

Diabetes during pregnancy and  
method of birth: a population study  
of women giving birth in New South  
Wales, Australia

Reem Samir Zeki

The Australian Centre for Public and Population Health Research

Faculty of Health, University of Technology Sydney

A thesis submitted for the degree of Doctor of Philosophy

at the

University of Technology Sydney

2019

# **Certificate of original authorship**

I, Reem Samir Zeki declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy in the Faculty of Health at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by an Australian Government Research Training Program.

Signature of student

Production Note:  
Signature removed prior to publication.

Reem Samir Zeki

2019

# Acknowledgement

First of all, I would like to express the deepest appreciation to my supervisor Distinguished Professor Elizabeth Sullivan. From the starting of this PhD and during the last four years you have provided me with your valuable guidance, support and encouragement. Thank you for your kindness, sympathy and nurturing and thank you for all the time you have provided for this PhD and your help in building my career as a researcher.

Thank you to my co-supervisors Distinguished Professor Caroline Homer, Professor Jeremy Oats and Associate Professor Alex Wang who have helped with their expertise and have given their insightful comments and suggestions on my research, they have been extraordinarily supportive and encouraging. Special thank you to my co-supervisor, Associate Professor Alex Wang, who, in addition to his role as a PhD co-supervisor, provided me with support and guidance since the start of my research career six years ago. Thank you for being an excellent teacher who has made me love epidemiology and biostatistics. To my friend and colleague Zhuoyang Li, thank you for your help from the first day of my career in research. Thank you for sharing your knowledge and expertise with me.

I would like to thank Associated Professor Kei Lui for his reading, critical review and clinical interpretation of the results in Chapter 5 and Dr Drew Marshall for his help in Chapters 6 and 7. I also would like to thank Dr Terry Fitzgerald and Paul Fitzgerald for their help in the language editing of this PhD thesis.

I also would like to thank my Family. To my husband Nadom for all your support and encouragement – thank you for standing beside me. Without your support I would not have been able to achieve my goals. To my children Sarah, Salam and Ragheed, thank

you for your patience and tolerance with your working and studying mum, and to my father Samir and my mother Selma, who despite living thousands of kilometres away, you always supported me with your encouraging words and your belief that I could do it.

To my great family, I dedicate this thesis.

## **Format of the thesis**

This PhD thesis is in a compilation format. Each of four studies is reported in a thesis chapter. Chapters 4 and 5 have been published, and Chapter 6 has been resubmitted with revision and I am awaiting the decision. The fourth manuscript, Chapter 7, is currently being prepared for publication. The next section provides the publication details of Chapters 4, 5 and 6.

## **Published works by the author incorporated into the thesis**

**Study one** (Chapter 4): Zeki, R., Oats, J.J.N., Wang, A.Y., Li, Z., Homer, C.S.E. & Sullivan, E.A. 2018, 'Cesarean section and diabetes during pregnancy: An NSW population study using the Robson classification', *Journal of Obstetrics and Gynaecology Research*, vol. 44, no. 5, pp. 890-8.

**Study two** (Chapter 5): Zeki, R., Wang, A.Y., Lui, K., Li, Z., Oats, J.J.N., Homer, C.S.E. & Sullivan, E.A. 2018, 'Neonatal outcomes of live-born term singletons in vertex presentation born to mothers with diabetes during pregnancy by mode of birth: a New South Wales population-based retrospective cohort study', *BMJ Paediatrics Open*, vol. 2, no. 1.p. e000224.

**Study three** (Chapter 6): Zeki, R., Li, Z., Wang, A.Y., Homer, C.S.E., Oats, J.J.N., Marshall, D., Sullivan, E.A. Obstetric anal sphincter injuries among women with gestational diabetes and women without gestational diabetes: a NSW population-based cohort study, *The Australian and New Zealand Journal of Obstetrics and Gynaecology*,

submitted on 21st January 2018, accepted on 2nd December 2018 and published online  
on 17 February 2019.

## **Statement of contributions to jointly authored works contained in the thesis**

Chapters 4, 5 and 6 have been submitted for publication in peer-reviewed journals. For each of these manuscripts, I have been responsible for deciding the research question, conducting the statistical analysis and drafting the manuscript.

During this process I have received support from my principal supervisor Distinguished Professor Elizabeth Sullivan and my co-supervisors Distinguished Professor Caroline Homer, Associate Professor Alex Wang and Professor Jeremy Oats (University of Melbourne). Additional assistance in statistical analysis interpretation of the data and review of the manuscripts was done by Zhuoyang Li.

For Chapter 5, Professor Kei Lui provided his clinical opinion in the interpretation of the data. For Chapter 6, Dr Drew Marshall provide his clinical opinion in the interpretation of the data.

I take responsibility for the accuracy of the results presented in these manuscripts.

## Abbreviations

ACOG	American College of Obstetricians and Gynecologists
ADA	American Diabetes Association
ADIPS	Australasian Diabetes in Pregnancy Society
AIHW	Australian Institute of Health and Welfare
AOR	adjusted odds ratio
APDC	Admitted Patient Data Collection
BMI	body mass index
CEMACH	Confidential Enquiry into Maternal and Child Health
CHeReL	Centre for Health Record Linkage
CI	confidence interval
CS	caesarean section
EPDS	Edinburgh Postnatal Depression Scale
GCT	glucose challenge test
GDM	gestational diabetes mellitus
HAPO	Hyperglycemia and Adverse Pregnancy Outcome
IADPSG	International Association of Diabetes in Pregnancy Study Group
ICU	intensive care unit
LGA	large for gestational age
NICE	National Institute for Health and Care Excellence
NICU	neonatal intensive care unit
NSW	New South Wales
OASI	obstetric anal sphincter injury
OGTT	oral glucose tolerance test



PDC	Perinatal Data Collection
PPH	post-partum haemorrhage
RR	relative risk
SCN	special care nursery
SGA	small for gestational age
TSV	term singleton in vertex presentation
UK	United Kingdom
USA	United States of America
WA	Western Australia
WHO	World Health Organisation

# Table of Contents

Certificate of original authorship.....	i
Acknowledgement .....	ii
Format of the thesis.....	iv
Published works by the author incorporated into the thesis.....	iv
Statement of contributions to jointly authored works contained in the thesis .....	vi
Abbreviations .....	vii
Table of Contents.....	ix
List of tables .....	xii
List of figures .....	xiv
Abstract .....	xv
Chapter 1: Introduction to this PhD thesis .....	1
1.1 Background .....	2
1.2 Objectives .....	3
1.3 Structure of this thesis .....	10
1.4 Conclusion to the chapter.....	11
Chapter 2: Background and Literature Review .....	13
2.1 Background .....	14
2.1.1 Definitions and aetiology: .....	14
2.1.2 Screening and diagnosis of GDM .....	15
2.1.3 Prevalence of diabetes during pregnancy .....	17
2.1.4 Outcomes of diabetes during pregnancy .....	18
2.2 Literature review .....	21
2.2.1 Method of birth for women with diabetes during pregnancy .....	22
2.2.2 Neonatal outcomes by method of birth .....	30
2.2.3 Timing of induction of labour.....	38
2.2.4 Maternal outcomes .....	38
2.2.5 Factors affecting decision around onset of labour and method of birth.....	40
2.2.6 Summary of the literature review and identified gaps in the literature.....	43
2.3 Rationale for the thesis .....	44
Chapter 3: Research methods .....	48
3.1 Choosing the study design .....	49
3.2 Study design.....	50
3.2 Study population.....	50

3.3 Data.....	51
3.3.1 Number of women reported in the NSW PDC during the study period .....	52
3.3.2 Validation Studies on the NSW PDC.....	53
3.3.3 Limitations of the NSW PDC related to this thesis .....	54
3.4 Statistical analysis: .....	57
3.5 Details of ethics approval.....	58
Chapter 4: Study one: Caesarean section and diabetes during pregnancy: A NSW population study using the Robson classification.....	59
4.1 About this chapter.....	61
4.2 Abstract .....	62
4.3 Introduction .....	63
4.4 Method.....	65
4.5 Results.....	69
4.6 Discussion .....	76
4.7 Chapter summary .....	81
Chapter 5: Study two: Neonatal outcomes of live-born term singletons in vertex presentation born to mothers with diabetes during pregnancy by mode of birth: a New South Wales population-based retrospective cohort study .....	84
5.1 About this chapter.....	85
5.2 Abstract .....	86
5.3 Introduction.....	90
5.4 Method.....	92
5.5 Results.....	95
5.6 Discussion .....	106
5.7 Chapter summary .....	111
Chapter 6: Study three: Obstetric anal sphincter injuries among women with gestational diabetes and women without gestational diabetes: a NSW population-based cohort study. ....	113
6.1 About this chapter.....	115
6.2 Abstract .....	116
6.3 Introduction .....	117
6.4 Method.....	119
6.5 Results.....	124
6.6 Discussion .....	131
6.7 Chapter summary .....	133

Chapter 7: Study four: Birth intervention, maternal and neonatal outcomes for women with diabetes during pregnancy giving birth in public and private hospitals.....	135
7.1 About this chapter.....	136
7.2 Abstract.....	137
7.3 Introduction.....	138
7.4 Method.....	140
7.5 Results.....	143
7.6 Discussion.....	150
7.7 Chapter summary.....	155
Chapter 8: Discussion, recommendation and conclusion.....	156
8.1 About this chapter.....	156
8.2 Why conduct this research.....	156
8.3 Main findings of this research.....	157
8.4 Implication of this thesis on the practice.....	157
8.5 Main results and discussion based on each four results chapters.....	158
8.6 Strengths and limitations.....	166
8.7 Directions for future research:.....	166
8.8 Concluding remarks:.....	167
Appendices.....	169
Appendix 1: Glossary.....	169
Appendix 2: Authors' contributions and signatures.....	172
Appendix 3: Published articles.....	181
References.....	211

## List of tables

Table 2.1: Guidelines for time and method of birth for women with diabetes during pregnancy .....	24
Table 2.2: Proportion of shoulder dystocia by birthweight and method of birth for women with diabetes during pregnancy.....	30
Table 2.3: Published observation studies that investigate the effect of induction of labour on caesarean section rate .....	36
Table 3.1: Odds ratios and 95% confidence intervals of GDM on neonatal outcomes from different datasets stratified by parity .....	56
Table 4.1: Extended Robson 10 groups .....	67
Table 4.2: Women’s socio-demographic factors by diabetes status 2002-2012 .....	70
Table 4.3: Summary statistics for cesarean section by diabetes 2002-2012.....	73
Table 4.4: Rate of CS within each Robson group for women with Pre-existing diabetes compared to women who did not have diabetes 2002-2012 .....	75
Table 4.5: Rate of CS within each Robson group for women who had gestational diabetes compared to women who did not have diabetes 2002-2012.....	76
Table 5.1: Maternal characteristics and birth outcomes for live-born term singletons in vertex presentation (TSV) born to women with pre-existing diabetes, 2002–2012.....	96
Table 5.2: Maternal characteristics and birth outcomes for TSV born to women with gestational diabetes, 2002–2012.....	98
Table 5.3: Adjusted odds ratios for adverse neonatal outcomes of TSV born to women with diabetes during pregnancy after pre- labour CS and planned vaginal birth, 2002–2012.....	103
Table 5.4: Adjusted odds ratios for adverse neonatal outcomes of TSV born to women with diabetes during pregnancy by mode of birth, 2002–2012.....	105
Table 6.1: Maternal and newborn characteristics of women who had GDM and women without GDM.....	125
Table 6.2: OASIs by method of birth, birthweight and GDM .....	128
Table 6.3: Percentage of combined episiotomy and method of birth by parity and GDM .....	129
Table 6.4: OASIs by method of birth, episiotomy and GDM .....	130

Table 7.1: Characteristics and interventions for women with pre-existing diabetes 2002–2012.....	145
Table 7.2: Characteristics and interventions for women with GDM 2002–2012.....	146
Table 7.3: Maternal outcomes in private and public hospitals, women with pre-existing diabetes and women with GDM 2007–2012.....	147
Table 7.4: Neonatal outcomes of term singletons born to women with diabetes by hospital sector <sup>a</sup> 2002–2012.....	150

## List of figures

Figure 1.1: Caesarean section and diabetes during pregnancy: A New South Wales population study using the Robson classification.....	5
Figure 1.2: Neonatal outcomes of live-born term singletons in vertex presentation (TSV) born to mothers with diabetes during pregnancy by mode of birth: A New South Wales population-based retrospective cohort study .....	6
Figure 1.3: Obstetric anal sphincter injuries among women with gestational diabetes and women without gestational diabetes: a NSW population-based cohort study .....	7
Figure 1.4: Birth intervention, maternal and neonatal outcomes for women with diabetes during pregnancy giving birth in public and private hospitals. ....	8
Figure 1.5: presents an overview of the relationship of the four studies included in this thesis.....	9
Figure 3.1: Proportion of women with pre-existing diabetes, women with GDM and number of total women included in NSW PDC 2002–2013 .....	53
Figure 5.1: Rates of pre-labour caesarean section.....	99
Figure 5.2: Onset of labour and mode of birth for mothers with pre-existing diabetes who gave birth to macrosomic and non-macrosomic TSV .....	100
Figure 5.3: Onset of labour and mode of birth for mothers with GDM who gave birth to macrosomic and non-macrosomic TSV .....	101

# **Abstract**

## **Background and aims**

Diabetes during pregnancy – including pre-existing diabetes and gestational diabetes mellitus (GDM) – is an increasing public health problem worldwide. The objective of this thesis is to investigate the association between method of birth and the perinatal outcomes of women with diabetes during pregnancy. It aims to:

- identify the main contributors to caesarean section amongst women with diabetes using the Robson classification for caesarean section
- determine neonatal outcomes for babies born to women with diabetes by method of birth
- compare the rate of obstetric anal sphincter injuries (OASIs) for women with and without GDM and investigate the association between combining episiotomy with method of birth and the risk of OASIs
- compare the perinatal outcomes for women giving birth with diabetes by public and private hospital sector.

## **Materials and method**

Four population-based studies were conducted using the New South Wales (NSW) Perinatal Data Collection. The study population comprised 1,103,380 women who gave birth in NSW between 2002 and 2013 and their babies. Of these women 7,200 (0.7%) had pre-existing diabetes, 57,822 (5.2%) had GDM and 1,038,358 (94.1%) had no diabetes. Women were stratified by onset of labour, method of birth, and birthweight. Neonatal outcomes included perinatal death, five minutes Apgar score, admission to



neonatal intensive care and/or special care nursery and neonatal resuscitation. The primary maternal outcome was OASI.

## **Results**

The total caesarean section rate was higher among women with pre-existing diabetes (53.6%) and women with GDM (36.8%) compared to women without diabetes (28.5%). Robson group five (multiparity with a history of caesarean section) was the main predictor of the total caesarean section rates in all women. Of the 39,625 women with diabetes who laboured, 32.1% had instrumental or caesarean births that were associated with poorer outcomes. Women with GDM who had an instrumental vaginal birth and gave birth to babies with birthweights  $\geq 4000\text{g}$  had a significant increase in the odds of OASIs compared to women without diabetes. Combining episiotomy and forceps was a protective factor on OASIs. Similar proportions of no labour caesarean section were observed among women with pre-existing diabetes in private and public hospitals. Proportions of induction of labour were similar among women with GDM in private and public hospitals.

## **Conclusion**

The Robson classification can be used to benchmark and monitor method of birth for women with diabetes. Information, education and counselling on the risks and complications associated with different methods of birth, should routinely be provided for women with diabetes antenatally.