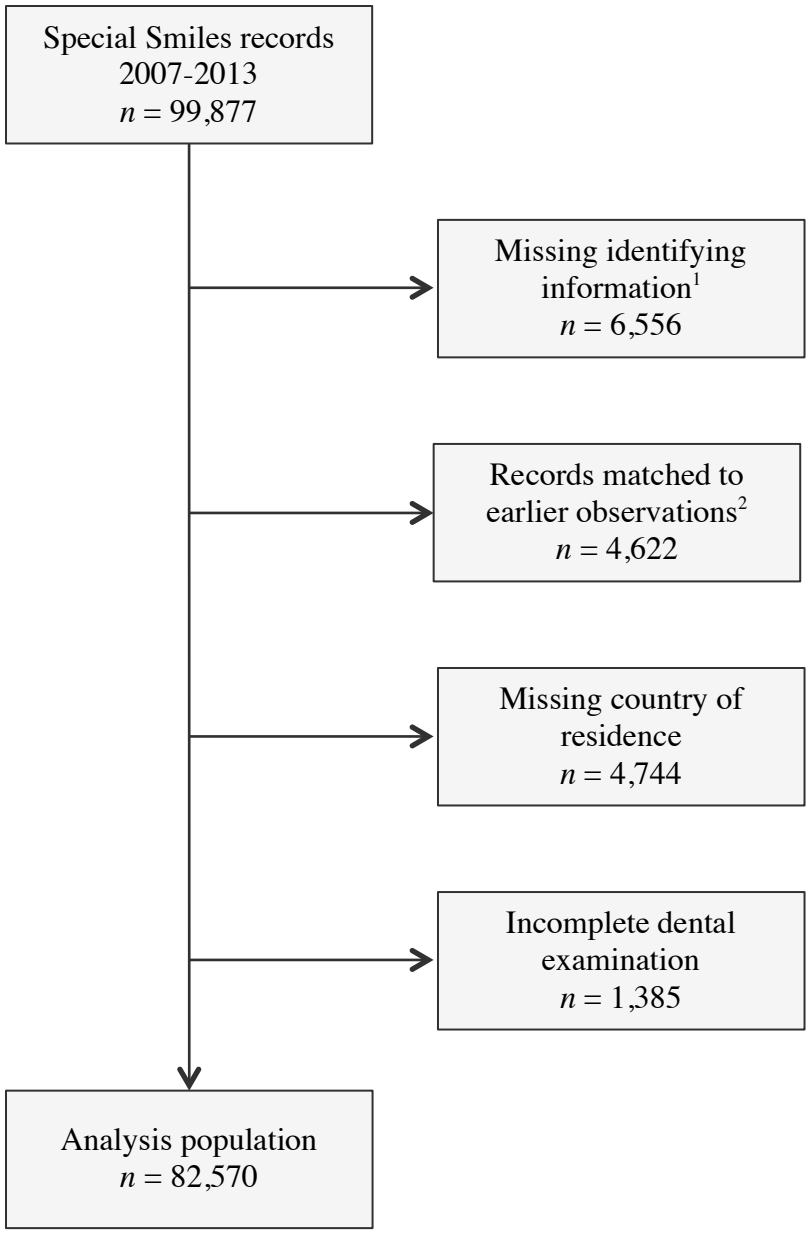
TABLES AND FIGURES

**Figure 1.** Enrollment and eligibility scheme for Special Olympics athletes between 8 and 80 years of age who participated in Healthy Athletes Special Smiles oral health screenings between 2007 and 2013.




[1] Identifying information includes name, date of birth, and sex.
[2] If athletes were screened multiple times at separate events, only results from the earliest event were retained.

**Table 1.** Distribution of population by world region among eligible study participants who completed Special Smiles oral health screening forms between 2007 and 2013.

| Region | n | % |
|---|---|---|
| Total | 82,570 | 100 |
| By income[1] | | |
| High-income | 52,708 | 64 |
| Upper middle-income | 17,131 | 21 |
| Lower middle-income | 9,224 | 11 |
| Low-income | 3,500 | 4 |
| By geography | | |
| North America | 40,164 | 49 |
| Europe | 13,330 | 16 |
| Latin America | 12,500 | 15 |
| Southern Africa | 6,255 | 8 |
| Asian Pacific | 5,177 | 6 |
| East Asia | 4,754 | 6 |
| Northern Africa/Middle East | 390 | 0.5 |

[1] International Bank for Reconstruction and Development. World Development Indicators. Washington, D.C.: The World Bank; 2012.

**Table 2.** Age and sex distributions of eligible study participants who completed Special Smiles oral health screening forms between 2007 and 2013, stratified by income group.

| | High-Income | | Upper Middle-Income | | Lower Middle-Income | | Low-Income | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| Characteristic | n | % | n | % | n | % | n | % | n | % |
| Age | | | | | | | | | | |
| 8 - 12 years | 2,914 | 6 | 1,157 | 7 | 1,649 | 18 | 1,064 | 30 | 6,784 | 8 |
| 13 - 19 years | 13,556 | 26 | 5,896 | 34 | 4,043 | 44 | 1,417 | 40 | 24,916 | 30 |
| 20 - 39 years | 27,943 | 53 | 6,048 | 35 | 2,476 | 27 | 597 | 17 | 37,067 | 45 |
| 40 - 59 years | 7,648 | 15 | 3,987 | 23 | 990 | 11 | 26 | 1 | 12,651 | 15 |
| 60 - 80 years | 647 | 1 | 43 | 0.3 | 66 | 1 | 396 | 11 | 1,152 | 1 |
| Sex | | | | | | | | | | |
| Male | 32,580 | 62 | 10,560 | 62 | 5,825 | 63 | 2,249 | 64 | 51,217 | 62 |
| Female | 20,128 | 38 | 6,571 | 38 | 3,399 | 37 | 1,251 | 36 | 31,353 | 38 |

**Table 3**. Oral health characteristics of eligible study participants who completed Special Smiles screening forms between 2007 and 2013, stratified by income group.

| | High-Income | | Upper Middle-Income | | Lower Middle-Income | | Low-Income | |
|---|---|---|---|---|---|---|---|---|
| Characteristic | n | % | n | % | n | % | n | % |
| Oral health | | | | | | | | |
| Edentulous | 1,007 | 2 | 89 | 1 | 109 | 1 | 20 | 1 |
| Dentulous | 51,701 | 98 | 17,042 | 99 | 9,115 | 99 | 3,480 | 99 |
| Missing teeth | 16,200 | 31 | 4,190 | 25 | 2,097 | 23 | 508 | 15 |
| Untreated decay | 13,591 | 26 | 9,179 | 54 | 5,673 | 62 | 1,235 | 35 |
| Mouth pain | 5,714 | 11 | 2,817 | 17 | 2,638 | 29 | 704 | 20 |
| Injury | 4,649 | 9 | 1,320 | 8 | 602 | 7 | 120 | 3 |
| Gingivitis | 24,478 | 47 | 7,187 | 42 | 4,016 | 44 | 1,194 | 34 |
| Treatment urgency[1] | | | | | | | | |
| Normal | 14,105 | 28 | 7,199 | 44 | 3,685 | 42 | 1,041 | 33 |
| Maintenance needed | 30,750 | 61 | 6,507 | 40 | 2,672 | 31 | 1,448 | 45 |
| Urgent care needed | 5,761 | 11 | 2,698 | 16 | 2,405 | 27 | 714 | 22 |

[1] 3,578 participants who completed an earlier version of the Special Smiles screening form were not evaluated for treatment urgency.

**Table 4.** Odds ratios (OR) and 95% confidence intervals (CI) of oral health outcomes for each income group compared to the high-income reference group controlling for age, sex, and frequency of mouth cleaning.

| | Upper Middle-Income vs. High-Income | | | Lower Middle-Income vs. High-Income | | | Low-Income vs. High-Income | | |
|---|---|---|---|---|---|---|---|---|---|
| Characteristic | OR | 95% CI | p | OR | 95% CI | p | OR | 95% CI | p |
| Missing teeth | 0.7 | (0.67, 0.73) | <.0001 | 0.7 | (0.70, 0.78) | <.0001 | 0.4 | (0.37, 0.46) | <.0001 |
| Mouth pain | 1.6 | (1.53, 1.69) | <.0001 | 3.5 | (3.31, 3.70) | <.0001 | 1.9 | (1.73, 2.09) | <.0001 |
| Untreated decay | 3.4 | (3.27, 3.52) | <.0001 | 4.9 | (4.62, 5.10) | <.0001 | 1.4 | (1.32, 1.54) | <.0001 |
| Injury | 0.8 | (0.77, 0.88) | <.0001 | 0.8 | (0.70, 0.84) | <.0001 | 0.4 | (0.31, 0.45) | <.0001 |
| Gingivitis | 0.8 | (0.79, 0.85) | <.0001 | 0.9 | (0.91, 1.00) | 0.0317 | 0.5 | (0.47, 0.55) | <.0001 |

## **Appendix A.** Special Smiles dental examination form

| **Firstname** | **Lastname** | **HAS ID** ____ ____ _____ ____ ____ |
|---|---|---|

| **Date** | **O Male O Female** | **DoB** | **Age (years) O Not sure** |
|---|---|---|---|
| Event | Location | O Athlete O Unified partner | Sport |
| Delegation | | SO Program | |

Screener's name

### Dental History

**1. Fill out this section for each athlete even if edentulous**

How often do you clean your mouth?

O Once or more a day
O 2 to 6 times per week
O Once per week
O Less than once per week
O Not sure

**2. Pain inside mouth**

O Yes O No
☐ Teeth
☐ Other

**3. ☐ Athlete refused/could not screen**

### Screening

**4. Edentulous**

O Yes **(-> stop here)** ☐ **Exam completed**
O No **(answer all questions 5 thru 14)**

**5. Untreated decay**

O Yes O No
☐ Anterior(s)
☐ Premolar(s)
☐ Molar(s)

**6. Filled teeth**

O Yes O No

**7. Missing teeth**

O Yes O No
☐ Anterior(s)
☐ Molar(s)

**8. Sealant(s)**

O Yes O No

**9. Injury**

O Yes O No
**Injury Treated** o Yes o No

**10. Fluorosis**

O Yes O No

**11. Gingival signs**

O Yes O No

**12. Treatment urgency**

O Maintenance
O Non-urgent
O Urgent

**13. Mouthguard recommended**

O Yes O No
☐ Mouthguard delivered

**14. Fluoride Varnish**

O Yes O No

**15. ☐ Exam completed**

**Appendix B.** Economic classifications[1]

| High-income | Upper middle-income | Lower middle-income | Low-income |
|---|---|---|---|
| Andorra | Albania | Angola | Afghanistan |
| Aruba | Algeria | Armenia | Bangladesh |
| Australia | American Samoa | Belize | Benin |
| Austria | Antigua and Barbuda | Bhutan | Burkina Faso |
| Bahamas, The | Argentina | Bolivia | Burundi |
| Bahrain | Azerbaijan | Cameroon | Cambodia |
| Barbados | Belarus | Cape Verde | Central African Republic |
| Belgium | Bosnia and Herzegovina | Congo, Rep. | Chad |
| Bermuda | Botswana | Côte d'Ivoire | Comoros |
| Brunei Darussalam | Brazil | Djibouti | Congo, Dem. Rep. |
| Canada | Bulgaria | Egypt, Arab Rep. | Eritrea |
| Cayman Islands | Chile | El Salvador | Ethiopia |
| Channel Islands | China | Fiji | Gambia, The |
| Croatia | Colombia | Georgia | Guinea |
| Curaçao | Costa Rica | Ghana | Guinea-Bissau |
| Cyprus | Cuba | Guatemala | Haiti |
| Czech Republic | Dominica | Guyana | Kenya |
| Denmark | Dominican Republic | Honduras | Korea, Dem. Rep. |
| Equatorial Guinea | Ecuador | India | Kyrgyz Republic |
| Estonia | Gabon | Indonesia | Liberia |
| Faeroe Islands | Grenada | Iraq | Madagascar |
| Finland | Iran, Islamic Rep. | Kiribati | Malawi |
| France | Jamaica | Kosovo | Mali |
| French Polynesia | Jordan | Lao PDR | Mozambique |
| Germany | Kazakhstan | Lesotho | Myanmar |
| Gibraltar | Latvia | Marshall Islands | Nepal |
| Greece | Lebanon | Mauritania | Niger |
| Greenland | Libya | Micronesia, Fed. Sts. | Rwanda |
| Guam | Lithuania | Moldova | Sierra Leone |
| Hong Kong SAR, China | Macedonia, FYR | Mongolia | Somalia |
| Hungary | Malaysia | Morocco | Tajikistan |
| Iceland | Maldives | Nicaragua | Tanzania |
| Ireland | Mauritius | Nigeria | Togo |
| Isle of Man | Mayotte | Pakistan | Uganda |
| Israel | Mexico | Papua New Guinea | Zimbabwe |
| Italy | Montenegro | Paraguay | |
| Japan | Namibia | Philippines | |

[1] International Bank for Reconstruction and Development. World Development Indicators. Washington, D.C.: The World Bank; 2012.

| High-income | Upper middle-income | Lower middle-income | Low-income |
|---|---|---|---|
| Korea, Rep. | Palau | Samoa | |
| Kuwait | Panama | São Tomé and Príncipe | |
| Liechtenstein | Peru | Senegal | |
| Luxembourg | Romania | Solomon Islands | |
| Macao SAR, China | Russian Federation | Sri Lanka | |
| Malta | Serbia | South Sudan | |
| Monaco | Seychelles | Sudan | |
| Netherlands | South Africa | Swaziland | |
| New Caledonia | St. Kitts and Nevis | Syrian Arab Republic | |
| New Zealand | St. Lucia | Timor-Leste | |
| Northern Mariana Islands | St. Vincent & Grenadines | Tonga | |
| Norway | Suriname | Turkmenistan | |
| Oman | Thailand | Tuvalu | |
| Poland | Tunisia | Ukraine | |
| Portugal | Turkey | Uzbekistan | |
| Puerto Rico | Uruguay | Vanuatu | |
| Qatar | Venezuela, RB | Vietnam | |
| San Marino | | West Bank and Gaza | |
| Saudi Arabia | | Yemen, Rep. | |
| Singapore | | Zambia | |
| Sint Maarten | | | |
| Slovak Republic | | | |
| Slovenia | | | |
| Spain | | | |
| St. Martin | | | |
| Sweden | | | |
| Switzerland | | | |
| Trinidad and Tobago | | | |
| Turks and Caicos Islands | | | |
| United Arab Emirates | | | |
| United Kingdom | | | |
| United States | | | |
| Virgin Islands (U.S.) | | | |