Curtin School of Population Health

The Role of Maternal Age and Ethnicity on Pregnancy Complications and Mode of Birth, and an Examination of Maternity Trends Amongst Primiparous Women in Western Australia

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Acknowledgement of Country

I acknowledge that Curtin University works across hundreds of traditional lands and custodial groups in Australia, and with First Nations people around the globe. I wish to pay my deepest respects to their ancestors and members of their communities, past, present, and to their emerging leaders. Curtin University's passion and commitment to work with all Australians and peoples from across the world, including our First Nations peoples, is reflective of the institutions' values and commitment to our roles as leaders in the Reconciliation space in Australia.

Statement of Inclusivity

It is recognised that gendered terminology is commonly used within maternity research. Whilst the words woman and women are used within this thesis these words are not exclusive and are intended to include the many diverse gender identities who have experienced the childbirth journey. The aim has been to preserve woman-centred language whilst endeavouring to include those who do not identify in this way.

Declaration

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) - updated March 2014. The proposed research study received Human research ethics approval from the Department of Health Western Australia Human Research Ethics Committee; Approval Number EC00422; and the Western Australian Aboriginal Health Ethics Committee; Approval Number HREC1085; and the Curtin University Human Research Ethics Committee, Approval Number HRE2021-0668.

Signature:

[redacted]

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Date: 29/08/2024

Statement from Principal Supervisor

Nicole Catalano's thesis has been prepared in accordance with the guidelines for a Master of Philosophy by thesis by and I am recommending the thesis now be sent for examination.

Signature: [redacted]

Date: 28/11/2023

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Abstract

Background

Welcoming a baby is a joyous occasion for many families. Worldwide, there is a notable trend of delaying childbearing, and the average age of first-time mothers is increasing. While evidence shows some associations between an increase in maternal age and pregnancy and labour complications, there remain gaps in evaluating the role of maternal age and ethnicity with a range of pregnancy and labour complications, and mode of birth using current data. Understanding the links between maternal sociodemographic information on pregnancy complications, particularly gestational diabetes and preeclampsia and the mode of birth may contribute to improved outcomes for mother and neonate. Whilst upholding the value of women-centred care, new knowledge and information increases awareness of potential issues without pathologising or increasing intervention. This thesis has two primary objectives: **i**) to examine the prevalence of pregnancy and labour complications among primiparous women, **ii**) to investigate the association between maternal age and ethnicity and with a range of maternal outcomes including pregnancy and labour complications and mode of birth among primiparous women in Western Australia.

Methods

This analysis uses a retrospective cohort study design using data collected in the Midwives Notification System between 2009-2019. The association between main exposure variables (maternal age and ethnicity) and selected outcome variables (pregnancy and labour complications and mode of birth) were investigated. I conducted descriptive and summary statistics to describe the study participants followed by bivariate and multivariate analysis. While the descriptive analysis presents a range of pregnancy and labour complications, selected pregnancy complications including gestational diabetes and pre-eclampsia, and labour complications including fetal distress were modelled using generalised linear models to investigate their association with maternal age and ethnicity. I considered the following covariates for adjustment - socioeconomic index for areas (SEIFA) index, smoking status, baby's year of birth, remoteness, marital status, maternal morbidity such as asthma, body mass index at the start of

pregnancy and other medical complications. I included 141,619 primiparous women over a 10-year period for final analyses. I have also run additional sensitivity analyses adjusting for body mass index as this variable was collected only from 2012.

Results

In the study, 8.5% (n=12,015) of women had Gestational Diabetes (GDM) and 4.2% (n=5,951) had preeclampsia. Asian/Indian women were about two and a half times more likely than their Caucasian counterparts to develop GDM (aOR =2.40; 95% CI 2.30, 2.52, p= <0.001). Aboriginal women were also at increased risk compared to Caucasian women, having 1.7 times higher odds to develop GDM (aOR =1.73, 95% CI 1.53, 1.97, p= <0.001). Thirty-seven percent of the cohort had a caesarean section, and 26% (n=15,634) were non-elective/emergency. The risk of caesarean section increased with maternal age, steadily increasing with each maternal age bracket. Women over 40 were 3.5 times more likely than women aged 20-24 to have a non-elective caesarean birth (aOR= 3.54; 95% CI: 2.95, 4.24 p= <0.001). Over the 10-year period in study, induction of labour, caesarean sections and pregnancy complications increased, whilst spontaneous labour onset and vaginal births decreased for primiparous women of all ages and ethnicities.

Conclusion

In the analysis, the most common complications were gestational diabetes (8.5%) and pre-eclampsia (4.2%) among primigravida women. Over the decade, we noted increasing rates of IOL and caesarean sections. Our findings were consistent with previous research demonstrating an association between ongoing increase in the maternal age of primiparous women and rising complications and interventions. Our study found that maternal age and ethnicity is associated with gestational diabetes. The risk increase is stratified at every age group, there is not an absolute age in which complications suddenly occur more frequently.

Table of Contents

Contents

List of abbreviations

aOR	Adjusted Odds Ratio
ABS	Australian Bureau of Statistics
BMI	Body Mass Index
CI	Confidence Interval
CTG	Cardiotocography
GDM	Gestational Diabetes Mellitus
HREC	Human Research Ethics Committees
IOL	Induction of Labour
MNS	Midwives Notification System
OR	Odds Ratio
PTB	Preterm Birth
SEIFA	Socioeconomic Index For Areas
SES	Socio-Economic Status
SVB	Spontaneous Vaginal Birth
TSI	Torres Strait Islander
USA	United States of America
WA	Western Australia
WHO	World Health Organization

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Preamble

Pregnancy and childbirth are a physiological phenomenon and a multi-dimensional process with physical, emotional, social, physiological, cultural, and psychological dimensions intertwined (1). Whilst upholding the value of women-centred care, new knowledge and information increases awareness of potential issues such as awareness of groups at increased risk of gestational diabetes or preeclampsia, which impacts outcomes for mothers and neonates. Increasing healthcare practitioner awareness and introducing earlier testing and therefore proactive management may result in improved outcomes. Understanding the links between maternal sociodemographic information such as maternal age and ethnicity on pregnancy complications, labour duration and mode of birth aims to contribute to education and improved outcomes for mother and baby. Between 2010-2019, over 300,000 births were recorded in Western Australia (WA) and of these over 40% were first time mothers (2). In Western Australia in 2019, 38% of all women gave birth by caesarean, above the World Health Organization's (WHO) recommendation of 10-15% (3, 4). The ethnicity of the women in WA remained diverse and rates steady in the period under study, allowing an analysis of trends over a ten-year period as well as analysis of the role of maternal age and ethnicity on pregnancy and birth outcomes. Chapter one presents the background and the significance of this research, objectives of the study, and provides an overview of the thesis.

1.2 Maternity care in Western Australia

For women in Australia, there are multiple options for care and support during pregnancy and birth. There are public health systems that are accessible for all women or alternatively, private sector options. There are differing costs associated with each model of care, with the public system being non-fee paying for Medicare card holders (5).

Maternity care in WA presents some challenges. WA is the largest state in Australia, making up 32% of Australia's land mass and covering an area over 2.5 million square kilometres, with the population concentrated in the southwest corner (6). Perth is one of the most remote cities in the world (7). The challenges of maternity care are magnified in WA due to the remoteness and sparseness of communities, with additional strain placed on resources due to the widespread nature of the inhabitants (8, 9). The catchment area for WA Country Health Services alone encompasses 531, 510 people of whom 11% identify as Aboriginal (9). Networks to help serve maternity clients' needs are heavily reliant on transport services, individual links and geography (10). Australia-wide antenatal care was accessed by 77% of pregnant women in 2019, up from 63% in 2010, and 96% of these women had at least 5 visits with a maternity care provider (11). For women having a baby, there are many options in WA. For hospital births, the majority of women received services from the public health system in 2019 (75%). The care provided in a public setting is appropriate to all level of maternity needs, catering for all women including those with complications. Private hospital births accounted for 22% of hospital births in WA, 3% of women gave birth in birth centres and 0.4% of women at home. A small proportion, 0.7% gave birth elsewhere, for example en-route to hospital, or with no health professional in attendance (12).

1.3 Trends in maternal childbearing age

Complications affecting pregnancy and birth are increasing as is intervention for such complexities globally (13). Overall, underlying maternal health morbidities are on the rise, which may contribute to development of maternal pregnancy complications (13). The world total for caesarean sections reached a peak of 21% in 2021, with evidence of an increasing rate of caesarean section is also demonstrated in WA, with rates rising from 32% in 2010 to 37% in 2019 (14). The stillbirth rate worldwide was 14% in 2021, with inequalities noted between countries of differing socio-economic status (15). Australia still records a stillbirth rate of 7.7 per 1,000 births, with disparities between population demographic profiles. For example, births from Aboriginal women having an increased incidence of stillbirths with 17 deaths per 1,000 births, and a higher rate of stillbirth among women from very remote areas at 15.3 deaths per 1,000 births (14). Women in WA had a stillbirth rate of 5.6 per 1,000 births, the second lowest in Australia (16).

In recent decades, the trend towards delayed childbearing has increased in many high-income countries, including Australia (11). In the United States, the proportion of births from women older than 35 years doubled from 8% in 1988 to 16% in 2015 (17). In addition, the proportion of births from women older than 40 years were eight times greater over the same time period (18). In Australia, the average age for childbearing in primiparous women has increased from 25.4 years in 1971 to 31.5 years in 2019 (**Error! Reference source not found.**). The Mothers and Babies Report stated a rise in the proportion of women over 40 years having babies from 4% in 2009 to 4.5% in 2019, and a decline in the women under 19 years from 4% in 2009 to 2% in 2019, demonstrating women aged 15-19 years had the lowest birth rate at 8.7 babies per 1,000 women, a reduction from 18.6 babies per 1,000 women in 1999 (19). In WA, the percentage of mothers 40 years and over rose from 3.9% (n=1,249) in 2011 to 4.2% (n=1,437) in 2021 (20). Similar trends have also been reported from other settings such as the United States (17) China (21) and Italy (22).

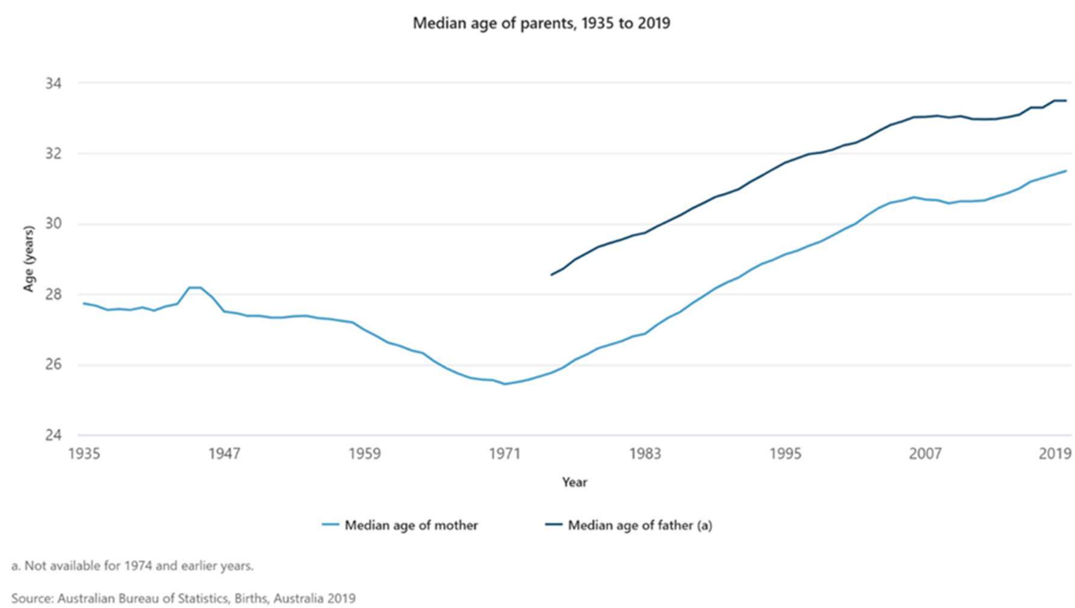


Figure 1. Trend in median age for mothers and fathers, Australia, 1935-2019

There are many reasons for the increase in maternal age in recent development, including career plans and aspirations, participation in higher education, meeting partners later, wanting to buy property, and being financially ready (23). An Australian prospective study demonstrated a link between women delaying childbearing with higher income and educational attainment and suggested these influence a woman's decision to postpone childbearing (24). Similarly, evidence from Canada and the United Kingdom (UK) indicated that delayed childbearing is a worldwide trend after purposeful decision making (25, 26). The demographic of WA childbearing women has also changed ethnically, with the 2016 census data showed that WA is one of the most diverse and the fastest growing of all the states and territories in Australia (27). According to the Australian Bureau of Statistics (ABS), the fastest growing overseas born populations in Perth included: The Philippines, India, South Africa and Thailand. This demonstrates the increasing variation of population demographics in WA (28).

Trends amongst WA women demonstrate a recent increase in women choosing to birth at home or in low-risk environments (12, 29). This increasing trend has also been demonstrated in the United States, with a homebirth rate rise by 5%, increasing the homebirth percentage to 0.6% of total births from 2004-2005 and to 1% in 2021 (30). In 2020, there was an increase by 63% of women birthing at home in WA (29, 31). This trend includes an increased proportion of Aboriginal women birthing at home, with almost double the rate from 1% in 2009 to 2% in 2010 (32).

1.4 Maternal age

As described above, the trend of increasing maternal age at first birth has been demonstrated in Australia and other high-income countries internationally. Increasing maternal age is associated with increased risk of maternal and neonatal morbidity and mortality (18, 25, 33, 34). In Australia, previous studies conducted a decade ago, have investigated the association between advanced maternal age (over 35 years in these studies) and pregnancy complications and caesarean birth (35-37). These studies showed an increasing risk of pregnancy complications and a higher rate of caesarean section for women over 35 years and a further increase for women the over the age of 40 years. One Australian study using retrospective data analysis from 2009-2013 determined that adolescents under 20 had higher rates of spontaneous vaginal births (SVB) than any other age group, demonstrating age at both extremes influences outcomes (38). However, studies from other countries reported conflicting findings with some of the maternal outcomes such of duration of labour. A study conducted in the United States reported labour length decreased as maternal age increased (39). For primiparous women, the mean time for active labour was 8.5 hours for under 20-year-olds, while it was 7.4 hours for the 30–40-year-old age group. In contrast, a Nepalese study in 2011 demonstrated an increased risk of prolonged labour with increasing maternal age; the median length of labour was 10 hours for the women age 20 years or younger, 12 hour labour duration for 12-25 years, and labour duration progressively increased for women in each age group (40). Maternal age has also been identified as a risk factor for certain pregnancy complications. Preeclampsia is one example, with a Finnish study demonstrating primiparous women over 35 years of age were 1.5 times more likely to develop preeclampsia than women under 35 years of age (41).

1.5 Maternal ethnicity

In addition to maternal age, women from certain ethnicities may be more at risk of pregnancy complications than other ethnic groups (42, 43). Maternal and neonatal health disparities are apparent between Indigenous and non-Indigenous women, with maternal mortality rates of Indigenous women 3 times higher than their counterparts (44). A recent study using a population database in WA indicated significant disparities in the rates of severe maternal morbidity such as shock, uterine rupture, hysterectomy and blood transfusion for Aboriginal and African women at birth (45). Another Australian study which demonstrated an increased incidence of Gestational Diabetes Mellitus (GDM) (intolerance of glucose diagnosed in pregnancy) among non-Caucasian women, particularly Asian women (46). Subsequent to these findings, screening for ethnic minority groups (Aboriginal and Torres Strait Islander, Asian, Indian, African, Polynesian, or Maori) is provided earlier in the pregnancy than for Caucasian women (47). The identification of this increased risk has improved outcomes for women and babies, with women receiving increased surveillance of fetal wellbeing, to reduce neonatal morbidity and mortality (47).

1.6 Birthing on country

Persisting maternal and neonatal health disparities amongst Aboriginal women has prompted the introduction of the ‘Birthing on Country’ initiative - designed to meets the needs of Aboriginal and

Torres Strait Islander women in Australia, with a community led model of care (44). The program includes continuity of care from one a known midwife, with support 24 hours a day, 7 days a week, up to 6 weeks postnatally (48). This continuity model has been found to significantly improve outcomes including reduction of preterm births, which globally is the leading cause of mortality for children under 5 years of age (49). Delivering high quality and culturally appropriate models of care such as 'Birthing on Country' for all women in Australia is an essential initiative to closing the gap on outcome disparities.

1.7 Other social determinants of health

Social determinants of health are often considered as proxy factors for higher burden of morbidity and mortality in the population and are also considered as a substantial driver of pregnancy and labour complications (50, 51). The WHO framework on social determinants of health consists of factors related to the material and social environmental conditions in which people are born, live, work, and age that may affect their health outcomes (52). Lack of social support can result in poorer outcomes, with an increase in pregnancy complications and low birth weight babies (under 2500gms), even more so when the mother is smoking, unemployed, has an unplanned pregnancy and is without a partner (53, 54). Social determinants of health also shape some of the mother's proximal factors, such as Body Mass Index (BMI), and worldwide chronic disease prevalence, contributing to caesarean section and maternal morbidity (55). Whilst social determinants of health are a contributing factor to maternal and neonatal outcomes and are considered in this study, there is a known link between poorer outcomes for women with a history of complex social determinants of health, regardless of maternal age or ethnicity (56). Broader details of the social determinants are described in Chapter Two.

1.8 Midwives and the West Australian perinatal data collection

As defined by the Australian Government, midwives are health professionals that have successfully completed a course of midwifery study, and who are registered practitioners (57). Midwives are responsible for providing care through the antenatal period, intrapartum period and the puerperium, the period up to six weeks after the birth. The origin of the word midwife is derived from old English, with ‘mid’ meaning ‘with’, and ‘wif’ meaning ‘woman’- essentially midwife means ‘with woman’ (58). A midwife’s professional duty encompasses providing nonbiased care to exercise high standards of conduct and practice in a culturally safe and appropriate manner (59). The WA Health (Miscellaneous Provisions) Act 1911 requires that midwives notify the Chief Health Officer of every birth they attend (60). This information is then received by the Midwives Notification System (MNS). Perinatal data is collected through the MNS in WA, a legally mandated data collection that has been in operation since 1975. All records of births over 20 weeks gestation or over 400gms birthweight are entered into the MNS. All births are registered through the MNS, whether they are through the public health system, the private health system, a publicly funded homebirth, with private practising midwives, or the midwife, nurse or medical practitioner at any site who provided care to a woman who has just given birth (12). There are three different digital systems and a paper system in use that capture these data, which are collated in the MNS and estimated to capture 99% of births in WA (61). Information and performance governance processes between staff and reporting midwives are in place to ensure the quality of the data is excellent and regular data audits also ensure the quality of the data (62). The data covers the time period from the conception to the end of the perinatal period and includes medical history, pregnancy, birth and neonatal details, extending into the puerperium. The MNS is a quality source for any data related to pregnancy, labour, birth, the neonate and puerperium (62).

1.9 About the researcher

I am a practicing midwife, having graduated from Curtin in 2013 with a Bachelor of Science (Midwifery) degree. Following graduation, I travelled to The Philippines and worked to consolidate and expand my midwifery skills and knowledge in an underprivileged area deprived of standard facilities and resources. My next positions were within a tertiary referral high-risk setting where I gained skills in complex midwifery care, followed by a low-risk midwifery led model of care for low-risk women where I developed a passion for empowering women and providing evidence-based information for women and their families. My current practice is as a Clinical Midwife in a high-risk setting, with an additional role as Research Midwife within the Neonatal Research team.

My curiosity for understanding factors that may contribute towards a more successful pregnancy and birth journey prompted my path towards researching links between women and outcomes. The knowledge that previous research has led to improved screening, practice and outcomes of women and neonates provided the impetus to commence this study.

1.10 Significance of the study

Whilst upholding the value of women-centred care, understanding the links between maternal sociodemographic information such as maternal age and ethnicity on pregnancy complications, labour duration and mode of birth may inform policies and practices on the provision of maternity care and aims to contribute to education and improved outcomes for mother and baby.

Early identification of complications and appropriate treatment could contribute to reducing perinatal morbidity and mortality.

New research is warranted as maternity is ever-changing in the past few decades (11, 63) in order to understand the current maternity trends and the driving factors of increasing intervention. This is an opportunity to document the health of childbearing women in WA, as well as understand the changes to perinatal care in WA over time, to inform future research and maternity care. Results from this study will provide information to enhance individualised care and inform future practices by demonstrating the potential role and influence of maternal age at first birth and ethnicity. Identifying specific demographic population group with greater risk of pregnancy complications will inform future programs to design targeted approach for priority screening and develop culturally responsive education maternal that would improve women's awareness on pregnancy complications.

1.11 Objectives of the study

The aim of the thesis was to investigate the association between sociodemographic factors, particularly maternal age and ethnicity on pregnancy complications, length of labour and mode of birth.

The study had two specific objectives:

1. To examine the prevalence of pregnancy and labour complications, and the mode of birth among primiparous women.
2. To investigate the association between maternal age and ethnicity and pregnancy complications (specifically gestational diabetes and preeclampsia) and mode of birth for primiparous women in WA.

1.12 Overview of the thesis

This thesis is presented in five chapters. Chapter One (this Chapter) is the introduction, including background, significance, and overview of the study. Chapter Two provides a review of the literature related to the study topic and background and it encompasses factors that may impact the pregnancy outcome of the woman such as maternal age, ethnic background, and other social determinants of health. The anthropology and evolution of birth are discussed, and maternal trends seen worldwide. In chapter Three, the methodology which includes study design, data sources, and analysis used for this thesis are described. Chapter Four presents the findings of the study. In Chapter Five, I discussed the key finding in the thesis, comparing with existing literature and present the implications of the findings, described the broader limitations of the study, and highlighted future research opportunities.

Chapter 2: Literature Review

2.1 Preamble

Pregnancy and birth are a source of great joy and hope for many families and most women start their childbearing journey with a positive view. In this chapter, to inform my study I aimed to investigate the association between maternal age and ethnicity on pregnancy and labour complications, duration of labour and mode of birth, factors that may impact the pregnancy outcome of the woman and neonate are examined, specifically, maternal age, ethnic background, and other social determinants of health. The anthropology and evolution of birth are reviewed, including information regarding younger and older maternal age and pregnancy and birth outcomes, ethnicity and pregnancy and birth outcomes, and social determinants of health.

2.2 Maternal age at first birth

Currently many women delay childbearing, particularly in high-income countries (25, 26, 64, 65); for example, in 2019 Australian mothers were mostly aged between 30-34 (36% of all mothers, median age 31 year) (19). In France, the median age rose to 30.4 years in 2016 from 29.5 years in 2010, with 5% of mothers being over 40 years of age (64). The ageing profile of the maternal population has implications for the mother, as women of advanced ages are at higher risk of morbidity (41, 66, 67). The increased risk alters approaches to clinical management, with women considered to be of advanced maternal age (varying between 35-40, as it differs in literature) often requiring additional monitoring and interventions (68).

In addition to maternal age, women from certain ethnicities are at increased risk of some pregnancy and birth complications, for example, evidence from studies conducted in the US determined Asians and Hispanics to be at increased risk of particular complications such as gestational diabetes (42, 43, 69).

Social determinant of health is a complex confounding factor that affects pregnancy and perinatal outcomes. A multitude of factors create the outcomes seen for this lower socioeconomic status cohort such as low birth weight, and these include poorer antenatal care, prenatal and perinatal health conditions, proximity to antenatal and health services, financial means and the level and perceptions of cultural safety (45, 70). Psychological state may also impact birth outcomes (71). A Canadian prospective study examined low risk women, both primiparous and multiparous and compared the relationships between women's childbirth fear, anxiety, sleep deprivation, fatigue with obstetric interventions, mode of birth, and neonatal outcomes. The outcomes included increasing associations between anxiety and high childbirth fear with epidural use and non-elective caesarean section, an increased incidence of assisted vaginal birth and adverse neonatal outcomes (71). While obstetric interventions are critical to address pregnancy complications, governments and clinicians have expressed concern due to the rise in obstetric interventions including caesarean section births, which might result in potential negative consequences for maternal and child health (3). The increasing trend in these obstetric interventions are partly attributed to their overuse without clear medical indications (72). For example, a study using data from Queensland showed that the incidence in caesarean births by maternal request increased 1.75 fold, from 4% in 2008 to 7% in 2017 (72).

2.3 Anthropology and evolution of birth practices

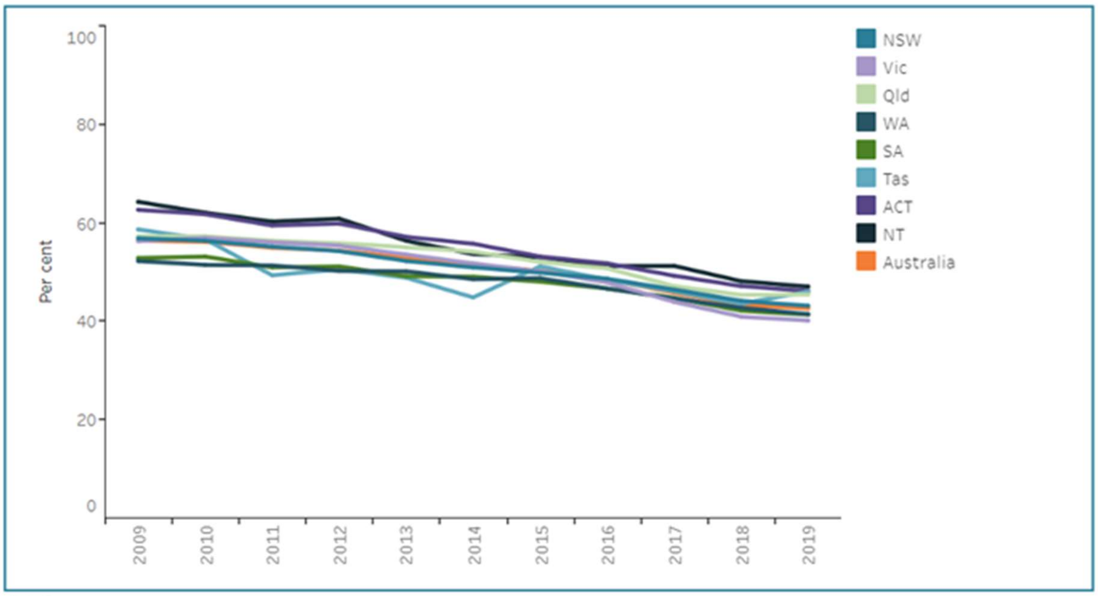
Birth can be thought of as a biological and cultural event (73). The method in which a baby is born has not changed throughout history, however the way birth is being managed is constantly evolving (74). Anthropologists state childbirth has always been a dangerous time for women and have demonstrated that humans have unique traits of bipedalism, large brains and infant helplessness resulting in a more dangerous and challenging child birthing process than other species endure (75). The birth canal has a uniquely curved shape that the fetus is required to negotiate during the birthing process (76). Ancient images show women being supported to birth in an upright position, and surrounded by other women during labour and birth, with each community often relying on one woman who had experience in birth; these were the first midwives (77). In the 5th century Before the Common Era, instrumental births were restricted only to stillbirths and carried a high risk of maternal mortality (78).

In the 19th century, childbirth remained challenging for some women, with health conditions such as rickets affecting pelvic formation (79). Maternal deaths occurred across all strata of socio-economic backgrounds, the most common cause being infection, affecting up to 8% of women, evident mostly in women who birthed outside of a hospital setting (78). Evidence also showed that the rate of infection was high in a birthing facility due to instruments used for childbirth and doctors being the unwitting sources of infection for women in childbed, transmitting contagion from previous patients (80). Maternal mortality rates did not start to significantly drop until mid-1900's when general hygiene improved, and antibiotics were being introduced (81). By the 1950's, majority of women birthed in hospital with a physician, as obstetricians argued it was the safest place of birth, as they could oversee mother and baby (74). In the 1960's ultrasound and electronic fetal monitoring became widely used and subsequently the caesarean rate rose due to the limited ability to correctly interpret fetal well-being from fetal heart rate patterns (78). The 20th century saw developments in antenatal care, ultrasound scans, reproductive technology, and the majority of women giving birth in hospital (82).

In 2005, 99% of maternal deaths occurred in a low and middle-income countries (83). In Australia in 2018, the overall maternal mortality rate was 5 deaths per 100,000 livebirths (84).

The rate of maternal mortality in Australia has declined dramatically since 1970's, and has been steady since 2012, during which time there has been an upward trend of obstetric intervention (85). The latest statistics from Australia's Mother and Babies Report demonstrate that only 42% of women had a spontaneous onset of labour in 2019 (11), suggesting more than half of pregnant women are subject to a non-physiological labour and birth. In Australia, the rate of induction of labour (IOL) has rapidly increased by 30% since 2007, with one in three labours are currently being induced (81). IOL is considered when the risk of continuing the pregnancy outweighing the risks associated with giving birth (86). There are maternal and neonatal risks associated with an IOL (86). IOL has recently been linked to increasing rates of caesarean section, assisted vaginal birth, retained placenta and lower Apgar scores, and decreased maternal satisfaction (83). Whilst IOL is part of the management for some perinatal complications such as gestational diabetes, growth restricted fetuses and preeclampsia as well as post maturity (81, 82), there are instances where IOL might be provided without justification or on maternal request (86). Studies in Australia demonstrated a rise in IOL due to maternal request, multiple studies demonstrating the increased harm for mother and neonate if used inappropriately (87).

As depicted below, there has been a decline in spontaneous onset of labour over time, a trend demonstrated in every state in Australia (**Figure 2**).



Notes:
1. 'Induced' may include cases where induction of labour was attempted but labour did not result.
2. For Tas, the labour onset logic provided by the electronic system was amended following a review by the hospitals. Data from 2015 onwards are therefore not comparable with earlier years.

Figure 2. Women who gave birth by onset of labour (spontaneous) and state and territory of birth, 2009-2019 (11).

2.4 Younger maternal age and pregnancy outcomes

Adolescent pregnancy refers to pregnancies in women under the age of 20 (88). Adolescent pregnancies can be regarded as a public health issue due to social, obstetric and medical complications (89). The rate of adolescent pregnancies in Australia is decreasing with a downward trend from 17.5 per 1,000 in 2005, to 11.4 per 1,000 in 2015 (89). Similar trends are observed in other high-income countries, for example Switzerland and the United States of America (USA), which currently demonstrate a downward trend of adolescent pregnancies since 1990 (90). In Australia, the rate births to teenage mothers dropped from a rate of 17.6 per 1,000 mothers to 9.2 per 1,000 mothers in 2017 (19). The reasons for this trend include higher education, access to income-generating work and family support (91). Additionally, contraception is more easily accessible to families from middle or higher socio-economic status (92, 93).

The findings from many studies worldwide, with data collected from over 12 countries, demonstrate adolescents are associated with increased risks of pregnancy and birth complications such as severe preeclampsia, eclampsia, postpartum haemorrhage, poor fetal growth and fetal distress (94-96). Women who become pregnant during adolescence also appear to be at higher risk of hypertension and anaemia (97). Anaemia, a result of iron deficiency, can increase the risk for preterm birth and low birth weight (90). A systematic review of 15 articles by Azevedo et al. (94) found that pregnancy complications such as prolonged rupture of membranes, preeclampsia, thyroid diseases, heart disease, and urinary tract infections were higher amongst adolescent women. Other studies have also reported similar findings of increased risk of neonatal morbidity and mortality to women under 20 years of age (18, 90, 98, 99). Similarly, the findings of a retrospective cohort study in Turkey, exploring pregnancy complications among 243 adolescents, demonstrated increased risk of depression and PTB among adolescent women (96). Preterm birth (PTB) is a complication of pregnancy and is the single greatest cause of death and disability in children up to 5 years of age in developed countries, such as Australia (100).

The reasons for the increased risk of pregnancy complications among young women is controversial but numerous factors, including biological immaturity, relative social determinants of health disadvantage, and behavioural factors may play a role (101).

In addition to physical health risks, adolescent pregnancy can also result in emotional strain, which can be tied to social, academic and economic circumstances. The majority of adolescent pregnancies are unintended, and the increasing emotional and mental strain can result in women not meeting educational or employment goals (90). The authors of a survey conducted in the United Kingdom with 290 participants reported the outcomes of adolescents aged 15-19 with intentional pregnancies. Adolescent women who planned their pregnancy were found to be older (18–19 versus 15–17) and have a relationship with a partner/significant other. The British study findings further demonstrated adolescents' increased risk of mental health issues, such as depressive symptoms but also highlighted increased adverse physical outcomes including PTB, anaemia, and hypertension (102).

Contradictory evidence regarding adolescents has demonstrated improved or unchanged pregnancy outcomes, with one Australian study finding no significant difference in neonatal mortality rate, small for gestational age, intrauterine growth restriction, admission to special care nursery, or hypertensive disorders of pregnancy rates between adolescents and their older counterparts (38). The Australian study compared 109 adolescents, defined as under 20-year-olds to 20–34-year-olds and investigated specifically the disparity in complications between the groups and found no significant difference in smoking rates, perinatal mortality rate, small for gestational age or intrauterine growth restriction rates. There was additionally, no increased rates of admission to special care nursery, or hypertensive disorders of pregnancy rates (38).

Whilst published papers have reported findings regarding childbearing women at both ends of the age spectrum, there are contradictions in findings. More research is required to help women understand the risks and benefits at all ages to determine a possible optimal time to improve outcomes. In addition, the published literature focuses on the under 20-year-olds and over 40-year-olds specifically, leaving a paucity of research in the middle 20-year span. The absolute risks at each maternal age remain unclear.

2.5 Younger maternal age and birth outcomes

In contrast to the evidence indicating higher rates of complications throughout pregnancy for adolescents, the outcomes for adolescents regarding labour and birth are more favourable. Numerous studies have linked adolescent women to an increased rate of vaginal births, with fewer birth complications (38, 94, 96, 103, 104). An Australian study revealed that adolescents had a significantly higher rate of spontaneous vaginal birth (SVB) (80% vs 66%) and therefore a significantly lower rate of caesarean section (15% vs 27%) than their 20-34 year old counterparts (38). Similarly, a Turkish study comparing adolescents of 14-18 years with older mothers of 19-34 years, found significant differences in their birth outcomes, with the adolescents having a lower rate of caesarean, and a shorter second stage of labour (96). However, the Turkish study was limited to only one study site and a small sample size of 243 women. In contrast, a large retrospective Swedish national study examined birth outcomes of over 3 million births, inclusive of adolescents over an 18-year period and found that despite a decline in the total number of adolescent births, rates of the mode of birth remained constant over the time period under study. Adolescents had a higher rate of SVB's, with an adjusted odds ratio (aOR) of 1.70 (95% CI 1.64, 1.75) compared to the 20-30-year-old group. The study reported that 16-17-year-olds had the highest rate of spontaneous onset of labour (103).

2.6 Older maternal age and pregnancy outcomes

The average age of birthing women is rising, mainly due to lifestyle choices but also partly due to the advancements of modern medicine in the field of reproductive technology (105) providing advanced treatments for older women wanting to become pregnant. However, starting the childbirth journey later comes with increased risk as advanced maternal age has been associated with declining fertility, miscarriage, chromosomal abnormalities, hypertensive complications, and stillbirth (18, 25, 33, 106). A Canadian study found that the risks of hypertensive disorders increased gradually until age 35 and accelerated further thereafter. The authors also observed that the risk of multiple pregnancies, major congenital anomalies, and maternal mortality or severe morbidity gradually increased until 30, then also accelerated (18). Findings from a study in Istanbul comparing perinatal outcomes in women under 18 and women over 40 against a control group were similar. There were 300 women in each group: adolescents, women over 40, and the control group of 20-40 years of age. The study concluded reclassification of the risk level for advanced maternal age to a high-risk category, as they identified increased anaemia, GDM, pregnancy hypertension and fertility issues requiring reproductive technology use, and therefore a higher rate of multiple pregnancies (106). Similarly, a Turkish study of almost 1,000 women divided into age categories of 18-34, 35-39 and over 40 demonstrated GDM, gestational hypertension, and caesarean section rates were more common in the advanced maternal age group (67).

The rate of GDM has increased in Australia from 8% to 14% over a 5-year period and is higher amongst women over 40, at 18% compared with 5% for women under 20 years (107). Within Australia in 2021, the rate of GDM was 18%, with women aged 45-49, having a fourfold increase in the incidence of GDM compared with women aged 15-19 years (107). A retrospective study using multivariate logistic regression was conducted on a Victorian population examining rates of GDM amongst maternal age groups and found a rate of 2% amongst women below 25 years, and a rate of 7% for women aged more than 35 years (108). Reassuringly the Australian Institute of Health and Welfare reported that the percentage of women who have gestational diabetes has remained at a stable rate since 2014, although nearly half of all pregnant diabetic women (48%) were overweight or obese, and most were over 40 years of age (107).

2.7 Older maternal age and birth outcomes

Despite the observation that women of maternal age over 35 are predominantly healthier and more socially advantaged compared to women of the same age in past decades, there is a growing body of evidence that giving birth at an older age increases the risks of poorer birth outcomes (35). It has been demonstrated that women over 35 have a higher risk of caesarean section, increasing further for women over 40 (18, 35, 104, 109). A large Australian study of over 100,000 women compared maternal age with caesarean rate and it was discovered that increased maternal age was associated with a decreasing rate of SVB's (110). Despite only 0.1% of Australian births occurring in women over 45 years of age, the findings of a Victorian population-based study in 2006 demonstrated that an advanced maternal age of over 45 had an 8 times increased risk of requiring a caesarean section, regardless of parity or plurality (36). Conversely, a systematic review undertaken in Australia in 2011 examined adverse outcomes of stillbirth, low birth weight, and preterm birth amongst women aged over 35 years, and found no evidence to justify intervention amongst women aged 35-39, as their rate of these adverse events was non-significant, until the age of 40 years (111). Worldwide, the authors of a Canadian study of over 200,000 primiparous women also demonstrated an increase in caesarean section with age (18). Risk profiles of these women were also considered in the Canadian study, to include women without medical disorders, non-smokers, no fertility issues and regular attenders of antenatal care. In contrast, a multi-centre retrospective study in the USA compared the duration of labour with maternal age and found the time of progression in labour from 4cm-10cm marginally decreased with age, with 7.8 hours as the median for 20-30 year olds, and the median 7.4 hours for 30-40 years of age (39). However, an increase of maternal age was also linked to increase of labour inductions, epidural use, operative vaginal births and caesarean sections in both primiparous and multiparous groups with advancing age (39).The American study included data from 19 hospitals, with over 228,000 births, and separately analysed primiparous women and multiparous women with a singleton baby with cephalic (head down) presentation. In comparison, a different American retrospective cohort study analysing more than 30,000 births over a 20-year period in one hospital had contrasting findings. Controlling for confounders, their research demonstrated that women over 20 years of age had shorter labours than women over 39 years by up to 97 minutes (112).

2.8 Ethnicity and pregnancy outcomes

Women from certain ethnic backgrounds have been found to be at increased risk of pregnancy and birth complications with multiple sources confirming this trend (42, 43, 45, 113). The authors of a study from the USA noted the rate of PTB (birth before 37 weeks of completed gestation), varied considerably by race/ethnicity (114). Similarly, a British study found disparities in ethnicity and PTB, with the highest rate occurring in the Asian population (115). Ethnic minority disparity has also been found in Australian studies with Aboriginal Australians experiencing significantly disproportionate poorer health outcomes compared to their non-Indigenous counterparts (116). Despite higher rates of spontaneous onset of labour and spontaneous vaginal births, Aboriginal babies were more likely to be born preterm and be low birth weight (116).

Gestational Diabetes Mellites (GDM) has been linked to poorer outcomes for both mother and baby (117). and is consistently proven to be linked to minority ethnic groups (43, 108, 117-120). Global prevalence of GDM is on the rise with an estimated 16% of pregnant women having diabetes (43). Similarly, authors of a USA study observed the higher rates of GDM for women born outside of the USA and found this was strongly associated with a large percentage of these women being of more advanced maternal age, identified as another risk factor for GDM (121).

Body Mass Index (BMI), used to categorise weight, has been independently associated with an increased risk of complications. An increased BMI has been linked to pregnancy hypertension, macrosomia, and increased risk of emergency caesarean sections (122-124). In contrast, worldwide, a low BMI has been found to be associated with lower birth weight neonates, lower Apgar scores and anaemia (125). BMI has also been found to be linked to ethnicity, which in turn impacts childbirth outcomes. A retrospective epidemiological study in England examined over 500,000 women to compare BMI and ethnicity with birth outcomes and found Asian women with low BMI are at increased risk of morbidities such as gestational diabetes, than their higher BMI Caucasian counterparts (126). The English study also found a rise in maternal obesity in first trimester across all ethnicities over a 13-year period, particularly across South Asian and Black women (126).

Length of pregnancy has also been found to be associated with ethnic background, as demonstrated in a study of 122,000 primiparous women in the UK, where spontaneous labour occurred at a mean gestation of 39 weeks for Black and Asian women, and 40 weeks for Caucasian women (115).

Stillbirth is an additional concern for women of ethnic minority origin, with a Melbourne study reporting a stillbirth rate significantly higher for ethnic minority groups in comparison with Caucasian women (120). The retrospective cross-sectional study analysed the findings from a cohort of over 44,000 women at 37–42 weeks gestation with no known fetal abnormalities, to determine the incidence of antepartum fetal demise. Using statistical analysis and adjusting for variables, it was found that South Asian women had a stillbirth rate 2.4 times higher than Australian born women, and 3.4 times higher than East Asian born women (120). However, this was not indicative that lower determinants of health status migrants were at greater risk, as South Asian migrant women born in the United Kingdom also demonstrated the increased risk, suggesting ethnicity and country of birth are risk factors, rather than social determinant of health status (120).

Another serious maternity complication is preeclampsia, a substantial contributor to maternal morbidity and mortality worldwide, which can have ongoing effects later in life (127). Women of 35 years of age or more have been found to demonstrate an increased occurrence of preeclampsia (41). Those aged over

35 years have been associated with increased severity of the disease and poorer outcomes than women under 35 years with preeclampsia (128). Ethnicity impacts the risks of preeclampsia, with some populations being up to 3 times higher risk than others (129). Worldwide, women from low-income countries and women from an African American ethnicity and found to be at increased risk of hypertensive disorders as preeclampsia (129). Preeclampsia has additionally been associated with higher rates amongst women from ethnic minority groups (113, 127) and within Australia, Campbell et al., reported that Aboriginal women have a higher rate of preeclampsia than Caucasian woman (130). Interestingly, in China, a country where Caucasian women are in the minority, they, as the minority group were found to be at higher risk of preeclampsia. The large retrospective study conducted in China, of over 67,000 women, reported opposite findings to those from countries where Caucasian women are the majority (131). Whilst it is known that contributors to the pathophysiology of preeclampsia include abnormalities of placental formation and development, vascular changes, and inflammation, few studies have examined race and the pathophysiology of preeclampsia, and no genetic basis for preeclampsia has been identified (127).

Adverse perinatal outcomes such as PTB, low birth weight and maternal and perinatal morbidity and mortality are found to be disproportionately higher for Aboriginal women in Australia, with the maternal mortality rates for Aboriginal women being reported as 13.8 versus 6.6 per 1,000 (132). A systematic review demonstrated higher rates of PTB, stillbirth and infant mortality rates in indigenous compared with non-indigenous women (133). Similarly, a retrospective data analysis of New Zealand mothers found rates of PTB and rates of small for gestational age babies were higher in Maori women than any other ethnic group, whilst the mortality rate remained similar to other ethnic groups (134).

2.9 Ethnicity and childbirth

There is little evidence in the literature to link ethnicity with mode of birth, however an Australian study, reporting on over 45,000 births and ethnicities, demonstrated Aboriginal women had an increased rate of spontaneous onset of labour and spontaneous vaginal birth and reduced incidence of epidural, assisted birth, caesarean section, and perineal trauma (116). A study using data for 400,000 births and reported on the ethnic differences regarding severe maternal morbidity. The study demonstrated there were disparities of severe maternal morbidity based on the women's ethnicity, with African and Aboriginal women being more at risk of severe maternal morbidity, such as maternal death, acute renal failure, acute psychosis, disseminated intravascular coagulopathy, shock, uterine rupture, hysterectomy and blood transfusions. An acknowledged limitation of the study was that no account was made for alcohol and drug use or maternal mental health status (45).

Evidence regarding maternity outcomes for ethnic minority groups have influenced clinical guidelines. A study using a cohort of over 1 million women evaluated if maternal ethnicity affects perinatal mortality. This study showed women of South Asian or Mediterranean ethnicity have an increased risk of perinatal mortality. Asian born women demonstrated an antepartum stillbirth rate of 2.4 times higher than Australian born women, with linear increasing risk and increasing gestation (120). Following this, clinical guidelines in Queensland recommend early IOL should be initiated based on ethnicity. In another retrospective cohort study to which the guidelines refer, outlines the absolute difference in risk between ethnicities (18 per 10,000 for black women vs 9.4 per 10,000 for Caucasian women) (135). The guidelines recommend using this information in consideration with other factors when making the decision of when IOL should be initiated (136).

Comparisons were made within a 2010 retrospective Taiwanese study between the birth outcomes of Taiwanese born women with immigrant women, which demonstrated that immigrants had lower vaginal birth rates (66% vs 79%), but higher rates of successful vaginal birth after caesarean than the Taiwanese born women (5% and 6% vs 4%) (65). In comparison, an American retrospective cohort study in 2017 examined ethnicity, attitudes toward birth and the mode of birth and found the rate of non-elective caesarean section was higher amongst Black and Latina women (137). The link between the increased risk of assisted vaginal birth or caesarean section amongst minority groups in first time low-risk mothers is not new evidence. Ibison (2005) reported on the records of East London women who received maternity care between 1988 and 1997 and found increased operative birth rates. There was a notable disparity between African women and Caucasian women, with African women having increased assisted vaginal birth rates (aOR: 2.8; 95% CI 2.4-3.1) (138). Findings were statistically significant even after consideration of maternal age, antenatal class attendance, late bookings, year of birth, hospital, intra-uterine growth restriction, birthweight, sex of the fetus, induction, and augmentation (138). In contrast, a large retrospective Scottish study. examined ethnicity and multiple birth outcomes for over 144,000 primiparous women, found no differences in rate of caesarean across the different ethnic groups (139).

2.10 Caesarean birth

Natural or vaginal birth is the preferred method of birth for the majority of women due to reduced risk of morbidity (8). An elective caesarean section can result in 3.1 times higher rate of maternal morbidity than a vaginal birth (140) although adverse outcomes, such as perineal trauma also occur during vaginal birth, it remains the preferred method by practitioners and women (141). Globally, the rate of caesarean sections has increased from 7% in 1990 to 21% 2021 and this number is expected to continue to rise (3). Some areas have higher than average rates, such as North Iran, which has a rate of 70%, even higher than the already inflated national average of 55% (1). This is a global concern (142) which could be partly attributed to the increasing trend of women delaying childbearing causing a parallel increase in pregnancy and labour complications, monitoring, intervention, and caesarean section rates (3, 26, 141, 143). According to worldwide studies, there are multiple and complex factors contributing to an increasing caesarean section rate, including non-clinical factors related to individual women, families and their interactions with health providers (142). For example, fear of pain, uncertainty with vaginal birth and positive views on caesarean sections have been found to guide women's decision making (142).

2.11 Social determinants of health

Social determinants of health are the factors that influence health outcomes, such as income, employment, education, housing, and social inclusion. Social determinants of health are multi-faceted and affect various aspects of a woman's preconception preparation, pregnancy, labour, birth and perinatal outcomes (144). There is an association between low socio economic (SE) group status and limited patient-centred communication and shared decision-making across all clinical settings (137). Healthcare professional bias, or attitudes of clinicians toward different social groups, can affect patient-clinician interactions, including communication, behaviours and treatment decisions, leaving women experiencing disempowerment, due to reduced involvement in decision making (137). The factors that create the large discrepancy in outcomes for women from the lower SE populations include reduced antenatal appointment attendance, often due to distance from antenatal and health services, financial means and the level and perceptions of cultural safety (45). In socioeconomically disadvantaged areas, remote or very remote locations, the incidence of pre-existing medical conditions, such as gestational diabetes is increased (45), a condition known to increase with the level of socioeconomic disadvantage (107).

Adolescents are a high-risk group for lack of social support and relatively poorer psychological states than their older counterparts (145-147). Maness' thesis confirmed the vulnerability of American pregnant adolescents, demonstrating that 6 of the 17 social determinants of health measures had an empirical relationship , including close school relationships, receipt of high school diploma, enrolling in higher education, participation in volunteering or community service, litter or trash in the neighbourhood, and living in a two-parent home (90). However, despite evidence linking low social determinants of health with poor outcomes, adolescents have fewer labour complications and higher vaginal birth rates (94, 96).

Low social determinant of health status in known to increase women's susceptibility to severe maternal morbidity (44). A state-wide retrospective cohort study in WA, found socioeconomically disadvantaged women were at greatest risk of severe morbidity, including acute renal failure, acute psychosis, disseminated intravascular coagulopathy, shock uterine rupture, hysterectomy, blood transfusion and maternal death (45) and in addition a recent American retrospective cohort study, involving over 25,000 mother-infant pairs demonstrated a consistent social gradient for the risk of PTB (114). Women who held a bachelor's degree or above, were associated with significantly decreased odds of PTB (aOR 0.74, 95% CI: 0.58, 0.94) (114). Factors associated were found by Dunlop et al., (2021) to be maternal level of education and income, marital and employment status, and type of health insurance (106). In validation, an American retrospective study of over 3,000 women demonstrated that women in the opposite end of SE status, who were well-educated and had private health insurance had a reduced caesarean section rate (137).

A government incentive in Korea aimed to provide equal access to antenatal care and financial antenatal support finances to reduce the outcome disparities between women from low socioeconomic status groups and the general population. A retrospective data analysis study examined the differences in outcomes following the introduction of the incentives. Although both groups were granted the same access, care and finances for the antenatal period, there remained a significant difference in maternal outcomes, with the lower social determinant of health group experiencing increased rates of obstetric complications such as preeclampsia, gestational diabetes, PTB and obstetric haemorrhage, even after adjustment for adequacy of prenatal care (148). Social determinant of health status remains an important risk factor and Kim at al.'s study demonstrates that there are many facets which cannot be remedied over the antenatal period.

Newer literature is needed to progress toward narrowing the disparities of adverse outcomes between women of different ethnic backgrounds and ages. As maternal age is on the rise, this research is required to ensure optimal outcomes and discover other causative factors for increasing risk of complications or ascertain a need for more interference with the physiological birth process. For women who are seeking physiological birth, age or ethnicity should not be a deterrent, and HCW's must treat women as individuals, taking into consideration a woman's desires as well as her health and demographic situation.

Chapter 3: Methodology

3.1 Preamble

This chapter describes the methodology used to conduct this study aiming to explore the association between sociodemographic factors on pregnancy and labour complications, duration of labour and mode of birth. I have also described the study design, data sources, study participants, and data analysis. Later, I have explained the ethical considerations taken into account in this thesis.

3.2 Study design

This study is a retrospective cohort study using population data collected in the Midwives Notification System, with detailed perinatal information over a span of ten years allowed for an analysis of longitudinal perinatal trends. The aim of the study was to investigate the effect of sociodemographic factors, specifically age and ethnicity, on pregnancy complications and mode of birth, as well as identifying trends over the decade under study.

3.3 Study population

3.3.1 Study cohort

Data were obtained from the Midwives Notification System collected between 2010-2019. The Midwives Notification System is a statutory data collection that captures maternal demographic, medical and obstetric information on the labour and birth outcomes, and other perinatal information. This database is estimated to capture 99% of all births in WA (61). Inclusion criteria used for the analysis were primiparous women with a singleton pregnancy. Women were further excluded if they had a birth before 20 weeks or gave birth to a fetus that weighed less than 400gms (non-viable) or were aged less than 14 years or more than 50 years (**Figure 3**). Women were also excluded if there were missing data for variables such as socioeconomic status (SES), remoteness index, neonatal presentation at birth or gender. As information on BMI was not captured until 2012, a secondary analysis was conducted where women with missing (BMI) information were excluded (**Figure 3**). For this further analysis, there were 111,211 women included.

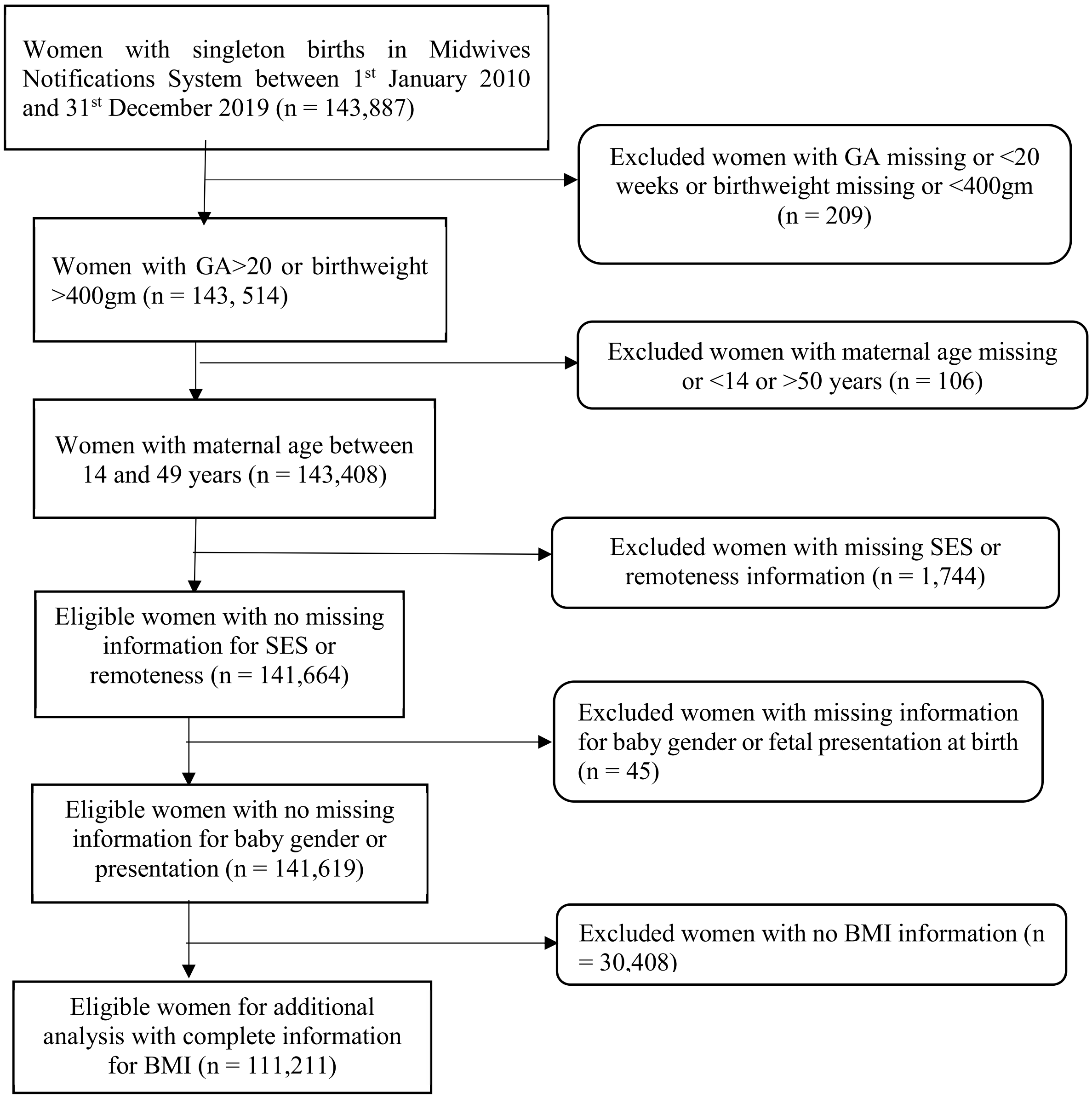


Figure 3. Flow chart for selection of the study cohort, Western Australia, 2010-2019

Footnote: Abbreviations: GA = gestational age, BMI= Body Mass Index; SES=socio-economic status

3.4 Outcome variables

The main outcome variables examined in this analysis were pregnancy complications, primarily GDM, preeclampsia, labour and birth complications with the intrapartum focus being fetal distress and the mode of birth, focussing on non-elective caesarean sections. GDM was defined as any pregnant women who tested positive on their 75gram two-hour Pregnancy Oral Glucose Tolerance Test (149). The diagnostic criteria for GDM changed in 2013. The WHO 1999 criteria indicated a woman was positive for GDM with fasting glucose levels above 5.8mmol/l and 2-hour post glucose load of greater than 11.1mmol/l. The 2013 GDM criteria changed the threshold to levels of fasting less than 5.1mmol/l and 2-hour post glucose load of 8.5mmol/l. This resulted in a rise in number of women diagnosed due to the lowered threshold (150-152). Pre-eclampsia was defined by a diagnosis of such by a medical professional during pregnancy, by persistent high blood pressure that develops during pregnancy or the postpartum period, associated with high levels of protein in the urine or the new development of decreased blood platelets, trouble with the kidneys or liver, fluid in the lungs, or signs of brain trouble such as seizures and/or visual disturbances (153). For this thesis, mode of birth was categorised into 4 types - spontaneous vaginal birth, instrumental (forceps or vacuum extraction), elective caesarean section or emergency/non-elective caesarean section. Given the decision for elective caesarean is influenced by cultural factors, fear of pain during childbirth, and interactions with health care professionals, understanding the risk of maternal age and ethnicity on emergency caesarean section is important (154). Therefore, after excluded births with elective caesarean, I defined a binary outcome for emergency caesarean birth outcome (yes vs no). Duration of labour was analysed as first and second stage labour, with the first stage of labour presented in hours and second stage in minutes.

I used the Robson Ten Group Classification System, established by the WHO, in order to compare perinatal events and outcomes (155). This allowed a thorough and accurate comparison of this group and their outcomes, giving a clearer image of the role that age and ethnicity have in labour and birth outcomes.

3.5 Exposure variables

The main exposure variables included maternal age and ethnic background (**Table 1**). Maternal age was categorised into 6 age ranges for comparison, <20, 20-24, 25-29, 30-34, 35-39 and >40 years. Based on literature, the reference group for the analysis were women aged 20-24 years, as this group had overall the least frequency of complication and is used as a reference group in other studies (156, 157). Maternal ethnicity was divided into 5 ethnic categories, Caucasian, Aboriginal/TSI, Asian/Indian, African, Maori, and ‘Others’, the latter defined as per MNS data dictionary as ‘women who self-report any ethnic origin not elsewhere specified in this list or who is unable to specify any ethnic origin’ (60). Caucasian women were chosen as the reference group when examining ethnicities due to majority of the cohort being Caucasian (72%, n=101,485).

3.6 Covariate variables

Covariates that were considered for the cohort included socioeconomic indexes for areas (SEIFA), based on the Index of Relative Socio-Economic advantage and disadvantage (quintiles), a composite area-based measure of education, skilled occupation status, and household income (158). Body mass index, calculated as weight in kilograms divided by height in metres squared, was also included. BMI was divided into 4 categories as per the Centre of Disease Control and Prevention guidelines (159). Higher BMI was associated with longer duration of labour, increased need for augmentation and increased risk of caesarean section birth (160, 161). Other covariates included in the models were mother’s smoking status, a remoteness index, partner status, and asthma as a maternal comorbidity. Neonates born to women who are smokers are more likely to be small for gestational age or growth restricted, experience an increased chance of birth defects and tissue damage, suffer stillbirth, miscarriage, placental damage, PTB, and the effects of preeclampsia (162). Remoteness index measures whether the women lived in a metropolitan or remote area, as this directly affects a woman’s access to maternity care and the maternity care options available to her. Women who live in remote areas of WA have higher rates of pregnancy under 20 years of age, are in the lower SES groupings, commence antenatal care at a later stage of pregnancy and attend fewer appointments (14). Research also demonstrates married women have higher rates of vaginal births, preeclampsia, lower rates of PTB, small for gestational age neonates and lower rates of admission to nurseries (163, 164). A previous Western Australian study has linked asthma with increased risk of placental abruption, threatened preterm labour and emergency caesarean sections (165). Medical conditions reported in the database as ‘other’ was defined per the MNS Data Dictionary as a ‘free text option for self-reported conditions, and included such conditions as Epilepsy, Malignant Neoplasms, Renal disease, Thyroid disease’ (60).

For our analysis exploring the association between maternal age and ethnicity with caesarean birth, I also considered the covariate onset of labour. Previous studies have demonstrated that induced labour affects outcomes such as longer duration of labour, increased rate of caesarean section and instrumental birth, increased epidurals, uterine hyper-stimulation and neonates with low Apgar scores and higher neonatal nursery admissions (166-168).

Table 1. Exposure variables, outcomes variables and covariates used for analysis of maternal age and ethnicity and complications among primiparous women in WA between 2010-2019.

Exposure variables	
Maternal age	<20, 20-24, 25-29, 30-34, 35-39, >40
Ethnicity	Caucasian, Aboriginal/TSI, Asian/Indian, African, Maori, Others
Outcome variables	
Gestational diabetes mellitus	Positive Glucose Tolerance Test Yes/No
Pre-eclampsia	Diagnosed during pregnancy Yes/No
Caesarean section birth	Yes/No
Fetal distress	Yes/No
Shoulder dystocia	Yes/No
Covariates	
SEIFA index	Categorised into 5 groups
Smoking during pregnancy	Yes/No
Baby’s year of birth	2010-2019
Remoteness	Metropolitan or remote
Marital status	Partnered/not partnered/unknown

Asthma	Yes/No
Body mass index*	<18.5 (underweight), 18.5-25 (normal), 25-30(overweight), >=30(obese)
Other medical complications	Yes/No

*available from 2012 onwards

3.7 Data analysis

Descriptive and summary statistics of demographic and health characteristics of study participants were estimated. I conducted bivariate and multivariate analysis models using used generalised linear models with binomial family and log link and expressed as odds ratios with a 95% confidence interval. In the bivariate model, first I investigated the association between each exposure variable (i.e., maternal age and ethnicity) and outcome variables including pregnancy complications such as gestational diabetes and preeclampsia, birth complications such as fetal distress and mode of birth, including non-elective caesarean section. Then, in the multivariate model, I investigated the independent effect of exposure variables and outcome variables by adjusting for potential confounding variables such as I have considered the following variables such as socioeconomic status measured by SEIFA index (158), smoking during pregnancy, year of birth, remoteness, marital status, asthma, body mass index, and other medical complications. Other medical conditions included such conditions include Epilepsy, Malignant Neoplasms, Renal disease and Thyroid disease (60). For mode of birth, I modelled the risk of caesarean birth by maternal age and ethnicity. I have also conducted additional analysis applying the Robson Ten Group Classification System to stratify the risk of caesarean section rates. This classification system System, established by the WHO in order to caesarean section rates globally (155). The ten categories in the established system are based on five maternal characteristics such as parity, onset of labour, gestational age, fetal presentation and number of fetuses. Of the 10 categories, Robson 1 which typically considers nulliparous women, singleton pregnancy, cephalic presentation, gestational age ≥ 37 weeks, spontaneous onset of labour was considered in the thesis. This allows for comparison of women with the similar risk classification. In this thesis, statistical significance was defined as $p<0.05$.

3.8 Ethical approval

This project obtained approval from the Department of Health Human Research Ethics Committee (HREC) (EC00422), Curtin University HREC (HRE2021-0668) and the WA Aboriginal Health Ethics Committee (HREC1085).

Identifiable information was removed from the data collection prior to provision to the researchers. Participants were not able to be identified by the researchers in the study dataset. A waiver of consent was granted as data are de-identified. To minimise the risk of identifying individuals in areas with small numbers, results were suppressed where there were fewer than five participants.

Chapter 4: Results

4.1 Preamble

This chapter presents results of the study in the thesis. Firstly, the descriptive results are presented. Then, inferential results examining the association between maternal age and ethnicity and pregnancy complications are provided. I also present time trends for maternal age, ethnicity, maternal smoking, and pregnancy complications.

4.2 Characteristics of the study cohort

A total of 141, 619 primiparous women with singleton pregnancies were included in the final analysis. The mean maternal age of the women at the time of birth was 28.6 years (SD ± 5.55), with the largest subgroup being women aged between 25-29 years (32%, n= 44,992). Over two thirds of women were Caucasian (72%, n=101,886), the majority were partnered (78%, n=110,623), and 8% (n=11,019) reported smoking during pregnancy. Majority of women resided in a metropolitan area (80%, n=113,797). Of those women with information on BMI (2012-2019), 42% (n= 60,215) were of normal weight (between 18.5-25kg/m^2) (**Table 2**).

Table 2: Maternal demographics of primiparous women in Western Australia between 2010-2019 (n=141, 619).

Characteristics	Number	Percent
Maternal age (years)		
<20	8,662	6.1
20-24	24,252	17.1
25-29	44,992	31.7
30-34	43,978	31.1
35-39	16,274	11.5
40+	3,461	2.4

Maternal ethnicity		
Caucasian	101,886	72.0
Aboriginal/TSI*	5,127	3.6
Asian/Indian	23,258	16.4
African	1,801	1.3
Maori	1,642	1.2
Others**	7,905	5.6
Indigenous status		
Not Aboriginal/TSI	136,492	96.4
Aboriginal/TSI	5,127	3.6
Marital status		
Partnered	110,623	78.1
Not partnered	27,685	19.6
Unknown	3,311	2.3
Pre-pregnancy Body Mass Index* (kg/m^2)**		
<18.5 (underweight)	4,165	2.9
18.5 -25 (normal weight)	60,215	42.5
25-30 (overweight)	30,095	21.3
>=30 (obese)	19,687	13.9
Missing	27,457	19.4
Smoking status		
Yes	11,019	7.8
No	130,600	92.2
Socioeconomic status** **		
Lowest	28,331	20.0

Low	28,465	20.1
Middle	28,490	20.1
High	28,077	19.8
Highest	28,256	20.0
Remoteness		
Metropolitan	113,797	80.3
Remote	27,822	19.7

Abbreviations: TSI*: Torres Strait Islander. **'Others' as per MNS Data Dictionary- Woman who self-reports any ethnic origin not elsewhere specified in this list or who is unable to specify any ethnic origin (60). ***For BMI, information was available since 2012, hence missing values. ****Socioeconomic status as collected by census (27).

4.3 Trends of selected demographic characteristics of women during the study period

The mean maternal age rose from 27.9 years in 2010 to a mean of 29.3 years in 2019 similar to the trend seen worldwide (.

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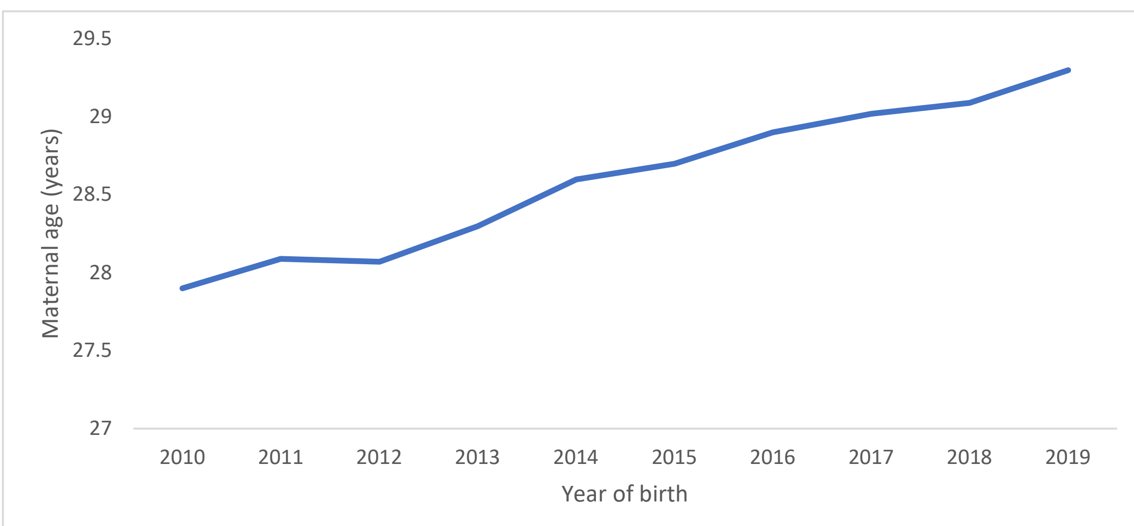

Figure 4. Mean maternal age of primiparous women in Western Australia from 2010-2019

The proportion of women in each ethnic category (Caucasian, Aboriginal/TSI, Asian/Indian, Maori and other over the study period is presented in **Error! Not a valid bookmark self-reference.**. Proportions in each category remained similar over the time period. Majority of women identified as Caucasian (72%, n=101,886), followed by Asian/Indian women (16%, n=23,258) (**Table 2**).

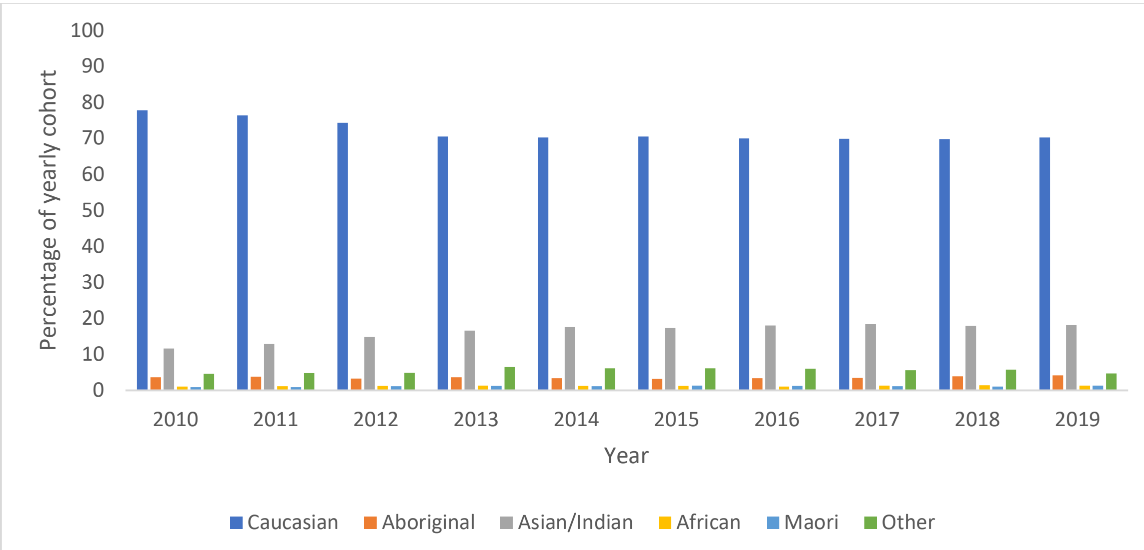

Figure 5. Proportion (or rate) of primiparous women in ethnic categories, Western Australia from 2010-2019

Women classified as obese based on BMI of >30 decreased from 19.1% (n=2,571) to 18.7% (n=2,512) and correspondingly women with BMI falling within a normal range of 18.5-25 increased from 50% (n=6,705) to 51% (6,729) (**Figure 6**). Underweight women with a BMI <18.5 rose from 2.3% (n=314) to 3.4% (n=431) and the remainder of the cohort with a BMI of 25-30 fell from 29% (n=3,865) to 27% (n=3,621).

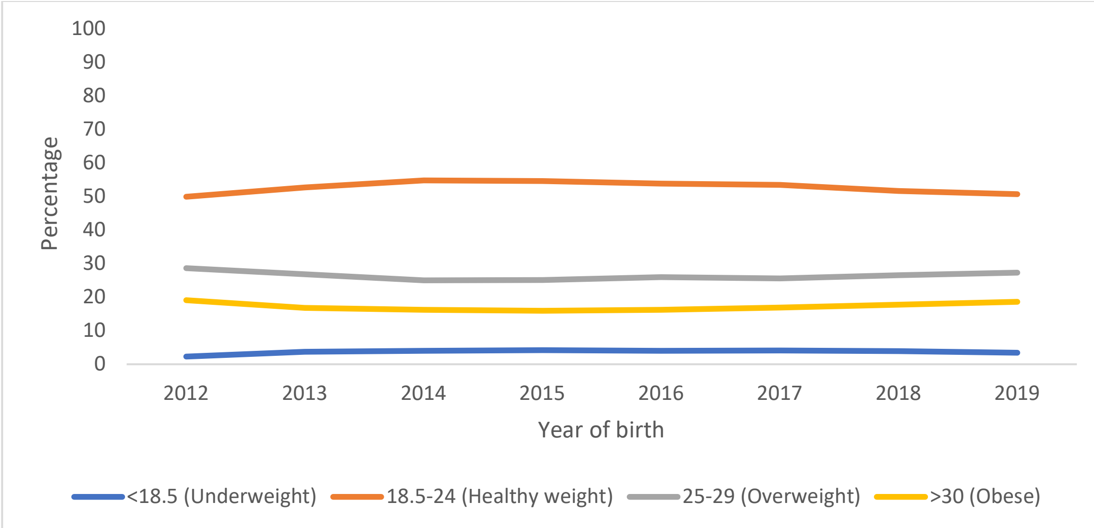

Figure 6. Percentage of women in each body mass index category, Western Australia, 2012-2019

The proportion of women who smoked decreased from 10% (n=1,274) at the beginning of the decade to 6% (n=787) in 2019 (Figure 7).

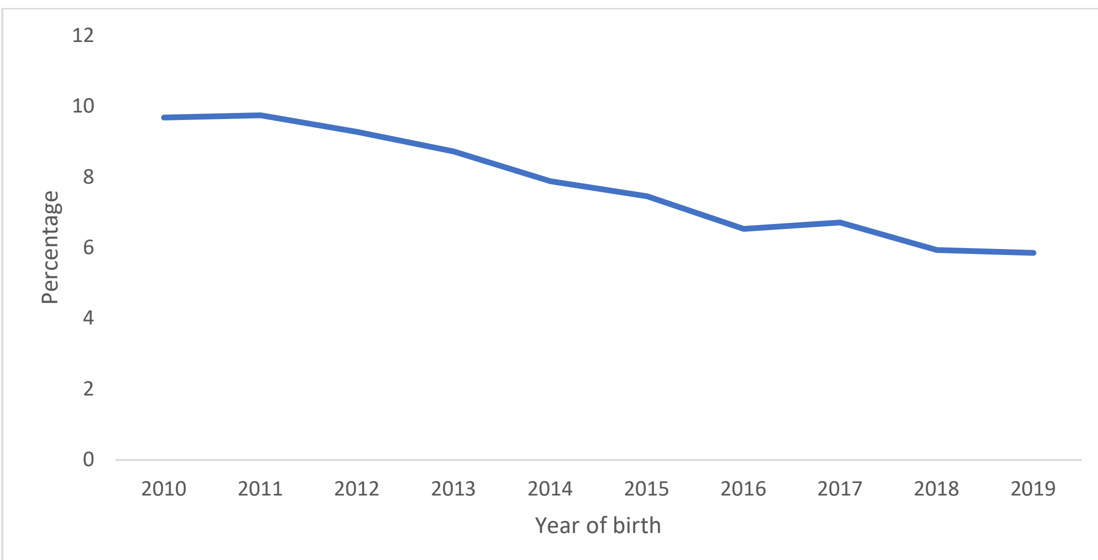

Figure 7. Proportion of women with reported smoking during pregnancy among primiparous women in Western Australia from 2010-2019

4.4 Prevalence of pregnancy complications among the study cohort

The most prevalent pregnancy complication was PTB (9.3%, n=13,240), followed by gestational diabetes (8.5%, n=12,015), preeclampsia (4.2%, n=5,951), antepartum haemorrhage (1.5%, n=2,061), and placenta praevia (1.2%, n=1,691) (Table 3). The PTB rate fluctuated slightly, peaking in 2016 (11%, n=1,446) and the lowest rate in 2010 (9%, n=1,215). Placenta praevia rates increased sharply in 2017, to 2%, from a previous 0.29% (Figure 9). Whilst still a small percentage of the cohort, this rate continued to increase from 2017 onwards, reaching 4% in 2019. The rates of antepartum haemorrhage and placental abruption remained largely steady during the study period, and overall affected a small number of the cohort.

Table 3. Number and proportion of primiparous women with pregnancy complications and selected other maternal morbidities in Western Australia between 2010-2019 (N=141,619)

Variable	Frequency	Percent
Preterm birth		
No	128,379	90.7
Yes	13,240	9.3
Gestational diabetes		
No	129,604	91.5
Yes	12,015	8.5
Pre-eclampsia		
No	135,668	95.8
Yes	5,951	4.2
Ante-partum haemorrhage		
No	139,558	98.5
Yes	2,061	1.5
Placental abruption		
No	141,243	99.7
Yes	376	0.3
Placenta praevia		
No	139,928	98.8
Yes	1,691	1.2
Essential hypertension		

No	132,490	93.6
Yes	9,129	6.4
Asthma		
No	127,865	90.3
Yes	13,754	9.7
Other medical complications*		
No	101,134	71.4
Yes	40,485	28.6

*Other as per MNS Data Dictionary- Free text option for self-reported conditions, such conditions include Epilepsy, Malignant Neoplasms, Renal disease, Thyroid disease (60).

The proportion of women with every complication examined increased over the period under study. The rates of PTB rose from 9.2% (n=1,215) to 9.5% (n=1,256) over this decade amongst primiparous women, whilst the rates of GDM rose from 6% (n=819) to 11% (n=1,439). The proportion of women with preeclampsia also increased from 4% (n=549) to 6% (n=803) at the end of the decade (Figure 8).

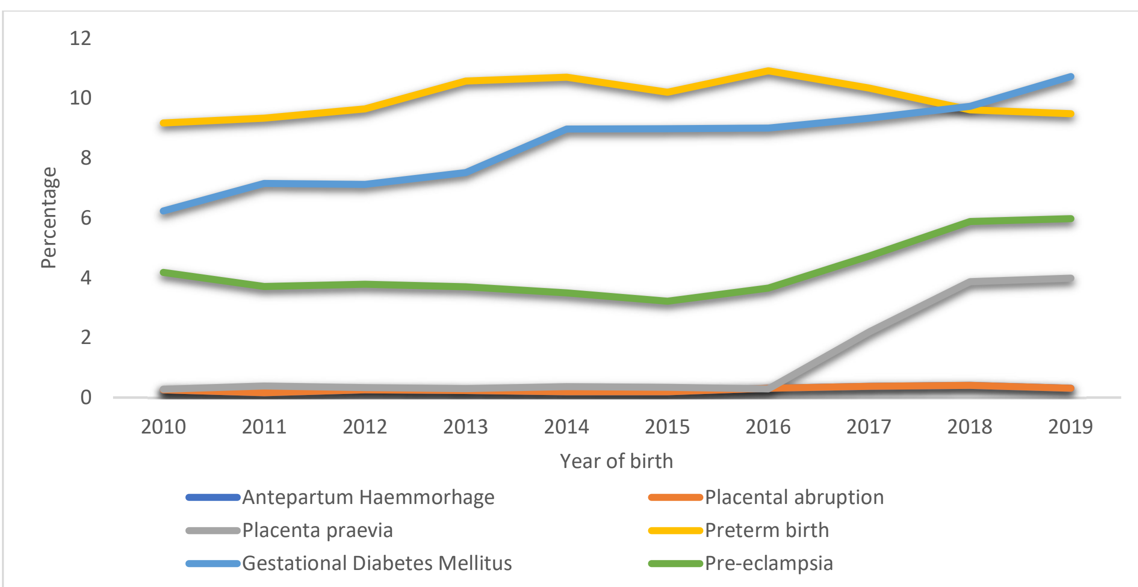

Figure 8. Percentage of selected pregnancy complications among primiparous women in Western Australia from 2010-20194.5

4.5 Association of maternal age and ethnicity

The association between maternal age and ethnicity and selected pregnancy complications were examined in multivariate logistic regression models, with SEIFA index, smoking status, baby's year of birth, remoteness, marital status, asthma status and other medical complications covariates used in the model to calculate adjusted odds ratios (**Table 4**). **Table 5** presents a sub-analysis of women who gave birth in the years 2012-2019 where BMI was included in the models.

4.5.1 Gestational Diabetes

Maternal age and ethnicity were associated with increased risks of GDM. Women who gave birth at the aged under 20 years were 50% less likely to develop GDM compared to women aged 20–24-year-old (aOR= 0.52; 95% CI 0.45, 0.59, p= <0.001). Women aged 25–29-years had 1.5 times odds of developing GDM compared to women aged 20-24 years (aOR= 1.48; 95% CI 1.38, 1.58, p= <0.001), and the risk increased for women aged 30–34-years (aOR= 1.94; 95% CI 1.81, 2.08, p= <0.001) (**Table 4**). Women aged 40-years or above had the highest odds, being almost 4 times the odds of having GDM compared to women aged 20-24 years (aOR= 3.85; 95% CI 3.46, 4.29, p= <0.001). Ethnicity was associated with GDM. The odds of GDM amongst Asian/Indian women were 2.4 times higher than Caucasian women (aOR= 2.40; 95% CI 2.30, 2.51, p= <0.001). Aboriginal women were also, being 1.7 times at higher odds to develop GDM (aOR= 1.73; 95% CI 1.53, 1.97, p= <0.001). Women categorised under "Others" had more than 1.5 times higher odds than the reference group (aOR= 1.67; 95% CI 1.5, 1.81, p= <0.001) (Table 4). The rate increased from 6%, in 2010 (n=819), to 11% in 2019 (n=1,439), with a notable jump from 7.5% (n=1,093) in 2013 to 9% in 2014 (n=1,354) (Figure 8).

4.5.2 Pre-eclampsia

In the study, the proportion of women diagnosed with preeclampsia was 4% (n=5,951) of our cohort. In 2010, the rate was 4%, which was increased to 6% by 2019. Overall, the proportion of women with preeclampsia increased with increasing maternal age. There was no association between maternal age and the odds of developing pre-eclampsia for all age categories except for women above the age of 35 years. Women aged 35-39 years were 1.2 times more likely than 20–24-year-olds to develop preeclampsia (aOR =1.22; 95% CI: 1.11, 1.35, p= <0.001). The over 40-year-old group was more than one and half times as likely to develop preeclampsia (aOR= 1.66;95% CI:1.42, 1.93, p= <0.001). Ethnicity appeared to impact development of preeclampsia. Asian and Indian women were found to be at lower odds of preeclampsia (aOR= 0.69; 95% CI 0.63, 0.75, p= <0.001) compared to Caucasian women, as were women from the 'Others' group (aOR= 0.86; 95% CI 0.76, 0.97, p= 0.012). Aboriginal women had increased risk of development of preeclampsia in comparison to Caucasian women (aOR= 1.47; 95% CI 1.28, 1.69, p= <0.001) (**Table 4**). Similar results were obtained when BMI was included for adjustment in the models (Table 5). The lowest risk group was under 20-year-olds, with a rate of 4%, rendering them less likely to develop preeclampsia than the reference group (aOR= 0.94; 95% CI 0.83, 1.08, p= 0.400). Women aged over 40 were 1.7 times more likely than the 20–24-year-olds to develop this, (aOR= 1.66; 95% CI 1.42, 1.93, p= <0.001).

Table 4. Association between maternal age and ethnicity and pre-eclampsia and gestational diabetes mellitus among primiparous women in Western Australia between 2010-2019 (N=141,619)

Variable		Gestational Diabetes Mellitus				Preeclampsia		
	Number of cases (%)	OR (95% CI)	aOR (95% CI)*	P-value	Number of cases (%)	OR (95% CI)	aOR (95% CI)*	P-value
<20	251 (2.9)	0.5 (0.47, 0.61)	0.5 (0.45, 0.60)	<0.001	337 (3.9)	1.0 (0.87, 1.12)	0.9 (0.83, 1.08)	0.400
20-24	1,284 (5.3)	Ref	Ref		958 (4)	Ref	Ref	
25-29	3,522 (7.8)	1.5 (1.42, 1.62)	1.5 (1.38, 1.58)	<0.001	1,813 (4.0)	1.0 (0.94, 1.11)	1.0 (0.96, 1.13)	0.359
30-34	4,320 (9.8)	1.9 (1.83, 2.08)	1.9 (1.81, 2.07)	<0.001	1,842 (4.2)	1.1 (0.98, 1.15)	1.1 (0.98, 1.16)	0.139
35-39	2,057 (12.6)	2.6 (2.41, 2.78)	2.7 (2.46, 2.86)	<0.001	781 (4.8)	1.2 (1.11, 1.35)	1.2 (1.11, 1.35)	<0.001
>=40	581 (16.8)	3.6 (3.25, 4.01)	3.8 (3.43, 4.26)	<0.001	220 (6.4)	1.7 (1.42, 1.92)	1.7 (1.42, 1.93)	<0.001
Caucasian	6,820 (6.7)	Ref	Ref		4,470 (4.4)	Ref	Ref	
Aboriginal/TSI	341 (6.7)	1.0 (0.89, 1.11)	1.7 (1.51, 1.94)	<0.001	279 (5.4)	1.3 (1.11, 1.42)	1.5 (1.28, 1.69)	<0.001
Asian/Indian	3,731 (16.0)	2.7 (2.55, 2.78)	2.4 (2.30, 2.52)	<0.001	737 (3.2)	0.7 (0.66, 0.77)	0.7 (0.63, 0.75)	<0.001
African	150 (8.3)	1.3 (1.07, 1.50)	1.3 (1.09, 1.53)	0.003	103 (5.7)	1.3 (1.08, 1.62)	1.3 (1.08, 1.62)	0.007
Maori	119 (7.3)	1.1 (0.90, 1.31)	1.5 (1.20, 1.75)	<0.001	63 (3.8)	0.9 (0.67, 1.12)	1.0 (0.75, 1.26)	0.840
Others	854 (10.1)	1.7 (1.57, 1.82)	1.7 (1.55, 1.81)	<0.001	299 (3.8)	0.9 (0.76, 0.97)	0.9 (0.76, 0.97)	0.012

Abbreviations: Unadjusted OR = Odds Ratio, aOR – adjusted Odds Ratio; CI: confidence interval. * adjusted for socioeconomic status measured by SEIFA index (158), smoking during pregnancy, year of birth, remoteness, marital status, asthma, essential hypertension, and **other medical complications. **Other medical complications as per MNS Data Dictionary- Free text option for self-reported conditions, such conditions include Epilepsy, Malignant Neoplasms, Renal disease, Thyroid disease.

Table 5. Association between maternal age and ethnicity and pre-eclampsia and gestational diabetes mellitus among primiparous women in Western Australia between 2012-2019, accounting for body mass index (N=111,211).

Variable		**Gestational Diabetes Mellitus**			**Preeclampsia**			
	Number of cases (%)	**OR**	**aOR (95% CI)***	**P-value**	**Number of cases (%)**	**OR**	**aOR (95% CI)***	**P-value**
<20	183 (3.1)	0.5 (0.44, 0.60)	0.5 (0.41, 0.57)	<0.001	220 (3.7)	0.9 (0.81, 1.10)	0.9 (0.78, 1.08)	0.844
20-24	1,063 (5.8)	Ref	Ref		715 (3.9)	Ref	Ref	
25-29	2,911 (8.2)	1.5 (1.34, 1.55)	1.4 (1.30, 1.52)	<0.001	1,450 (4.1)	1.1 (0.95, 1.15)	1.1 (0.96, 1.17)	0.135
30-34	3.665 (10.2)	1.9 (1.72, 1.98)	1.9 (1.71, 1.99)	<0.001	1,531 (4.3)	1.1 (1.00, 1.20)	1.1 (0.99, 1.21)	0.012
35-39	1,712 (13.2)	2.5 (2.28, 2.67)	2.5 (2.32, 2.75)	<0.001	636 (4.9)	1.3 (1.14, 1.42)	1.3 (1.12, 1.41)	<0.001
>=40	490 (18.0)	3.6 (3.16, 3.99)	3.8 (3.36, 4.27)	<0.001	169 (6.2)	1.6 (1.37, 1.94)	1.6 (1.37, 1.95)	<0.001
Caucasian	5,547 (7.1)	Ref	Ref		3,525 (4.5)	Ref	Ref	
Aboriginal/TSI	282 (7.5)	1.1 (0.93, 1.20)	1.7 (1.52, 2.00)	<0.001	195 (5.2)	1.2 (1.00, 1.35)	1.4 (1.17, 1.63)	<0.001
Asian/Indian	3,257 (16.7)	2.6 (2.52, 2.76)	2.4 (2.31, 2.54)	<0.001	639 (3.3)	0.7 (0.66, 0.78)	0.7 (0.65, 0.77)	<0.001
African	125 (8.6)	1.2 (1.03, 1.50)	1.3 (1.05, 1.52)	0.011	80 (5.5)	1.2 (0.99, 1.56)	1.3 (1.00, 1.59)	0.039
Maori	102 (7.7)	1.1 (0.90, 1.35)	1.4 (1.17, 1.77)	0.243	49 (3.7)	0.8 (0.61, 1.09)	1.0 (0.69, 1.24)	0.123
Others	711 (11.1)	1.7 (1.52, 1.79)	1.7 (1.52, 1.79)	<0.001	233 (3.7)	0.8 (0.70, 0.92)	0.8 (0.72, 0.94)	0.010

Abbreviations: aOR – adjusted Odds Ratio; CI: confidence interval * adjusted for socioeconomic status measured by SEIFA index (158), smoking during pregnancy, year of birth, remoteness, marital status, asthma, body mass index, and **other medical complications. **Other medical conditions as per MNS Data Dictionary- Free text option for self-reported conditions, such conditions include Epilepsy, Malignant Neoplasms, Renal disease, Thyroid disease.

4.6 Onset of labour and birth characteristics

Nearly two thirds of women gave birth vaginally (62.7%, n=88,857), with more women experiencing spontaneous vaginal birth than any other method (37.0%, n=52,463) (**Table 6**). Less than half of the women in this cohort went into labour spontaneously (48.3%, n=68,393). The vast majority (93.0%, n=131,683) of women had a vertex presentation. The majority of births were at term gestation, inclusive of inductions and elective caesareans (54.0%, n=76,490) (**Table 6**).

Table 6. Birth characteristics among primiparous women in Western Australia from 2010-2019 (N=141,619).

Variable	Frequency	Percent
Mode of birth		
Spontaneous vaginal	52,463	37.0
Instrumental*	36,394	25.7
Elective caesarean	15,634	11.0
Emergency caesarean	37,128	26.2
Caesarean birth		
Yes	52,762	37.3
No	88,857	62.7
Onset of labour		
Spontaneous	68,393	48.3
Induced	52,446	37.0
No labour/elective caesarean	20,780	14.7
Presentation		
Vertex	131,683	93.0
Breech	7,909	5.6
Face	242	0.2
Brow	238	0.2

Other	1,547	1.1
Gestational age at birth (weeks)		
20-28	867	0.6
28-32	1,214	0.9
33-37	11,159	7.9
37-40	76,490	54.0
40	35,980	25.4
41	16,513	11.7
>=42	619	0.4
Neonatal weight at birth (grams)		
<2500	11,082	7.8
2500-3000	25,382	17.9
3000-3500	54,801	38.7
3500-4000	39,182	27.7
4000-5000	11,089	7.9
>5000	83	0.1
Neonatal gender at birth		
Male	73,027	51.6
Female	68,592	48.4

*Instrumental inclusive of vacuum and forceps

The proportion of women who had an induced labour has increased over the decade under study, from 8% in 2010 to 11% in 2019 (Figure 9). The most common reasons for IOL included prolonged pregnancy (16%, n=3,122), prelabour rupture of membranes (14%, n=2,726), and diabetes (11%, n=2,143).

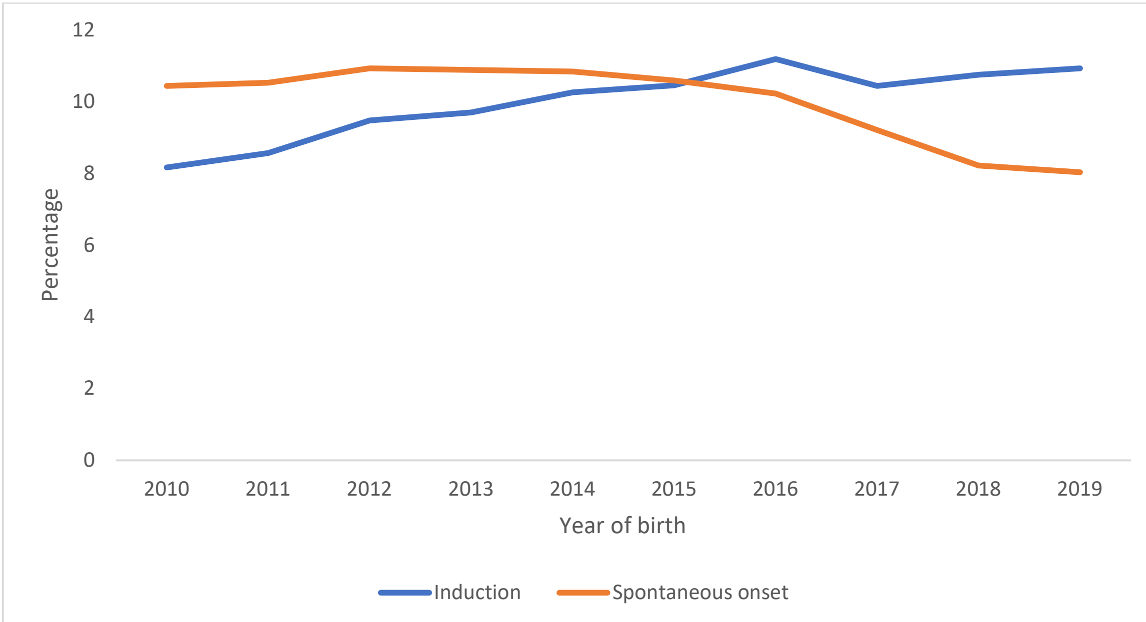

Figure 9. Rates of induction of labour and spontaneous labour among primiparous women in Western Australia by year between 2010-2019 (n=52,446)

The percentage of primiparous women who underwent an elective caesarean rose from 9% (n=1,340) in 2010 to 10% (n=1,546) by the end of the decade. Similarly, the rate of non-elective caesarean section rate also rose from 24.5% (n=3,227) in 2010 to over 28.6% (n=3,840) by 2019.

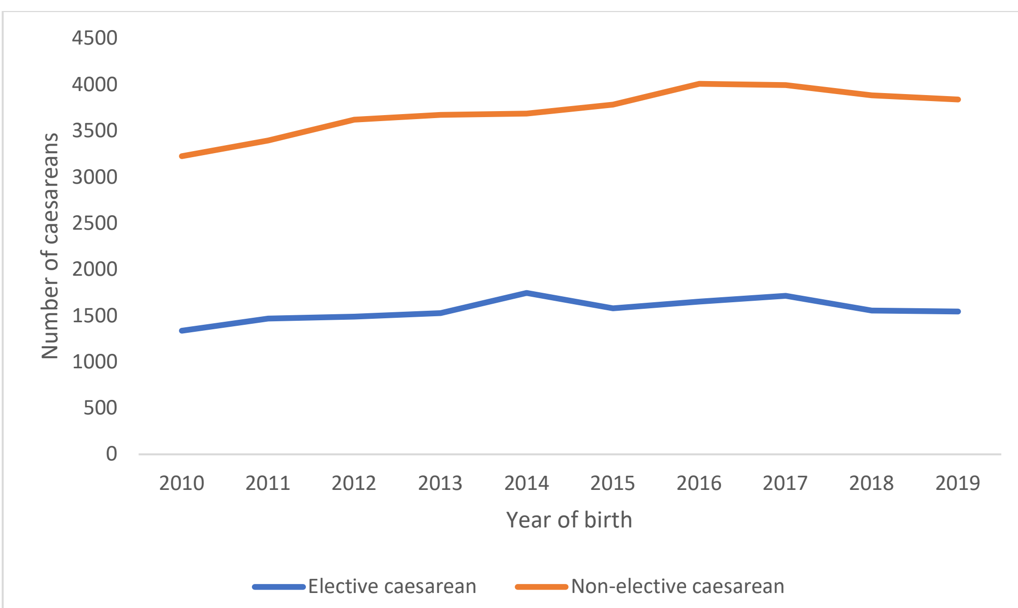

Figure 10. Rates of elective and non-elective caesarean section amongst primiparous women in Western Australia between 2010-2019 (N=52,762).

For women who gave birth vaginally, the labour commonly took between 4-8 hours for the first stage of labour (41.1%, n=23,282). The second stage most frequently took 60-120 minutes (33.3%, n=29,598) (**Error! Not a valid bookmark self-reference.**).

Table 7. Duration of stages of labour among primiparous women in Western Australia who birthed vaginally between 2010-2019 (N=88,857).

Duration of first stage (hours)	**Frequency**	**Percent**
<4	30,413	34.2
4-8	36,549	41.1
8-12	15,401	17.3
>12	6,484	7.3
Missing	10	0.0
Duration of second stage (minutes)		
<30	19,930	22.4
30-60	23,197	26.1
60-120	29,598	33.3
120-180	12,036	13.6
>180	3,872	4.4
Missing	224	0.3

4.7 Labour and birth complications

The most common labour complications were fetal distress (25.0%, n=31,788), and 'cord tight around the neck' (3.8%, n=4,893) (**Table 8**). Of the women who gave birth vaginally, close to half had an episiotomy (39.2%, n=34,909) (**Table 9**).

Table 8. Labour complications amongst primiparous women in Western Australia between 2010-2019 excluding birth by elective caesarean (N=127,089).

Complication	Frequency	Percent
Cephalopelvic disproportion		
No	125,113	98.5
Yes	1,976	1.5
Cord tight around neck		
No	122,196	96.2
Yes	4,893	3.8
Fetal distress		
No	95,301	75.0
Yes	31,788	25.0
Persistent occipito-posterior		
No	125,220	99.9
Yes	51	0.01

Table 9. Birth complications amongst primiparous women in Western Australia between 2010-2019, excluding birth by caesarean (N=88,857)

Complication	Frequency	Percent
Retained placenta		
No	87,252	98.2
Yes	1,605	1.8
Shoulder dystocia		
No	86,630	97.5
Yes	2,227	2.5
Episiotomy		
No	53,948	60.8
Yes	34,909	39.2

4.8 Association of age and ethnicity with non-elective caesarean section

The proportion of women with a caesarean section increased with increasing maternal age, with 34.3% the over 40-year-old group having a birth by caesarean, compared to only 11.2% of women under 20 years. The occurrence of non-elective caesarean was strongly associated with increasing age, with women aged 35-40 over 2.5 times increased odds of having a non-elective caesarean than the reference group (aOR 2.62; 95% CI 2.43, 2.87) and women over 40 having 3.5 times increased odds than the reference group (aOR 3.54; 95% CI 2.95, 4.24). Women of African ethnicity were 2 times more likely to have a caesarean than Caucasian women (aOR 2.02; 95% CI 1.72, 2.37). By percentage, Maori women were the least likely to have a caesarean section (14.6%, n=122), however this association was not significant (Table 10).

Table 10. Association between maternal age and ethnicity and birth by caesarean for all primiparous women in Western Australia from 2010-2019 using ROBSON 1* criteria (N=60,736)

Variable	Number of cases (%)	OR (95% CI)	**aOR (95% CI)	P- value
Maternal age (years)				
<20	506 (10.6)	0.76 (0.68, 0.85)	0.70 (0.63, 0.78)	<0.001
20-24	1,644 (13.4)	Ref	Ref	
25-29	3,559 (17.4)	1.36 (1.28, 1.45)	1.40 (1.31, 1.49)	<0.001
30-34	3,712 (21.2)	1.73 (1.62, 1.84)	1.81 (1.69, 1.94)	<0.001
35-39	1,443 (27.9)	2.50 (2.31, 2.71)	2.62 (2.43, 2.87)	<0.001
>=40	196 (34.1)	3.33 (2.78, 3.99)	3.54 (2.95, 4.24)	<0.001
Maternal Ethnicity				
Caucasian	7,254 (17.1)	Ref	Ref	
Aboriginal/TSI	419 (16.1)	0.93 (0.84, 1.04)	1.44 (1.28, 1.63)	0.187
Asian/Indian	2,336 (22.0)	1.37 (1.30, 1.44)	1.33 (1.25, 1.40)	<0.001
African	221 (27.2)	1.81 (1.55, 2.11)	2.02 (1.72, 2.37)	<0.001
Maori	122 (13.6)	0.76 (0.63, 0.92)	1.00 (0.82, 1.21)	0.006
Others	708 (20.7)	1.26 (1.16, 1.38)	1.32 (1.21, 1.44)	<0.001

Abbreviations: OR – odds ratio, aOR – adjusted odds ratio *Robson 1 classification- Singleton, term, cephalic, spontaneous onset of labour* adjusted** for socioeconomic status measured by SEIFA index(158), smoking during pregnancy, year of birth, remoteness, marital status, asthma, other medical complications

Table 11. Association between maternal age and ethnicity and birth by caesarean among primiparous women using Robson 1* criteria accounting for body mass index in Western Australia between 2012-2019 (N=60,736)

Variable	Number of cases (%)	OR (95% CI)	** aOR (95% CI)	P-value
Maternal Age (years)				
<20	361 (11.2)	0.81 (0.71, 0.92)	0.82 (0.72, 0.94)	0.001

20-24	1,210 (13.5)	Ref	Ref	
25-29	2,677 (17.1)	1.32 (1.23, 1.42)	1.38 (1.28, 1.49)	<0.001
30-34	2,898 (20.9)	1.70 (1.58, 1.83)	1.84 (1.70, 1.99)	<0.001
35-39	1,090 (27.7)	2.46 (2.24, 2.70)	2.75 (2.49, 3.03)	<0.001
>=40	144 (34.3)	3.35 (2.72, 4.14)	3.95 (3.18, 4.90)	<0.001
Maternal Ethnicity				
Caucasian	5,345 (16.9)	Ref	Ref	
Aboriginal/TSI	297 (15.8)	0.92 (0.81, 1.05)	1.50 (1.30, 1.73)	<0.001
Asian/Indian	1,921 (22.3)	1.41 (1.33, 1.50)	1.69 (1.59, 1.80)	<0.001
African	167 (26.7)	1.79 (1.49, 2.14)	2.06 (1.71, 2.48)	<0.001
others	550 (20.3)	1.26 (1.14, 1.38)	1.39 (1.26, 1.54)	<0.001
Maori	100 (14.6)	0.82 (0.66, 1.01)	0.86 (0.69, 1.08)	0.170

Abbreviations: CI: Confidence interval; OR – odds ratio, aOR – adjusted odds ratio. *Robson 1 classification- Singleton, term, cephalic, spontaneous onset of labour. Adjusted** for socioeconomic status measured by SEIFA index, body mass index, smoking during pregnancy, year of birth, remoteness, marital status, asthma, other medical complications.

Chapter 5: Discussion and Conclusion

5.1 Preamble

Longitudinal analysis of a decade of perinatal data on West Australian women has highlighted notable changes in the population of primiparous women, the health of their pregnancies and birth experiences, including some changes they may have implications and risks at a population level. Increasing maternal age in Western Australia followed a national trend of increasing maternal age, whilst the ethnic distribution of primiparous women in WA remained steady over the decade. Whilst the odds of some complications such as gestational diabetes and preeclampsia were associated with an increasing maternal age or ethnicity, the major finding is the trend of increasing interventions in the form of increasing frequency of IOL and caesareans. Over the study period (2010-2019), the rates of pregnancy complications, IOL and caesarean sections increased, whilst spontaneous labour and spontaneous vaginal births decreased for women at their first birth. These trends are consistent with trends in other high-income countries and have major implications for future pregnancy and birth journeys for all women and their families, healthcare providers and the worldwide healthcare systems (49).

5.2 Trends in demographic characteristics, exposure variables and selected outcomes over the period in study

Increasing maternal age at birth is consistent with other Australian studies (11), and studies in other high-income countries (25, 26, 64, 65). For example, the mean age for women having their first baby in Estonia in 2005 was 25 years, and in 2021 was 29 years. Similarly, age at first birth for women in Norway was 28 years in 2012 to 30 years in 2021(169). In the US, there was a 70% increase in mothers having children at age 40-44 years from 1991-2001 (25).

Diagnosis of pregnancy complications have risen, and there is a correlation between these and increasing maternal age and some ethnicities such as Asian and Indian women being associated with a higher risk of GDM. IOL rates have risen, as have caesarean section rates, both elective and non-elective. Increasing caesarean rates have been associated with anaesthetic problems, haemorrhage, internal organ injury, surgical site infection, and neonatal physiology alterations (170-172). This can impact population health, as it may result in rising incidence of infections, lower breastfeeding rates, mortality, disability and childhood obesity (3, 173). Conversely, caesareans have also been associated with decreasing maternal mortality and adverse birth outcomes. Caesarean section is a critical and lifesaving surgery when performed with appropriate indication.

In our study, an encouraging demographic change was the decline in the prevalence of women who smoke during pregnancy, likely attributable to assistance for smoking cessation which is widely available through antenatal clinics with health practitioners (174). A Cochrane review in 2009 evaluated smoking interventions such as motivational interviews and behavioral cognitive therapy and ascertained a reduction in smoking of 6% when these interventions were implemented during pregnancy (175). Smoking is a modifiable risk factor associated with complications such as low birthweight, being small for gestational age, pre-term birth and perinatal death (174). Non-disclosure of smoking status can make it difficult to ascertain the true rate amongst pregnant women (176). Whilst smoking interventions have proven effective in reduction of rates, healthy eating does not appear to have resonated as well with the pregnant population. BMI in fact increased over the period under study for first time mothers.

My analysis showed an increasing number of IOL of labour for primiparous women. Previous research into IOL when not indicated in comparison to spontaneous labour showed an increased rate of intervention, including increasing rates of caesarean section, assisted vaginal birth and decreased maternal satisfaction for primiparous women (12, 177-179). My study demonstrated the women undergoing IOL had higher rates of fetal distress (48%), when the overall rate of fetal distress was almost half that, at 25%. The *ARRIVE* trail, a large multicentre trial that took place across 41 hospitals in the US, examined early induction of labour in 39th week of pregnancy versus spontaneous onset for low-risk primiparous women and found that women who underwent early IOL did not have an improvement of the primary outcome, reduction of death or serious complications for neonates (180) but did report a reduction in caesarean section rates in the intervention group. However, this trial was mostly conducted with women having obstetric care from an obstetrician (94%), not a midwifery model of care. In the USA at the time of the study, a 5-6% caesarean rate was achieved with a midwifery led model of care, compared with the obstetrician-led caesarean rate of 32%-60%. The findings of the *ARRIVE* trial, were a caesarean rate of 19% for the induction group and 22% for expectant group (180). In addition, feasibly due to the possible requirement of being subjected to induction of labour one week prior to the expected due date, only 27% of all eligible participants agreed to take part, indicating selection bias in the population under study. The participants who elected to be involved had no medical indication for an IOL, demonstrating a policy of universal early IOL is unlikely to be acceptable to women. and should be considered when writing policies and guidelines. Whilst tertiary hospitals in WA have guidelines in place for appropriating IOL, further analysis of whether these guidelines are being adhered to is warranted. There is indication for more in-depth analysis into the causative factors of increasing IOL rates (83, 173, 174).

The median duration of labour for our cohort for first stage was 4-8 hours, which is aligned with other studies (181, 182). The accuracy of duration of labour is subjective, with many women remaining at home whilst establishing in labour, and interventions such as augmentation, induction, and labour support affecting to the duration (183, 184). Diagnosis of failure to progress was the second main cause for non-elective caesarean sections for the cohort in this study. A misdiagnosis of failure to progress results in unnecessary interventions, including caesarean section, which increases maternal and neonatal morbidity (8, 167), demonstrating a need for definitive evidence-based diagnosis which determines accurately whether labour progress is slow, stalled or has in fact stopped.

Another notable finding in our data was regarding mode of birth. Decreasing spontaneous vaginal birth, despite being the optimal method of birth from the perspective of women and health care practitioners due to lower rates of morbidity and mortality, occurred in less than half of our cohort. Caesarean section, with an overall prevalence of 37.0% in our cohort, is more than double the WHO's recommended population level caesarean rate of 10-15% (3).

5.2.1 Impact of demographic characteristics- maternal age

There is no universally agreed upon definition for advanced maternal age. Increasing maternal age is a trend seen worldwide and was consistent with my findings. The literature clearly demonstrates that adverse outcomes increase with maternal age (18, 35, 104). However, the literature is contradictory on what is considered advanced maternal age, and guidelines that are utilised result in interventions for women above these thresholds. For example guidelines from a tertiary hospital in WA recommend women aged over 35 be educated on the risks of GDM and preeclampsia, undergo additional scans from 36 weeks, and additional antenatal appointments from 39 weeks, and if the mother is over 40 years old an IOL is offered at 39 weeks, inclusive of the absence of any other risk factors (185). Queensland guidelines also recommend an IOL at 39 weeks for women over 40 years of age (186). In Victoria, maternal age alone is not an indication for an IOL (187). My research has discovered that rates of GDM, preeclampsia, fetal distress and caesarean section do increase with increasing maternal age. Similar to another Australian study (111), my research demonstrates these increasing rates of complications with maternal age are modest, and HCW's and women should be educated that outcomes are favourable toward supporting physiological labour and birth. In the absence of any other risk factors, intervention and testing based on maternal age alone does not appear to be warranted based on the outcomes examined amongst the cohort in this study.

The risk factors for GDM should be considered when women are making decisions about undergoing antenatal testing, as increased risk amongst certain groups such as women of Asian or Indian ethnicity warrants antenatal testing. The risk of GDM is 2 times higher for 30–34-year-olds, 2.5 times higher for 35–39-year-olds and 3.8 times higher for women over 40, than the 20–24-year age group. This elevated risk should be considered for women and HCW's providing education regarding antenatal testing and maternal age. Similarly, education regarding preeclampsia and alertness to symptoms should be enhanced for women over 40, with the risk of preeclampsia being 1.6 higher in this age group, compared to 20–24-year-olds.

5.2.2 Impact of demographic characteristics- maternal ethnicity

Further studies are needed to determine the mechanism underlying observed differences in outcomes. The impact ethnicity had on our outcomes was observed and in order to optimise outcomes in the future, should be taken into consideration when educating and screening women for GDM and preeclampsia. Asian and Indian women had a significant increased rate of GDM, with the risk 2.6 times higher than

Caucasians. More research is required to determine contributing factors, including genetic predisposition to diabetes, and whether this alters outcomes or should alter thresholds. Women of Aboriginal or African ethnicity have an increased risk of preeclampsia, with Aboriginal women at the highest risk of any ethnicity in this cohort, being 1.4 times more likely to develop preeclampsia than Caucasian counterparts (aOR 1.4: 95% CI 1.17, 1.63, p= <0.001). Similarly, genetic predisposition may play a role in this, which is explained in more detail in section 5.3.2. This study demonstrated that ethnicity plays a role in particular outcomes, particularly GDM and preeclampsia, but also fetal distress, with African women being the highest risk group (aOR 1.56: 95% CI 1.39, 1.71) and caesarean section, with African women also being the most at risk group for this outcome.

5.3 Pregnancy and labour complications and mode of birth

The primary pregnancy outcomes of focus were GDM and preeclampsia. There was a notable rise in the occurrence of GDM and preeclampsia over the decade. Both studied complications were associated with steadily increasing maternal age.

5.3.1 Gestational diabetes

Gestational diabetes mellitus is the fastest growing type of diabetes within Australia, and understanding the association between age and ethnicity with GDM is pertinent to minimising risk and optimising outcomes for women and babies with GDM (107). Although non-modifiable risk factors, age and ethnicity appear to impact the risk of GDM and being aware can alert women and health care providers to the importance of early testing for these higher risk groups, and appropriate ongoing support, education and management for women who do have GDM. In WA, a women is referred to a tertiary hospital for her maternity care upon diagnosis, and is seen by a team who give testing equipment and dietary advice, with regular appointments and an induction of labour booked in for the 39 week gestation (188). Currently, more than half of women manage this condition without the need for medication (107). Early advice regarding diet and exercise by the health care provider may be useful in management and avoidance of insulin (189). Previous studies (43, 108, 117-120) showed that the risk of GDM is higher among minority ethnic groups and this was consistent with my study, indicating that women from Asian and Indian background were at higher risk of GDM compared with Caucasian women. This is consistent across the literature, and reported widely, including studies conducted in Australia, US and Norway (69, 108, 119, 190, 191). While the causal mechanisms by which Asian women have an increased risk of developing GDM are not well understood, it was hypothesised that multiple factors, including genetic predisposition, social–cultural factors and differences in dietary intake in pregnancy could lead Asian women to be more susceptible to GDM (192, 193). Genetic predisposition appears to be a factor contributing to this increased rate (194). Although high BMI is one predisposing risk factor for development of GDM, people of Asian ethnicity are generally associated with lower BMI's (190). Our sensitivity analysis adjusting for BMI did not change the results. Aboriginal women demonstrating increased odds of developing GDM, which was in line with another study although the authors examined women of all parity in contrast with this study, which focused solely on primiparous women (191). Lifelong consequences can prevail for both mother and neonate if GDM is not successfully treated during pregnancy (47), for example large for gestational age neonates, a known morbidity caused by GDM, which is increasingly prevalent with Aboriginal women (191).

My results support the current practice of implementing earlier screening of women with risk factors for GDM as this may improve maternal and neonatal morbidity with earlier diagnosis and treatment. GDM screening and treatment have been shown to reduce adverse perinatal outcomes and therefore beneficial for women with established risk factors for GDM (195). Treatment and intervention for preeclampsia contributed to substantially reduce maternal morbidity and mortality in high income countries, reducing the maternal mortality rate to less than 1%, which compared with the mortality rate of 7 times higher for low-income countries from this complication (196, 197). Barriers to compliance with screening have been previously reported, with access for remote women and dissatisfaction regarding communication within the hospital system suggested as reasons (198). Early engagement with a healthcare professional for education and ongoing continuity of care are potential solutions to help women recognise how to achieve the best possible outcomes (198).

5.3.2 Pre-eclampsia

The consequences of untreated preeclampsia are severe, with high rates of maternal and neonatal mortality (129). Preeclampsia can be considered the most threatening of all pregnancy complications, being a leading cause of maternal death worldwide with acute and long-term complications (129, 199-201). Preeclampsia affects 5% to 7% of all pregnant women but is responsible for over 70 000 maternal deaths and 500 000 fetal deaths worldwide every year (202). In the United States, it is a leading cause of maternal death, severe maternal morbidity, maternal intensive care admissions, caesarean section, and prematurity (129). In developing countries, a woman is seven times as likely to develop preeclampsia than a woman in a developed country (203). Two-thirds of preeclampsia cases occur in otherwise healthy, nulliparous women, so there is no single most important recognisable risk factor (204).

In my study, ethnicity and maternal age appeared to impact development of preeclampsia. The rate of preeclampsia increased over the decade from 4% to 6%, which could be due to increasing maternal age and ethnic diversity across the study period, but also increased and better testing methods and better recognition (205). Rates of preeclampsia increased with maternal age. Aboriginal women were almost 1.5 times more likely to develop preeclampsia than Caucasian women. In contrast, Asian/Indian women had the lowest odds of developing preeclampsia during pregnancy, as previously reported (141). Of the ethnic groups, African women had the highest risk of developing preeclampsia during pregnancy. Previous research has demonstrated this increased risk may be due to biological or genetic factors and is responsible for a disparity in health outcomes, with preeclampsia being the second highest major cause of maternal morbidity and mortality in sub-Saharan Africa, following only haemorrhage (206). Patrick et al., showed that African women had less folic acid and more of a certain amino acid than their Caucasian counterparts, putting them at higher risk for preeclampsia and cardiovascular disease, although there is limited other literature on this (207, 208). The demographics of the WA population may be impacted by migration, with more South African and neighbouring Zimbabwe families migrating to WA than any other state (209).

More studies are warranted on preeclampsia and genetics, in order to ascertain severity of complications from preeclampsia and if a universal screening test for predicting preeclampsia in early stages of pregnancy can be developed. Information gained from my study can further stratify the risks of women and development of preeclampsia, with African ethnicity being a risk factor, proven in my studies which correlates with worldwide studies.

5.3.3 GDM and preeclampsia

When comparing links between preeclampsia and GDM, the positive correlation between preeclampsia and GDM remains unconfirmed, but both complications have similar underlying risk factors, such as maternal age and ethnicity, albeit different ethnic groups (210). Aboriginal women in our cohort were at risk of both GDM and preeclampsia. It is recommended that remote Aboriginal women are provided with local care from providers to identify and manage pregnancy complications without having to relocate any women away from their support networks, home and families. An Australian study has identified the early post-natal period as the best time to educate these women about future pregnancies, risk of recurrent GDM, and education regarding management and prevention in subsequent pregnancies (211).

5.3.4 Fetal distress

Fetal distress is determined through several indicators. These include either individually or combined labour indicators such as meconium-stained liquor or fetal heartrate abnormalities and collection of fetal blood samples. There are many causes for fetal distress, often not fully understood until after the birth (212). The intention behind fetal monitoring is to guide clinical decision-making regarding timing of birth in order to prevent birth asphyxia and complications (213). Technology surrounding fetal monitoring has not altered greatly since the 1970's, and whilst cardiotocographs (CTG) are considered mandatory for women with complicated labours there are limitations, demonstrated by lack of reduced rates of perinatal mortality and longer-term outcomes associated with injury, such as cerebral palsy (213). Another indicator used as a marker of fetal distress, meconium, can also be caused by a mature fetus' gastrointestinal tract in absence of fetal distress, and studies have shown meconium stained liquor is not an accurate evaluation of a distressed fetus (214).

This study demonstrated ethnicity and age were contributing factors to fetal distress, determined in the database by the aforementioned indicators and further research of this subject would add to our understanding of any direct links, and whether they are indicative of requiring intervention in order to optimise outcomes, or a physiological normality.

5.3.5 Caesarean Section

Whilst it is the priority of many women and HCW's to support physiological process of pregnancy and birth, it is a fact that interventions for complications save lives. Caesarean section is a critical and lifesaving surgery when performed with indication, and according to WHO, a less than 10% caesarean rate is considered dangerous, whilst anything over 15% demonstrates no improvement in maternal or neonatal outcomes (3, 173, 215). When medically justified, a caesarean section can effectively prevent maternal and perinatal mortality and morbidity (3). According to worldwide studies, there is a trend of multiple and complex factors contributing to an increase of caesarean section rate, including non-clinical factors related to individual women, families and their interactions with health providers, both medical and mental health factors contributing to this (142, 216). Maternal choice, for a variety of reasons, medical indications, practitioner preference, health service practices, some limits in practitioner skills, for example breech vaginal births, and many factors formulate the decision-making process (217). Outcome-affecting factors include attitudes of attending healthcare professionals and women, medical co-morbidities and individual confounding factors such as maternal height, body weight, and social determinants of health status (143). The WHO's recommended rate is 15% was decided over 30 years ago, and with the rapidly changing maternity healthcare trends, it is contested if this rate is still the ideal figure (218). A multitude of factors affect caesarean section rates, and the emphasis should be on safe and appropriate use. Having a caesarean section for the first birth is the greatest indication for a caesarean section for following births, and in my study, 26% (n=37,128) of the women had a caesarean that they did not elect, impacting their future birthing options. Increasing women's knowledge, minimising fear and promotion of normality is known to decrease intervention. An Australian study with over 500 primiparous women reported women attending psychoprophylaxis education for childbirth had a vaginal birth rate of 79%, compared with a group of women with no antenatal education resulted in a vaginal birth rate of 60% (219).

5.4 Strengths and limitations

The main strength of our study was that the data set was a large, state-wide, population-based cohort with detailed information on birth and perinatal information. This allowed examination of longitudinal trends over the decade in study. Perinatal data is collected through the MNS in WA, a legally mandated data collection that has been in operation since 1975. All births are registered through the MNS, whether they are through the public health system, the private health system, a publicly funded homebirth, with private practising midwives, or the midwife, nurse or medical practitioner at any site who provided care to a woman who has just given birth (220). The MNS is estimated to capture 99% of births in WA and is thus representative of the whole state with minimal selection bias (61). Information and performance governance processes between staff and reporting midwives are in place to ensure the quality of the data is reliable and regular data audits also ensure the quality of the data (62). The data covers the time from the conception to the end of the perinatal period and includes medical history, pregnancy, birth and neonatal details, extending into the postnatal period. The MNS is a quality data source for any data related to pregnancy, labour, birth, the neonate and postnatal period (62). State-wide population-based data avoids selection bias of the cohort.

I was limited with data on BMI as this was not available until 2012. BMI information was missing for 30,408 women, which comprised 21% of the total cohort. However, to account for this, I conducted a sensitivity analysis of women from 2012-2019, where BMI was included in the models. I acknowledge there might be a potential limitation in the quality of our data as data entry is reliant on the input of the individual healthcare worker however these errors would apply randomly to all women included in the cohort. For other variables included in the models, missing data on co-variates was less than 10%, including missing information on maternal age, gestational age, missing birth weight, neonatal gender or presentation at birth. Reliability and completeness of midwife notification records have been established with up to 95% positive predictive value (PPV), 78% sensitivity, >99% specificity, and >99% agreement with medical records (61).

The change of diagnostic criteria of GDM saw a worldwide increase of diagnosis of GDM which is a noticeable trend in our analysis also (150, 152). I acknowledge this as a limitation, as the diagnosis criteria changed in 2013, effecting our cohort's results from 2009-2013.

I also acknowledge a limitation regarding ethnicity for this cohort. Ethnicity was self-defined by the women and was limited to 6 options. This information was not inclusive of their migration status, time spent in Australia, primary language or country of birth rather, it was reported in the MNS as a self-reported variable and is thus predisposed to subjective interpretation. This is a common problem encountered by studies examining ethnicity that is difficult to resolve.

5.5 Implications and future research

Rates of complications, interventions, inductions, and caesarean section are increasing (3, 11). The rising intervention rates seen worldwide lead to increased incidence of morbidity and mortality (221). Given my research focused on pregnancy complications related to women, the role of maternal age and ethnicity on neonatal outcomes needs to be investigated in the future. Suggestions on how to reduce intervention rates have been noted in research, and recommended by WHO (49).

Continuity of care with a midwife is known to improve pregnancy and birth outcomes and can be applied to any risk model (222). Australian studies show reduction in caesarean sections with midwifery led models (223, 224) and worldwide evidence confirms that continuity of care by a midwife also reduces the rates of preterm birth, intervention, pharmacological analgesia, admission of babies to the neonatal nursery, is more cost effective than other models and reports increased maternal satisfaction, demonstrating the need for all women to be offered access to continuity of care by a midwife (225-229).

My research suggests that an individualised approach, risk-based screening and accurate and timely identification of complications and therefore management is another way in which to reduce interventions. For example, early identification of GDM, following screening based on risk factors such as Asian or Indian ethnicity, will allow ample time for education, management and therefore reduce the need for induction of labour, which increases a woman's chance of following the 'cascade of intervention', increasing her chances of a physiological birth experience (230).

Access to education across the pregnancy spectrum to all women and their families can provide empowerment through education. By giving women and families appropriate education, this can encourage informed decision making, working in partnership with the women, allowing her to feel in control. Previous research has demonstrated education improves maternal outcomes such as less inductions and lower use of analgesia, and increased rates of vaginal birth (231, 232). Providing education for women and their families from as early as preconception, throughout pregnancy, and education targeting more at-risk groups, such as diabetes education for Asian/Indian women may encourage earlier testing but also earlier dietary and lifestyle modifications to minimise impact and improve maternal and neonatal outcomes (233). Helping women and their families to navigate the guidelines and literature is something every health practitioner can do. This encourages education and promotes understanding of the pregnancy and birth continuum.

Having skilled attendants is of the utmost importance of ensuring optimal outcomes (234). Retention of skills such as breech vaginal birth can lower caesarean section rates, especially in resource poor countries where a caesarean puts maternal and neonatal lives at risk (235, 236). Fetal distress was the most common cause of non-elective caesarean sections in this study; therefore, interpretation has a direct impact on this rate. There is currently an undertaking of research into use of CTG's and best practice for fetal monitoring. The findings from this study will no doubt make a notable impact on monitoring during labour, reducing caesarean section rates therefore improving morbidity, by aligning practice with research evidence (237).

Further research into specific areas within my WA study would benefit women and babies. Additionally, investigation into genetic factors that predispose women to either preeclampsia or diabetes would enhance our understanding and allow us to more accurately screen and identify women who are at risk of developing these complications.

5.6 Conclusions

Findings of this thesis showed increasing trends of pregnancy complications and caesarean birth among primigravid women in WA during 2010-2019. Moreover, the findings showed associations between maternal age and ethnicity and pregnancy complications and caesarean birth in primiparous women in

WA. Disparities amongst ethnic groups and identification of ethnicity and maternal age as independent risk factors may provide signposts to optimise maternity health care and outcomes. However, care needs to be given to avoid racial and age profiling and discrimination. Instead, access to education and support, encouragement of early intervention and testing and understanding through education may lead to improved outcomes for pregnancy complications.

Monitoring and evidence-based management after diagnosis will provide best outcomes for women and their neonates. Whilst striving for optimal outcomes, with knowledge gained of patterns and trends under the decade in study, the findings may provide a foundation for further research, such as qualitative research exploring the perspective women and healthcare providers on the increasing trends of caesarean birth. Research into management strategies of common conditions and highlighting models of care that improve outcomes of women and neonates can assist in the reduction of intervention and optimising the woman's experience.

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Appendix

Appendix 1: WA DOH HREC approval

Appendix 2: WAAHEC approval

Appendix 2: HREC approval reciprocal agreement

Appendix 3: MNS data dictionary

Government of **Western Australia**
Department of **Health**

Department of Health WA Human Research Ethics Committee
Level 1 C Block
189 Royal Street
East Perth Western Australia 6004

07 September 2021

Dr Gizachew Tessema
Curtin University
Building 400, Kent St
Bentley WA 6845

Dear Dr Tessema

PRN:	RGS0000004711
Project Title:	The effect of maternal age and ethnicity on pregnancy complications, length of labour, and mode of birth
Protocol Number:	V1 27/5/2021

Thank you for submitting the above research project for ethical review. This project was considered by the Department of Health WA Human Research Ethics Committee at its meeting held on 07 September 2021. To find the original letter and any possible attachments, click here when logged into RGS.

I am pleased to advise you that the above research project meets the requirements of the *National Statement on Ethical Conduct in Human Research (2007)* and ethical approval for this research project has been granted by Department of Health WA Human Research Ethics Committee.

The Committee considered your application under the Guidelines under the National Statement on Ethical Conduct in Human Research 2.3.10 and was satisfied that it met the criteria to grant a waiver of consent.

The nominated participating site(s) in this project is/are:

Department of Health

[Note: If additional sites are recruited prior to the commencement of, or during the research project, the Coordinating Principal Investigator is required to notify the Human Research Ethics Committee (HREC). Notification of withdrawn sites should also be provided to the HREC in a timely fashion.]

The approved documents include:

Document	Version	Version Date
Application for Data	1	02/03/2021
Data Management Plan	2	23/07/2021
Feasibility letter	1	02/03/2021
Midwives Variables List	1	06/04/202
Research protocol	2	23/07/2021

Ethical approval of this project from Department of Health WA Human Research Ethics Committee is valid from 07 September 2021 to 07 September 2024 subject to compliance with the 'Conditions of Ethics Approval for a Research Project' (Appendix A).

A copy of this ethical approval letter must be submitted by all site Principal Investigators to the Research Governance Office or equivalent body or individual at each participating institution in a timely manner to enable the institution to authorise the commencement of the project at its site/s.

It is a requirement of this approval that all draft outputs pertaining to this project are submitted to RDS via email dataservices@health.wa.gov.au for review prior to being submitted for publication.

<u>This letter constitutes ethical approval only.</u> This project cannot proceed at any site until separate site authorisation has been obtained from the Chief Executive or Delegate of the site under whose auspices the research will be conducted at that site.

Should you have any queries about the Department of Health WA Human Research Ethics Committee's consideration of your project, please contact the Ethics Office at hrec@health.wa.gov.au or on 08 9222 4278. The HREC's Terms of Reference, Standard Operating Procedures and membership are available from the Ethics Office or from https://ww2.health.wa.gov.au/Articles/A_E/Department-of-Health-Human-Research-EthicsCommittee.

The HREC wishes you every success in your research.

Yours sincerely

Dr Peter Bentley
Chair
Department of Health WA Human Research Ethics Committee

Clinical Senior Lecturer
UWA Medical School
Division of Internal Medicine

Appendix A

CONDITIONS OF ETHICS APPROVAL FOR A RESEARCH PROJECT

The following general conditions apply to the research project approved by the Human Research Ethics Committee (HREC) and acceptance of ethical approval will be deemed to be an acceptance of these conditions by all project investigators:

1. The responsibility for the conduct of this project lies with the Coordinating Principal Investigator (CPI).
2. The investigators recognise the reviewing HREC is registered with the National Health and Medical Research Council and that it complies with the current version of the National Statement on Ethical Conduct in Human Research.
3. A list of HREC member attendance at a specific meeting is available on request, but no voting records will be provided.
4. The CPI will immediately report anything that might warrant review of ethical approval of the project.
5. The CPI will notify the HREC of any event that requires a modification to the protocol or other project documents and submit any required amendments to approved documents, or any new documents, for ethics approval. Amendments cannot be implemented at any participating site until ethics approval is given.
6. The CPI will submit any necessary reports related to the safety of research participants in accordance with the WA Health Research Governance Standard Operating Procedures.
7. Where a project requires a Data Safety Monitoring Board (DSMB), the CPI's will ensure this is in place before the commencement of the project and notify the HREC. All relevant reports from the DSMB should be submitted to HREC.
8. For investigator-initiated and collaborative research group projects the CPI may take on the role of the sponsor. In this case, the CPI is responsible for reporting to the Therapeutic Goods Administration (TGA) any unexpected serious drug or device adverse reactions, and significant safety issues in accordance with the TGA guidelines.
9. If the project involves the use of an implantable device, the CPI will ensure a properly monitored and up to date system for tracking participants is maintained for the life of the device.
10. The CPI will submit a progress report to the HREC annually from the ethics approval date and notify the HREC when the project is completed at all sites. The HREC can request additional reporting requirements as a special condition of a research project. Ethics approvals are subject to the receipt of these reports and approval may be suspended if the report is not received.
11. The CPI will notify the HREC of his or her inability to continue as CPI and will provide the name and contact information of their replacement. Failure to notify the HREC can result approval for the project being suspended or withdrawn.
12. The CPI will notify the HREC of any changes in investigators and/or new sites that will utilise the ethics approval.
13. The HREC has the authority to audit the conduct of any project without notice if some irregularity has occurred, a complaint is received from a third party or the HREC decides to undertake an audit for quality improvement purposes.

14. The HREC may conduct random monitoring of any project. The CPI will be notified if their project has been selected. The CPI will be given a copy of the monitor's report along with the HREC and Research Governance (RG) Office at the site/s.
15. Complaints relating to the conduct of a project should be directed to the HREC Chair and will be promptly investigated according to the WA Health's complaints procedures.
16. The CPI should ensure participant information and consent forms are stored within the participant's medical record in accordance with the WA Health's Record Keeping Plan.
17. The CPI will notify the HREC of any plan to extend the duration of the project past the expiry date listed above and will submit any associated required documentation. A request for an extension should be submitted prior to the expiry date. One extension of 5 years may be granted but approval beyond this time period may necessitate further review by the HREC.
18. Once the approval period has expired or the project is closed, the CPI will submit a final report. If the report is not received within 30 days the project will be closed and archived.
19. Projects that do not commence within 12 months of the approval date may have their approval withdrawn and the project closed. The CPI must outline why the project approval should remain.
20. The CPI will notify the HREC if the project is temporarily halted or prematurely terminated at a participating site before the expected completion date, with reasons provided. Such notification should include information as to what procedures are in place to safeguard participants.
21. If a project fails to meet these conditions the HREC will contact the CPI to address the identified issues. If, after being contacted by the HREC, the issues are not addressed, the ethics approval will be withdrawn. The HREC will notify the RG Office at each site within WA Health that the project procedures must discontinue, except for those directly related to participant's safety.

WAAHEC Western Australian Aboriginal Health Ethics Committee

Approval Letter

Date: 3 November 2021

HREC Reference number: HREC1085

Project title: The effect of maternal age and ethnicity on pregnancy complications, length of labour, and mode of birth in Western Australia

Dear Dr Gizachew Tessema

Thank you for submitting the above research project for ethics approval. The research project was considered by the WA Aboriginal Health Ethics Committee (WAAHEC) at the meeting held on 26 October 2021. I am pleased to advise that the WAAHEC has reviewed and approved the following documents submitted for this project:

Documents:

WAAHEC Coverletter_response_20092021.

WAAHEC application for submission_v2.

Research protocol v7.

Noted Documents:

202102.03_Feasibility_letter_06.04.2021.

9778_2109070803_DOH WA HREC (EC00422)_Ethics Approved - HREC.

The WAAHEC has granted approval of this research project from , pending your agreement of the following conditions:

Conditions:

1. The WAAHEC will be notified in writing, giving reasons, if the project is discontinued before the expected date of completion.
2. The Chief Investigator will provide a Progress Report by 30 June each year in the specified format. This form can be found on the AHCWA website (www.ahcwa.org.au).

450 Beaufort Street, Highgate WA 6003 / PO Box 8493, Stirling Street, Perth WA 6849
Phone: (08) 9227 1631 **Fax:** (08) 9228 1099 **Email:** ethics@ahcwa.org **Web:** www.ahcwa.org.au
ABN: 48 114 220 478 **ACN:** 114 220 478

3. The approval is for a period of ONLY 3 years from . Research projects should commence and conclude within that period of time. Projects must be resubmitted if extension over three years becomes necessary.
4. Information about publications and/or conference presentations may be incorporated into Progress and Final Reports. This enables the WAAHEC to maintain a record of publications. Researchers can contact the WAAHEC if they require support or feedback prior to publication.
5. Aboriginal and Torres Strait Islander communities are formally acknowledged for their contribution to this research project.
6. If amendments to the research project become necessary, these should be submitted using the form provided on the AHCWA website (www.ahcwa.org.au).

Please contact ethics@ahcwa.org if you have any queries about the WAAHEC's consideration of your project. The WAAHEC wishes you every success in your research.

Kind regards

Peter Miller
For, **Vicki O'Donnell**
Chairperson, WAAHEC

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research* (2007), *NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007) and the CPMP/ICH Note for Guidance on Good Clinical Practice.* The process this HREC uses to review multicentre research proposals has been certified by the NHMRC.

450 Beaufort Street, Highgate WA 6003 / PO Box 8493, Stirling Street, Perth WA 6849
Phone: (08) 9227 1631 **Fax:** (08) 9228 1099 **Email:** ethics@ahcwa.org **Web:** www.ahcwa.org.au **ABN:** 48 114 220 478 **ACN:** 114 220 478

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27-Oct-2021

Name: Gizachew Tessema
Department/School: Curtin School of Population Health
Email: Gizachew.Tessema@curtin.edu.au

Dear Gizachew Tessema

RE: Reciprocal ethics approval
Approval number: HRE2021-0668

Thank you for your application submitted to the Human Research Ethics Office for the project RECIPROCAL - The effect of maternal age and ethnicity on pregnancy complications, length of labour, and mode of birth in Western Australia.

Your application has been approved by the Curtin University Human Research Ethics Committee (HREC) through a reciprocal approval process with the lead HREC.

The lead HREC for this project has been identified as DOH WA Human Research Ethics Committee.

Approval number from the lead HREC is noted as RGS0000004711.

The Curtin University Human Research Ethics Office approval number for this project is **HRE2021-0668**. Please use this number in all correspondence with the Curtin University Ethics Office regarding this project.

Approval is granted for the period **27-Oct-2021** to **07-Sep-2024**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Tessema, Gizachew	Supervisor
Sarna, Minda	Supervisor
Kuliukas, Lesley	Supervisor
Wallace, Nicole	Student

You must comply with the lead HREC's reporting requirements and conditions of approval. You must also:

- Keep the Curtin University Ethics Office informed of submissions to the lead HREC, and of the review outcomes for those submissions
- Conduct your research according to the approved proposal
- Report to the lead HREC anything that might warrant review of the ethics approval for the project
- Submit an annual progress report to the Curtin University Ethics Office on or before the anniversary of approval, and a completion report on completion of the project. These can be the same reports submitted to the lead HREC.
- Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
- Data and primary materials must be managed in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
- Where practicable, results of the research should be made available to the research participants in a timely and clear manner
- The Curtin University Ethics Office may conduct audits on a portion of approved projects.

This letter constitutes ethical approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

Amy Bowater
Ethics, Team Lead

Government of **Western Australia**
Department of **Health**
Performance, Activity & Quality

Purchasing & System Performance

Data & Information Maternal and Child Health Unit

Data Variables - Midwives Notification Systems

Items in bold red are sensitive and require justification.

Variable Name	Variable Code	Variable Description	Values	Comments
Mother's Details				
Date of birth	MDOB	Date of birth of mother	**DDMMYYYY** MMYYYY YYYY	From Jan 1980
Maternal age	MATAGE	Mother's age in years at time of delivery	Number	Calculated in completed years from mother's DOB and infant's DOB
Maternal Postcode	PCODE		Number (NNNN)	From Jan 1980
State	STATE	State/Territory of residence	Number	From Jan 1980
Height	HT	Number in centimetres	Number (NNN)	From Jan 1980
Weight	MWEIGHT	First weight measured during pregnancy Number in kilograms	Number (NNN)	From Jan 2012
Marital status	MS	Marital Status of mother	1 = never married 2 = widowed 3 = divorced 4 = separated 5 = married (inc. defacto) 6 = unknown	From Jan 1980, changed 1998

Updated: August 2018
Filename: K:\DOCUMENTATION\DATASETS\Midwives\Midwives Notification System Data Variables Sep 2018.docx

Variable Name	Variable Code	Variable Description	Values	Comments
Ethnic origin	ETHNIC	Ethnic origin of mother	01 = Caucasian 02 = Aboriginal/TSI 03 = Asian 04 = Indian 05 = African/Negroid 06 = Polynesian 07 = Maori 08 = Other 10 = Aboriginal not Torres Strait Islander 11 = Torres Strait Islander not Aboriginal 12 = Aboriginal and Torres Strait Islander	From Jan 1980, amended 1998, 2013 Item 03 not reported from 1st Jan 2013 Items 10, 11, or 12 available for reporting from 1st Jan 2013
Interpreter service required	INTERPRET_IND	Indication of whether mother required an interpreter during pregnancy	1-Yes 2-No	From Jul 2016
Language requiring interpreter	LANGUAGE_CODE	ABS language code for language of interpreter service required for mother	N(4) See ABS language codes	From Jul 2016
Pregnancy Details				
Previous pregnancies	MPREGS	Total number of previous pregnancies	Number	From Jan 1980
Previous pregnancy outcomes	DEAD ALIVE SB	3 Outcomes of previous pregnancies provided as total numbers Liveborn, Now dead Liveborn, Now living Stillborn	Number (NN) Number (NN) Number (NN)	From Jan 1980 Number of previous outcomes included, e.g. 2 SB = two previous children were stillborn Each infant of a multiple birth is included in the count so will not equal number of previous pregnancies Blank or zero if there are no previous children

Variable Name	Variable Code	Variable Description	Values	Comments
Previous Parity	PARITY	Total number of previous pregnancies that resulted in a birth of one or more infants and pregnancy was at least 20 weeks gestation	Number (NN)	From July 2016
Previous Caesarean Section	PREVCAES	Previous caesarean section	1 = Yes 2 = No	From Jan 1998
Number of Previous Caesarean Sections	NUMPREVCAES	Total number of pregnancies ending in CS before this preg	Number (N)	From Jan 2012
Caesarean last delivery	CAESLD	Birth mode was caesarean section for infant born from last pregnancy that reached at least 20 weeks gestation	1 = Yes 2 = No	From Jan 1998
Previous multiple birth	PREVMBTH	More than one infant was born from a single previous pregnancy that reached at least 20 weeks gestation	1 = Yes 2 = No	From Jan 1998
Estimated Gestation at first antenatal visit	ANCWEEKS	Gestation in weeks at first health care visit that included pregnancy care	Number (NN) 98 = No Antenatal care 99 = Null/undetermined	From Jan 2010
Total number of Antenatal Care Visits	TOTAL_AN_VISITS	Total number of health care visits attended that included pregnancy care	Number (NN)	From Jul 2012

Date of last menstrual period	LMP	Date of first day of menstrual period that was the last experienced prior to this birth (LMP)	DDMMYYYY or unknown	From Jan 1980 Not a mandatory field
Is the LMP date certain?	CERT	Is the woman certain that her LMP date provided is accurate?	1 = Yes 2 = No	From Jan 1980
Expected due date	DATEXP	The estimated date of delivery using LMP or ultrasound or other means to determine the date the pregnancy will be 40 weeks gestation	DDMMYYYY	From Jan 1980
Basis of expected due date	BASELMP	What method was used to calculate the due date	1 = Clinical signs/dates 2 = Ultrasound <20 weeks 3 = 20-40 weeks 8 = Unknown	From Jan 1998
Smoking during pregnancy	SMOKE	Did the woman smoke tobacco at any time during pregnancy	1 = Yes 2 = No	From Jan 1980
Number of tobacco cigarettes usually	SmKB420	Number of tobacco cigarettes usually	998 = Occasional or smoked less than 1 999 = Null/undetermined	From Jan 2010

Variable Name	Variable Code	Variable Description	Values	Comments
smoked each day during first 20 weeks of pregnancy		smoked each day during first 20 weeks of pregnancy	000 = No tobacco smoking	
Number of tobacco cigarettes usually smoked each day after 20 weeks of pregnancy	SmKAF20	Number of cigarettes usually smoked each day after 20 weeks of pregnancy	998 = Occasional or smoked less than 1 999 = Null/undetermined 000 = No tobacco smoking	From Jan 2010

Frequency of drinking an alcohol drink	ALCOHOL_FREQUENCY	How often did the woman usually drink alcohol during this pregnancy	01 = Never 02 = monthly 03 = 2 to 4 times a month 04 = 2 to 3 times a week 05 = 4 or more times a week 99 = unknown or undetermined	From Jul 2017
Number of standard alcohol drinks on a typical day	ALCOHOL_DRINKS		Number (NN)	From Jul 2017
Was screening for depression and/or anxiety conducted?	EPDS_SCREENING		1 = Yes 2 = Not offered 3 = Declined 9 = Unknown	From Jul 2017
Was additional followup indicated for perinatal mental health risk factors?	EPDS_FOLLOWUP		1 = Yes 2 = No 7 = Not applicable 9 = Unknown	From Jul 2017
Complications of pregnancy	COMPRG	Complications of pregnancy	1 = Threatened abortions (<20 weeks) 2 = Threatened preterm labour (<37 weeks) 3 = Urinary tract infection 4 = Pre-eclampsia 5 = APH – placenta praevia 6 = APH – placental abruption 7 = APH – other 8 = Pre-labour rupture of membrances 9 = Gestational diabetes 11 = Gestational hypertension 12 = pre-eclampsia superimposed on essential hypertension 10/99 = Other – ICD-10AM codes	From Jan 1980, amended changed 1993 A case may have nil to many values. ICD-10 codes reported for "Other" are not provided. From Jul 2014, items 11 and 12 were added From Jul 2017, ICD-10 codes not provided for Other conditions.

Variable Name	Variable Code	Variable Description	Values	Comments

Medical conditions	MEDCOND	Medical conditions	1 = Essential hypertension 2 = Pre-existing diabetes mellitus 3 = Asthma 4 = Genital herpes 5 = Type 1 Diabetes 6 = Type 2 Diabetes 8 = Other – ICD-10AM codes	From Jan 1980, amended 1993 A case may have nil to many values. From Jul 2014, item 2 was ceased and items 5 and 6 were added ICD-10 codes reported for "Other" are not provided. From Jul 2017, ICD-10 codes not provided for Other conditions.
Influenza vaccination during pregnancy	FLU_VAC_CODE	Vaccination for influenza	01 = Vaccinated during 1st trimester 02 = Vaccinated during 2nd trimester 03 = Vaccinated during 3rd trimester 04 = Vaccinated in unknown trimester 05 = Not vaccinated 99 = Unknown if vaccinated	From Jul 2016
Pertussis vaccination during pregnancy	PERT_VAC_CODE	Vaccination for pertussis	01 = Vaccinated during 1st trimester 02 = Vaccinated during 2nd trimester 03 = Vaccinated during 3rd trimester 04 = Vaccinated in unknown trimester 05 = Not vaccinated 99 = Unknown if vaccinated	From Jul 2016
Procedures/treatments	PROCTRM	Procedures/Treatments	1 = Fertility treatments 2 = Cervical suture 3 = CVS/placental biopsy 4 = Amniocentesis 5 = Ultrasounds 6 = CTG antepartum 7 = CTG intrapartum	From Jan 1993 A case may have nil to many values.
Intended place of birth at onset of labour	INTBTH	Intended place of birth at onset of labour	1 = Hospital 2 = Birth centre attached to hospital 3 = Birth centre free standing 4 = Home 8 = Other	From Jan 1998
Labour Details				

Onset of labour	ONSET		1 = Spontaneous 2 = Induced 3 = No labour (caesarean)	From Jan 1980, amended 1988

Variable Name	Variable Code	Variable Description	Values	Comments
Principal reason for Induction of Labour	REASON_INDUCTION	Main reason that induction of labour was performed	01 = Prolonged pregnancy 02 = Prelabour rupture of membranes 03 = Diabetes 04 = Hypertensive disorders 05 = Multiple pregnancy 06 = Chorioamnionitis 07 = Cholestasis of pregnancy 08 = Antepartum haemorrhage 09 = Maternal age 10 = Body Mass Index (BMI) 11 = Maternal mental health indication 12 = Previous adverse perinatal outcome 19 = Other maternal obstetric or medical indication 20 = Fetal compromise 21 = Fetal growth restriction 22 = Fetal macrosomia 23 = Fetal death 24 = fetal congenital anomaly 80 = Administrative or geographical indication 81 = maternal choice in the absence of any obstetric, medical, fetal, administrative or geopgraphical indication 89 = Other indication not elsewhere classified	From July 2016

Augmentation	AUGLAB		1 = None 2 = Oxytocin 3 = Prostaglandins 4 = Artificial rupture of membranes 8 = Other	From Jan 1990 A case may have one to many values.
Induction	INDUCTN		1 = None 2 = Oxytocin 3 = Prostaglandins 4 = Artificial rupture of membranes 5 = Dilatation device i.e. Foley Catheter 8 = Other	From Jan 1998 A case may have one to many values. Item 5 added from July 2014
Analgesia (during labour)	ANALG	Anaelgesia during labour	1 = None	From Jan 1990, amended Jan 2013

Variable Name	Variable Code	Variable Description	Values	Comments
			2 = Nitrous oxide 3 = intra-muscular narcotics 4 = epidural/caudal 5 = spinal 6 = systemic opioids 7 = combined spinal/epidural 8 = Other	A case may have one to many values. Item 3 ceased from Jan 2013 Item 6 from Jan 2013
Delivery Details				
Duration of labour 1st stage	HRS1ST	Duration of 1st stage of labour in hours and minutes	HH:MM	From Jan 1998. First stage of labour commences when contractions are of sufficient frequency, intensity and duration bring about dilation of the cervix.
Duration of labour 2nd stage	HRS2ST	Duration of 2nd stage of labour in hours and minutes	HH:MM	From Jan 1998. Second stage of labour commences when dilation of the cervix is complete and ends with delivery of the final child.

Postnatal blood loss in mLs	PN_BLOOD_LOSS	Measured and/or estimated blood loss within 24 hours of delivery	Number (NNNNN)	From Jul 2014

Variable Name	Variable Code	Variable Description	Values	Comments
Anaesthesia (during delivery)	ANAES		1 = None 2 = Local anaesthesia to perineum 3 = Pudendal 4 = Epidural/Caudal 5 = Spinal 6 = General 7 = Combined Spinal/Epidural 8 = Other	From Jan 1984, amended 1998 A case may have one to many values.
Complications of labour and delivery	COMPLAB		1 = Precipitate delivery 2 = Fetal distress 3 = Prolapsed cord 4 = Cord tight around neck 5 = Cephalopelvic disproportion 6 = PPH (≥ 500mLs) 7 = Retained placenta – manual removal 8 = Persisten Occipito Posterior 9 = Shoulder dystocia 10 = Failure to progress ≤ 3cms 11 = Failure to progress > 3cms 12 = Previous caesarean section 13 = Other – ICD-10AM codes	From Jan 1984, amended 1993, 1998 A case may have zero to many values. Item 6 ceased from Jul 2014 From Jul 2017, ICD-10 codes not provided for Other conditions.

Variable Name	Variable Code	Variable Description	Values	Comments
Principal reason for CS	REASON_CAESAREAN		01 = fetal compromise 02 = suspected fetal macrosomia 03 = malpresentation 04 = lack of progress <= 3cm 05 = lack of progress in the 1st stage, 4cm to < 10cm 06 = lack of progress in the 2nd stage 07 = placenta praevia 08 = placental abruption 09 = vasa praevia 10 = antepartum/ intrapartum haemorrhage 11 = multiple pregnancy 12 = unsuccessful attempt at assisted delivery 13 = unsuccessful induction 14 = cord prolapse 15 = previous caesarean section 16 = previous shoulder dystocia	From Jul 2014
			17 = previous perineal trauma/4th degree tear 18 = previous adverse fetal/neonatal outcome 19 = other obstetric, medical, surgical, psychological indications 20 = maternal choice in the absence of any obstetric, medical, surgical, psychological indications	

Variable Name	Variable Code	Variable Description	Values	Comments
Perineal status	PERINEAL		1 = Intact 2 = 1st degree tear/vaginal tear 3 = 2nd degree tear 4 = 3rd degree teat 5 = Episiotomy 6 = Episiotomy plus tear 8 = Other 9 = Not stated	From Jan 1993, amended 1998, 2013 A case may have one to many values. Item 6 not reported from 1st Jan 2013 From Jan 2013, able to report multiple values instead of just one.
Baby Details				
Aboriginal status of baby	BABY_IND_CODE	Aboriginal Status of baby	1 = Aboriginal but not TSI 2 = TSI But not Aboriginal 3 = Aboriginal and TSI 4 = Other	From Jan 2011
Adoption Flag	ADOPTN	Indicator of potential for adoption of infant	1 = Yes 2 = No	From Jan 1980 Not reported from Jul 2014
Born before arrival	BBA		1 = Yes 2 = No	From Jan 1998 BBA for booked homebirths is reported if birth occurs at home before homebirth midwife arrived
Date of birth	BDOB		**DDMMYYYY** MMYYYY YYYY	From Jan 1980
Plurality	PLURAL	Number of babies in this birth	Number 1 = Singleton 2 = Twins 3 = Triplets etc	From Jan 1980, amended 1979
Baby number	BABYNO		Number	From Jan 1980 Birth Order i.e. 1 = singleton or 1st baby in a multiple group 2 = 2nd baby in multiple group
Presentation	PRSNT		1 = Vertex	From Jan 1980

			2 = Breech 3 = Face 4 = Brow 8 = Other 9 = Not stated	
Waterbirth	WATER_BIRTH	Was infant born into water i.e. mother was immersed in water at time of birth	1 = Yes 2 = No	From Jul 2016
Method of birth	TYPEBTH	Delivery method-hierarchical	01 = Spontaneous vaginal 02 = Vacuum successful 03 = Vacuum unsuccessful 04 = Forceps successful 05 = Forceps unsuccessful 06 = Breech (vaginal) 07 = Elective caesarean 08 = Emergency caesarean	From Jan 1980 A case may have one to many values. Reporting is mostly hierarchical so the last two digits represent the last delivery mode except where forceps are used at CS or at vaginal breech.
Accoucheur(s)	ACCOUCH		1 = Obstetrician 2 = Other medical practioner 3 = Midwife 4 = Student 5 = Self/no attendant 8 = Other	From Jan 1998 A case may have one to many values. Other includes ambulance officer, partner etc
Gender	GENDER		1 = Male 2 = Female 3 = Indeterminate	From Jan 1980
Status of baby at birth	BSTATUS		1 = Liveborn 2 = Stillborn (unspecified) 3 = Antepartum Stillborn 4 = Intrapartum Stillborn	From Jan 1980, amended 2009 Items 3 and 4 commenced Jan 2009
Infant weight	INFANTWT		Number in grams	From Jan 1980
Length of baby (cms)	BLGTH		Number in centimetres	From Jan 1980
Head circumference	HEADC		Number in centimetres	From Jan 1990

Time to establish unassisted regular breathing	TSR	Time in minutes taken to establish Spontaneous Respirations	Number rounded to nearest minute	From Jan 1980, amended 1988 Livebirths that take less than 1 minute are reported as 1 minute

Variable Name	Variable Code	Variable Description	Values	Comments
Resuscitation	RESUSC		For data extracts provided from Jul 2014 1 = None 2 = Suction only 3 = Oxygen therapy 4 = Continuous Positive Airway Pressure (CPAP) 5 = Bag and mask 6 = Endotrachaeal intubation 7 = Ext. cardiac massage and ventilation 8 = Other	From Jan 1980, amended 1993,1998 A case may have only one value. Prior to 1998 values reported were: 1 = None 3 = Intubation 5 = bag and mask 8 = oxygen only For period 1998 to Jun 2014 values reported and data extracts were 1 = None 2 = Suction only 3 = Oxygen therapy 4 = Bag and mask 5 = endotrachel Intubation 6 = Ext. cardiac massage and ventilation 8 = other
Agpar score at 1 minute	AGPAR1		Number (NN)	Collected from Jan 1990
Agpar score at 5 minutes	AGPAR5		Number (NN)	Collected from Jan 1980
Estimated gestation	ESTGEST	Completed weeks	Number (NN)	Collected from Jan 1984 This is the gestation estimated by midwife at time of birth with reference to the LMP, EDD and appearance of infant
Gestation	GEST		Number (NNN)	Calculated in days from EDD and infant's DOB

Baby separation date	BSEPDATE	Date baby left hospital	DDMMYYYY	Collected from Jan 1980 Date when admission completed by neonatal death, transfer or discharge to a private residence or foster home For homebirths reported as date of birth.
Baby length of stay	BLOS	Baby's length of stay in hospital in days	Number (NNN)	Calculated field from Baby DOB and Baby Separation date. Is 0 for homebirths.
Mode of separation	BMOS	Baby mode of separation	1 = Transferred 8 = Died 9 = Discharged home	Collected from Jan 1980
Transferred To	BDISCHTO	Establishment code of health service or other	0900 = home 0908 = died	Collected from Jan 1980

Variable Name	Variable Code	Variable Description	Values	Comments
		institution where infant was transferred to	0906 = homebirth service 0910 = Gaol 0915 = foster home 0921 = child welfare/adoption 0935 = Graylands Hospital 0985 = Other hospital in Australia 0999 = Unknown hospital 0104 = KEMH etc 0103 = PMH 0107 = Perth Childrens 2102 = Gaol - Bandyup	
Special Care	SPEC	Whole days spent in a level 2 or level 3 nursery at the birth site	Number (NNN)	Collected from Jan 1980 If stay less than 1 day then reported as 1 day.
Geocoding				
Postcode	PCODE	Postcode of usual residence	Number (NNNN)	Overseas visitors will usually have an overseas postcode reported here

Variable Name	Variable Code	Variable Description	Values	Comments
Collector's District	**CD**	Collectors District	Number (##)	The Collector's District (CD) is the smallest geographic unit used in the collection and dissemination of census data and which, in urban areas, has about 300 dwellings, and fewer in rural CD's. The census division code, census subdivision letter and CD letter combine to provide a CD map reference. The CD Serial Number (6 digits) runs from 1 to n in each State with CD's in LGA-CD code order except where new LGA codes have been inserted. The value of n for WA is 1392. The CD number (3 digits) runs sequentially from 1 within an LGA to a maximum of 269 in the largest LGA. Due to the need to add CD's with small numbers of dwellings to adjoining CD's to avoid publishing confidential data, not all serial numbers are present in the CD Summary File data file records.
LGA	LGA	Local Government Area	Number	Collected 1996 onwards. Wouldn't this
				be associated with postcode or suburb?
SLA	SLA	Statistical Local Area	Number	Collected 1996 onwards. Wouldn't this be associated with postcode or suburb?
Radius	RAD	Radius	Number	Collected 1993 – 2003. Wouldn't this be associated with postcode or suburb?

Notes:

Updated: August 2018
Filename: K:\DOCUMENTATION\DATASETS\Midwives\Midwives Notification System Data Variables Sep 2018.docx

Where there are multiple values on the NOCA form, the extracted data will appear as numbers and spaces.
E.g. a record with complications of labour could have ‘urinary tract infection’, ‘pre-eclampsia’ and ‘APH – placental abruption’. In the data extract, this would look like: ‘_ _ _ _0304_ _06_ _ _ _ _ _ _ _’