



THE UNIVERSITY  
*of* ADELAIDE

---

# **Social gradient in child oral health: individual, school and area variation.**

---

Jennifer Lynn Miller  
a1080325

School of Dentistry  
The University of Adelaide

Submitted for the Degree of Doctor of Philosophy November 2015

---

Supervised by:

Professor A. John Spencer, School of Dentistry, The University of Adelaide

Professor Kaye Roberts-Thomson, School of Dentistry, The University of Adelaide

Professor Anthony Blinkhorn, Centre of Oral Health Strategy, The University of Sydney

---

## TABLE OF CONTENTS

<b>LIST OF FIGURES</b> .....	<b>V</b>
<b>LIST OF TABLES</b> .....	<b>V</b>
<b>LIST OF ABBREVIATIONS</b> .....	<b>VIII</b>
<b>ABSTRACT</b> .....	<b>XI</b>
<b>SIGNED STATEMENT</b> .....	<b>XIII</b>
<b>ACKNOWLEDGEMENTS</b> .....	<b>XIV</b>
<b>THESIS FORMAT</b> .....	<b>XV</b>
<b>CHAPTER 1 INTRODUCTION</b> .....	<b>1</b>
1.1 CHILD ORAL HEALTH.....	1
1.1.1 Basic mechanism of caries .....	2
1.1.2 Social determinants .....	3
1.1.3 Distribution.....	4
1.2 INEQUALITIES IN ORAL HEALTH .....	5
1.3 MEASURING THE SOCIAL GRADIENT IN ORAL HEALTH.....	7
1.3.1 Social gradient in oral health using individual SES indicators .....	8
1.3.2 Social gradient in oral health using school SES indicators .....	9
1.3.3 Social gradient in oral health using area SES indicators .....	10
1.3.4 Inter-relatedness of SES indicators .....	11
1.4 POPULATION HEALTH POLICY AND HEALTH SERVICE PROVISION .....	13
1.4.1 Epidemiology and surveillance data in oral health.....	15
1.4.2 Public health approaches .....	16
1.4.2.1 Whole population approach .....	18
1.4.2.2 Common risk factor approach.....	19
1.4.2.3 Targeted care approach.....	20
1.4.2.4 Health care organisation .....	21
1.5 PROBLEM TO BE INVESTIGATED.....	22
1.5.1 School dental services in Australia.....	22
1.5.2 NSW ‘Save Our Kids Smiles’ Program (SOKS) .....	23
1.5.3 NSW ‘School Assessment Program’ (SAP).....	24
1.6 RATIONALE FOR STUDYING THE PROBLEM .....	25
1.7 RESEARCH FRAMEWORK.....	26
1.8 OBJECTIVES .....	30
1.8.1 Specific Objectives.....	30

1.8.2	Hypotheses.....	30
<b>CHAPTER 2</b>	<b>MATERIALS AND METHODS .....</b>	<b>31</b>
2.1	STUDY DESIGN .....	31
2.1.1	Sampling procedures.....	32
2.1.1.1	Sampling: NSW CDHS 2007 .....	32
2.1.1.2	Sampling: Supplementary study of the socioeconomic variation .....	32
2.2	DATA COLLECTION METHODS.....	33
2.2.1	Examinations .....	33
2.2.2	Questionnaires .....	34
2.2.3	School and area SES information .....	35
2.2.4	Examiner reliability .....	35
2.3	DATA MANAGEMENT .....	35
2.3.1	Survey return and data entry .....	36
2.3.2	Oral health items .....	36
2.3.3	Explanatory items .....	37
2.3.4	Sociodemographic items.....	37
2.3.5	Socioeconomic status items .....	38
2.3.6	Survey Weighting .....	39
2.3.7	Analysis plan .....	40
2.4	ETHICAL IMPLICATIONS AND APPROVALS .....	43
<b>CHAPTER 3</b>	<b>RESULTS .....</b>	<b>45</b>
3.1	PARTICIPATION .....	46
3.1.1	Participation results of NSW examination phase.....	46
3.1.2	Participation results of supplementary questionnaire phase .....	47
3.2	DESCRIPTIVE FINDINGS – EXPLANATORY VARIABLES .....	48
3.2.1	Sociodemographic data from the sample.....	48
3.2.1.1	Population benchmarking .....	50
3.2.1.2	Child Dental Health Survey comparison .....	52
3.2.2	Individual socioeconomic indicators .....	53
3.2.3	School socioeconomic indicators.....	54
3.2.4	Area socioeconomic indicators .....	55
3.3	CORRELATION AND CONCORDANCE STATISTICS FOR EXPLANATORY VARIABLES.....	56
3.3.1	Correlation statistics .....	56
3.3.2	Concordance analysis .....	58

3.4	CARIES PREVALENCE.....	69
3.4.1	Caries prevalence in deciduous dentition.....	69
3.4.2	Caries prevalence in permanent dentition.....	78
3.5	CARIES SEVERITY.....	88
3.5.1	Caries severity in deciduous dentition.....	88
3.5.2	Caries severity in permanent dentition.....	97
3.6	SIGNIFICANT CARIES GROUP.....	106
3.6.1	Significant caries in deciduous dentition.....	106
3.6.2	Significant caries in permanent dentition.....	116
3.7	MULTI-LEVEL ANALYSIS TO EVALUATE SES VARIATION.....	127
3.7.1	Multi-level modelling for deciduous caries prevalence.....	129
3.7.2	Multi-level modelling for permanent caries prevalence.....	132
3.7.3	Multi-level modelling for deciduous caries severity.....	135
3.7.4	Multi-level modelling for permanent caries severity.....	137
3.7.5	Multi-level modelling for membership of the deciduous significant caries group.....	140
3.7.6	Multi-level modelling for membership of the permanent significant caries group.....	143
3.8	MEASURES OF ASSOCIATION AND POPULATION IMPACT.....	148
3.8.1	Caries prevalence.....	149
3.8.2	Caries severity.....	153
3.8.3	Significant caries.....	157
<b>CHAPTER 4</b>	<b>DISCUSSION.....</b>	<b>162</b>
4.1	OVERVIEW – STRENGTHS AND LIMITATIONS.....	162
4.2	PARTICIPATION AND RESPONSE.....	164
4.3	DISTRIBUTION OF CHILD ORAL DISEASE.....	165
4.3.1	Distribution of child oral health by the individual-, school- and area-level socioeconomic characteristics.....	166
4.4	ASSOCIATION ACROSS INDIVIDUAL-, SCHOOL- AND AREA-LEVEL SES INDICATORS.....	168
4.5	EFFECTIVENESS OF TARGETING DENTAL SERVICES USING SES INDICATORS.....	171
4.5.1	Policy and service provision.....	172

4.5	FURTHER RESEARCH .....	175
<b>CHAPTER 5</b>	<b>SUMMARY AND CONCLUSIONS .....</b>	<b>176</b>
5.1	MAJOR THEMES.....	176
5.1.1	Distribution by SES characteristics .....	176
5.1.1.1	Caries prevalence.....	176
5.1.1.2	Caries severity .....	177
5.1.1.3	Significant caries group .....	178
5.1.2	Associations across individual, school and area-level SES indicators .....	179
5.1.3	Effectiveness of targeting dental services by SES indicators .....	180
5.2	CONCLUSIONS .....	180
5.3	PRINCIPAL CONCLUSIONS.....	183
	<b>REFERENCE LIST .....</b>	<b>184</b>
	<b>APPENDICES.....</b>	<b>194</b>
1.	NSW Information and Consent form .....	195
2.	Supplementary study - Primary Approach letter and Questionnaire.....	201
3.	Reminder card and Follow-up letters.....	212
4.	Examination protocol and examination form.....	215
5.	Diagrammatic Acyclical Graph (DAG) .....	259
a.	individual-level .....	260
b.	school-level.....	261
c.	area-level.....	262
6.	Estimate variation tables (sensitivity analysis) .....	263
a.	Model selection for multivariable analysis – deciduous caries prevalence .....	264
b.	Model selection for multivariable analysis – permanent caries prevalence.....	265
c.	Model selection for multivariable analysis – deciduous caries severity .....	266
d.	Model selection for multivariable analysis – permanent caries severity .....	267
7.	Test for Multicollinearity – Variance Inflation Factor .....	268
8.	Letter for Ethical Approval .....	269

## LIST OF FIGURES

Figure 1:	Conceptual Model for NSW survey .....	29
-----------	---------------------------------------	----

## LIST OF TABLES

Table 1:	Research framework in relation to NSW survey .....	28
Table 2:	Enrolment rate for the CDHS and supplementary study .....	46
Table 3:	Returns for supplementary questionnaire .....	47
Table 4:	Participation results across Area Health Service Regions.....	47
Table 5:	Sociodemographic characteristics of participants .....	49
Table 6:	Comparison of characteristics of participants of supplementary study and the NSW ABS Census 2006.....	51
Table 7:	Comparison of sociodemographic characteristics of NSW CDHS 2007 and supplementary study.....	52
Table 8:	Sample socioeconomic characteristics .....	53
Table 9:	School socioeconomic characteristics .....	54
Table 10:	Area socioeconomic characteristics .....	55
Table 11:	Correlation statistics for individual demographic and socioeconomic characteristics .....	57
Table 12:	Correlation statistics for the individual-, school- and area-level socioeconomic characteristics .....	57
Table 13:	Concordance statistics for individual and school ICEA SES characteristics .....	59
Table 14:	Concordance statistics for individual and school type characteristics.....	60
Table 15:	Concordance statistics for individual and area SES (LHD SEIFA) .....	62
Table 16:	Concordance statistics for individual and area SES (LHD wealth).....	64
Table 17:	Concordance statistics for school SES and area SES (LHD SEIFA) .....	66
Table 18:	Concordance statistics for school SES and area SES (LHD wealth) .....	68
Table 19:	Caries prevalence in deciduous dentition by sociodemographic characteristics ....	70
Table 20:	Caries prevalence in deciduous dentition by individual socioeconomic characteristics .....	71
Table 21:	Caries prevalence in deciduous dentition – school socioeconomic characteristics	72
Table 22:	Caries prevalence in deciduous dentition – area socioeconomic characteristics....	73
Table 23:	Sequential and regression models for deciduous caries prevalence for individual-level SES.....	75
Table 24:	Sequential and regression models for deciduous caries prevalence for school-level SES.....	76
Table 25:	Sequential and regression models for deciduous caries prevalence for area-level SES .....	77
Table 26:	Caries prevalence in permanent dentition – sociodemographic characteristics .....	79
Table 27:	Caries prevalence in permanent dentition – socioeconomic characteristics.....	80
Table 28:	Caries prevalence in permanent dentition – school socioeconomic characteristics	81
Table 29:	Caries prevalence in permanent dentition –area socioeconomic characteristics ....	82
Table 30:	Sequential and regression models for permanent caries prevalence for individual-level SES.....	83
Table 31:	Sequential and regression models for permanent caries prevalence for school-level SES.....	84

Table 32:	Sequential and regression models for permanent caries prevalence for area-level SES.....	85
Table 33:	Summary of findings related to caries prevalence.....	87
Table 34:	Caries severity in deciduous dentition – sociodemographic characteristics .....	89
Table 35:	Caries severity in deciduous dentition – individual socioeconomic characteristics.....	90
Table 36:	Caries severity in deciduous dentition – school socioeconomic characteristics .....	91
Table 37:	Caries severity in deciduous dentition – area socioeconomic characteristics.....	92
Table 38:	Sequential and regression models for deciduous caries severity caries for individual-level SES .....	94
Table 39:	Sequential and regression models for deciduous caries severity caries for school-level SES .....	95
Table 40:	Sequential and regression models for deciduous caries severity caries for area-level SES.....	96
Table 41:	Caries severity in permanent dentition – sociodemographic characteristics .....	98
Table 42:	Caries severity in permanent dentition – individual socioeconomic characteristics.....	99
Table 43:	Caries severity in permanent dentition – school socioeconomic characteristics ..	100
Table 44:	Caries severity in permanent dentition – area socioeconomic characteristics .....	101
Table 45:	Sequential and regression models for permanent caries severity caries for individual-level SES .....	102
Table 46:	Sequential and regression models for permanent caries severity caries for school-level SES .....	103
Table 47:	Sequential and regression models for permanent caries severity for area-level SES .....	104
Table 48:	Summary of findings related to caries severity.....	105
Table 49:	SiC <sub>10</sub> mean dmfs in deciduous dentition – sociodemographic characteristics.....	106
Table 50:	Prevalence of SiC <sub>10</sub> in deciduous dentition – sociodemographic characteristics..	108
Table 51:	Prevalence of SiC <sub>10</sub> in deciduous dentition – individual socioeconomic characteristics.....	109
Table 52:	Prevalence of SiC <sub>10</sub> in deciduous dentition – school socioeconomic characteristics.....	110
Table 53:	Prevalence of SiC <sub>10</sub> in deciduous dentition – area socioeconomic characteristics.....	111
Table 54:	Sequential and regression models for deciduous SiC <sub>10</sub> caries for individual-level SES .....	113
Table 55:	Sequential and regression models for deciduous SiC <sub>10</sub> caries for school-level SES .....	114
Table 56:	Sequential and regression models for deciduous SiC <sub>10</sub> caries for area-level SES.....	115
Table 57:	SiC <sub>10</sub> mean DMFS in permanent dentition – sociodemographic characteristics ..	116
Table 58:	Prevalence of SiC <sub>10</sub> in permanent dentition – sociodemographic characteristics .	118
Table 59:	Prevalence of SiC <sub>10</sub> in permanent dentition – individual socioeconomic characteristics.....	119
Table 60:	Prevalence of SiC <sub>10</sub> in permanent dentition – school socioeconomic characteristics.....	120
Table 61:	Prevalence of SiC <sub>10</sub> in permanent dentition – area socioeconomic characteristics.....	121

Table 62:	Sequential and regression models for the prevalence of permanent SiC <sub>10</sub> caries for individual-level SES.....	122
Table 63:	Sequential and regression models for the prevalence of permanent SiC <sub>10</sub> caries for school-level SES.....	123
Table 64:	Sequential and regression models for the prevalence of permanent SiC <sub>10</sub> caries for area-level SES .....	124
Table 65:	Summary of findings related to SiC <sub>10</sub> .....	126
Table 66:	Association between individual-, school- and area-level factors for deciduous caries prevalence in children aged 8-9 years .....	131
Table 67:	Association between school and area-level factors of permanent caries prevalence in children aged 12 years.....	134
Table 68:	Association between school and area-level factors of deciduous caries severity in children aged 8-9 years.....	136
Table 69:	Association between school and area-level factors of permanent caries severity in children aged 12 years .....	139
Table 70:	Association between school and area-level factors of deciduous SiC <sub>10</sub> caries in children aged 8-9 years .....	142
Table 71:	Association between school and area-level factors of permanent SiC <sub>10</sub> caries in children aged 12 years .....	145
Table 72:	Summary of findings related to multi-level analysis of SES indicators for caries prevalence, caries severity and SiC <sub>10</sub> .....	147
Table 73:	Distribution of cases, prevalence ratios and population attributable fraction or deciduous caries prevalence (weighted data).....	150
Table 74:	Distribution of cases, prevalence ratios and population attributable fraction for permanent caries prevalence (weighted data).....	152
Table 75:	Rate ratios and population attributable fraction for deciduous caries severity (weighted data) .....	154
Table 76:	Rate ratios and population attributable fraction for permanent caries severity (weighted data) .....	156
Table 77:	Distribution of cases, prevalence ratios and population attributable fraction for deciduous SiC <sub>10</sub> (weighted data).....	158
Table 78:	Distribution of cases, prevalence ratios and population attributable fraction for permanent SiC <sub>10</sub> (weighted data).....	160
Table 79:	Summary of population impact.....	161



## **LIST OF ABBREVIATIONS**

ABS	Australian Bureau of Statistics
ACARA	Australian Curriculum, Assessment and Reporting Authority
ACORN	Acorn is a Geo-demographic Index used in the UK
AIHW	Australian Institute Health and Welfare
AHS	Area Health Service
AIC	Akaike Information Criterion
ARCPHOH	Australian Research Centre for Population Oral Health
CDBS	Child Dental Benefits Schedule
CDHS	Child Dental Benefits Schedule
CI	Confidence Interval
COHS	Centre for Oral Health Strategy
DAG	Diagrammatic Acyclical Graph
DMFS	Decayed Missing Filled Surfaces
DMFT	Decayed Missing Filled Teeth
NSW	New South Wales
ICC	Intra-Class Correlation
ICSEA	Index of Community Socio-Educational Advantage
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
LHD	Local Health District
LIFESTYLE	LIFESTYLE is a demographic Index used in Canada
NT	Northern Territory
OHE	Oral Health Education
OMR	Optical Mark Reader
OR	Odds Ratio
PAF	Population Attributable Fraction
PAS	Priority Action Schools
PR	Prevalence ratio
PSP	Priority Schools Program
QLD	Queensland
RR	Rate Ratio
SA	South Australia
SAP	School Assessment Program
SCUDS	Study into the Child Use of Dental Services

SEIFA	Socio-economic Indexes for Areas
SES	Socio-economic Status
SiC	Significant Caries Index
SOKS	Save Our Kids Smiles
TAS	Tasmania
VIC	Victoria
VIF	Variance Inflation Factor
WA	Western Australia
WHO	World Health Organisation



## **ABSTRACT**

This thesis describes the oral health of New South Wales (NSW) children aged 5-12 years by socioeconomic (SES) characteristics utilising the individual-, school- and area-level socioeconomic indicators. It also quantifies the usefulness of SES indicators for targeting of dental services.

## **Methods**

A cross-sectional study of NSW 5–12 year-olds was conducted in 2007 using a multi-stage, stratified, cluster sample approach. Explanatory SES variables were explored at three levels: individual, school and area. Caries prevalence, caries severity and significant caries were calculated. Bivariate analysis was undertaken. Prevalence ratios (PR) of caries prevalence and SiC<sub>10</sub> were modelled by Poisson regression (PROC LOGLINK, SUDAAN 10.0). Rate ratios (RR) of caries severity were modelled using Poisson regression (PROC GENMOD, SAS 9.2). Multi-level analysis (SAS PROC GLIMMIX) was undertaken accounting for the nested structure. Use of SES variables to target dental services was examined using number of cases, relative risk and population attributable fraction (PAF%).

## **Results**

Just under 40% of NSW children had a prevalence of deciduous caries with mean dmfs of 3.18 surfaces and just over 22% had experienced permanent caries with mean DMFS of 0.61 surfaces.

### ***Variation in oral health by SES indicators***

There was significant variation in caries prevalence, caries severity and SiC<sub>10</sub> by socioeconomic characteristics; children from the lowest SES category had significantly higher caries prevalence and severity compared to the highest SES category for all SES indicators in both the deciduous and permanent dentition. Membership of the SiC<sub>10</sub> group showed lower SES groups had a higher proportion of children who formed part of the SiC<sub>10</sub> group.

### ***Associations across individual, school and area-level SES indicators***

In the final models, income was significant for all three caries measures for both dentitions. The children from the lowest income category had significantly higher odds of caries, more severe caries and membership of the SiC<sub>10</sub> group. School type as an explanatory factor was not significant for caries prevalence and SiC<sub>10</sub> in the multi-level model, although the

children attending a disadvantaged public school had significantly higher odds of permanent caries severity.

### ***Effectiveness of targeting by SES indicators***

In both the deciduous and permanent dentition there were fewer cases of caries and SiC<sub>10</sub> cases in the designated SES target group, the lowest SES group, than outside the designated target group. SES demonstrated a low population attributable fraction for deciduous and permanent caries prevalence, caries severity and significant caries.

### **Conclusions**

The study demonstrated that caries was higher among lower SES groups whether measured by individual, school or area characteristics. In many instances there were three and five-fold differences among those in the lowest SES categories providing a consistent association with poor oral health. Income was independently associated with variation in child oral health when adjusting for the nested structure. Low SES categories did not identify the majority of those with caries or the highest levels of caries and would therefore be limited as a basis for a targeted oral health strategy and a population health focus that uses a social determinants approach would be more appropriate.

**SIGNED STATEMENT**

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

Signed:

Jennifer Miller

Date:

4-11-2015  
.....

## **ACKNOWLEDGEMENTS**

There are many who have contributed in making this thesis possible. I wish to express my gratitude to the following individuals and organisations. It is a pleasure to thank the many people who made this thesis possible.

Emeritus Professor A John Spencer for his guidance, encouragement and continued support in pursuing this area of research. His inspiration, mentorship and intellectual advice helped me to develop an understanding of the subject.

Professor Kaye Roberts-Thomson for her guidance and mentorship, friendship and great efforts to explain things clearly and simply. Throughout my thesis development and writing, she provided encouragement and sound advice.

Professor Anthony Blinkhorn and Associate Professor Loc Do for their support, guidance and different perspectives that added to the overall project.

I would like to thank the participating organisations and study participants without which this study would not have been possible.

Ms Dana Teusner for her assistance in data management and analysis and for providing a stimulating and fun environment in which to learn.

Ms Anne Ellershaw for development of the sample framework, weighting of the data, and guidance with data syntax.

I am grateful to my student colleagues for helping me get through the difficult times, and for all the emotional support, camaraderie, and caring they provided.

The colleagues at ARCPOH for valuable support.

The Australian Dental Research Foundation Inc and The University of Adelaide (School of Dentistry) for their kind financial support for this study.

I offer my regards to all of those who supported me in any respect during the completion of the research.

Above all, I thank my family who supported me and encouraged me constantly, my thanks to my children, Tegan and Matt for giving me love and understanding, for my parents, Neidra and Warren for their continuous support and interest in what I do.

## **THESIS FORMAT**

This thesis presents an introductory chapter that provides background information on child oral health in Australia, literature on social gradients in oral health and the various indicators of SES and the association of socioeconomic factors with oral health. It highlights the provision of dental services for children and the variation across Australian states and territories. It also introduces the rationale and conceptual framework, aims, study objectives, hypotheses and rationale. The second chapter describes the study design, sampling procedures and requirements, data collection methods, including details of mail questionnaire SES indicators and oral epidemiological examinations. Data management incorporates data linkage, data weighting, analysis plan and the conceptual model. The third chapter includes responses from the schools in the sampling frame, including the examination and questionnaire phase. The results are described using three caries measures in relation to individual-, school- and area-level characteristics. The fourth chapter discusses the major findings of the study on the associations of SES indicators at an individual-, school- and area-level with caries measures and compares those findings with the available literature. It also includes limitations of the data and further research. The final chapter concludes with the major themes, implications of the findings and principal conclusions.

Tables and figures are presented together with their corresponding text where possible. References to published work are in the text with the author name(s) and the year of publication in parenthesis. Where there were three or more authors, the first author is listed, followed by et. al., in the text. The complete list of authors is listed in the reference list at the end. Where there were multiple references for an author, references are listed in the bibliography in alphabetical order of authors and then by year of publication. The appendices include: consent form; primary approach letter to study participants with the enclosed questionnaire; reminder card and follow-up letters; oral epidemiological examination form; letters for ethical approval of the study; Diagrammatic Acyclical Graphs; and, model selection tables (Appendices 1-8).