Perinatal Mortality in Counties Manukau

October 2011

Report prepared for CMDHB by Dr Catherine Jackson
Public Health Medicine Registrar, Planning and Funding

Acknowledgements

I would like to acknowledge and thank my supervisors, Gary Jackson, Doone Winnard and Philippa Anderson for their thoughtful and constructive review and feedback. The support and advice of the Counties Manukau DHB team of public health physicians, Siniva Sinclair, and Wing Cheuk Chan was much appreciated throughout the drafting of this report. I would also like to acknowledge Keming Wang, CMDHB analyst for providing population denominators.

This project would not have been possible without Healthware data provided with much patience by Dianne Wilson, and hospital admission data from Dean Papa.

I would also like to thank the project sponsors and key stakeholders who patiently answered my many questions, provided constructive review, and offered much food for thought and interesting debate during the course of this project - Nettie Knetsch, Sue Miller, Debra Fenton, Thelma Thompson, Keith Allenby, and Sarah Wadsworth.

Suggested Citation: Jackson C (2011) Perinatal Mortality in Counties Manukau. Auckland: Counties Manukau District Health Board.

Abbreviations

BDM	Births, Deaths, and Marriages registry
BRD	Birth Registration Dataset
CMDHB	Counties Manukau District Health Board
DHB	District Health Board
ICD10	International Statistical Classification of Diseases and Related Health Problems, 10th Revision
LMC	Lead Maternity Carer
NDC	Neonatal Death Classification
NICE	National Institute of Health and Clinical Excellence
NICU	Neonatal Intensive Care Unit
NMDS	National Minimum Dataset
NZHIS	New Zealand Health Information Service
OR	Odds Ratio
PDC	Perinatal Death Classification PDC
PHO	Primary Health Organisation
PMMRC	Perinatal and Maternal Mortality Review Committee
PPOR	Perinatal Periods of Risk
SGA	Small for Gestational Age
TFR	Total Fertility Rate
VLBW	Very Low Birthweight (<1,500g)
WHO	World Health Organization

Table of Contents

List of Figures

List of Tables

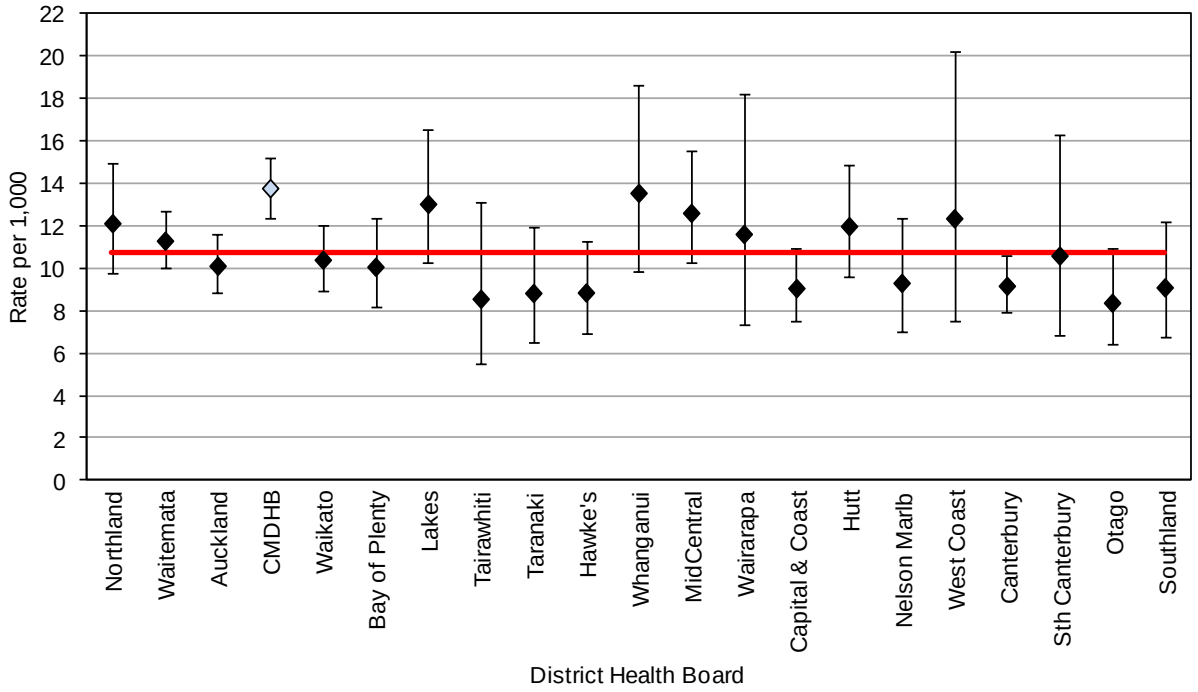
Executive Summary

Counties Manukau District Health Board (CMDHB) is home to 11% of the New Zealand population whilst 14% of all births in New Zealand are to women that live in CMDHB. CMDHB birthing facilities together provide one of the largest birthing services in Australasia, with approximately 8,500 births per year in a population that is predominantly Maaori and Pacific and in which a high proportion of mothers live in areas of high socio-economic deprivation.

CMDHB has consistently had a higher perinatal mortality rate than the national rate.[1-3] This finding was highlighted in the last three reports from the Perinatal and Maternal Mortality Review Committee (PMMRC) (Figure 1) and a recommendation was made for this to be examined further.[1-3] This project examines perinatal mortality in CMDHB resident women in order to aid understanding of the key drivers in this population. Initiatives for reducing perinatal mortality may be implemented within the context of the provision of antenatal care, therefore this report should be read in conjunction with its companion report: *Antenatal Care in Counties Manukau DHB: A focus on primary antenatal care*.[4]

Perinatal mortality in New Zealand is defined as fetal deaths occurring from 20 weeks gestation until delivery (or with a birth weight of at least 400g if gestation is unknown) and all deaths in infants aged less than 28 days old.[1] Fetal deaths include those that occur as a result of a late termination of pregnancy and stillbirths. Perinatal outcomes are influenced by maternal health, gestation, and maternity and newborn care.[5-7] In order to interpret differences in perinatal mortality rates reported by different organisations, an understanding of differences in methodology in calculating these rates is important. The elements to consider when interpreting perinatal mortality statistics include the source of the data, the source population, and the definition of a fetal death (based on gestation and birth weight). The PMMRC provides the highest quality perinatal mortality data in New Zealand.[1]

Figure 1: Crude Perinatal Mortality by District Health Board, New Zealand 2007-09



Source: PMMRC[3]

Project Objectives

The objectives of this project were to:

1. Review the literature to identify the main risk factors for perinatal mortality and describe the distribution of these in the Counties Manukau population.
2. Describe the epidemiology of perinatal mortality in Counties Manukau.

Summary of Main Findings

It is likely that all, or most, of the variation in perinatal mortality across the DHBs in New Zealand can be accounted for by differences in population structure. However crude rates of perinatal mortality are important because they describe what is happening in any given population. CMDHB does have more perinatal deaths per 1,000 births than is seen on average across New Zealand. If CMDHB women had the same perinatal mortality rate as New Zealand women living outside of CMDHB there would be approximately 27 fewer stillbirths and neonatal deaths per year.

The disparity in crude perinatal mortality rates for Maaori and Pacific compared to European/Other women suggests that there are modifiable factors influencing perinatal mortality in Maaori and Pacific women that are amenable to change. This hypothesis is supported by a multivariate analysis that examined the odds of a stillbirth or neonatal death by ethnic group after adjusting for exposure to socio-economic deprivation, parity, smoking, maternity provider, SGA, gestation, or multiple birth in CMDHB women who delivered in a CMDHB facility during 2007-09. This analysis found that ethnicity was not an independent risk factor for a perinatal death i.e. it is not being Maaori or Pacific that places you at higher risk. It is an increased odds of exposure to risk factors such as smoking, obesity, premature birth etc. A review of the main risk factors for perinatal mortality revealed that CMDHB women, and CMDHB Maaori and Pacific women in particular, carry a higher burden of the main drivers of perinatal mortality than women living across New Zealand as a whole.

The most important potentially modifiable risk factors identified during this project were overweight and obesity, advanced maternal age, smoking, pre-existing hypertension, pre-existing diabetes, and placental abruption. Other important risk factors were pregnancy-induced hypertension, fetal growth restriction, and no antenatal care. With the exception of advanced maternal age, the prevalence of all of the other risk factors in CMDHB were similar to or higher than the prevalence nationally. In addition, the prevalence for CMDHB Maaori and Pacific women were higher again.

A number of important findings have been detailed throughout this report, and a summary of the key messages are listed here:

Key Risk Factors for Perinatal Mortality in CMDHB Women

- Extreme prematurity is the leading risk factor for stillbirth and neonatal death.
- Fetal growth restriction contributes to perinatal mortality independently of smoking.
- PMMRC data on the primary antecedent causes of perinatal death in CMDHB infants suggest that diabetes and hypertension during pregnancy are contributing to an increased stillbirth rate in CMDHB.
- Smoking during pregnancy contributes significantly to perinatal mortality in CMDHB independent of any other risk factors. If no CMDHB women smoked during pregnancy the total perinatal mortality rate (excluding terminations) could be expected to decrease by 21% for all infants and by 67% for infants born to Maaori women.

- Overweight and obesity in CMDHB mothers is contributing to stillbirths in infants born weighing 1,500g or more. If all CMDHB mothers had a weight in the normal range at conception, the total perinatal mortality rate (excluding terminations) could be expected to decrease by 12% for all infants and by 26% for infants born to Pacific women.

- After controlling for the effects of identified risk factors, perinatal mortality does **not** vary by ethnicity and socio-economic status. This finding supports the hypothesis that perinatal mortality rates are higher in Maaori and Pacific women and women living in the most deprived area due to greater exposure to other risk factors.

- Teenage women delivering in a CMDHB facility are **not** at higher risk of stillbirth or neonatal death.

Impact of Maternity Care on Perinatal Mortality in CMDHB

- Perinatal mortality does not differ by primary maternity provider in CMDHB.

- Being under Secondary Care is independently associated with increased odds of stillbirth but not neonatal death. This finding was expected as Secondary Care provides specialist care to women with high risk pregnancies.

- Women who have no antenatal care have the highest crude perinatal mortality.

- Having no antenatal care does **not** increase the odds of having a stillborn infant weighing ≥1,500g or a neonatal death independently of other risk factors, suggesting that women with no antenatal care have greater exposure to other risk factors than women who engage with antenatal care.

- Having no antenatal care was an independent risk factor for having a stillborn infant weighing <1.500g. However, the number of stillbirths <1,500g in women that did not access antenatal care was very small (17 in three years).

- Reducing perinatal mortality via improving engagement with antenatal care assumes that these deaths can be prevented versus being reclassified as deaths in women who accessed care. However without engagement with antenatal care there is little potential for prevention.

Recommendations

A Perinatal Periods of Risk analysis suggests that a total population focus on deaths in the Maternal Health / Prematurity risk period is appropriate and would address more than half (58%) of the excess perinatal mortality in CMDHB. In addition, a focus on the Maternal Care period of risk for Pacific women could address approximately half of the excess mortality in this group, and 27% of the total excess perinatal mortality in CMDHB. A focus on neonatal mortality in infants weighing ≥1,500g (Newborn Care risk period) could be considered a lower priority on the basis of this analysis, as the number of excess deaths in this risk period was lower. In addition, actions focussing on the other two risk periods are likely to contribute to reduced mortality in the Newborn Care risk period also (e.g. reducing smoking in pregnancy). The recommendations for the Counties Manukau District Health Board to consider are summarised here and discussed in more detail in Chapter 5.

1. That community engagement be a key component of developing approaches for reducing perinatal mortality in CMDHB

While it is clear that reducing perinatal mortality in CMDHB is a priority for the Ministry of Health, it is not clear that it is a recognised priority in the lives of women living in CMDHB. The actions required for improving perinatal mortality in CMDHB primarily involve behavioural changes that are often challenging - planning pregnancy, weight management, improving nutrition, smoking cessation, engagement in antenatal care. As part of community engagement, research exploring attitudes and understanding of perinatal mortality in Maaori and the main Pacific groups in CMDHB is recommended.

A population wide (universal) approach is recommended as the "flags" for identifying women at high risk for a poor perinatal outcome recommended by the PMMRC are applicable to the majority of the CMDHB maternity population (see section 3.10). If preventing perinatal deaths is a priority for communities these changes may be easier to achieve, and community groups may be able to be mobilised to support women and whaanau during pregnancy. Practical and material support from whaanau/friends/communities could include help with transport to antenatal clinics, smoking cessation in all whaanau / marae / church members, community fruit and vegetable gardens.

2. That the Maternal Health / Prematurity risk period be a main focus

Potential approaches for addressing high perinatal mortality in the Maternal Health / Prematurity risk period include improving wellbeing in women of childbearing age (e.g. reduce smoking, improving nutrition, reducing obesity, increase planned pregnancies, sexually transmitted infection prevention), preconception care (e.g. folate to reduce the risk of neural tube defects), and early engagement with antenatal care.[5, 6] Population level approaches delivered to all women of child bearing age would be more appropriate in CMDHB, as the provision of pre-pregnancy counselling is unlikely to target those women at highest risk of a poor outcome because rates of unplanned pregnancy are likely to be highest in these women.[8]

Smoking cessation should be a primary focus including:

- Ongoing audit of the implementation of screening and brief intervention for smoking cessation
- An assessment of the effectiveness of current smoking cessation programmes within the DHB, particularly those focussed on smoking cessation in Maaori
- Engagement with Maaori health providers regarding the dissemination of the findings of this project with respect to the impact of smoking in pregnancy on outcomes
- A review of the CMDHB role in prevention of smoking uptake in young people, with a particular focus on Maaori who have the highest rates of smoking in pregnancy in the teenage years.

There is a role for audit of the implementation of recommendations made by the PMMRC with respect to:

- Early initiation of antenatal care (before 10 weeks gestation)
- Taking weight and height measurements at the first antenatal visit
- Use of customised fetal growth charts to identify fetal growth restriction

Additional actions that could be considered include:

- Early antenatal scan (<10 weeks) to improve pregnancy dating accuracy, detection of fetal growth restriction, and reduce induction of labour for post-dates pregnancies[4]
- Screening and brief intervention for alcohol and recreational drug use
- Programmes aimed at reducing unwanted pregnancy e.g. free and timely provision of longer-term or permanent contraception options (intrauterine devices (e.g. mirena), tubal ligation, vasectomy)

Areas for future research include:

- Barriers to planning pregnancy and accessing contraception in CMDHB
- Population attitudes to and understanding of perinatal mortality
- Review of the literature on effective interventions to prevent pre-term birth, and application to the CMDHB setting

3. That the Maternal Care risk period be a primary focus for Pacific Women

For increased mortality in the Maternal Care risk period, actions include providing adequate antenatal care, screening, smoking cessation programmes, risk assessment and referral, and appropriate use of secondary maternity care.[5, 6] Overweight and obesity are contributing to perinatal mortality during this period, however a review of the evidence for management of obese women during pregnancy was beyond the scope of this project. Each year in CMDHB approximately 1,640 overweight and 2,300 obese women have a delivery.

There is cross over in actions in this period with those recommended for the Maternal Health / Prematurity risk period. In addition:

Overweight and obesity should be a particular focus with the following actions considered:

- A review of the evidence for the appropriate management of obese women during pregnancy
- A focus on increasing the documentation of weight and height measurements at the first antenatal visit
- Development of advice regarding appropriate weight gain in pregnancy for all women
- Development of explicit nutritional guidelines in pregnancy
- Post-partum weight management programmes

There is a role for audit of the implementation of recommendations made by the PMMRC with respect to:

- Diabetes screening, follow-up, and referral
- Screening and referral for fetal growth restriction
- Appropriate referral to Secondary Care

4. That CMDHB Maternity Information Systems be Improved

Improvements for the CMDHB collection of maternity data are recommended in the companion antenatal care report.[4] These recommendations include the review of current variables collected and the development of a core data set of mandatory fields, with little other data collected. All data should be collected with a clear understanding of its utility; the

process for determining this would be enhanced by the development of a CMDHB maternity data collection data dictionary. This document would also standardise definitions, standardise data entry, inform staff training and facilitate research. The development of a web-based system is supported and consideration should be given to how private LMCs and Shared Care providers can be incentivised to submit data.

In order to inform future CMDHB perinatal research, important data elements should be added. These should include date of first antenatal visit, completion of screening events during pregnancy (i.e. yes, no, declined), and the presence of important risk factors (e.g. pre-existing hypertension, pregnancy induced hypertension, pre-existing diabetes, diabetes diagnosed in pregnancy, antepartum haemorrhage). Consideration should be given to ways of increasing the completeness of smoking and body mass data.

Chapter 1. Introduction

CMDHB has consistently had a higher perinatal mortality rate than the national rate.[1, 9] This warrants investigation to identify the aetiology of excess perinatal mortality in this population. Actions the DHB can take to reduce perinatal mortality in the CMDHB population are likely to occur within the context of the provision of antenatal care. The model of primary antenatal care in CMDHB was reviewed and described in a previous project, with recommendations for changes in this model discussed.[4]

The way perinatal mortality has been determined and reported has varied over time in New Zealand. Understanding these changes is important, particularly as the number of deaths has declined, because small differences in numbers between reports can create the appearance of differences in rates. Therefore, interpreting perinatal mortality data, and particularly in making comparisons between publications both nationally and internationally, requires an understanding of the methodologies employed.

This chapter provides a brief introduction to the CMDHB model of antenatal care and describes important changes and differences in the way perinatal mortality is calculated and reported.

1.1 CMDHB Model of Antenatal Care

A review of the CMDHB model of antenatal care was the focus of a parallel project that is reported separately in a companion report entitled *Antenatal Care in Counties Manukau DHB: A focus on primary antenatal care*.[4] These two reports should be read in conjunction, however a brief description of the CMDHB model of antenatal care is provided here to aid interpretation of the analyses presented in this report.

All women living in CMDHB are entitled to access free maternity care within the DHB. Women can access primary maternity services via a private lead maternity carer (LMC) who can be a self-employed midwife, GP, or private obstetrician, or via CMDHB maternity services. Maternity services offered by CMDHB are described in Table 1. The primary maternity services offered include community and hospital based primary midwifery services (Closed Unit and Caseloading) and Shared Care. Shared Care is unique to CMDHB and developed in response to a Private LMC shortage. Women who choose Shared Care receive most of their antenatal care from a GP that enters into a Shared Care arrangement with the DHB. In addition, these women are offered three antenatal visits with a DHB employed community midwife and are delivered at a CMDHB facility by a DHB employed midwife. GPs that provide Shared Care are not required to have specific training in antenatal care and are not required to have a postgraduate Diploma of Obstetrics and Gynaecology. Women identified as high risk are referred to Secondary Care, which includes both the Obstetric Medical Clinic and Diabetes in Pregnancy Service.

Women have a choice of birthing location and in CMDHB there are three primary birthing units located in Botany Downs, Papakura, and Pukekohe in addition to a delivery suite at Middlemore Hospital. Primary birthing units are staffed by CMDHB midwives but can be used by self-employed LMCs. These units are suitable for women with a low risk pregnancy.

In summary, the range of maternity services available to CMDHB resident women is similar for the most part to that offered elsewhere in New Zealand. In addition, CMDHB resident women have the option of receiving their antenatal care from their GP in a Shared Care arrangement with CMDHB midwives if their GP offers this service.

Table 1: CMDHB Maternity Services

Service	Description
Closed Unit	Antenatal, labour, and postnatal care is provided by a CMDHB employed midwife with clinics held at Middlemore Hospital, Manukau or Botany SuperClinic, or in the community. Antenatal and postnatal care is provided by a CMDHB community midwife, whilst labour care is provided DHB employed midwives at Middlemore Hospital or one of the Primary Maternity Units. High risk women may receive closed unit care in conjunction with an Obstetric Senior Medical Officer.
Shared Care	Maternity care is shared between the woman's GP and a CMDHB midwife. Most antenatal care is provided by the GP, with three antenatal visits offered with a CMDHB community midwife. Labour care is provided by a CMDHB employed midwife, and postnatal care is provided by the CMDHB community midwife service. If a woman becomes high risk, care is transferred to the Closed Unit service.
Caseloading	This service provides continuity of care throughout pregnancy, labour, and the postnatal period. A CMDHB employed midwife works within a team to provide care as per the LMC model. Women deemed at high risk may continue with Caseloading care in conjunction with an Obstetric Senior Medical Officer.
Teenage Pregnancy	CMDHB community midwife clinics for young mothers aged <18 years run at Awhitia (on the Middlemore site) and at Manukau SuperClinic with social work and transport support. Home visits are provided if needed. This service provides continuity of care throughout pregnancy, labour, and the postnatal period.
Diabetes in Pregnancy	For women with previous or newly diagnosed diabetes (Type I & II or Gestational) and provided by a multidisciplinary team comprised of an obstetrician, midwife, diabetes physician, and dietician. CMDHB employed midwives provide antenatal and postnatal continuity of care.
Obstetric Medical Clinic	This clinic provides maternity care for women with complex medical problems during pregnancy and is located at Manukau SuperClinic. Women are seen by the specialist team with midwifery care provided by the women's LMC or a CMDHB employed midwife.

Source: CMDHB[4, 10]

1.2 Perinatal Mortality

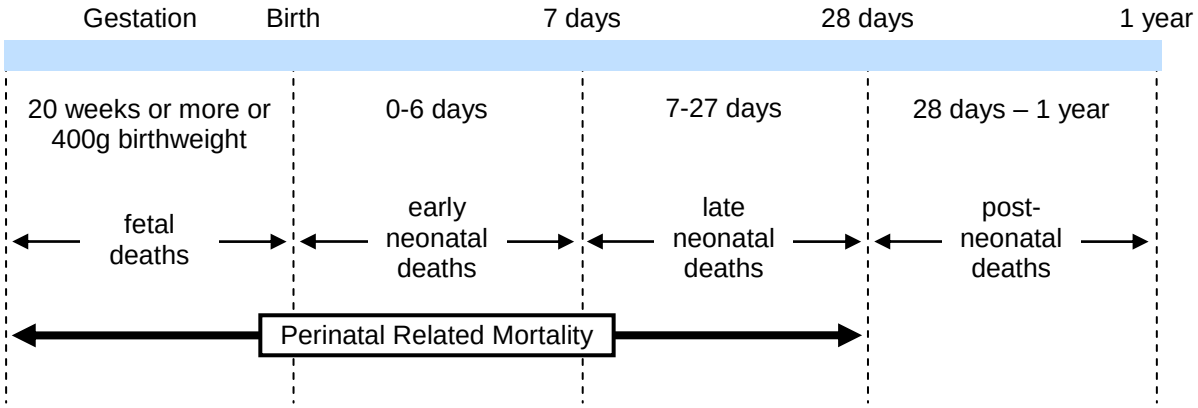
Perinatal mortality is comprised of fetal deaths (stillbirths) and deaths in the neonatal (newborn) period. The New Zealand Births, Deaths, Marriages, and Relationships Registration Act 1995 requires birth registration and a death certificate for stillborn infants who weigh 400g or more at birth or that were born after 20 weeks of pregnancy, including those resulting from a termination of pregnancy.[11] Early neonatal deaths are those that occur within 7 days of birth and late neonatal births are those that occur within 28 days of birth.

Perinatal deaths are traditionally the combination of fetal deaths and early neonatal deaths. In this report, in line with the Perinatal and Maternal Mortality Committee (PMMRC) methodology, perinatal related mortality also includes late neonatal deaths i.e. those occurring on days 7-27 of life (Figure 2).[1]

1.2.1 New Zealand Perinatal Mortality Surveillance

In New Zealand, fetal death and perinatal mortality rates are available from the Ministry of Health, Statistics New Zealand, and most recently PMMRC. Published rates from these sources differ as a result of varying methodology used. Sources of perinatal mortality data are discussed here.

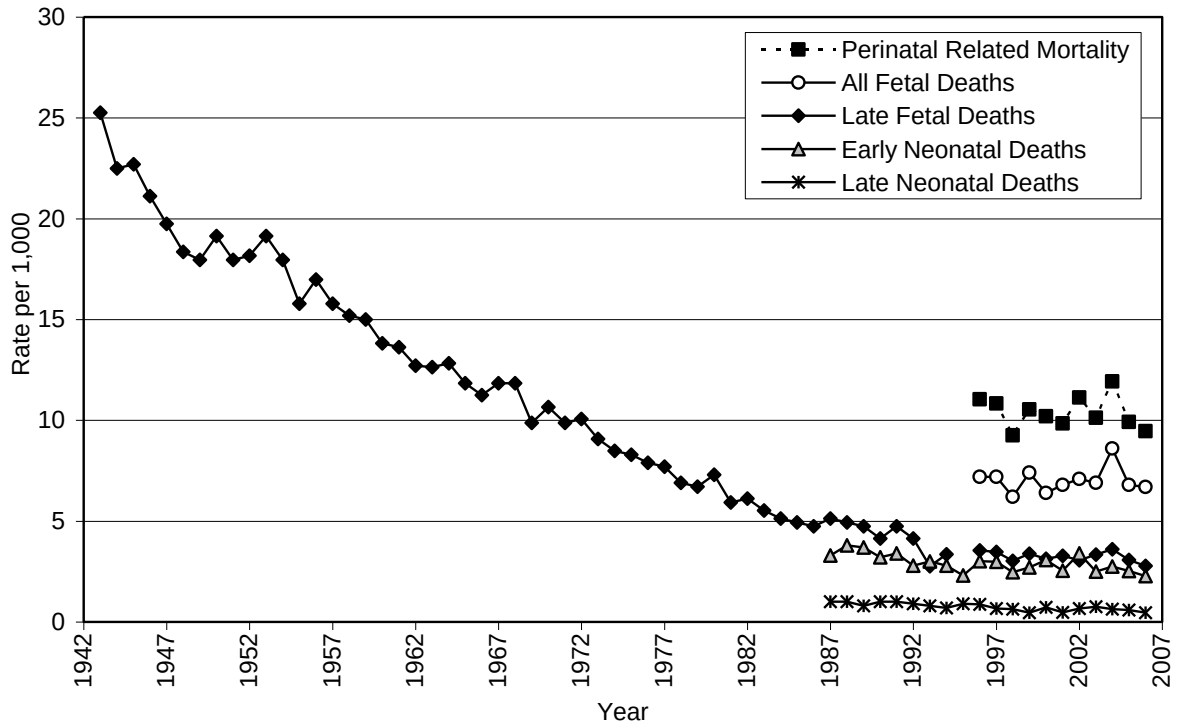
Figure 2: Fetal and Infant Death Periods



1.2.1.1 Ministry of Health

Fetal death rates since the 1940's are available from the Ministry of Health calculated as a rate per 1,000 births. Prior to September 1995 only births that occurred from 28 weeks gestation legally required registration although fetal deaths from 20 weeks required a Medical Certificate of Cause of Death. As a result, fetal death rates up until 1995 are for late fetal deaths that occurred from 28 weeks gestation only (Figure 3). Since 1996, fetal deaths include those of 20 or more weeks gestation or with a birthweight of at least 400g. Annual *Fetal and Infant Deaths* surveillance reports are available from the Ministry of Health.[12] Rates are calculated using the number of perinatal deaths registered in a calendar year divided by the total number of births registered in the same year with data sourced from the National Mortality Collection and the Birth Registration Dataset respectively.

Figure 3: Perinatal Mortality, New Zealand 1943-2007



Source: Ministry of Health[12]. Note: Perinatal related mortality (from 1996) includes all fetal deaths, early neonatal deaths and late neonatal deaths. Perinatal related mortality and fetal death rates are per 1,000 births. Neonatal deaths are per 1,000 live births.

Mortality Collection

Perinatal death data is sourced from the national Mortality Collection. The Mortality Collection is maintained by the Ministry of Health's Sector Services (formerly the New Zealand Health Information Service).[13] Each month Births, Deaths, and Marriages (BDM) submits electronic death registration and stillbirth data (for the previous month's registrations), Medical Certificates of Causes of Death (BDM 50 and BDM 167), and Coroners' reports. Additional information on the underlying cause of death is obtained from the National Minimum Dataset (NMDS) and private hospital discharge returns, the New Zealand Cancer Registry, the Department for Courts, the Police, the Land Transport Safety Authority, Water Safety NZ, Media Search, and from writing letters to certifying doctors, coroners, and medical records officers in public hospitals. Causes of death are coded using World Health Organization (WHO) Rules and Guidelines for Mortality Coding and *International Statistical Classification of Diseases and Related Health Problems, 10th Revision* (ICD-10) codes.[13]

Ministry of Health published mortality rates from this collection are based on the year of death registration. Data availability relies on all of the deaths registered within a calendar year having the cause(s) of death coded, and data is generally available 2-3 years in arrears i.e. mortality data is currently available for deaths registered up until 2007.

National Minimum Dataset (NMDS)

Perinatal mortality is reported in the following Ministry of Health reports: the *Maternity Reports* 1999-2004, *the Hospital-Based Maternity Events* reports for 2005-2006, and the *Maternity Snapshot* for 2007-2008.[14] These all report in-hospital fetal death rates but only the 1999-2005 reports include neonatal mortality. Data is sourced from the NMDS which captures all hospital events.

A comparison of births captured by the NMDS and the Birth Registration dataset shows that during 2004-2009 4.8% of live births were not recorded on the NMDS. Fetal deaths are not captured as an infant birth event in the NMDS, but are recorded as a stillbirth in the maternal birth event record. A neonatal death that occurs in hospital is captured in the infant's record. Consequently, NMDS data under-reports fetal and neonatal deaths as deaths that occur outside of hospital are not captured.

1.2.1.2 Statistics New Zealand

The annual number of stillbirths (fetal deaths) and neonatal deaths are available from Statistics New Zealand by year of death registration.[15] Statistics New Zealand birth data is by birth registration year and excludes late birth registrations (more than two years after the birth) and births to mothers who usually reside overseas. Fetal or neonatal deaths where the mother usually resides overseas are also excluded. As a consequence, data sourced from Statistics New Zealand under-estimates fetal death and neonatal mortality rates (Table 3).

The number of stillbirth and neonatal deaths per year up until 2009 are available. These data are sourced by Statistics New Zealand from the BDM Registry.

1.2.1.3 Perinatal and Maternal Mortality Review Committee (PMMRC)

The PMMRC was established in 2005 under the *New Zealand Public Health and Disability Act 2000* and is appointed by, and accountable to, the Minister of Health. The committee are required to investigate and report on all perinatal deaths, develop strategic plans and methodologies for reducing perinatal mortality, and to promote ongoing quality assurance programmes.[16] To this end a perinatal deaths database was established and began prospectively collecting data on 1 July 2006. The PMMRC reports annually to the Minister of Health with these reports available via the PMMRC website (www.pmmrc.health.govt.nz).

The PMMRC collects perinatal mortality data independent of the Mortality Collection and reports rates by year of death and not registration year.[1] The perinatal deaths database compiles data from local coordinators in each DHB, death notifications and data from Births, Deaths and Marriages (BDM). Lead maternity carers (LMCs) are required to complete rapid reporting forms within 48 hours of a perinatal death for the mother and the infant.[17] Perinatal deaths that occur outside hospital are most often identified via the coroner or the BDM registry.

The PMMRC classifies fetal and neonatal deaths using the Perinatal Society of Australia and New Zealand (PSANZ) classification system with all deaths assigned a Perinatal Death Classification (PDC) Neonatal deaths are also assigned a Neonatal Death Classification (NDC).[18] The PDC identifies the obstetric antecedent factors that initiated the sequence of events leading to the death and the NDC identifies fetal and neonatal factors associated with the death.[19]

1.2.1.4 Summary of the Main Perinatal Mortality Surveillance Issues

The differences in the methodology used to determine perinatal mortality are summarised in Table 2. Methodological differences result in different published fetal and neonatal mortality rates (Table 3 and Table 4).

The PMMRC provides the highest quality perinatal mortality data. It is the most accurate, complete (all deaths and not just in-hospital deaths), timely (vs. Mortality Collection), and reports deaths by date of death and not year of death registration.[1] This last distinction is important because it can take up to 2-3 years for a death to be registered; therefore Mortality Collection data for deaths that occurred in 2007 and were registered in 2008 or 2009 may not be available until 2011 or 2012. In contrast, in 2011 PMMRC published data on all perinatal deaths that occurred in 2009.[3] Late registrarion of a death is common. Of the fetal deaths registered during 2003-2007, 14% occurred up to 3 years before they were registered. For neonatal deaths registered during 2003-2007, 7% occurred up to 3 years before they were registered.

Table 2: New Zealand Perinatal Mortality Data Sources

Source	Numerator (number of deaths)	Denominator (number of births)	Notes
Ministry of Health	Deaths by registration year. Data sourced from the Mortality Collection.	Total births from the Birth Registration Dataset	Reported in the Fetal and Infant Death Reports
Ministry of Health	Deaths by year of death. Data sourced from the NMDS.	Total births with an associated hospital admission (NMDS)	In-hospital births and deaths.
Statistics New Zealand	Deaths by registration year. Data sourced from the Births, Deaths and Marriages Registry.	Total births from the Birth Registration Dataset. Excludes registrations >2 years after the birth	Excludes births and deaths where the mother usually resides overseas
PMMRC	Deaths by year of death. Data collected by local coordinators, LMCs, from death registrations (BDM), coroner.	2006 report – total births from the NMDS 2007+ reports - total births from the Birth Registration Dataset	Reports greater case ascertainment than the Mortality Collection[1]

Note: NMDS: National Minimum Dataset; LMC: Lead Maternity Carer; BDM: Births, Deaths and Marriages Registry

Table 3: Fetal Mortality by Data Source, New Zealand 2004-2009

Year	Ministry of Health				Statistics New Zealand[15]		PMMRC[1-3]	
	Mortality Collection[12]		NMDS[14]					
	No.	Rate	No.	Rate	No.	Rate	No.	Rate
2000	369	6.4	406	7.3	---	---		
2001	387	6.8	379	6.9	325	5.8		
2002	390	7.1	401	7.4	354	6.5		
2003	393	6.9	414	7.5	346	6.1		
2004	505	8.6	441	7.9	483	8.2		
2005	403	6.8	393	7.1	360	6.2		
2006	409	6.7	407	7.1	370	6.2		
2007	---	---	421	6.9	459	7.1	510	7.8
2008	---	---	476	7.8	507	7.8	524	8.0
2009	---	---	---	---	384	6.1	539	8.5

Note: Fetal mortality rate is per 1,000 total births. NMDS: National Minimum Dataset. PMMRC: Perinatal and Maternal Mortality Committee. ---: not available.

Table 4: Neonatal Mortality by Data Source, New Zealand 2004-2009

Year	Ministry of Health				Statistics New Zealand[15]		PMMRC[1, 2]	
	Mortality Collection[12]		NMDS[14]					
	No.	Rate	No.	Rate	No.	Rate	No.	Rate
2000	216	3.8	191	3.5	---	---		
2001	170	3.0	134	2.5	154	2.8		
2002	221	4.1	187	3.4	189	3.5		
2003	184	3.3	182	3.3	163	2.9		
2004	198	3.4	167	3.0	180	3.1		
2005	183	3.1	179	3.2	182	3.2		
2006	165	2.7	---	---	158	2.7		
2007	---	---	---	---	171	2.7	167	2.6
2008	---	---	---	---	188	2.9	176	2.7
2009	---	---	---	---	175	2.8	182	2.9

Note: Neonatal mortality rate is per 1,000 live births. NMDS: National Minimum Dataset. PMMRC: Perinatal and Maternal Mortality Committee. ---: not available.

1.2.2 International Comparisons

The World Health Organisation (WHO) recommends international perinatal mortality comparisons be made using stillbirth defined as the death of a fetus weighing at least 1000g, or from 28 weeks gestation if the birthweight is unknown.[20] Using this definition, New Zealand fetal death and perinatal mortality rates compare favourably with international rates (Table 5).[20]

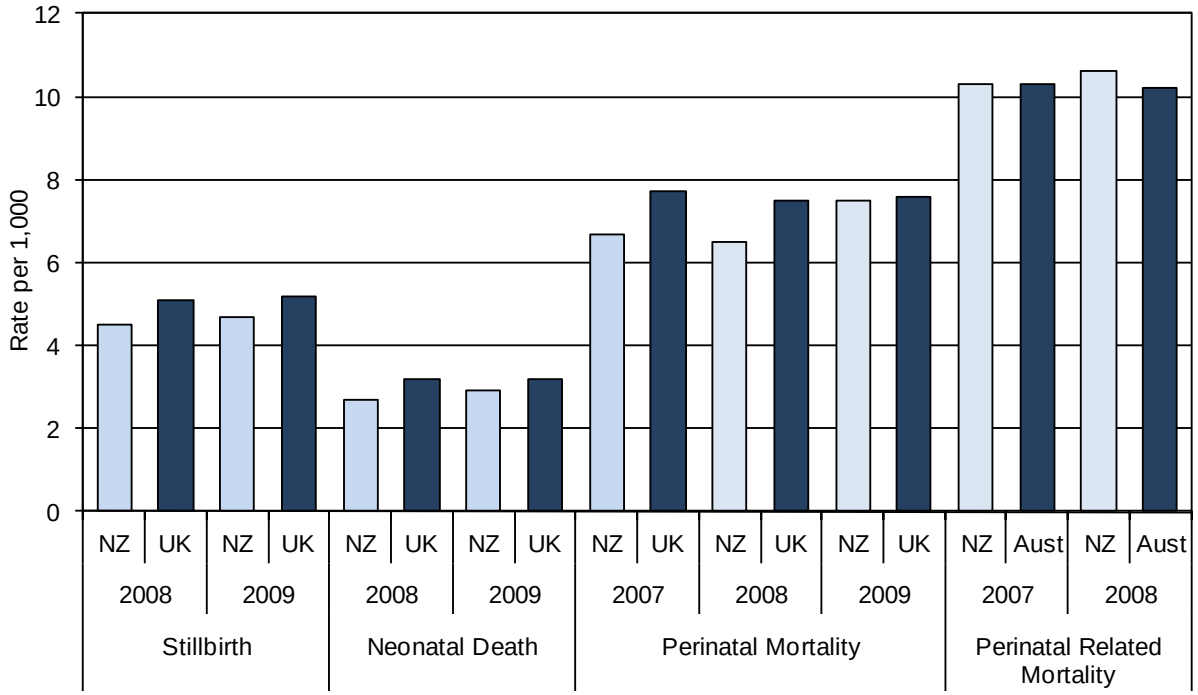
Table 5: Country Estimates of Late Stillbirth and Perinatal Mortality Rates, 2000

	Late Fetal Death Rate (per 1000 births)	Perinatal Mortality (per 1000 births)
New Zealand	**3**	**6**
Australia	3	6
North America	3	7
Western Europe	4	6
United Kingdom	5	8
Developed Countries	6	10
Polynesia	11	20
Samoa	12**	21
Tonga	10**	18
Cook Islands	11**	20
Niue	12**	22

Source: World Health Organisation[20]. Note: Late fetal death includes the death of a fetus weighing at least 1000g, or from 28 weeks gestation if the birthweight is unknown. Perinatal mortality is late fetal deaths and infant deaths within the first week of life combined. **Estimated.

The PMMRC has published more recent comparisons of New Zealand perinatal mortality with Australia and the United Kingdom[1, 2] . These comparisons use equivalent methodologies and all include deaths from 24 weeks gestation. New Zealand continues to compare favourably in these more recent comparisons (Figure 4).

Figure 4: Country Estimates of Perinatal Mortality, 2007-2009



Source: PMMRC[1-3]. Note: Methodologies aligned between New Zealand and comparison country. Perinatal mortality and stillbirths in this graph exclude fetal deaths before 24 weeks gestation, and perinatal mortality includes neonatal deaths up to 6 days of age. Perinatal related mortality includes neonatal deaths up to 27 days of age.

1.2.3 Provider vs Population Data

In addition to national perinatal mortality reports, individual District Health Boards (DHB) can analyse and report data collected locally. DHBs frequently report on both provider level data and population level data. These two groups of people can vary significantly, particularly when examining maternity and perinatal data as women have a choice of maternity provider.

With respect to maternity and perinatal data in Counties Manukau DHB (CMDHB), provider level data is collected for all women and infants who accessed maternity services provided by CMDHB, irrespective of where they usually reside. In CMDHB during 2007-09, an annual average of 602 women who lived outside of CMDHB delivered in a CMDHB facility (~8% of the total births in a CMDHB facility).[4]

Population level perinatal mortality data for CMDHB is any deaths that occur in an infant born to a woman who resides within the CMDHB boundary, irrespective of where she delivers. This is the data reported by the PMMRC.[3] During 2007-09, 14% of CMDHB resident women delivered outside of CMDHB.[4]

As a provider, CMDHB submits provider level data to the Women's Hospitals Australasia (WHA) organisation that are reported (anonymised) annually to member hospitals.[21] In these reports CMDHB perinatal mortality reported is lower than that reported by the PMMRC causing some confusion (Table 6).

Table 6: Counties Manukau DHB Perinatal Mortality Rates by Source, 2007-08

Mortality Rate per 1,000	PMMRC[1, 2] Domiciled Population			WHA[21] Provider Population	
	NZ 2007	CMDHB 2007	CMDHB 2008	CMDHB 06/07	CMDHB 07/08
Stillbirth	**7.8**	9.0	9.3	8.7	8.6
Neonatal	**2.6**	4.6	3.3	4.0	3.9
Perinatal	**10.3**	13.4	12.6	13.2	12.2

Stillbirth and perinatal rates are per 1,000 total births. Neonatal rate is per 1,000 live births

Because at a DHB level, perinatal deaths are relatively rare events, small differences in methodology and case ascertainment can result in apparent differences in rate calculations. If confidence intervals were provided they would most likely suggest that the differences are not statistically significant. The differences in rates shown in Table 6 are attributable to the following factors:

1. *Reporting Timeframes*: The PMMRC reports by calendar year and the WHA by financial year.
2. *Sample Population*: The PMMRC reports by domiciled population and the WHA by the population using a facility.
3. *Case Ascertainment*: The PMMRC reports all deaths with cases ascertained from numerous sources whereas the WHA reports are based on locally collected data which does not completely capture stillbirths at home and deaths that occur following discharge.

In addition, in the WHA reports CMDHB is not an outlier for stillbirth or neonatal mortality, and sits towards the middle for contributing facilities, and close to the average rate for facilities with a level III neonatal intensive care unit (NICU).[21] However reported rates by facility varied markedly, for example for stillbirths the rates reported ranged from 3.2 per 1,000 in a facility with no level III NICU to 15.7 in a facility with a level III NICU. Because data are reported by facility and not population, some facilities report much higher stillbirth

and neonatal mortality rates than for either New Zealand or Australia. This is primarily due to high rates in hospitals with level three NICUs that deliver high risk women and infants, particularly those that are tertiary referral centres.

1.3 Chapter Summary

Perinatal mortality in New Zealand has declined markedly over the last fifty years, although little change in rates is observed over the last twenty years. Of note, there is no observable difference in national perinatal mortality rates following changes in the model of primary maternity care that occurred in New Zealand during the 1990s. The establishment of the PMMRC in 2006 has refocused attention on perinatal mortality.

In order to interpret differences in perinatal mortality rates reported by different organisations, an understanding of differences in methodology is important. The elements to consider when interpreting perinatal mortality statistics include, identifying the source of the data, the source population, and the definition of a fetal death (based on gestation and birth weight). The PMMRC provides the highest quality perinatal mortality data in New Zealand. It is the most accurate, complete (all deaths and not just in-hospital deaths), and timely (vs. Mortality Collection) data source.[1]

Investigating perinatal mortality is particularly challenging at a DHB level due to a limited capacity to identify deaths of infants born to resident mothers that occur outside of the DHB or outside of the hospital setting. This issue is illustrated in Chapter 4 in a comparison of CMDHB local data with CMDHB data reported by the PMMRC. DHBs would be better able to investigate perinatal mortality in their resident population if data collected by the PMMRC were made available to the local DHB PMMRC coordinator.

The focus of this report is the CMDHB resident population. Each DHB has a responsibility for the population that resides in their geographical catchment area irrespective of where this population accesses health care. This focus is an important distinction from other reports and analyses published by the CMDHB provider arm that are understandably focused on data related to the women and infants to whom they provide care, irrespective of where these women live.

Chapter 2. Report Methodology

The methods used to compile the information presented in this report include sourcing published data from the grey and medical literature, secondary analysis of data held in the Birth Registration Dataset (BRD), the National Minimum Dataset (NMDS) and locally in Healthware, and a review of the medical literature. This Chapter briefly describes the data sources used in this report, highlighting important limitations. Issues related to interpretation of the data presented in this report are highlighted here and throughout the text where significant issues were identified.

2.1 Literature Review Methods

A literature review was undertaken with the aim of identifying risk factors for perinatal mortality. The results are presented in Chapter 3, along with an estimate of the prevalence of important risk factors in CMDHB and New Zealand. Pubmed and Medline were searched with an emphasis on systematic review articles in the first instance. The following search terms were used:

- systematic[sb] AND (perinatal mortality)
- systematic[sb] AND (stillbirth)
- systematic[sb] AND (neonatal mortality)
- "Perinatal Care/statistics and numerical data"[MeSH Terms]
- "Perinatal Mortality"[Mesh] and risk factors
- "Perinatal Mortality"[Mesh] and New Zealand

The Cochrane Library was also search using the terms “perinatal mortality”,“stillbirth”, and “neonatal death”. Reference lists within publications were also reviewed in order to identify relevant articles.

2.2 Data Sources and Methods

Data to inform this project were sourced from the PMMRC, the NMDS and HealthWare. The particular issues and limitations of these data sources are described here:

2.2.1 Perinatal and Maternal Mortality Review Committee

The best source of perinatal mortality data in New Zealand is the PMMRC. This is presented in aggregated form in annual reports[1-3], with aggregated DHB level data provided to DHBs on request. For 2007-08 data these reports for CMDHB were limited to perinatal mortality rates by type of death, ethnicity, NZ deprivation index decile (NZDep) at census area unit level, and perinatal death classification.

2.2.1.1 Strengths

The PMMRC dataset is the most complete dataset of perinatal deaths in New Zealand, with data collected prospectively. Reports of this data are timelier than those published prior to the establishment of this group. Ethnicity and NZ deprivation index data in this dataset are sourced from the Birth Registration Dataset and are of high quality (see section 2.2.3).

2.2.1.2 Limitations

The current data access policy for the PMMRC does not allow access to individual patient level data, therefore a dataset containing all known data for all perinatal deaths in CMDHB for 2007-08 was not supplied.

Detailed data are collected by the PMMRC for all perinatal deaths; however similar data for mother-infant dyads that do not result in a perinatal death are not collected by this group, limiting the ability to investigate perinatal mortality in New Zealand in any great depth. In particular, risk factor data are not available for all child-bearing women. One of the key recommendations of the PMMRC has been the expansion of the birth registration dataset to include the collection of risk factor data (e.g. parity, major complications, mode of birth, history of smoking and previous obstetric history).[2]

2.2.2 HealthWare

Healthware is a software package used at CMDHB since October 2004 to capture maternity data, replacing Terranova which was implemented in the late 1990's. A local database for maternity data was necessary to enable claiming for the provision of primary maternity services under Section 88; however this function is no longer needed as DHBs are now bulk-funded for these services. Healthware has undergone various upgrades since its introduction but remains clumsy and difficult to use. Recently, the requirements of a web-based maternity data system for the DHB have been scoped, and CMDHB has had input into the development of a national system. It is likely to be several years before a national maternity data system is in place.

Healthware is used to record antenatal, labour and delivery, and postnatal data for the women and their infants who use CMDHB maternity services. Data are generally entered by CMDHB employed midwives and CMDHB administrative staff. Private LMCs and Shared Care GPs do not currently enter data directly into the system.

2.2.2.1 Strengths

Healthware provides a rich source of data not available from other sources including maternity service provider, booking date, estimated delivery date (EDD), antenatal visit data, body mass index, smoking, alcohol use, and parity. In Healthware mothers can be linked to their infant's, allowing more in depth analyses to be performed.

2.2.2.2 Limitations

Data are limited for women who do not have all of their antenatal care provided by CMDHB (i.e. those women with a private LMC or Shared Care via a GP), and are generally limited to booking and delivery information only. In addition, antenatal care data for women under Secondary Care are limited in Healthware. The limitations of Healthware data are described in more detail in the companion report and summarised briefly here:[4]

1. *Data Access*: There is currently limited in-house capacity to extract data from Healthware, therefore much of the data collected is never analysed in a systematic way.

2. *Data Quality*: The accuracy of Healthware data is unknown.

3. *Ethnicity Data*: The ethnicity data provided for this project came from the CMDHB Patient Information Management System (PIMS) and was not prioritised ethnicity. Ethnicity data in Healthware come from PIMS. At CMDHB, ethnicity data are collected on admission to hospital by administrative staff who verbally enquires about ethnicity (personal communication: Dianne Wilson, Decision Support). If more than one ethnic group is specified, then the patient is asked to indicate which ethnic group they would

like recorded first, and this is entered into the first of three fields. This is what was supplied and in accessing Healthware, this is the ethnic group displayed if more than one ethnic group was specified. This could be regarded as a preferred ethnicity, and is referred to as such throughout this report when Healthware data are presented. This process does not comply with national standards of collecting and analysing ethnicity data.[22]

4. *Domicile Codes*: Each woman in Healthware is assigned a domicile code based on where she lives. As it is a live database a woman's residential address is updated if she moves. Therefore, the domicile code extracted from Healthware may not coincide with where she lived at the time she delivered, if she subsequently moved residence. Where available, the address of her infant at birth was used for analyses presented in this report. Domicile codes map to Census Area Units, and therefore do not provide as good an indication of socio-economic status compared to meshblock data (see section 2.3.1).

5. *Important risk factors are poorly recorded:* Healthware does not adequately capture high risk maternal conditions (e.g. diabetes, hypertension, antepartum haemorrhage) and past obstetric history which are important perinatal mortality risk factors. While there is some capacity to record this data, data are recorded across several fields, inconsistent terminology is used requiring time consuming analysis of free text, and the accuracy is unknown.

2.2.2.3 Use in This Project

While this project focused on the CMDHB resident population, Healthware captures data for CMDHB provided services therefore includes data for women who reside outside CMDHB if they use CMDHB maternity services. In addition, data collection for CMDHB resident women who delivered in a facility outside CMDHB, or that had a planned homebirth, are incomplete. Therefore, Healthware data used in this report are limited to data for CMDHB resident women who delivered in, or on route to, a CMDHB facility (Table 7). Any duplicate data were removed.

Table 7: Healthware Data Use in This Report, 2007-2009

Women Using CMDHB Maternity Services	25125
Excluded:	
Non-CMDHB resident women	1,900
CMDHB women delivered outside CMDHB	741
Women with deliveries <20 weeks gestation or <400g*	11
Planned home birth	6
CMDHB Resident Women Delivering in CMDHB	22,467

Source: Healthware. Note: Duplicate data were removed prior to exclusions being made. *These births are not legally required to be registered and are not captured as births in the National Minimum Dataset or the Birth Registration Dataset.

Data Cleaning and Validation

Several weeks of data cleaning were undertaken in the course of this project prior to analyses being performed. The purpose of this was to increase the completeness and accuracy of the data presented here and in other reports arising from this project. Particular attention was given to the accuracy of data for perinatal deaths.

Missing Data

For key data elements, missing data were sought from other fields in Healthware or from Concerto. These included maternal date of birth, maternal ethnicity, infant and maternal

domicile codes, booking date, estimated date of delivery, type of antenatal care, delivery location, delivery gestation, birth weight, height, weight, and smoking status.

Inconsistent Data:
Data inconsistencies were sought and data verified. These included verification of data in the case of date inconsistencies (e.g. date of death occurred before the date of birth, antenatal visit date after the date of birth or before the last menstrual period), a body mass index of <15 or >45, babies born with a gestation <20 weeks or >45 weeks, birth weight of <400g.

Comparison of Data Sourced from Healthware with data from the NMDS

Data for CMDHB resident women delivering in CMDHB facilities used in this report were sourced from both the NMDS (n=22,215) and Healthware (n=22,467) as shown in Table 8. Healthware identified 252 additional deliveries.

Table 8: CMDHB Mothers Delivering in CMDHB Facility by Data Source, 2007-09

	NMDS		Healthware		Difference	
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Ethnicity						
Maaori	5,611	25.3	5,141	22.9	-470	-9.1
Pacific	8,172	36.8	8,209	36.5	37	0.5
Asian	2,698	12.1	2,834	12.6	136	4.8
Chinese	*419*	*1.9*	*433*	*1.9*	*14*	*3.2*
Indian	*1,491*	*6.7*	*1,597*	*7.1*	*106*	*6.6*
Other Asian	*788*	*3.5*	*804*	*3.6*	*16*	*2.0*
Other	5,734	25.8	6,052	26.9	318	5.3
Unknown	-	-	231	1.0	231	
Total	22,215	100.0	22,467	100.0	252	1.1
Maternal Age						
<20 years	2,352	10.6	2,365	10.5	13	0.5
20-24 years	5,259	23.7	5,306	23.6	47	0.9
25-29 years	5,938	26.7	5,999	26.7	61	1.0
30-34 years	4,956	22.3	5,028	22.4	72	1.4
35-39 years	2,979	13.4	3,021	13.5	42	1.4
40+ years	731	3.3	748	3.3	17	2.3
NZ Deprivation Index Decile 2006(CAU*)						
1-2 (least deprived)	1,787	8.1	1,830	8.1	43	2.3
3-4	1,112	5.0	1,060	4.7	-52	-4.9
5-6	2,540	11.5	2,615	11.6	75	2.9
7-8	2,726	12.3	2,080	9.3	-646	-31.1
9-10 (most deprived)	13,999	63.2	14,876	66.2	877	5.9
Suburb						
Howick	2,553	11.5	2,573	11.5	20	0.8
Otara	2,531	11.4	2,594	11.6	63	2.4
Papatoetoe	2,835	12.8	2,987	13.3	152	5.1
Mangere	3,736	16.9	3,789	16.9	53	1.4
Manurewa	5,178	23.4	5,180	23.1	2	0.0
Papakura	2,567	11.6	2,562	11.4	-5	-0.2
Franklin	2,764	12	2,782	12	18	0.6

Note: Only includes data for women who were both resident in CMDHB and delivered in a CMDHB facility. *NZ Deprivation Index is at Census Area Unit level (see section 2.2.3.1). Ethnicity is prioritised for NMDS data and preferred for Healthware data. Please note that 63% of Chinese women that reside in CMDHB deliver outside of the DHB therefore this group are under-represented in local data.[4]

There are several potential reasons for this:

1. *Infants Born Before Arrival*
   In Healthware, 57 infants were identified during data cleaning as being born before the mother arrived at hospital (BBA). None of these deliveries were identified as planned home births. Healthware does not have a consistent process for identifying infants who are BBA, therefore this number is likely to be an underestimate. In contrast, women's records in the NMDS do not capture births that occurred outside a hospital facility and so do not include women who delivered prior to admission to hospital.

2. *Assignment of Domicile Code*
   Healthware is a live database and the woman's residential address is updated if she moves. The domicile code assigned during data extraction was the domicile for the infant where available, as these records are not updated again in Healthware. Where no infant domicile code was available, the woman's domicile code will be for her last known residence and this may not be the same address she lived at when she delivered in 2007-2009. In contrast, the NMDS records a woman's domicile code at the time of each birth event. Therefore, domicile code as recorded in Healthware may not be as good at determining CMDHB residency as that captured in the NMDS, and some women who did not reside in CMDHB during 2007-2009 may be included in the Healthware data.

3. *Non-resident Non-eligible Women*
   Women who are both non-resident and not eligible for free maternity care in New Zealand occasionally birth at CMDHB. It is possible that the NMDS better identifies these women and excludes them from the CMDHB population than Healthware.

In addition to 252 extra women being included in the Healthware data base, the demographic profile of the women in Healthware differed from that reported in the NMDS data (Table 8). The following observations were made:

- The ethnic profile of women in Healthware differed from the NMDS with Maaori under-represented in Healthware. This difference is most likely a consequence of ethnicity data collection processes, with Healthware data being preferred ethnicity (see Section 2.2.2.2) and NMDS data being prioritised ethnicity.

- The age structures of these two data sources are similar, with a tendency for the additional women captured by Healthware to be older.

- The distribution by NZ Deprivation index decile and residential area differ between the two data sources. This may have occurred as a consequence of Healthware domicile coding in Healthware changing with a woman's moves. In Healthware a greater proportion of women are recorded as living in the most deprived areas (decile 9-10) whilst women living in decile 7-8 are under-represented. There is a tendency for the additional women captured in Healthware to reside in Papatoetoe or Otara.

Statistical Methods

Healthware data were imported into SAS 9.2 for analysis. In maternal analyses, data for each pregnancy were only included once (i.e. in the case of a twin pregnancy the pregnancy was only counted once). In perinatal mortality analyses of infant outcome, data from women with multiple pregnancies were included for each infant born.

Univariate analyses were performed for all available variables and involve an analysis of an outcome (e.g. perinatal death) or risk factor (e.g. smoking) by a single variable e.g. age. Univariate analyses provide descriptive epidemiology and inform the development of

multivariate analyses. Crude rates were determined and logistic regression was performed to calculate crude odds ratio's with 95% confidence intervals.

Multivariate logistic regression analyses were performed in order to explore the relationship between an outcome (e.g. stillbirth) and a number of variables. Prior to a multivariate analysis for an outcome being performed, univariate analyses were conducted to examine the effect of individual variables (e.g. ethnicity, age, smoking) on the outcome of interest (e.g. stillbirth). If a variable was found to affect the outcome in a univariate analysis, it was included in the multivariate logistic regression model. This enabled the calculation of the adjusted odd ratios for the outcome of interest (e.g. stillbirth) for each variable in the model independent of the other variables in the model. This is a way of examining one variable (e.g. ethnicity) while accounting for the effects on the outcome of another variable (e.g. smoking) or variables. For example, crude stillbirth rates are higher in Maaori women and women who smoke in pregnancy, however a high proportion of Maaori women report smoking in pregnancy raising the question of whether stillbirth rates in Maaori are higher because these women have higher rates of smoking in pregnancy. Such questions can be examined through multivariate analyses.

2.2.3 Birth Registration Dataset

The Birth Registration Dataset (BRDS) is a register of all births in New Zealand and is maintained by the Department of Internal Affairs. The *Births, Deaths, Marriages, and Relationships Registration Act 1995* requires registration and of all live and stillborn infants who weigh 400g or more at birth or that were born after 20 weeks of pregnancy, including those resulting from a termination of pregnancy.[11] Hospitals and LMCs are required to notify Internal Affairs of births that require registration under the act within 5 days of the birth occurring by submitting the mother's contact details and the infant's gestation and birth weight.[23] In addition, parents are required to complete a Notification of Birth for Registration form as soon as is reasonably practical after birth, and within 2 years.[24] Once both notifications are received by Internal Affairs they are merged into one record. Data from the birth registration data set are used as the denominator in perinatal mortality rate calculations using data sourced from the PMMRC.

2.2.3.1 Strengths

The BRD is the most complete measure of the number of births in New Zealand and it is estimated that 99.9% of births in New Zealand are captured, including both hospital and home births. The BRD captures demographic data for the mother, father, and infant. In addition, occupation, citizenship, the number of children from the current relationship, and the nature of the parent's relationship are recorded, as are birth weight, gestation, and birth order in the case of multiples, and the outcome of the birth (live or stillborn).

The recording of ethnicity in the BRD is considered to be of exceptionally high quality, as it is self-reported on the birth registration form that the parents complete, and is thought to be more accurate than ethnicity recorded at birth in the NMDS. The BRD codes the mothers address at meshblock level, unlike the NMDS in which captures area of residence at the census area unit level (see section 2.3.1).

2.2.3.2 Limitations

Parents have up to two years to register a birth, and a birth will not appear in the BRD until this has been done. When using the BRD as a denominator, year of registration and not year of birth is usually used, even though this means that some births will be included that occurred in earlier years.[2] This maintains a consistent methodology over time, and avoids underestimating the total number of births for the current year which would occur if late registrations were excluded because a number of births in the current year will not yet have

been registered. During 2007-09, 98% of births were registered within a year of occurring, and <1% were late registrations (registered more than two years after the birth).

Some important maternity data are not available in the BRD that would be extremely useful at a national level for investigating maternity outcomes, including information on the location of birth, maternal risk factors (e.g. smoking, body mass index), and antenatal care (e.g. LMC, gestation at the first antenatal visit, and number of antenatal visits). This level of detail is collected in the United States and has enabled sophisticated analyses of maternity outcomes and antenatal care use, identification of disparities, and informed strategies to improve maternity outcomes.[25-27]

The BRD does not record the National Health Index (NHI) for mothers of infants; therefore the BRD can't be linked to other datasets that contain relevant perinatal data, for example the National Mortality Collection which records fetal and neonatal deaths, or the NMDS which may capture co-morbidity data.

2.2.3.3 Use in This Project

Birth registration data are used to provide dominators for perinatal mortality calculations for which numerator data were provided by the PMMRC. Birth registration data were supplied by the Ministry of Health and imported into SAS 9.2 for analysis. In assessing the prevalence of maternal risk factors, a woman was included only once for each pregnancy.

2.2.4 National Minimum Dataset

The National Minimum Dataset (NMDS) is maintained by the Ministry of Health and is a national collection of publically funded hospital discharge information, including clinical information, for inpatients and day patients. All hospital admissions during pregnancy are captured in this dataset, and birth events are recorded for both mothers and infants.

2.2.4.1 Strengths

In-hospital birth events are recorded for both mothers and infant's allowing analyses of either the maternal or the infant's data. NMDS data are readily available, and include maternity data not currently captured in other datasets including location of birth, type of birth (forceps, caesarean, etc), hospital admissions that occurred during pregnancy, and clinical data in addition to demographic data. Patients in the NMDS are assigned a code that identifies their DHB of usual residence, so hospital data are available for CMDHB resident women, irrespective of where they were admitted during their pregnancy, or which hospital facility they delivered in.

2.2.4.2 Limitations

The NMDS only captures births that occur in hospital; therefore homebirths and births that occur before arrival at hospital (e.g. in a car or ambulance) are not captured. A comparison of births captured by the NMDS and the Birth Registration dataset shows that during 2005-2009 95.2% of registered live births were recorded on the NMDS (97.5% for CMDHB). Because not all births are captured, NMDS data should only be used for analyses of hospital events only.

The event of a stillbirth is recorded in maternal records, but an infant record is not created. The NMDS is not a good source of data for stillborn infants and underestimates stillbirth rates. Neonatal deaths in the first 27 days of life are only recorded in the NMDS if the death occurred in hospital, therefore the NMDS under-estimates neonatal mortality.

Although an infant's NHI is currently recorded against their mother's NHI, and is therefore captured in her birth event record, current Ministry of Health policy dictates that the linked

infant's NHI cannot be provided along with the mothers for privacy reasons. Although probabilistic linking can be undertaken to create maternal-infant dyads, the accuracy of this linkage is unknown (see section 2.2.4.3).

The NMDS captures a domicile code at birth for each woman and infant based on their residential address at that time. Domicile codes map to census area units (CAU), and therefore do not provide as good an indication of socio-economic status compared to meshblock data (see section 2.3.1).

2.2.4.3 Use in This Project

NMDS data for all birth events in 2009 were used to examine the prevalence of important risk factors. Maternal birth event data were probabilistically matched to infant birth event data so that both could be searched for ICD10 coding of specific risk factors. Probabilistic matching was successful for 54,871 mother-infant dyads representing 89% of all New Zealand hospital birth events. How well hospital admission data captures the risk factors of interest is unknown, therefore this analysis should be considered exploratory.

Table 9: ICD Codes Used for Identifying Risk Factors in the National Minimum Dataset

	Maternal ICD10 codes	Timing	Infant ICD10 codes
Diabetes			
Pre-existing	E10-E14, O24.0-O24.3	Last 5 years	P70.1
Previous GDM	O24.4, O24.9	Last 5 years	
Gestational diabetes	O24.4, O24.9	Current Pregnancy	P70.0
Gestational Diabetes on insulin	O24.42	Current Pregnancy	
Hypertension			
Pre-existing HT	O10-O11, I10-I15	Last 5 years	
Fetus affected by maternal HT			P00.0
Pregnancy induced HT	O13, O16	Current Pregnancy	
Pre-eclampsia	O14	Current Pregnancy	
Eclampsia	O15	Current Pregnancy	
Antepartum Haemorrhage			
Antepartum Haemorrhage	O20, O46	Current Pregnancy	
Placental Abruption	O45	Current Pregnancy	
Placenta Previa	O44	Current Pregnancy	P02.0
Congenital Abnormality			
Fetal abnormality - any	O35, O36.0-O36.2	Current Pregnancy	Q00-Q99

Depending on the risk factor of interest, maternal data for the current pregnancy was searched as well as data from any admission that during the previous 5 years, while infant data for the birth event and any hospital admissions up until the age of 6 weeks were searched. The ICD10 codes used for each risk factor are shown in Table 9. Women who had more than one code for a particular risk factor were only counted once. Data were were imported into SAS 9.2 for analysis. In assessing the prevalence of maternal risk factors, a woman was included only once for each pregnancy.

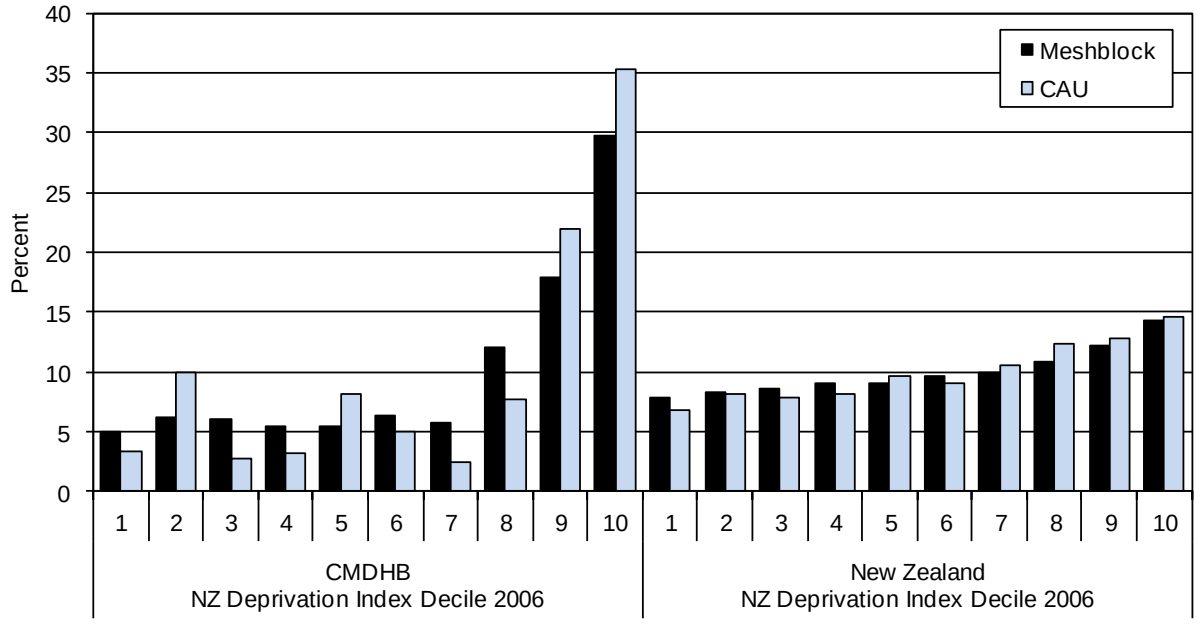
2.3 Other Data Issues

2.3.1 NZ Deprivation Index Decile

The BRD and the PMMRC code the mothers address at meshblock level, unlike the NMDS and Healthware which capture area of residence at the census area unit (CAU) level. The New Zealand Deprivation Index (NZDep) is determined at the meshblock level (based on 90-100 people), and a weighted average is provided at CAU level (based on 3,000-5,000 people). It is an area based measure of deprivation, with decile 1 representing the least deprived 10% of small areas and decile 10 representing the most deprived 10% of small areas. Therefore, while the decile is for the area a woman lives in and not for her personally, it is likely to be a better reflection of her socio-economic status the smaller the area is.

When comparing the distribution of women who delivered in 2007-09 across the NZDep deciles at a national level, CAU deciles tend to over-estimate the proportion living in the most deprived areas and underestimate the proportion living in the least deprived area (Figure 5). For CMDHB, the difference between meshblock level and CAU level deciles is more marked due to way in which affluent and deprived meshblocks are distributed around the DHB, with pockets of affluence within deprived area and vice versa. When undertaking analyses by NZDep it is essential that the numerator and denominator deciles are assigned in the same way (i.e. both at CAU level, or both at meshblock level).

Figure 5: Mothers by NZ Deprivation Index Decile 2006 at Meshblock vs Census Area Unit level, 2007-2009



Source: Birth registration dataset

2.4 Chapter Summary

Maternity data are available from a number of sources; however analyses are hampered by the lack of access to PMMRC data at an individual level. Instead, data for this report was sourced from the Birth Registration Dataset, the National Minimum Dataset, and a CMDHB local dataset, Healthware. There was no consistent unique identifier across these three data sources to allow reliable data linkage between them.

The strengths and limitations of each data source with respect to maternity information have been described. Importantly, analyses of Healthware data in this report are novel and exploratory, as the reliability of this data source is unknown at this time.

IMPORTANT CAUTION: The Healthware/CMDHB data presented in this report have not been checked for accuracy or validity and should be interpreted with caution. Analyses of these data are exploratory and intended to demonstrate the potential of this data source and to stimulate, discussion, strategy development, and further research.

Chapter 3. Perinatal Mortality Risk Factors

The aetiology of perinatal deaths is complex, with many factors identified that contribute to the risk of a perinatal death.[1, 6, 7, 28-31] Factors influencing perinatal mortality vary somewhat according to the timing of the death. For example, factors influencing the rate of late termination of pregnancy may include screening rates and timing, the prevalence of maternal medical conditions, risk factors for congenital abnormality, and societal and cultural beliefs. Predicting a poor pregnancy outcome has proved difficult, and a systematic review of risk assessment tools reported by the National Institute of Clinical Excellence failed to identify an ideal tool.[32] This was not a surprising outcome as perinatal deaths are relatively rare in comparison to the prevalence of perinatal mortality risk factors.

This Chapter describes the main risk factors that have been associated with perinatal mortality in high income countries identified via a review of the literature. Each section begins with a description of the risk factor and a summary of the evidence for the association informed by a review of the literature. Where available the population attributable risk in high income countries is presented as reported by Flenady and colleagues.[33] The population attributable risk is the proportion by which the mortality rate could be expected to decrease if the entire maternity population was not exposed to the risk factor examined, compared to the current level of exposure. The size of the population attributable risk is determined by how common the risk factor is and the odds of a death with exposure. For example, placental abruption is rare but if it occurs the odds of a stillbirth is very high resulting in a relatively high population attributable risk. An assessment of the prevalence of each risk factor in CMDHB is presented using available data sources, with a comparison made to national data where possible.

CAUTION: In this chapter some analyses presented use local CMDHB data sourced from Healthware. The accuracy of this data is unknown, and the completeness of some data variables is sub-optimal. Where data completeness is an issue this is highlighted in the text. These data should be interpreted with caution (see section 2.2.2).

3.1 Maternal Ethnicity

Evidence for the Association

Although maternal ethnicity is frequently described as a risk factor for perinatal mortality, it should be considered a surrogate marker of other risk factors rather than a risk factor in and of itself.

In New Zealand, rates of late termination, stillbirth and neonatal death by ethnicity vary for each of these modes of perinatal death making the relationship between ethnicity and perinatal mortality complex.[2] A multivariate analysis reported by the PMMRC showed that women reporting Maaori or Pacific as their only ethnicity had an increased odds of stillbirth compared to women from other ethnic groups after adjusting for the influence of age and socio-economic deprivation.[2] Crude rates of neonatal death are higher in Maaori and Pacific women than in NZ European women, however late termination rates are higher in Asian and NZ European women than in Maaori and Pacific women.

Prevalence in CMDHB and New Zealand

A higher proportion of the women giving birth each year in CMDHB were Maaori or Pacific (57%) than seen across New Zealand (34%) during 2007-09 (Table 10). In Maaori, Pacific, and Asian women living in CMDHB had a higher birth rate on average than women with

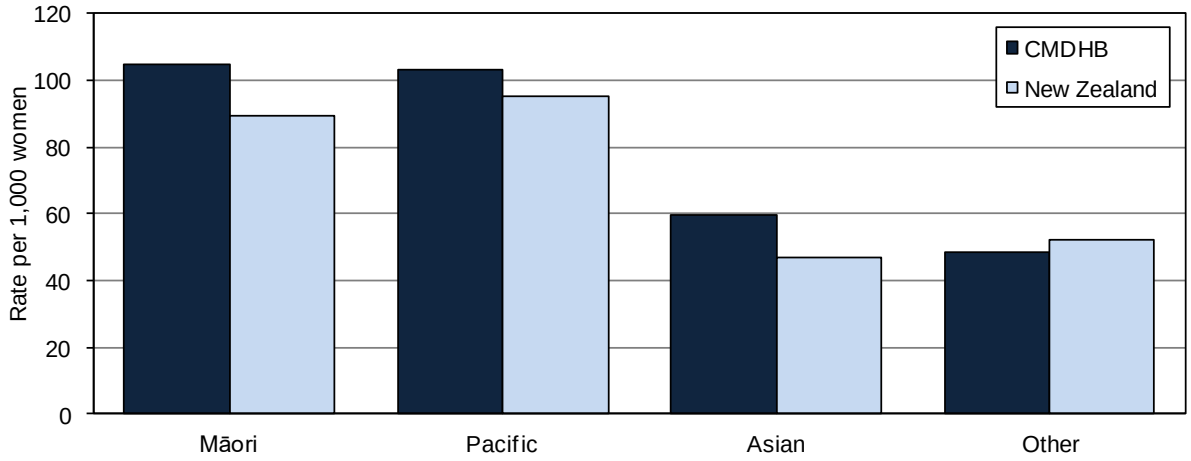
these ethnicities across New Zealand during this time (Figure 6). These differences were driven by higher birth rates in women aged <30 years old living in CMDHB.[4]

Table 10: Mothers in CMDHB and New Zealand by Ethnicity, 2007-09

	CMDHB		New Zealand	
Ethnicity	**Number**	**Percent**	**Number**	**Percent**
Maaori	6,616	25.0	44,967	23.5
Pacific	8,356	31.6	20,291	10.6
Asian	4,327	16.4	19,645	10.3
Chinese	*1,245*	*4.7*	*6,303*	*3.3*
Indian	*2,056*	*7.8*	*6,500*	*3.4*
Other Asian	*1,026*	*3.9*	*6,842*	*3.6*
European/Other	7,129	27.0	106,551	55.7

Source: Birth Registration Dataset. Note: Ethnicity is prioritised.

Figure 6: Birth Rates in CMDHB and New Zealand by Ethnicity, 2007-09



Numerator: Birth Registration Dataset; Denominator: NZ Census. Ethnicity is prioritised.

3.2 Maternal Age

Evidence for the Association

A relationship between maternal age and perinatal mortality has been reported in a number of studies[2, 34] In New Zealand in 2007-08, the highest stillbirth rates were seen in young mothers (<20 years old) and mothers aged 40 years and older, whilst the highest rate of neonatal death was observed in infants born to mothers aged <20 years old, and the highest rate of late termination was seen in women aged 40 years and older.[2] Maternal age (<20 or ≥40 years) was found to be associated with an increased odds of perinatal mortality in New Zealand women independent of the effects of ethnicity and socio-economic status, however this analysis did not control for potential confounders including gestation and birthweight.[2]

An international meta-analysis examining the association between maternal age and stillbirth in high income countries showed a 65% increased in the odds of a stillbirth in women aged ≥35 years and a doubling of the odds for women aged 40 years and older (compared to women aged <35 years old).[33] This study estimates that advanced maternal age contributes to 7-11% of the stillbirth rate in high income countries. No relation between young maternal age (<20 years) and stillbirth was found in a meta-analysis that included six studies although

two studies reported a significant increase in the odds of stillbirth in very young mothers (<15 years).[33] It may be that the association between young age and stillbirth is unique to the New Zealand setting[2], or that this finding is influenced by factors not controlled for in New Zealand analyses to date, and it warrants further examination.

3.2.1 Young Mothers (<20 years)

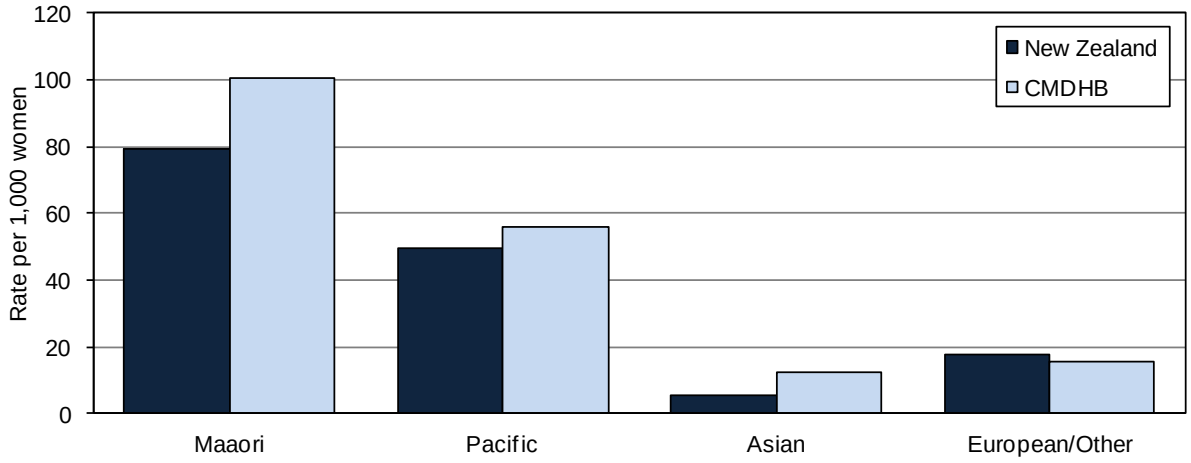
Prevalence in CMDHB and New Zealand

The birth rate in young women aged <20 years in CMDHB has been consistently higher than the national teenage birth rate for many years.[35] During 2007-09, the teenage birth rate in CMDHB was 43.9 per 1000, compared with 32.2 nationally. Less than 1% of births to teenagers in New Zealand during this time were to mothers aged <15 years old, although 23.0% of these were to a young woman who lived in CMDHB.

Marked variation in teenage birth rate is observed by ethnicity across New Zealand and CMDHB, with the highest rates observed in Maaori and Pacific teens (Figure 7). During 2007-2009, the birth rate in Maaori teens living in CMDHB was 100.3 per 1,000 compared with 79.0 per 1,000 observed in Maaori teens across New Zealand. The teenage birth rate for Pacific and Asian teens living in CMDHB was also higher than for those living across New Zealand.

During 2007-09, of all the CMDHB resident women who gave birth 9.6% were aged <20 years compared with 7.9% nationally. Most CMDHB resident pregnant teens (95%) delivered in a CMDHB facility during this time, and comprised 10.5% of all CMDHB mothers that delivered in a CMDHB facility.[4] Of these young women, approximately two thirds were aged 18-19 years, three quarters were Maaori or Pacific, nearly 20% were having their second or subsequent child, 3% had no antenatal care and an additional 43% booked after 18 weeks, 10% delivered prematurely, and 18% delivered post-term (41+ weeks gestation) (Table 11).

Figure 7: Teenage Birth Rates in CMDHB and New Zealand by Ethnicity, 2007-09



Numerator: Birth Registration Dataset; Denominator: NZ Census. Ethnicity is prioritised. Rate is per 1,000 women aged 15-19 years.

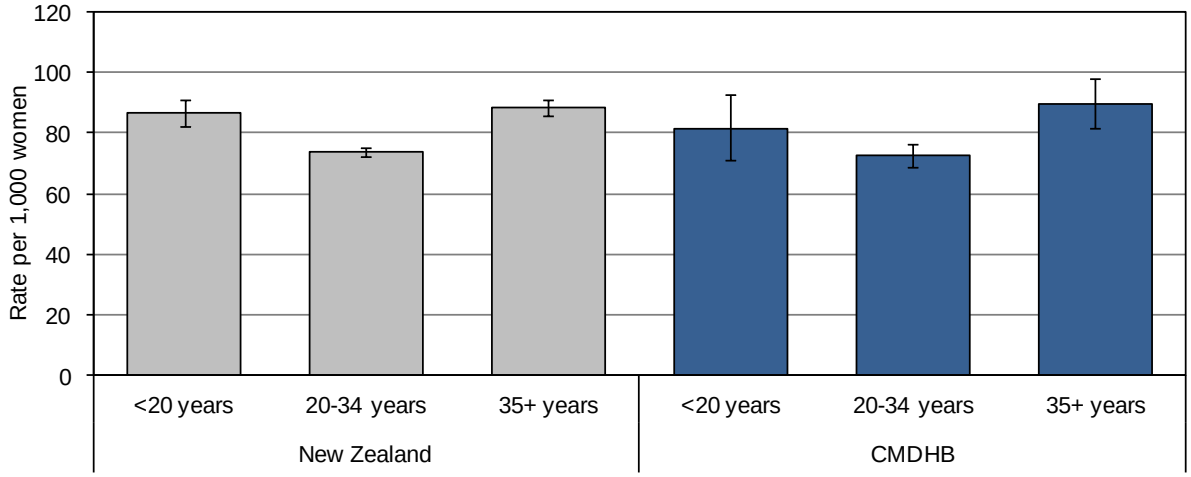
During 2007-09, young women in New Zealand had a preterm delivery rate of 86.4 per 1,000 which was significantly higher than the rate in women aged 20-34 years (73.7 per 1,000). This same trend was observed for women living in CMDHB (Figure 8) and may be driving the higher crude rate of perinatal mortality in this age group. This issue is examined in more detail in section 3.5.1.

Table 11: Profile of Teenage Mothers in CMDHB, 2007-09

Ethnicity	Num	Percent	Deprivation	Num	Percent
Maaori	990	42.1	Decile 1-2	86	3.6
Pacific	811	34.5	Decile 3-4	58	2.5
Chinese	10	0.4	Decile 5-6	205	8.7
Indian	31	1.3	Decile 7-8	179	7.6
Other Asian	39	1.7	Decile 9-10	1,837	77.7
Euro/Other	469	20.0	**Suburb**	**Num**	**Percent**
Maternity Provider	**Num**	**Percent**	Howick	140	5.9
Private LMC	979	41.4	Otara	353	14.9
Shared Care	574	24.3	Papatoetoe	246	10.4
Closed Unit	682	28.8	Mangere	432	18.3
Secondary Care	42	1.8	Manurewa	632	26.7
Caseloading	16	0.7	Papakura	321	13.6
Unbooked	72	3.0	Franklin	241	10.2
Parity	**Num**	**Percent**	**Booking Gestation***	**Num**	**Percent**
Nulliparous	1,933	81.7	<10 weeks	312	13.2
Para 1-2	428	18.1	10-18 weeks	960	40.6
Para 3-5	4	0.2	19-28 weeks	709	30.0
Para 6+	0	0.0	>28 weeks	312	13.2
Delivered	**Num**	**Percent**	**Delivery Gestation**	**Num**	**Percent**
Botany	71	3.0	<28 weeks	48	2.0
MMH	1,990	84.1	29-36 weeks	193	8.2
Papakura	176	7.4	37-40 weeks	1,710	72.3
Pukekohe	128	5.4	41+ weeks.	414	17.5

Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB. See section 1.1 for a description of maternity providers. Ethnicity is preferred. See section 1.1 for a description of maternity providers. **Booking gestation includes Unbooked women in the denominator.

Figure 8: Preterm Birth Rates by Age Group in New Zealand and Counties Manukau DHB, 2007-09



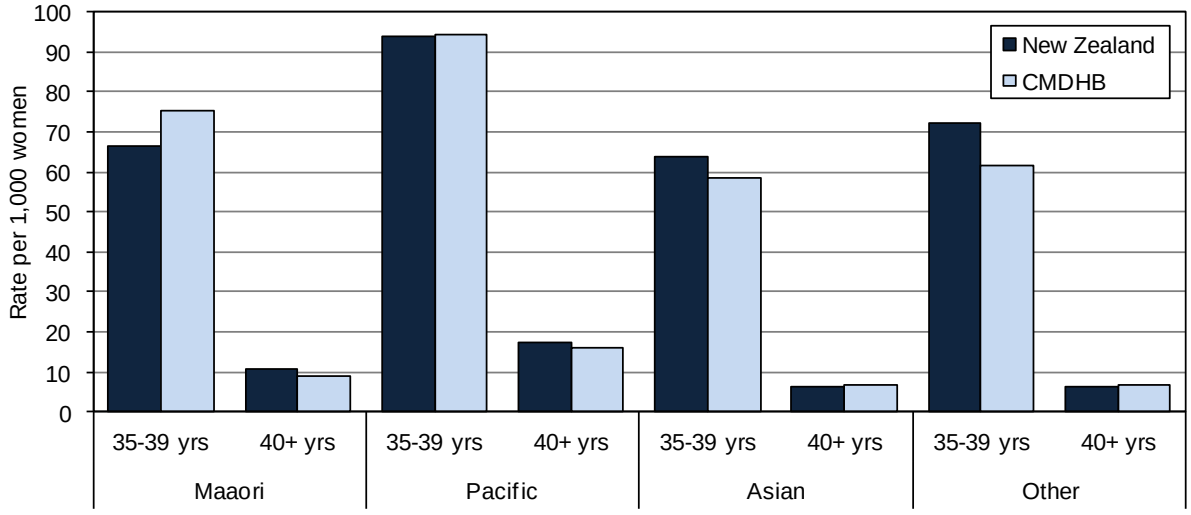
Source: Birth Registration Dataset. Note: Error bars indicate 95% confidence intervals.

3.2.2 Older Mothers (≥35 years)

Prevalence in CMDHB and New Zealand

The birth rate in women aged 35 years and older in CMDHB (29.9 per 1,000) is similar to the national rate (29.0 per 1,000). For women aged 35-39 years old some differences in the birth rates for CMDHB and New Zealand are observed by ethnic group (Figure 9). During 2007-09, Maaori women aged 35-39 years living in CMDHB had a higher birth rate (75.5 per 1,000) than women in this age group nationally (66.5 per 1,000), and birth rates in Asian and European/Other women in this age group living in CMDHB were lower than seen nationally. For women aged 40 years and older, little difference in birth rates were seen for those living in CMDHB compared to nationally.

Figure 9: Birth Rates in Women Aged 35 Years and Older by Ethnicity, CMDHB and New Zealand, 2007-09



Numerator: Birth Registration Dataset; Denominator: NZ Census. Ethnicity is prioritised.

During 2007-09, 18.2% of all the CMDHB resident women who gave birth were aged 35 years or older compared with 21.7% nationally. During this time, nearly one in five CMDHB mothers in this age group delivered in a maternity facility outside of the DHB, therefore of the CMDHB women who delivered in a CMDHB facility only 16.8% were aged 35 years or older (Table 12).[4]

Older CMDHB women who delivered in a CMDHB facility during 2007-09 were most often Pacific (36.2%), or European/Other (35.0%), 41% were having their fourth or subsequent child, 2.1% had no antenatal care and an additional 43% booked after 18 weeks gestation, 9% delivered prematurely, and 18% after 40 weeks gestation.

During 2007-09, older women in New Zealand had a preterm delivery rate of 88.3 per 1,000 which was significantly higher than the rate in women aged 20-34 years (73.7 per 1,000). This same trend was observed for women living in CMDHB (Figure 8) and may be driving the higher rate of perinatal mortality in this age group. This issue is examined in more detail in section 3.5.1.

Table 12: Profile of Mothers Aged 35 Years and Older in CMDHB, 2007-09

Ethnicity	Num	Percent	Deprivation	Num	Percent
Maaori	608	16.4	Decile 1-2	468	12.4
Pacific	1,345	36.2	Decile 3-4	247	6.6
Chinese	138	3.7	Decile 5-6	544	14.5
Indian	166	4.5	Decile 7-8	304	8.1
Other Asian	154	4.2	Decile 9-10	2,203	58.5
Euro/Other	1,300	35.0	**Suburb**	**Num**	**Percent**
Maternity Provider	**Num**	**Percent**	Howick	553	14.7
Private LMC	1,849	49.1	Otara	408	10.8
Shared Care	838	22.2	Papatoetoe	407	10.8
Closed Unit	755	20.0	Mangere	588	15.6
Secondary Care	104	2.8	Manurewa	760	20.2
Caseloading	144	3.8	Papakura	400	10.6
Unbooked	79	2.1	Franklin	653	17.3
Parity	**Num**	**Percent**	**Booking Gestation***	**Num**	**Percent**
Nulliparous	624	16.6	<10 weeks	596	15.8
Para 1-2	1,588	42.1	10-18 weeks	1,771	47.0
Para 3-5	1,156	30.7	19-28 weeks	875	23.2
Para 6+	400	10.6	>28 weeks	449	11.9
Delivered	**Num**	**Percent**	**Delivery Gestation**	**Num**	**Percent**
Botany	171	4.5	<28 weeks	50	1.3
MMH	3,212	85.2	29-36 weeks	289	7.7
Papakura	159	4.2	37-40 weeks	2,768	73.4
Pukekohe	227	6.0	41+ weeks.	662	17.6

Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB. See section 1.1 for a description of maternity providers. Ethnicity is preferred. *Booking gestation includes Unbooked women in the denominator.

3.3 Maternal Socio-Economic Deprivation

Evidence for the Association

In 2010, the PMMRC reported higher rates of stillbirth and neonatal death for women living in area's with a NZ deprivation index decile of 8-10, reflecting geographic areas of relative socio-economic deprivation.[2] In contrast, late termination of pregnancy rates were lowest in women living in areas of high socio-economic deprivation.

Socio-economic deprivation was found to be independently associated with a higher odds of stillbirth (adjusted OR 1.3 (95% CI: 1.1–1.5)) after adjusting for the effects of ethnicity and age in New Zealand women.[2] Flenady and colleagues conservatively estimate the population attributable risk of low socio-economic status on stillbirth to be 9% in high income countries.[33] Low maternal education is another indicator of socio-economic status. A meta-analysis of five studies in high income countries found higher odds of stillbirth (adjusted OR 1·7 (95% CI: 1·4–2·0)) in women with low education (<8-10 years) with an estimated population attributable risk for stillbirth of 5%.[33]

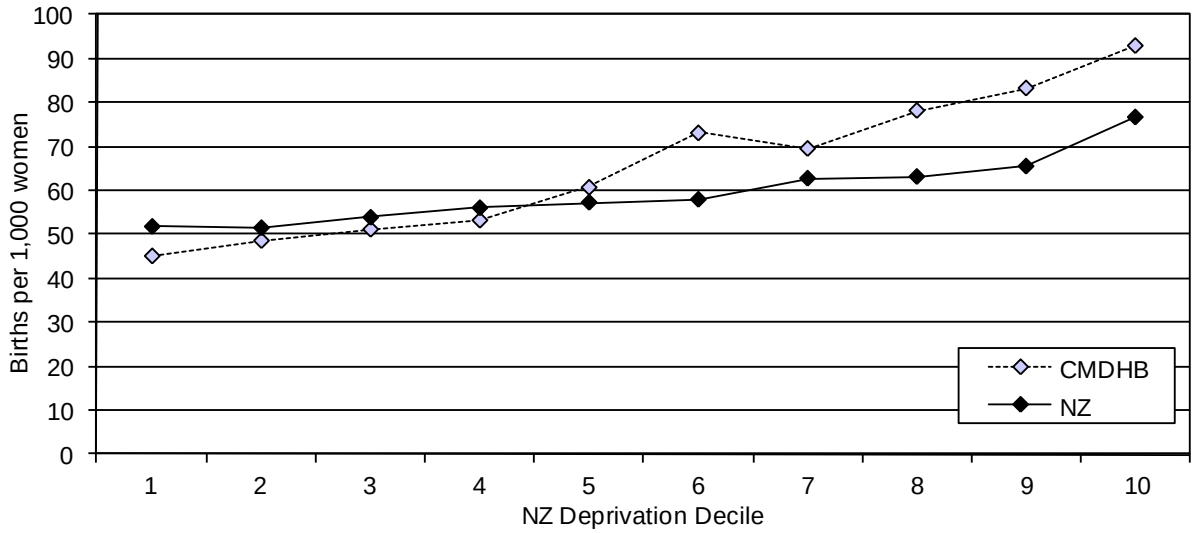
3.3.1 Socio-Economic Deprivation (NZ Deprivation Index)

Prevalence in CMDHB and New Zealand

New Zealand birth rates demonstrate a socio-economic gradient such that for each increase across the NZ deprivation index deciles an increase in birth rate is seen (Figure 10).[4] The social gradient in CMDHB is steeper than the national gradient, with a greater difference seen between birth rates in women living in decile 1 areas and decile 10 areas. During 2007-09, women living in the most socio-economically deprived areas of CMDHB (deciles 8-10) had a higher birth rate than women living in areas with the same decile score across New Zealand (Figure 10).[4]

During 2007-09, 60% of the CMDHB women who delivered lived in a decile 8-10 area, compared to 37% across New Zealand. Three out of four Maaori women and nearly nine out of 10 Pacific women living in CMDHB that delivered during this time lived in a decile 8-10 area (Figure 11). A greater proportion of young mothers (<25 years) in CMDHB live in a decile 8-10 area (75%) than mothers of any other age group in the DHB. However, older mothers (≥ 35 years) living in CMDHB are nearly twice as likely to live in a decile 8-10 area compared with older mothers living across New Zealand as a whole.

Figure 10: Birth Rates in CMDHB and New Zealand by New Zealand Deprivation Index Decile, 2007-2009

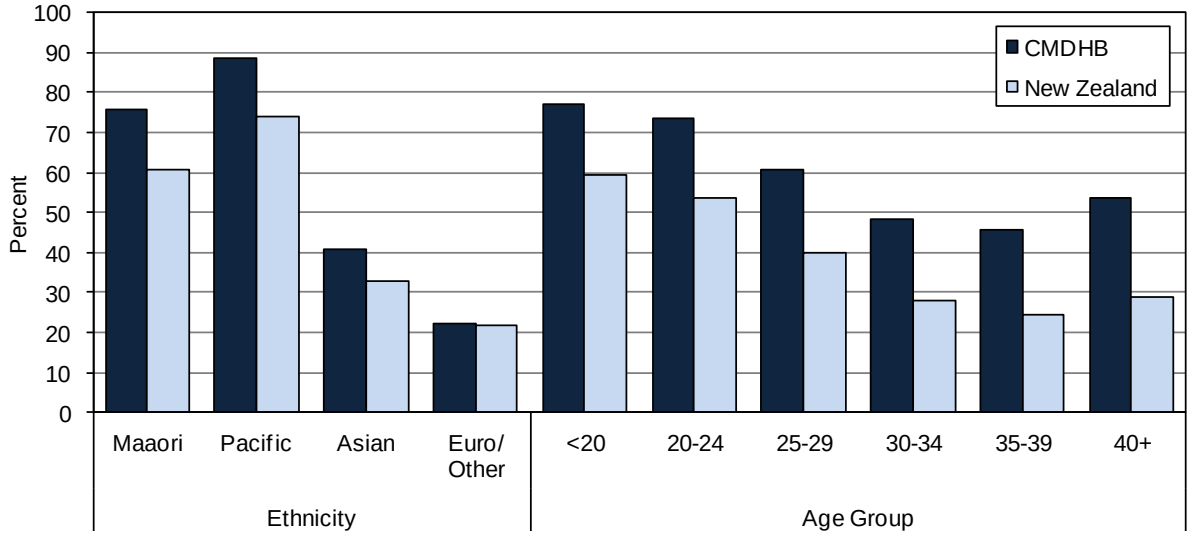


Numerator: Birth Registration Dataset; Denominator: Statistics New Zealand Estimated Resident Population.
Note: NZ Deprivation Index is at Census Area Unit level (see section 2.2.3).

During 2007-09, the proportion of CMDHB resident women delivering in a facility outside of the DHB decreased with increasing socio-economic deprivation so that only 6% of CMDHB mothers living in a decile 8-10 area delivered outside of the DHB compared with 37% of CMDHB women living in a decile 1-2 area.[4]

Of the CMDHB resident women who delivered in a CMDHB facility during this time, 16,537 (73.6%) lived in area of high relative socio-economic deprivation (decile 8-10) (Table 13). These women were most frequently Pacific (47%) or Maaori (27%), 38% were aged <25 years old and 15% were aged 35 year or older, 3% were Unbooked and an additional 37% booked after 18 week gestation, 9% delivered prematurely and 19% delivered post-term (≥41 weeks).

Figure 11: Proportion of Mothers Living in the Most Socio-Economically Deprived Areas in CMDHB and New Zealand, 2007-09



Source: Birth Registration Dataset. Note: Most socio-economically deprived areas include meshblocks with a NZ deprivation index decile of 8-10 (see section 2.2.3). Ethnicity is prioritised.

Table 13: Profile of Mothers Living in a Decile 8-10 Area in CMDHB, 2007-09

Ethnicity	Num	Percent	Age Group	Num	Percent
Maaori	4,363	26.6	<20 years	1,980	12.0
Pacific	7,622	46.5	20-24 years	4,330	26.2
Chinese	145	0.9	25-29 years	4,507	27.3
Indian	1,133	6.9	30-34 years	3,279	19.8
Other Asian	438	2.7	≥35 years	2,441	14.8
Euro/Other	2,707	16.5	**Suburb**	**Num**	**Percent**
Maternity Provider	**Num**	**Percent**	Howick	0	0.0
Private LMC	7,380	44.6	Otara	2,594	15.7
Shared Care	3,219	19.5	Papatoetoe	2,982	18.0
Closed Unit	4,787	29.0	Mangere	3,695	22.3
Secondary Care	330	2.0	Manurewa	4,223	25.5
Caseloading	310	1.9	Papakura	2,107	12.7
Unbooked	511	3.1	Franklin	936	5.7
Parity	**Num**	**Percent**	**Booking Gestation***	**Num**	**Percent**
Nulliparous	6,074	36.7	<10 weeks	2,909	17.6
Para 1-2	6,725	40.7	10-18 weeks	6,957	42.1
Para 3-5	3,129	18.9	19-28 weeks	4,012	24.3
Para 6+	608	3.7	>28 weeks	2,149	13.0
Delivered	**Num**	**Percent**	**Delivery Gestation**	**Num**	**Percent**
Botany	387	2.3	<28 weeks	235	1.4
MMH	14,513	87.8	29-36 weeks	1,248	7.6
Papakura	1,114	6.7	37-40 weeks	11,917	72.1
Pukekohe	523	3.2	41+ weeks.	3,137	19.0

Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB. Most socio-economically deprived areas include meshblocks with a decile of 8-10 (see section 2.2.3). See section 1.1 for a description of maternity providers. Ethnicity is preferred. *Booking gestation includes Unbooked women in the denominator.

3.3.2 Maternal Education

Prevalence in CMDHB and New Zealand

Maternal education level is not recorded in any maternity dataset available for this project. However, data regarding education at a population level are available from the Ministry of Education and are collated for CMDHB by the NZ Child and Youth Epidemiology Service.[36]

In New Zealand during 2008, 86% of 16.5 year old girls and 79% of 16.5 year old boys were attending school.[36] This proportion varied significantly by ethnicity and was lowest for Maaori (65%), compared with Pacific (80%), European (83%) and Asian (>100%). The proportions of 17.5 year olds attending school are lower and were 67% for girls and 57% for boys in 2009. Only 40% of Maaori 17.5 year olds are still in school compared to 63% of European, 68% of Pacific, and 96% of Asian young people. Overall, the proportion of CMDHB young people still attending school in 2009 at 16.5 and 17.5 years of age were similar to the national rates. However, a lower proportion of young Maaori in CMDHB were still in school (58% vs 65% at 16.5 years and 32% vs 40% at 17.5 years). Retention at school in CMDHB Pacific, European, and Asian young people is similar to the national rate.

In the most recent truancy survey (2006), CMDHB young people were more likely to have had an unjustified absence from school (absent for a full day without an adequate explanation) or to have been frequently truant (three or more unjustified absences in a week) than young people across New Zealand.[36] While the proportion of European and Asian school children with an unjustified absence or frequent truancy were similar for CMDHB and New Zealand, for Maaori and Pacific school children differences were observed. In 2006, 8.1% of Maaori children (5.9% of Pacific) at school in CMDHB had an unjustified absence compared with 5.0% of Maaori children (4.2% of Pacific) across New Zealand. A higher proportion of Maaori school children in CMDHB were frequently truant (4.7% vs 2.7% nationally). Similarly, Pacific children in at school in CMDHB had a higher rate of frequent truancy (3.1% vs 2.0% nationally).

The proportion of young people in CMDHB that leave school with little or no formal education is similar to that seen nationally (6%), although a lower proportion achieve a UE standard (40% vs 44% nationally).[36] Maaori young people in CMDHB most frequently leave school with little or no formal attainment (11%) although significant gains have been observed in recent years. For CMDHB Maaori leaving school prior to 2003, 40-50% had little or no formal attainment. Similarly, while 6% of CMDHB Pacific young people left school with little or no formal attainment, prior to 2003 the rate was around 30%. Notably, much of the gains in achievement have occurred since the introduction of NCEA in 2004.

In summary, Ministry of Education data suggest that a significant proportion of Maaori and Pacific women of child bearing age who have grown up in CMDHB are likely to have low levels of education. While these women may no longer live in CMDHB, the proportion of teenage women who leave school early and with little or no education remains a concern.

3.4 Parity

Evidence for the Association

A U-shaped relationship has been demonstrated between parity and perinatal mortality, with higher odds of a poor outcome observed in primiparous women and women with a parity of 3 or more.[33, 37, 38] Flenady and colleagues reported an increase in the odds of stillbirth in primiparous women of 42% in a meta-analysis that included three studies, and estimated the population attributable risk for stillbirths from primiparity to be around 15% in high income countries.[33] Further to this finding, several studies have reported a higher risk of stillbirth in primiparous women aged 35 years or older than in primiparous women aged <35 years.[33]

While primiparity is a non-modifiable risk factor, antenatal care schedules attempt to mitigate this risk by providing more antenatal visits to primiparous women.[32]

Prevalence in CMDHB and New Zealand

Parity recorded in the birth registration dataset is for the current partner only, and therefore is likely to underestimate a woman's parity. A comparison of Healthware data and birth registration data supports this hypothesis (Table 15). During 2007-09, 49% of CMDHB women were recorded with a parity of zero in the birth registration dataset, however only 38.3 percent of CMDHB resident women who delivered in CMDHB during this time were primiparous according to Healthware. The number of CMDHB women who deliver outside of Counties Manukau is not enough to account for the difference.

In addition, while the birth registration dataset recorded 11% of CMDHB women to have a parity of 3 or more during 2007-09, 19% of CMDHB resident women who delivered in a CMDHB facility were recorded in Healthware to have a parity of 3 or more during this time. If only birth registration data is considered, there is a suggestion that greater proportion of CMDHB mothers have a parity of 3 or higher (11%) than seen nationally (7%). Notably while 14% of all women who delivered in NZ during 2007-09 were living in CMDHB, 28% of NZ women with a parity of 6 or more recorded in the birth registration dataset were living in CMDHB, and 22% of those with a parity of 3-5 were living in CMDHB.

Table 14: Profile of CMDHB Mothers with a Parity of 3 or More, 2007-09

Ethnicity	**Num**	**Percent**	**Deprivation**	**Num**	**Percent**
Maaori	1,372	31.7	Decile 1-2	143	3.3
Pacific	2,312	53.4	Decile 3-4	92	2.1
Chinese	24	0.6	Decile 5-6	320	7.4
Indian	37	0.9	Decile 7-8	284	6.5
Other Asian	52	1.2	Decile 9-10	3,501	80.7
Euro/Other	532	12.3	**Suburb**	**Num**	**Percent**
Maternity Provider	**Num**	**Percent**	Howick	200	4.6
Private LMC	1,666	38.4	Otara	765	17.6
Shared Care	927	21.4	Papatoetoe	476	11.0
Closed Unit	1,334	30.7	Mangere	995	22.9
Secondary Care	91	2.1	Manurewa	1,095	25.2
Caseloading	102	2.4	Papakura	475	10.9
Unbooked	221	5.1	Franklin	335	7.7
Age group	**Num**	**Percent**	**Booking Gestation***	**Num**	**Percent**
<25 years	325	7.5	<10 weeks	611	14.1
25-29 years	1,092	25.2	10-18 weeks	1,512	34.8
30-34 years	1,368	31.5	19-28 weeks	1,217	28.0
35+ years	1,556	35.9	>28 weeks	781	18.0
Delivered	**Num**	**Percent**	**Delivery Gestation**	**Num**	**Percent**
Botany	160	3.7	<28 weeks	54	1.2
MMH	3,688	85.0	29-36 weeks	329	7.6
Papakura	316	7.3	37-40 weeks	3,118	71.8
Pukekohe	177	4.1	41+ weeks.	840	19.4

Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB. See section 1.1 for a description of maternity providers. Ethnicity is preferred. *Booking gestation includes Unbooked women in the denominator.

Table 15: Annual Average Number of Births by Parity, NZ and CMDHB 2007-09

Parity	New Zealand (BRD)		CMDHB (BRD)		CMDHB (HW*)	
	No.	%	No.	%	No.	%
0	33,098	51.6	4,350	49.2	2,864	38.3
1-2	26,532	41.4	3,499	39.6	3,177	42.4
3-5	4,035	6.3	871	9.9	1,222	16.3
6+	418	0.7	115	1.3	225	3.0
Total	64,083	100.0	8,835	100.0	7,489	100.0

Source: BRD: Birth registration dataset. HW: Healthware: *Only includes CMDHB resident women who delivered in a CMDHB facility.

On average of 1,447 CMDHB resident women with a parity of 3 or more delivered in a CMDHB facility each year during 2007-09. Of these women, 53% were Pacific, 32% were Maaori, 81% lived in areas of high relative socio-economic deprivation (decile 9-10), 36% were aged 35 years or older, 5% were Unbooked and an additional 46% booked after 18 weeks gestation, 9% delivered preterm and 19% delivered at 41 weeks gestation or later.

3.5 Gestation

Evidence for the Association

The New Zealand PMMRC reports have consistently demonstrated that perinatal mortality decreases with increasing gestation (Table 16).[1-3] While Flenady and colleagues did not identify prematurity as a major modifiable risk for stillbirth in and of itself; causes of preterm birth including chorio-amnionitis, hypertension, eclampsia, placental abruption, and maternal smoking were identified as important risk factors in high income countries.[33, 34] In contrast, post-term pregnancy (≥42 weeks) was identified as making a small contribution to the population attributable risk of stillbirth (0.3%) in such countries with an adjusted odds ratio of 1.3 (95% CI 1.1-1.7).[33]

Table 16: Stillbirth and Neonatal Mortality by Gestation, New Zealand 2007-09

Gestation	Stillbirths			Neonatal Deaths		
	Num	Rate per 1,000	95% CI	Num	Rate per 1,000	95% CI
20–23 weeks*	319	-	-	156	-	-
24–27 weeks	158	182.87	158.54-210.13	95	147.1	121.84-176.62
28–31 weeks	125	76.22	64.34-90.16	43	28.7	21.34-38.58
32–36 weeks	179	15.02	12.99-17.38	67	5.7	4.50-7.27
37–40 weeks	308	2.15	1.92-2.40	119	0.8	0.70-1.00
≥41 weeks	56	1.54	1.18-2.00	45	1.2	0.92-1.66

Source: PMMRC[1-3]. Note: *Inaccurate denominator precludes rate calculation. Stillbirth rates are per 1,000 total births; neonatal rates are per 1,000 live births.

3.5.1 Prematurity (Infants Born <36 Weeks Gestation)

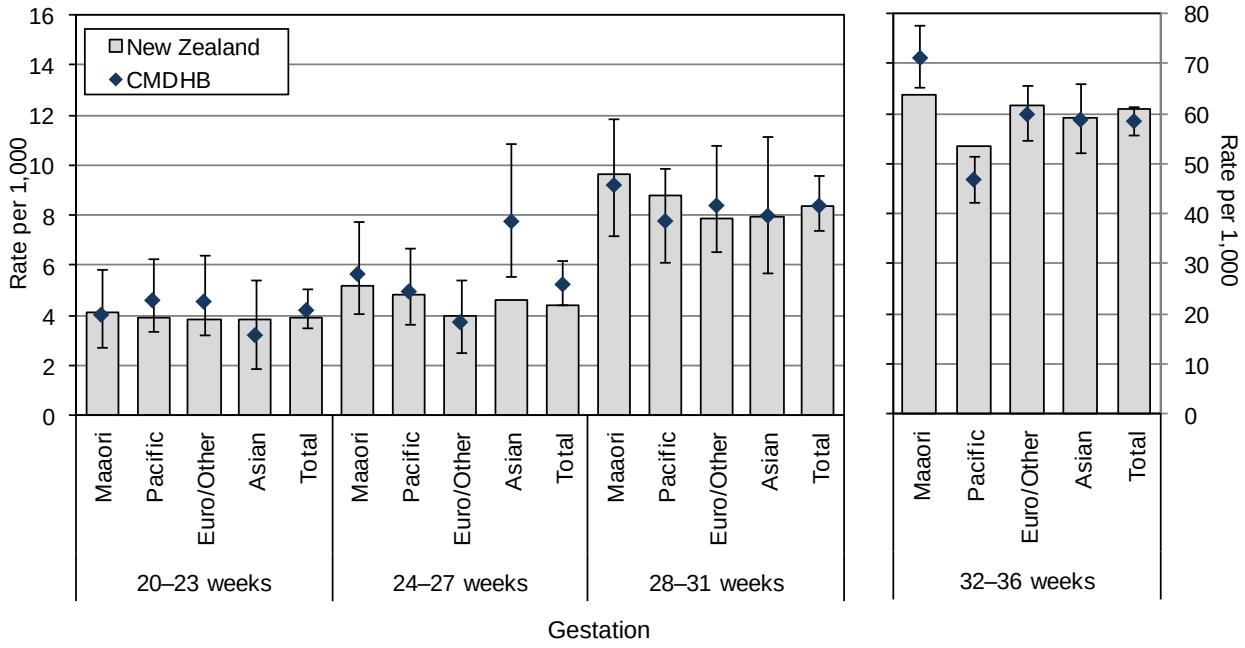
Prevalence in CMDHB and New Zealand

In NZ during 2007-2009, while <1% of all births occurred before 28 weeks gestation, infants born this early accounted for 54% of all perinatal deaths.[1-3] Infants born at 28-36 weeks comprise 6.8% of all births but 21% of all perinatal deaths. Infants born before 24 weeks

gestation are unlikely to survive, however during 2007-09 there was a discrepancy between the number of births reported to have occurred <24 weeks (773) and the number of deaths in infants born this early (811). If these differences reflect regional variation in birth registration then they could contribute to regional differences in perinatal mortality.

The CMDHB preterm birth rate (76.3 per 1,000), births at a gestation of <37 weeks, does not differ significantly from the national rate (77.8 per 1,000). However, the preterm birth rate for CMDHB Maaori (90.1 per 1,000) is significantly higher than the NZ rate for Maaori (82.8 per 1,000), driven by a significantly higher rate of births at 32-36 weeks gestation (Figure 12). While the total preterm birth rate for Asian women living in CMDHB is not significantly higher than the NZ rate, when this rate is disaggregated by gestation Asian women in CMDHB have a significantly higher rate of births at 24-27 weeks gestation. The higher rate of preterm births in CMDHB Asian women occurring at 24-27 weeks gestation is driven by higher rates in Indian women living in CMDHB (10.1 per 1,000) compared to Indian women living across NZ (6.2 per 1,000).

Figure 12: Preterm Birth Rates in CMDHB and New Zealand by Ethnicity, 2007-09

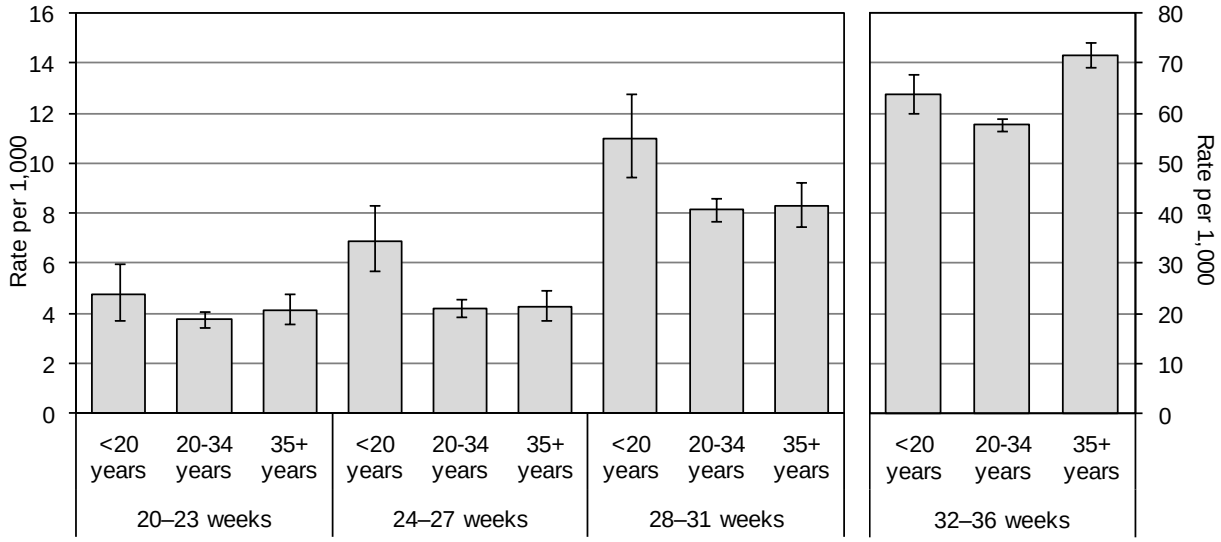


Source: Birth registration dataset. Note: Error bars indicate 95% confidence intervals. Scale differs for rates at a gestation of 32-36 weeks.

In New Zealand, preterm birth rates are significantly higher in young women aged <20 years (86.4 per 1,000) and in women aged 35 years and older (88.3 per 1,000) than in those aged 20-24 years (73.7 per 1,000) (Figure 8). This trend is also observed in women living in CMDHB. This tendency for young and older mothers to deliver prematurely is likely to be contributing to higher perinatal mortality rates in infants born to these women, particularly young women.

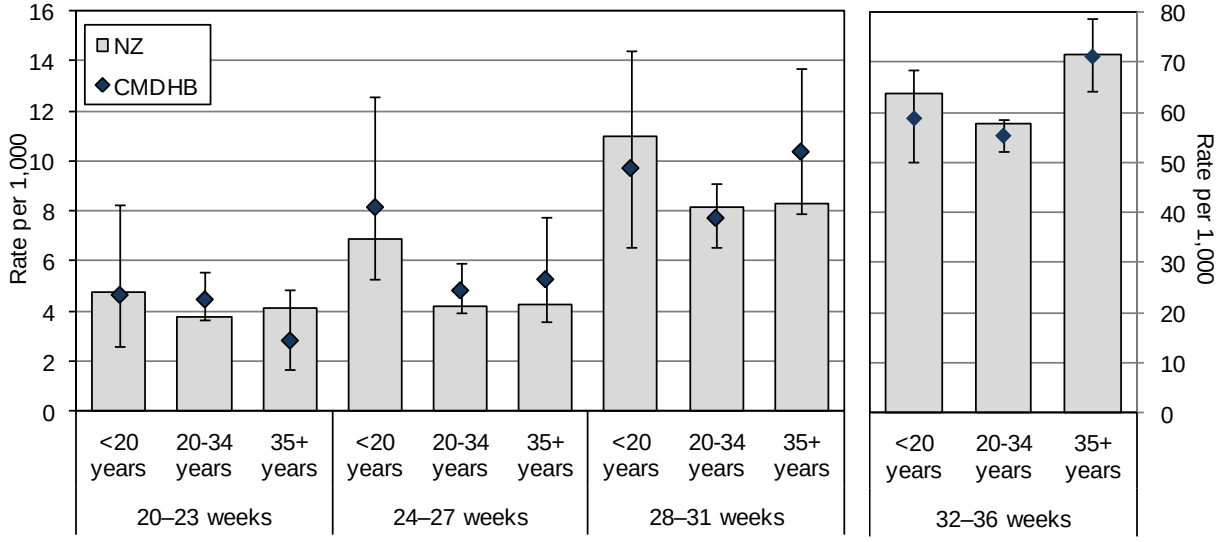
Across New Zealand, not only are young women more likely to deliver prematurely than women aged 20-34 years, the higher rate in this age group is driven by higher rates of delivery of very preterm infants born at 24-27 weeks gestation and at 28-31 weeks gestation (Figure 13). This trend is also observed in women living in CMDHB (Figure 14). Delivery at these earlier gestations is much more likely to result in a stillbirth or neonatal death than a delivery at term (Table 16).

Figure 13: Preterm Birth Rates by Gestation and Age Group, New Zealand 2007-09



Source: Birth registration dataset. Note: Error bars indicate 95% confidence intervals. Scale differs for rates at a gestation of 32-36 weeks.

Figure 14: Preterm Birth Rates by Gestation and Age Group in New Zealand and Counties Manukau DHB, 2007-09



Source: Birth registration dataset. Note: Error bars indicate 95% confidence intervals. Scale differs for rates at a gestation of 32-36 weeks.

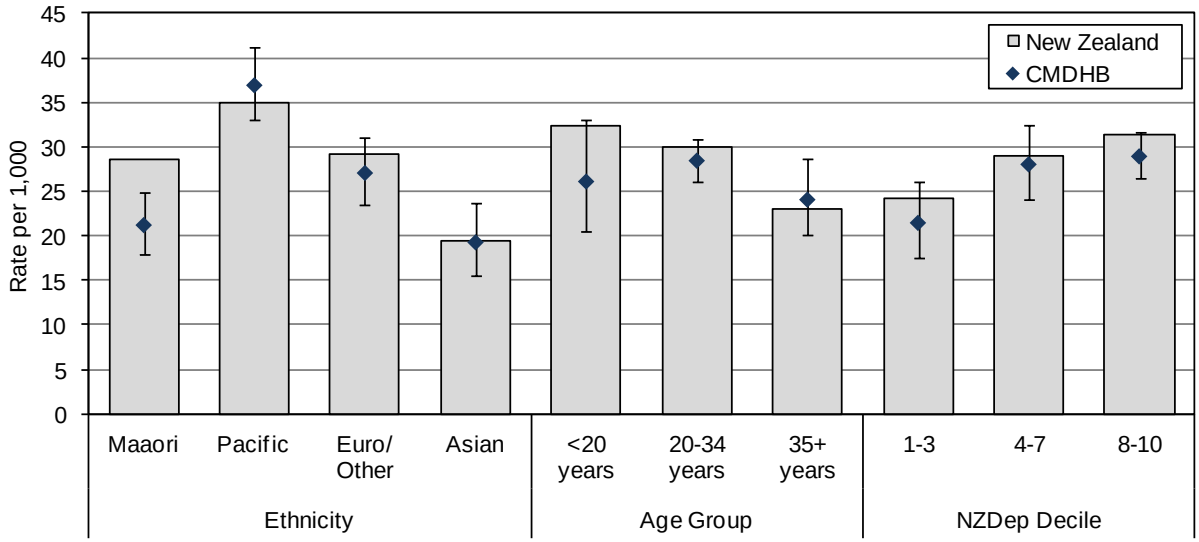
In contrast, the higher preterm delivery rate in older women (35 years and older) in New Zealand is driven by a higher preterm delivery rate at 32-36 weeks (Figure 13). Births at this gestation are still more likely to result in a stillbirth or neonatal death than birth at term; however mortality is significantly lower than for infants born before 32 weeks gestation (Table 16). While premature delivery trends in older women living in CMDHB are similar to national trends, older CMDHB women have a higher tendency to deliver at 28-31 weeks gestation than women in this age group nationally; although this difference is not statistically significant.

3.5.2 Post-Term (Infants Born ≥42 Weeks Gestation)

Prevalence in CMDHB and New Zealand

Post-term births make a small contribution to the population attributable risk of stillbirth in high income countries.[33] There is no significant difference between the CMDHB post-term delivery rate (27.4 per 1,000 (95% CI: 25.5-29.4)) and the national rate (28.7 per 1,000 (95% CI: 27.9-29.4). Across New Zealand, post-term delivery rates are highest in Pacific women, women aged <20 years, and in those living in New Zealand's most socio-economically deprived areas (NZDep decile 8-10) (Figure 15). Trends in CMDHB women generally follow national trends with the exception of the post-term delivery rate in CMDHB Maaori which is significantly lower than that for Maaori women across New Zealand as a whole.

Figure 15: Post-Term Birth Rates in CMDHB and New Zealand by Ethnicity, 2007-09



Source: Birth registration dataset. Note: Error bars indicate 95% confidence intervals. Ethnicity is prioritised. NZ deprivation decile is at 2006 meshblock level.

3.6 Fetal Growth Restriction (Small for Gestation Age)

Evidence for the Association

Suboptimal fetal growth has been associated with poor pregnancy outcomes, including stillbirth, neonatal morbidity (e.g. necrotising enterocolitis, bronchopulmonary dysplasia, severe retinopathy of prematurity), and neonatal mortality, and also with poorer outcomes later in life such as learning difficulties, cardiovascular disease, and diabetes.[39-41]

Flenady reports a meta-analysis of three studies that demonstrated that a gestational size of less than 10% was associated with a four-times higher risk of stillbirth, and estimated the population attributable risk of small for gestation age at 23% for stillbirth in high income countries.[33] The PMMRC recommend the use of GROW customised growth charts that are customised for New Zealand women based on height and weight in early pregnancy, parity and ethnicity.[3, 42] Birth registration data does not capture maternal height and weight, and likely underestimates parity, so cannot be used to calculate customised birthweight centiles for identifying growth restricted infants.

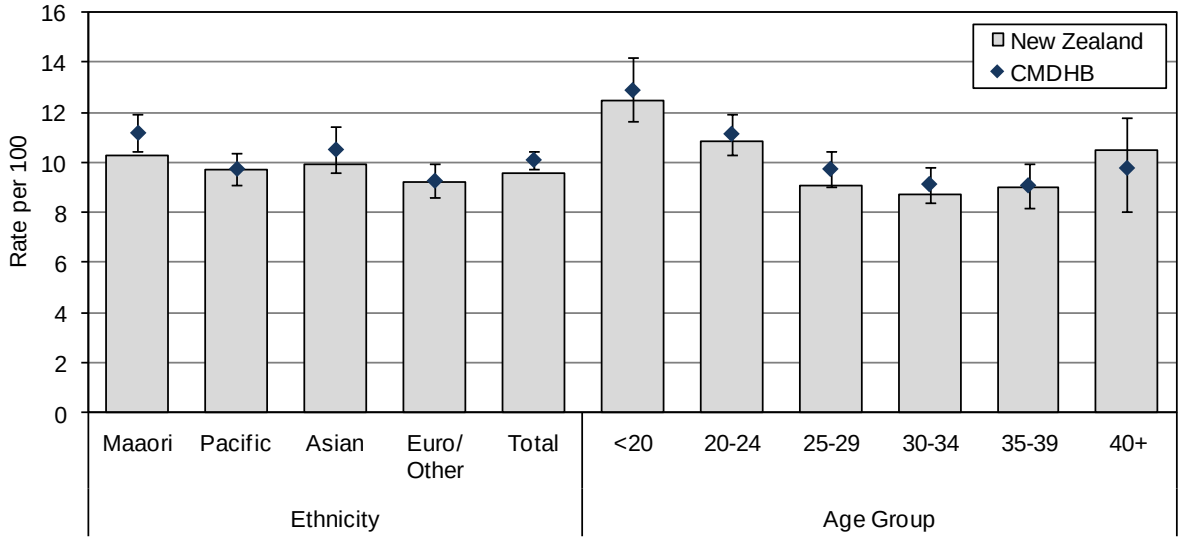
3.6.1 National Estimates using Birth Registration Data

Prevalence in CMDHB and New Zealand

To estimate small for gestational age (SGA) rates using population centiles, birthweight data for 2000-2009 were used to determine a cut-off birthweight for the tenth centile by ethnicity, gestation, and sex. This cut-off was then used to identify infants who had the lowest 10% of birthweights in New Zealand each year by ethnicity, gestation, and sex. While this methodology can applied consistently across regions, it is likely to underestimate SGA rates compared to using GROW customised birthweight centiles.[43]

During 2007-09, this methodology identified 10.1% of CMDHB infants as SGA compared with 9.6% of infants across NZ (Figure 16). CMDHB Maaori infants had a significantly higher rate of SGA (11.2%) than Maaori infants born anywhere in New Zealand (10.3%). No other differences by ethnicity were observed and no significant differences by age group were demonstrated.

Figure 16: Estimated Small for Gestation Age Rates Using Population Birthweight Centiles by Ethnicity and Age Group, CMDHB and New Zealand 2007-09



Source: Birth registration dataset. Note: Small for gestational age is a birth weight below the 10th centile for gestation, sex, and ethnicity. Ethnicity is prioritised. Error bars indicate 95% confidence intervals.

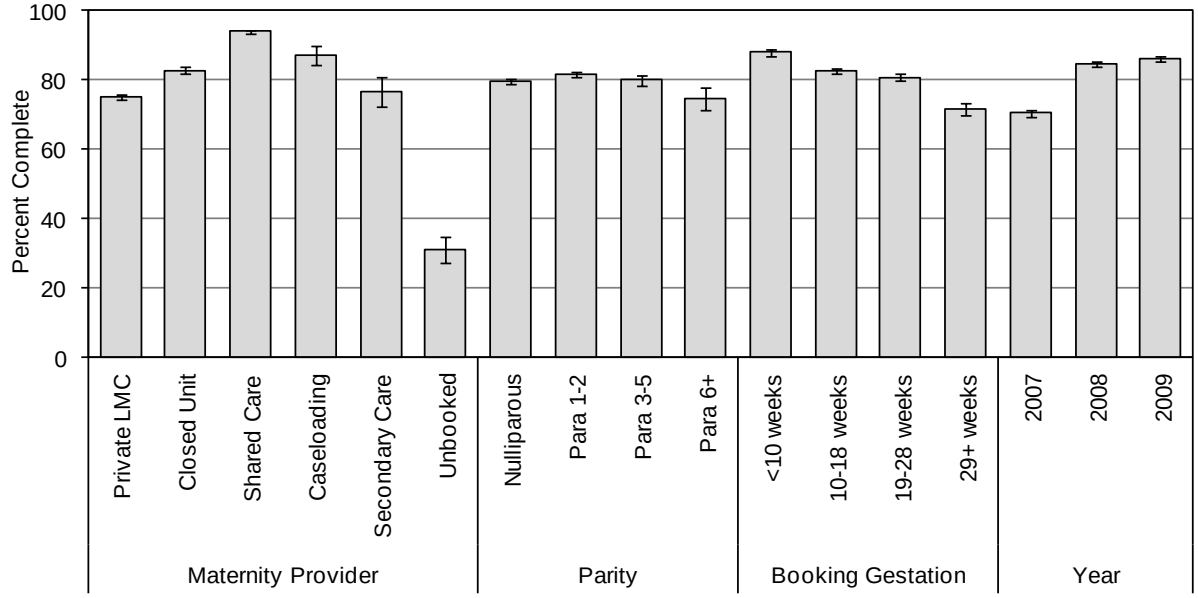
3.6.2 SGA in CMDHB using GROW Customised Centiles

Prevalence in CMDHB and New Zealand

A customised birth weight centile of <10% signifies SGA.[2] Healthware records the necessary data to calculate GROW customised birthweight centiles, and these data were 80.5% complete for CMDHB infants born to CMDHB resident women during 2007-09. The most frequently missing data were maternal weight and height (18.7%) followed by maternal ethnicity (1.0%), infant sex (0.05%), birth weight (0.04%) and maternal parity (<0.01%), while gestation was known for all infants. All six variables are required to calculate a customised centile. Customised birthweight centile data completeness varied significantly by the mother's maternity provider, parity, booking gestation, year, ethnicity, age group, and socio-economic deprivation (Figure 17, Figure 18). In particular, customised birthweight centiles were only available for 31% of the infants of Unbooked women who had no evidence of having had structured antenatal care.

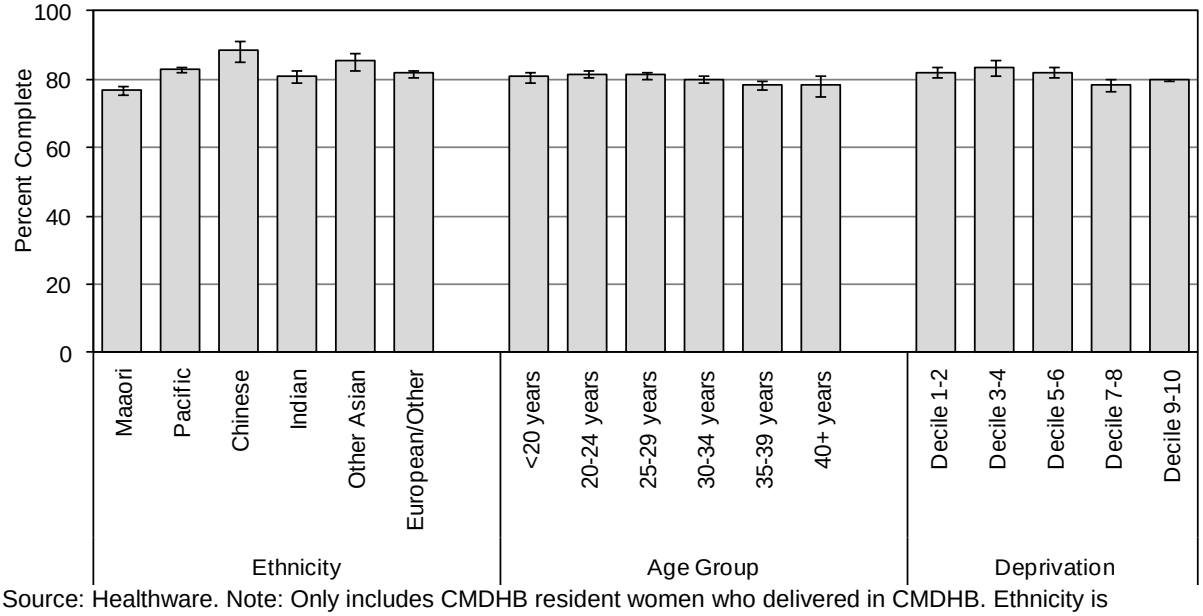
During 2007-09, 15.9% (95% CI: 15.4-16.4) of CMDHB infants born to CMDHB resident women were SGA. Although data completeness increased during the three years examined, there was no significant change in the proportion of infants born SGA during this time (p=0.07). No equivalent national data are available for comparison. In addition, Healthware ethnicity data is preferred ethnicity; therefore direct comparison of the results presented here with national analyses that should use prioritised ethnicity would be inappropriate in the event that these become available.

Figure 17: Customised Birthweight Centile Completeness by Pregnancy Feature, CMDHB 2007-09



Source: Healthware. Note: Only includes CMDHB resident women who delivered in CMDHB. Error bars indicate 95% confidence intervals.

Figure 18: Customised Birthweight Centile Completeness by Demographic Characteristic, CMDHB 2007-09



Source: Healthware. Note: Only includes CMDHB resident women who delivered in CMDHB. Ethnicity is preferred. Error bars indicate 95% confidence intervals.

Of the 2,917 CMDHB infants who were SGA 43.3% were Pacific, 25.7% were Maaori, 72.0% live in the most socio-economically deprived areas (decile 9-10), and 14.6% were born

prematurely. Nearly 2% were born to mothers who had no antenatal care (Unbooked), although this is likely to be an underestimate as these women were the least likely to have sufficient data recorded to allow calculation of customised growth centiles.

Table 17: Demographic and Pregnancy Characteristics for Infants Born Small for Gestation Age to CMDHB Women, 2007-09

	No.	Crude Rate per 100 (95% CI)	Crude OR (95% CI)	p	Adjusted OR (95% CI)	p
Ethnicity						
Maaori	749	18.7 (17.5-19.9)	1.7 (1.5-1.9)	<0.0001	1.3 (1.2-1.6)	0.0001
Pacific	1,264	18.3 (17.4-19.2)	1.6 (1.5-1.8)	<0.0001	1.5 (1.3-1.8)	<0.0001
Asian	292	12.2 (10.9-13.5)	1.0 (0.9-1.2)	ns	1.2 (1.0-1.4)	ns
Euro/Other	612	12.2 (11.3-13.1)	ref	ref	ref	ref
Age Group						
<20 years	298	15.5 (13.8-17.1)	1.0 (0.8-1.1)	ns	0.8 (0.7-1.0)	ns
20-24 years	731	16.7 (15.6-17.8)	1.1 (0.9-1.2)	ns	0.9 (0.8-1.0)	ns
25-29 years	792	16.0 (15.0-17.1)	1.0 (0.9-1.1)	ns	1.0 (0.8-1.1)	ns
30-34 years	656	16.0 (14.9-17.2)	ref	ref	ref	ref
35-39 years	440	14.4 (13.0-15.8)	0.9 (0.8-1.0)	ns	0.9 (0.7-1.0)	ns
40+ years	298	15.8 (12.9-18.7)	1.0 (0.8-1.2)	ns	0.9 (0.7-1.2)	ns
NZ Derivation Index Decile						
Decile 1-2	165	10.8 (9.3-12.4)	ref	ref	ref	ref
Decile 3-4	108	12.0 (9.9-14.2)	1.1 (0.9-1.5)	ns	1.0 (0.8-1.3)	ns
Decile 5-6	297	13.7 (12.2-15.1)	1.3 (1.1-1.6)	0.0099	1.1 (0.9-1.4)	ns
Decile 7-8	248	15.0 (13.3-16.7)	1.5 (1.2-1.8)	0.0005	1.1 (0.8-1.4)	ns
Decile 9-10	2,099	17.4 (16.7-18.0)	1.7 (1.5-2.0)	<0.0001	1.1 (0.9-1.3)	ns
Suburb						
Howick	248	11.2 (9.9-12.5)	ref	ref	ref	ref
Otara	413	18.3 (16.7-19.9)	1.8 (1.5-2.1)	<0.0001	1.3 (1.0-1.6)	ns
Papatoetoe	377	15.5 (14.1-17.0)	1.5 (1.2-1.7)	<0.0001	1.1 (0.9-1.4)	ns
Mangere	568	18.2 (16.9-19.6)	1.8 (1.5-2.1)	<0.0001	1.3 (1.0-1.6)	ns
Manurewa	679	16.8 (15.7-18.0)	1.6 (1.4-1.9)	<0.0001	1.2 (1.0-1.5)	ns
Papakura	318	17.0 (15.3-18.7)	1.6 (1.4-1.9)	<0.0001	1.3 (1.0-1.7)	ns
Franklin	314	13.1 (11.7-14.4)	1.2 (1.0-1.4)	ns	1.1 (0.9-1.3)	ns
Parity						
Nulliparous	1,065	15.4 (14.5-16.2)	ref	ref	ref	ref
1-2	1,222	15.4 (14.6-16.2)	1.0 (0.9-1.1)	ns	1.0 (0.9-1.1)	ns
3-5	506	17.0 (15.7-18.4)	1.1 (1.0-1.3)	ns	0.8 (0.7-1.0)	ns
6 or more	124	24.2 (20.5-27.9)	1.8 (1.4-2.2)	<0.0001	1.3 (1.0-1.6)	ns
Maternal Smoking						
No	1,911	13.9 (13.3-14.5)	ref	ref	ref	ref
Yes	655	23.6 (22.0-25.2)	1.9 (1.7-2.1)	<0.0001	1.8 (1.6-2.1)	<0.0001
Multiple Birth						
No	2,721	15.3 (14.7-15.8)	ref	ref	ref	ref
Yes	196	40.0 (35.7-44.3)	3.7 (3.1-4.5)	<0.0001	3.8 (3.1-4.7)	<0.0001
Gestation						
<24 weeks	49	56.3 (45.9-66.7)	7.7 (5.1-11.9)	<0.0001	6.6 (4.2-10.4)	<0.0001
24-27 weeks	31	31.0 (21.9-40.1)	2.7 (1.8-4.1)	<0.0001	2.4 (1.4-3.9)	0.001
28-31 weeks	49	30.4 (23.3-37.5)	2.6 (1.9-3.7)	<0.0001	2.7 (1.8-3.8)	<0.0001
32-36 weeks	229	18.5 (16.3-20.7)	1.4 (1.2-1.6)	<0.0001	1.0 (0.9-1.2)	ns
37-41 weeks	1,786	13.5 (12.9-14.1)	ref	ref	ref	ref
42+ weeks	314	31.2 (28.3-34.0)	2.7 (2.4-3.1)	<0.0001	2.8 (2.4-3.3)	<0.0001

Source: Healthware. Note: OR: Odds Ratio. Only includes CMDHB infants who delivered in CMDHB and had sufficient data to calculate. Ethnicity is preferred.

Crude customised centile SGA rates varied significantly by maternal ethnicity, socio-economic deprivation, suburb, parity, maternal smoking, multiple births and gestation at delivery ($p<0.0001$ for all). No significant differences in rates by maternal age were identified. The highest rates were seen in infants born to Maaori and Pacific women, women living in the most deprived areas, women with a parity of 6 or more, women who smoked during pregnancy, multiple births, and infants born prematurely or at 42 weeks gestation or beyond (Table 17).

In order to determine whether these characteristics effected SGA rates independent of each other, a multivariate logistic regression analysis was performed with SGA as the outcome of interest and maternal ethnicity, age, NZDep06, suburb, parity, smoking status during pregnancy, multiple pregnancy, and delivery gestation as the explanatory variables. After controlling for the effects of these variables on SGA rates, only maternal ethnicity, maternal smoking during pregnancy, multiple births and gestation at delivery remained independent associated. The following observations were made:

- Infants born to Maaori women had 1.3 times higher odds of being SGA than infants born to European/Other women, and infants born to Pacific women had 1.5 times higher odds.
- Infants born to women who smoked during pregnancy had 1.8 times higher odds of being SGA than infants born to women who did not smoke.
- Twins and triplets had 3.8 times higher odds of being SGA than singleton infants.
- Infants who were born before 32 weeks had higher odds of being born SGA than infants being born at term, with the odds increasing with increasing prematurity.
- Infants born post-term (42 weeks or more) had nearly three times higher odds of being born SGA than infants born at term.

3.7 Maternal Body Mass

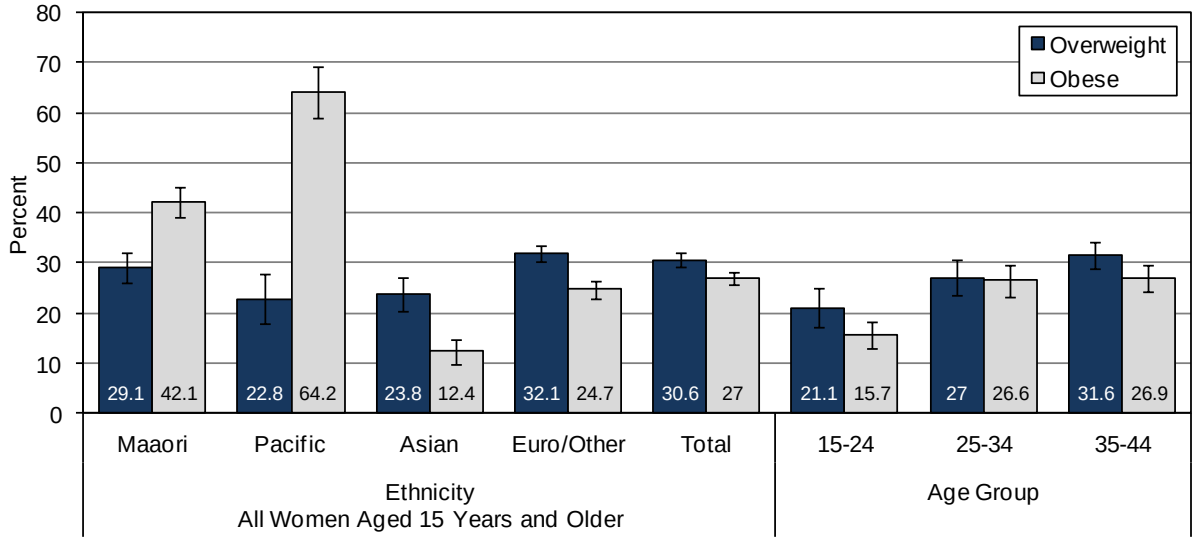
Evidence for the Association

Overweight and obesity in pregnancy have been associated with an increased odds of urinary tract infection, pre-eclampsia, gestational diabetes, preterm and post-term birth, induction of labour, caesarean section, macrosomia, stillbirth, and neonatal and maternal death.[44-48] Flenady and colleagues identified pre-pregnancy overweight and obesity as the top ranking modifiable risk factor for stillbirth in five high income countries including Australia, the UK, USA, Canada, and the Netherlands, increasing the odds of stillbirth by 23% and 60% respectively.[33] The combined prevalence of overweight and obesity in these countries ranged from 28%-58% resulting in a population attributable risk for stillbirth of 8-18%. A large Swedish study reported that the risk of stillbirth increased linearly with weight gain between pregnancies, so that an increase in BMI of 3 kg/m^2 or more between a first and second pregnancy increased the odds of a stillbirth by 60%, with a greater effect seen for term stillbirths compared to preterm stillbirths.[49]

3.7.1 Prevalence of Overweight and Obesity in New Zealand Women

National level data on the prevalence of overweight and obesity in pregnancy are not available. The New Zealand Health Survey (2006-07) found that 21-32% of women of child bearing age (15-44 years) were overweight and 16-27% were obese (Figure 19).[50] Marked differences in the prevalence of overweight and obesity were reported by ethnicity.[50] In women of all ages, being overweight was most common in European/Other and Maaori women, whereas Pacific women and Maaori women had the highest prevalence of obesity.

Figure 19: Overweight and Obesity in New Zealand Women, 2006-07



Source: New Zealand Health Survey, Ministry of Health[50]. Note: Ethnicity is prioritised. Error bars indicate 95% confidence intervals.

3.7.2 Prevalence of Overweight and Obesity in CMDHB Mothers

CMDHB Body Mass Index Data

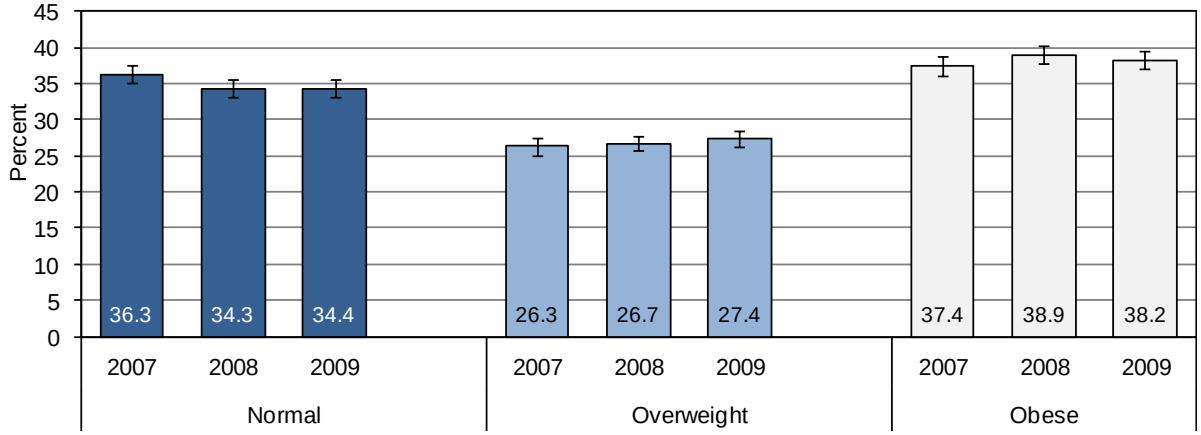
At CMDHB height and weight are recorded on the booking form and captured in Healthware allowing BMI calculation. During 2007-09, sufficient data were available to calculate a BMI for 81.4% of the CMDHB resident women who delivered in CMDHB. The proportion of women for whom a BMI was available increased significantly ($p<0.0001$) during the three years examined from 71.3% (95% CI: 70.3-72.4) in 2007 to 87.1% (95% CI: 86.3-87.9) in 2009. While three years of data is insufficient to be confident of this trend, it is encouraging.

The completeness of BMI data differed by maternity provider, ethnicity, parity, deprivation, and residential suburb. Unbooked women least frequently had sufficient data recorded to allow BMI calculation (32%) followed by women with a Private LMC (76%) or Secondary Care (78%). In contrast, 95% of women with Shared Care, 88% of woman with a Caseloading midwife, and 84% of women with Closed Unit care had their BMI captured. Groups of women in whom <85% had a BMI captured in Healthware were, Maaori (77%), Indian (81%), European/Other (82%) and Pacific (83%) women; women living in Papakura (73%), Manurewa (77%), Papatoetoe (81%) or Mangere (82%); and women living in decile 7-10 areas (80%), decile 5-6 areas (83%) and decile 1-2 areas (84%). By parity, all groups had <85% with a BMI captured, however completeness declined with increasing parity (para 3-5: 80%; para 6+: 74%). BMI data completeness was <85% for all age groups, however it was lowest in women aged 35 years and older (80%).

Note: BMI data are not recorded equally in all groups of CMDHB women. Groups for whom recording is the lowest are likely to be those at highest risk being overweight or obese. Therefore, the data reported here are likely to underestimate overweight and obesity.

During 2007-2009, 35% of CMDHB women who delivered in a CMDHB facility had a BMI in the normal range, 27% were overweight, and 38% were obese. Some changes in body size distribution were observed during the study period (Figure 20). The proportion of women whose body size was in the normal range declined from 36% in 2007 to 34% in 2009. Consequently, an increase in the proportion of overweight and obese women was observed.

Figure 20: Body Size at Booking for CMDHB Resident Women, 2007-09



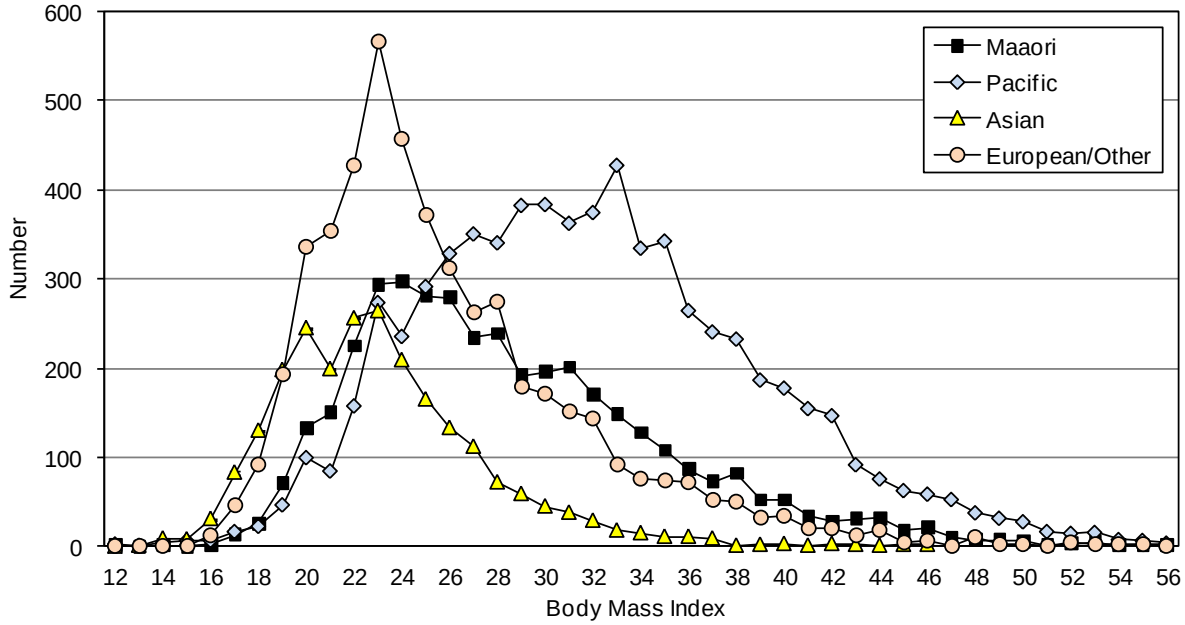
Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB and had their BMI recorded. Error bars indicate 95% confidence intervals.

There are several potential reasons for this observed change including an increase in body size in this population, improved data acquisition for overweight or obese women, later booking gestation therefore higher BMI, or increased capture of measured weight and height data as opposed to self-reported data which tend to underestimate BMI. Caution must be taken with interpretation as three years of data are insufficient to be confident of a trend.

3.7.2.1 Body Size by Demographic Characteristics

During 2007-09, body size at booking varied by ethnicity, age group, deprivation and residential suburb. The greatest variation in BMI was observed by ethnic group (Figure 21, Table 18). Pacific women had the highest median BMI at 32, followed by Maaori (27) and European/Other (27) women, while Asian women had the lowest median BMI (23). This is reflected in the distribution of BMI's by ethnic group (Figure 21). During pregnancy, 86% of Pacific women, 69% of Maaori women, and 50% of European/Other women were overweight or obese during 2007-09.

Figure 21: Body Mass Index Distribution During Pregnancy by Ethnicity (for BMI≤56), CMDHB Resident Women 2007-09



Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB and had their BMI recorded. To avoid compression of curves, 47 women with a BMI >56 were excluded (11 Maaori, 32 Pacific, and 4 European/Other). Ethnicity is preferred.

During 2007-09, the proportion of CMDHB women who were overweight or obese increased with increasing age from 57% in young women <20 years to 76% in women aged 40 years and older. Consequently, young women (<20 years) had the lowest median and mean BMI, while women aged 40 years and older had the highest (Table 18).

Table 18: Body Size at Booking Ethnicity, Age Group, Deprivation, and Suburb, CMDHB 2007-09

	BMI		Normal		Overweight		Obese	
	Median	Mean	Num	%	Num	%	Num	%
Total	27	28.5	6,379	34.9	4,907	26.9	6,991	38.3
Ethnicity								
Maaori	27	28.6	1,213	30.7	1,225	31.0	1,517	38.4
Pacific	32	32.1	962	14.1	1,696	24.8	4,174	61.1
Chinese	22	21.9	318	82.6	57	14.8	10	2.6
Indian	23	24.0	778	60.0	360	27.8	158	12.2
Other Asian	22	22.2	537	78.3	124	18.1	25	3.6
European/Other	24	25.9	2,488	50.2	1,400	28.3	1,066	21.5
Age Group								
<20 years	25	26.3	829	43.2	610	31.8	479	25.0
20-24 years	27	28.1	1,502	34.5	1,243	28.6	1,607	36.9
25-29 years	27	28.5	1,726	35.0	1,283	26.0	1,917	38.9
30-34 years	27	28.9	1,397	34.2	1,028	25.2	1,657	40.6
35-39 years	28	29.5	781	32.5	581	24.1	1,044	43.4
40+ years	29	30.7	144	24.3	162	27.3	287	48.4
NZ Deprivation Index Decile (CAU)								
Decile 1-2	23	24.4	935	61.1	409	26.7	187	12.2
Decile 3-4	24	25.6	476	52.8	220	24.4	205	22.8
Decile 5-6	25	26.2	1,061	48.6	614	28.2	506	23.2
Decile 7-8	26	27.3	705	42.5	443	26.7	509	30.7
Decile 9-10	29	29.8	3,201	26.7	3,218	26.8	5,584	46.5
Suburb								
Howick	23	24.9	1,318	59.0	538	24.1	379	17.0
Otara	31	31.3	428	19.2	562	25.2	1,239	55.6
Papatoetoe	27	28.2	866	35.8	648	26.8	906	37.4
Mangere	31	31.3	597	19.3	762	24.6	1,742	56.2
Manurewa	28	28.9	1,223	30.5	1,161	28.9	1,627	40.6
Papakura	26	27.4	780	41.6	505	27.0	588	31.4
Franklin	25	25.9	1,167	48.5	731	30.4	510	21.2

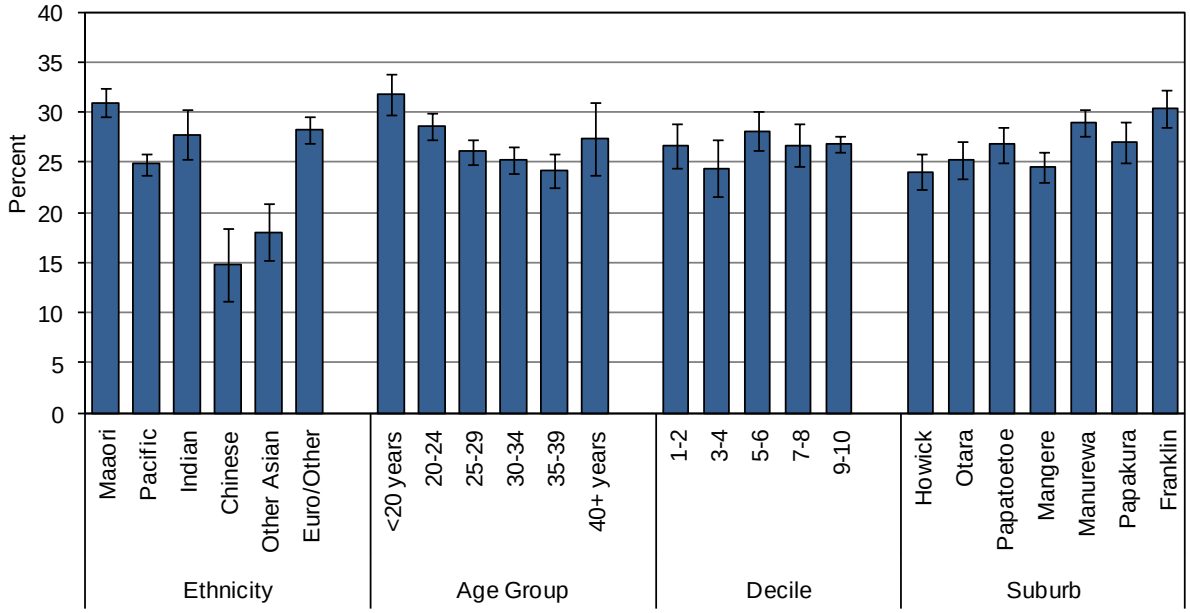
Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB and had their BMI recorded. Normal: BMI <25, Overweight: BMI 25-29; Obese: BMI ≥30.

Mean and median BMI's increased with increasing deprivation, driven by the increasing proportion of women in each decile that were obese. During 2007-09, 73% of CMDHB living in the most socio-economically deprived areas (decile 9-10) compared to 38% of those living in the least deprived areas. Women living in Howick had the lowest mean and median BMI, while women living in Otara and Mangere had the highest. The suburbs within CMDHB with the highest rate of overweight and obesity during pregnancy were Otara and Mangere. In these suburbs, 81% of the women were overweight or obese during pregnancy, reflecting the ethnicity and socioeconomic deprivation of these localities.

Overweight

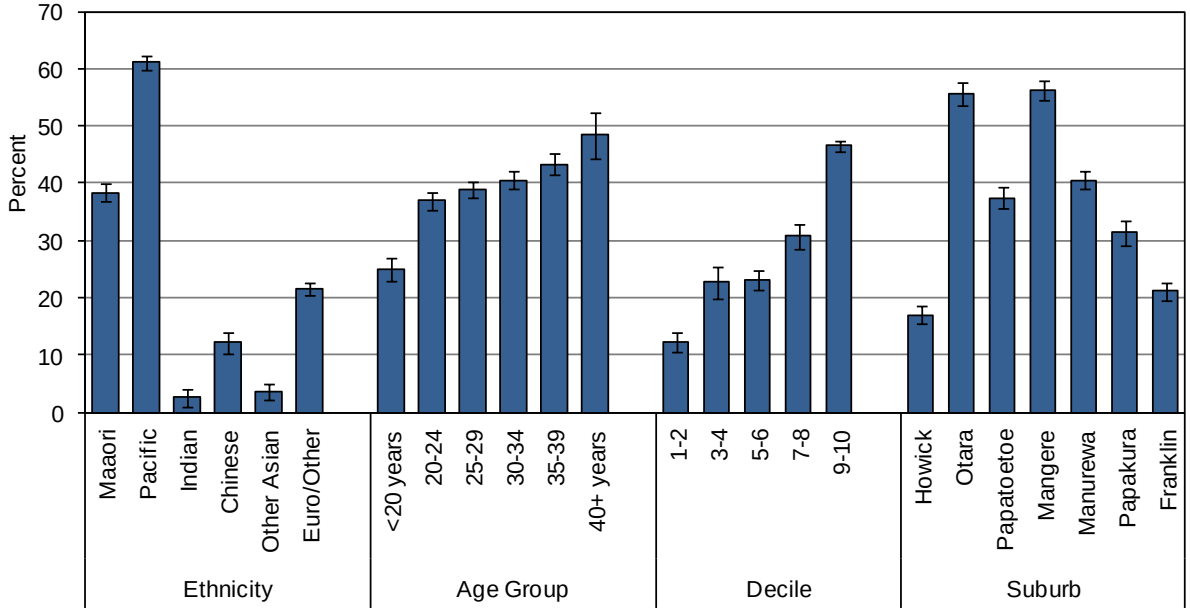
During 2007-09 crude overweight rates varied significantly by ethnicity, age group, and suburb (p<0.0001 for all, Figure 22) and were highest in Maaori (31%), Indian (28%), and European/Other women (28%); women aged <20 years (32%) or 20-24 years (29%); and in women living in Franklin (30%) and Manurewa (29%). No significant differences in crude overweight rates were observed by socio-economic deprivation decile (p=0.33).

Figure 22: CMDHB Women who were Overweight during Pregnancy by Ethnicity, Age Group, Decile, and Suburb, 2007-09



Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB and had their BMI recorded. Ethnicity is preferred. Error bars indicate 95% confidence intervals.

Figure 23: CMDHB Women who were Obese during Pregnancy by Ethnicity, Age Group, Decile, and Suburb, 2007-09



Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB and had their BMI recorded. Ethnicity is preferred. Error bars indicate 95% confidence intervals.

Obesity

During 2007-09 crude obesity rates varied significantly by ethnicity, age group, deprivation and suburb (p<0.0001 for all, Figure 23) and were highest in Pacific (61%) and Maaori (38%) women. Crude obesity rates increased with increasing age from 25% in women aged <20 years to 40% in women aged 25-29 years, to 48% in women aged 40 years and older. Crude obesity rates also increased with increasing relative socioeconomic deprivation of the area in which a woman lives, from 12% for women living in decile 1-2 areas, to 23% for women living in decile 5-6 areas, to 47% for women living in decile 9-10 areas. Crude obesity rates differed significantly by residential suburb with the highest rates seen in women living in Otara (56%), Mangere (56%), and Manurewa (41%) (Table 18).

3.7.2.2 Body Size by Pregnancy Characteristics

Overweight and obese women in CMDHB are cared for in pregnancy by all types of maternity providers. During 2007-09, the maternity providers with the highest proportion of their women who were overweight or obese were Secondary Care (79%) and Shared Care (75%) providers. Unbooked women were least likely to have their BMI data recorded; of those that did 74% were overweight or obese.

Booking before 10 weeks gestation is recommended for pregnant women in CMDHB by the PMMRC. During 2007-09, Healthware data suggests that only 17% of pregnant women booked this early, although the robustness of this data is unknown. A slightly higher proportion of obese women (20%) booked before 10 weeks during this time.

The proportion of CMDHB women who were overweight or obese during pregnancy increased with increasing parity during the study period. Half of the nulliparous women were overweight or obese during pregnancy, compared with 91% of women with a parity of 6 or more.

Table 19: Body Size at Booking by Maternity Provider, Booking Gestation, Parity, Delivery Gestation, and Delivery Location, CMDHB 2007-09

	Normal		Overweight		Obese	
	Num	**%**	**Num**	**%**	**Num**	**%**
Maternity Provider						
Private LMC	3,509	41.5	2,318	27.4	2,634	31.1
Closed Unit	1,300	35.0	963	25.9	1,453	39.1
Shared Care	1,265	24.7	1,350	26.3	2,510	49.0
Caseloading	192	39.5	156	32.1	138	28.4
Secondary	65	21.2	64	20.9	177	57.8
Unbooked	48	26.2	56	30.6	79	43.2
Booking Gestation						
<10 weeks	1,094	32.6	870	25.9	1,396	41.5
10-18 weeks	3,392	40.3	2,259	26.8	2,775	32.9
19-28 weeks	1,330	31.0	1,174	27.4	1,781	41.6
29+ weeks	515	25.4	548	27.1	961	47.5
Parity						
Nulliparous	3,047	43.9	1,955	28.2	1,942	28.0
Para 1-2	2,758	35.0	2,161	27.4	2,969	37.6
Para 3-5	529	18.0	680	23.1	1,733	58.9
Para 6+	45	8.9	111	22.1	347	69.0

Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB and had their BMI recorded. See section 1.1 for a description of maternity providers. Normal: BMI <25, Overweight: BMI 25-29; Obese: BMI ≥30.

3.8 Smoking in Pregnancy

Evidence for the Association

Smoking during pregnancy is associated with a number of adverse pregnancy outcomes including miscarriage, placental abruption, intrauterine growth restriction, premature delivery, and stillbirth.[51] In addition, smoking during pregnancy has been associated with an increased risk of neonatal death, particularly as a result of Sudden Unexplained Death in Infancy (SUDI).[51] A meta-analysis of four studies based on maternal self-report of any smoking in pregnancy reported increased odds of stillbirth by 36% in women who smoked.[33] Smoking more than 10 cigarettes a day increased in odds of a stillbirth by 86%. Stronger associations with smoking have been reported; with one high quality study reporting an adjusted odds ratio of 2.48 (95% CI: 1·89–3·11).[52]

Flenady and colleagues estimated the population attributable risk of any smoking on stillbirth rates as 4-7% across 5 high income countries.[33] Populations with heavy smoking (10 or more cigarettes per day) and with a higher prevalence of smoking will have a higher population attributable risk. For example, assuming an adjusted odds ratio for any smoking of 1.36 and a prevalence of smoking of 50-60% the population attributable risk would increase to 20%.[33]

Prevalence in CMDHB and New Zealand

There is currently no national maternity data collection that records smoking during pregnancy for all New Zealand women. Smoking during pregnancy is recorded in the hospital admission dataset for hospital births; however the accuracy of these historical data is unknown. During 2004-2008, 15.8% of New Zealand women giving birth in hospital had tobacco use recorded in hospital admission data; 16.1% of women who lived in CMDHB.[36] Across New Zealand, tobacco use in pregnancy was highest during this time for women aged <20 years (33.1%), Maaori women (37.5%), and those living in the socio-economically deprived decile 9-10 areas (24.2%).[36]

3.8.1 CMDHB Smoking Data

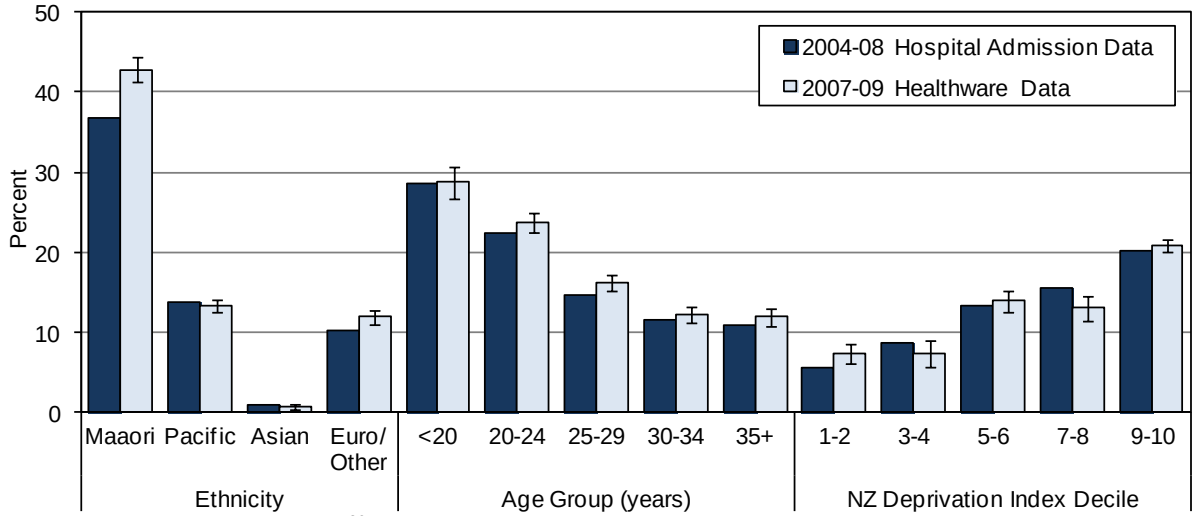
At CMDHB smoking status is recorded on the booking form (see Appendix 3) and captured in Healthware. During 2007-2009, smoking status during pregnancy was recorded for 88.2% of women, and over the three years reviewed the completeness of smoking data did not change significantly. Smoking data completeness varied by maternity provider, ethnicity, age group, parity, deprivation, and suburb. Unbooked women were least likely to have their smoking status recorded (70%) followed by those with Shared Care (86%). Women with Secondary (95%), Closed Unit (90%), Caseloading (89%) or Private LMC (89%) care were most likely to have smoking status. Groups of women in whom the proportion of smoking data recorded was <90% were Maaori women (82%), women aged <20 years (81%) or 20-24 years (86%), nulliparous women (84%), women living in areas of high deprivation (decile 7-8: 89%; decile 9-10: 87%), and women living in Papakura (84%), Otara (86%), Mangere and Franklin (89%).

Note: Smoking data are not recorded equally in all groups of CMDHB women. The groups in which recording is the lowest are likely to be those at highest risk of smoking in pregnancy. Therefore, smoking data reported here are likely to be an underestimate.

3.8.1.1 Smoking in Pregnancy in CMDHB Resident Women

During 2007-2009, 3,469 (17.5% (95% CI: 17.0-18.0) CMDHB women who delivered in CMDHB reported smoking during their pregnancy. This is a very similar proportion to that estimated from hospital admission data for all CMDHB women which was 16.1% during 2006-2008.[36] The demographic trends in smoking during pregnancy reported using hospital admission data were also similar to those reported using Healthware data (Figure 24). The most prominent difference was higher smoking rates for Maaori women reported in Healthware (43%) than in the hospital admissions data (37%). This difference may have occurred as a result of different ethnicity data collection processes used for the two dataset (see 2.2.2).

Figure 24: Smoking in Pregnancy in CMDHB Women using National (Hospital Admission) and Local (Healthware) Data



Source: Hospital Admission Data[36] and Healthware. Note: Healthware data only includes CMDHB resident women who delivered in CMDHB and had smoking status recorded. Ethnicity is prioritised for hospital admission data and preferred for Healthware data. Error bars indicate 95% confidence intervals.

Of the CMDHB resident women who reported smoking during pregnancy during 2007-09, 64.7% smoked 1-4 cigarettes per day, 24.1% smoked 5-10 per day, 9.7% smoked 11-20 per day, and 1.5% smoked more than 20 cigarettes per day. Just over half of these women were Maaori (52%), 28% were Pacific, and 19% were European/Other, nearly half were aged <25 years old (47%), 78% lived in the most socioeconomically deprived areas (decile 9-10), and 11% had a preterm delivery (Table 20). More than half of the women received at least some of their antenatal care from a CMDHB maternity provider, with 29% using Shared Care, 23% using Closed Unit, while 2.4% had a Caseloading midwife, and 2.1% had Secondary Care. In addition, 39% had a Private LMC and 4.8% were Unbooked.

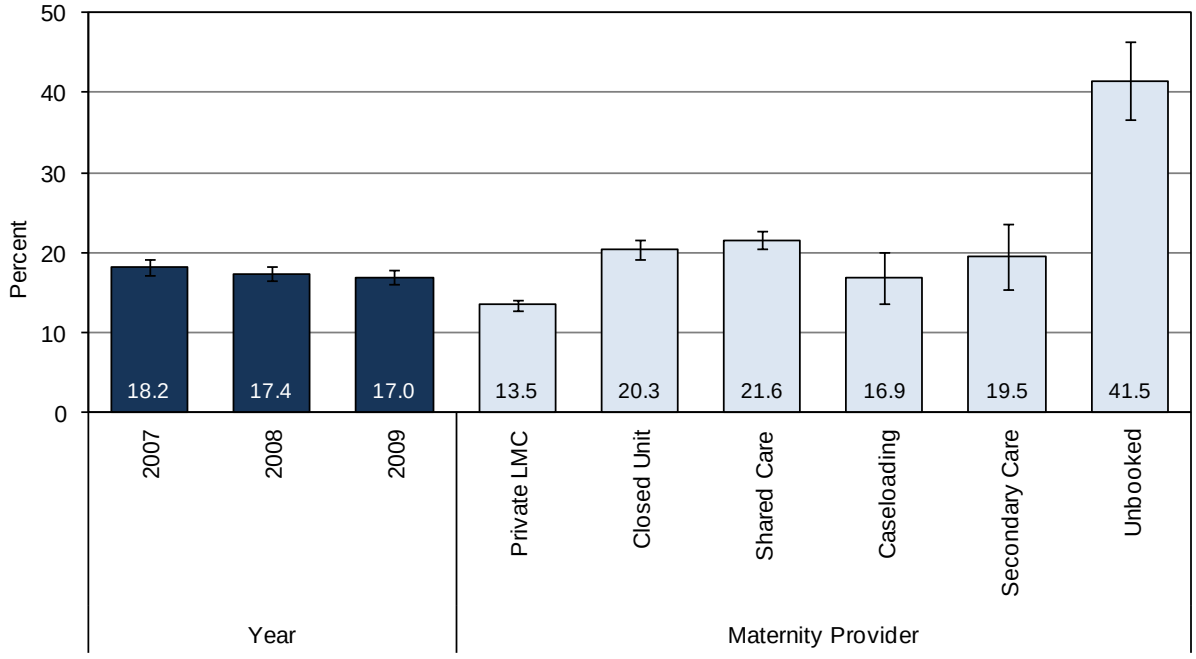
No significant change in the smoking rate was observed during the three years examined (p=0.19) (Figure 25). However, within the cohort of CMDHB women with available smoking data, some groups were more likely to smoke during pregnancy than others. Women who didn't book during their pregnancy had the highest smoking rate at 42%, followed by women using Shared Care (22%), Closed Unit (20%), Secondary (20%), and Caseloading (17%) (Figure 25). Women who used a Private LMC had the lowest smoking rate (14%).

Table 20: Profile of CMDHB Women who Smoked During Pregnancy, 2007-2009

Ethnicity	Num	Percent	Deprivation	Num	Percent
Maaori	1,805	52.3	Decile 1-2	122	3.5
Pacific	978	28.3	Decile 3-4	69	2.0
Chinese	7	0.2	Decile 5-6	326	9.4
Indian	9	0.3	Decile 7-8	241	7.0
Other Asian	5	0.1	Decile 9-10	2,710	78.1
Euro/Other	648	18.8	**Suburb**	**Num**	**Percent**
Age Group	**Num**	**Percent**	Howick	160	4.6
<20 years	550	15.9	Otara	478	13.8
20-24 years	1,077	31.1	Papatoetoe	366	10.6
25-29 years	879	25.3	Mangere	604	17.4
30-34 years	558	16.1	Manurewa	948	27.3
35-39 years	320	9.2	Papakura	566	16.3
40+ years	85	2.5	Franklin	347	10.0
Parity	**Num**	**Percent**	**Booking Gestation**	**Num**	**Percent**
Nulliparous	1,050	30.3	<10 weeks	583	17.6
Para 1-2	1,427	41.1	10-18 weeks	1,294	39.2
Para 3-5	802	23.1	19-28 weeks	903	27.3
Para 6+	190	5.5	>28 weeks	524	15.9
Delivered	**Num**	**Percent**	**Delivery Gestation**	**Num**	**Percent**
Botany	121	3.5	<28 weeks	67	1.9
MMH	2,863	82.5	29-36 weeks	309	8.9
Papakura	334	9.6	37-40 weeks	2,494	71.9
Pukekohe	151	4.4	41+ weeks.	599	17.3

Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB and who reported smoking in pregnancy. Ethnicity is preferred.

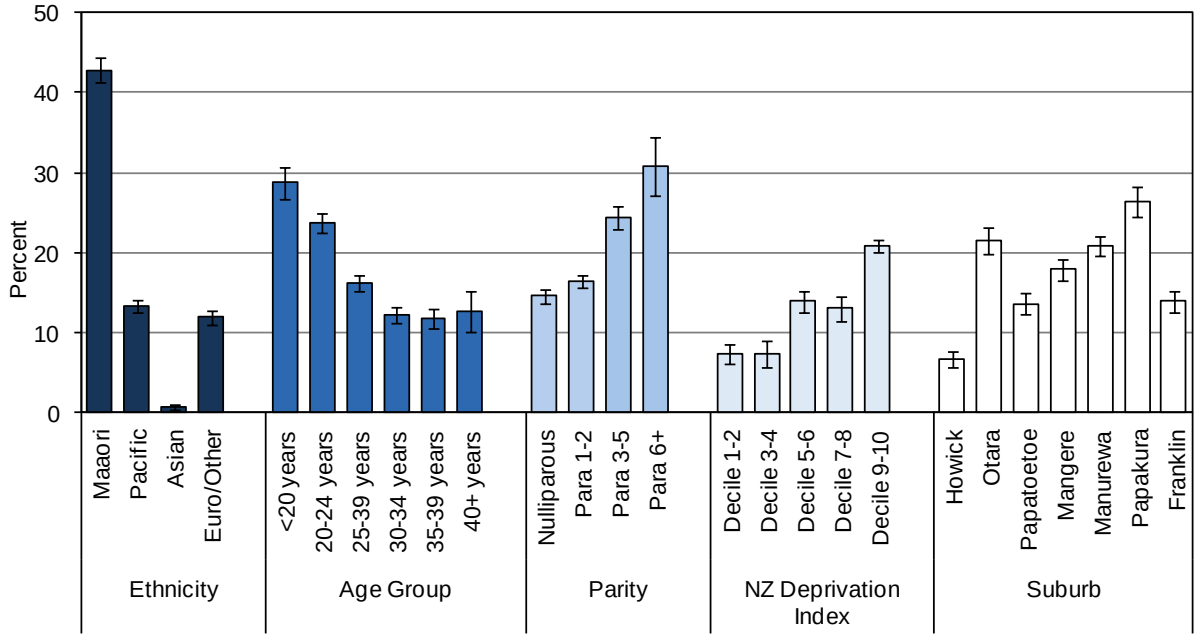
Figure 25: Smoking During Pregnancy in CMDHB Resident Women by Year and Maternity Provider, 2007-09



Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB had their smoking status recorded. Error bars indicate 95% confidence intervals

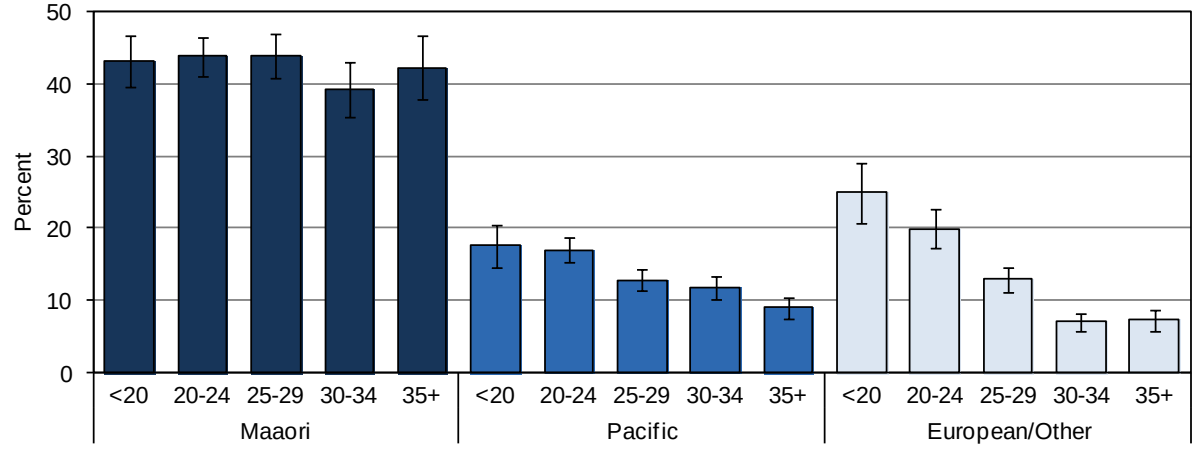
A greater proportion of CMDHB Maaori women smoked during pregnancy (43%), than Pacific (13%), European/Other (12%), or Asian women (<1%) (Figure 26). Smoking rates declined with increasing age overall from 29% in women aged <20 years to 12% in women aged 30 years and older, and for Pacific and European/Other women. In contrast, for Maaori women there were no significant differences in rates of smoking during pregnancy across the age groups (Figure 27). Rates increased with parity from 15% in nulliparous women to 31% in women with a parity of 6 or more. Rates also increased with increasing deprivation in the area of residence from 7% in decile 1-2 areas to 21% in decile 9-10 areas. Smoking in pregnancy rates also varied by suburb and were highest in Papakura (26%), Otara (22%), and Manurewa (21%) and lowest in Howick (7%).

Figure 26: Smoking During Pregnancy in CMDHB Resident Women by Ethnicity, Age, Parity, Deprivation, and Suburb, 2007-09



Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB had their smoking status recorded. Ethnicity is preferred. Error bars indicate 95% confidence intervals

Figure 27: Smoking During Pregnancy in CMDHB Resident Women by Ethnicity and Age Group, 2007-09

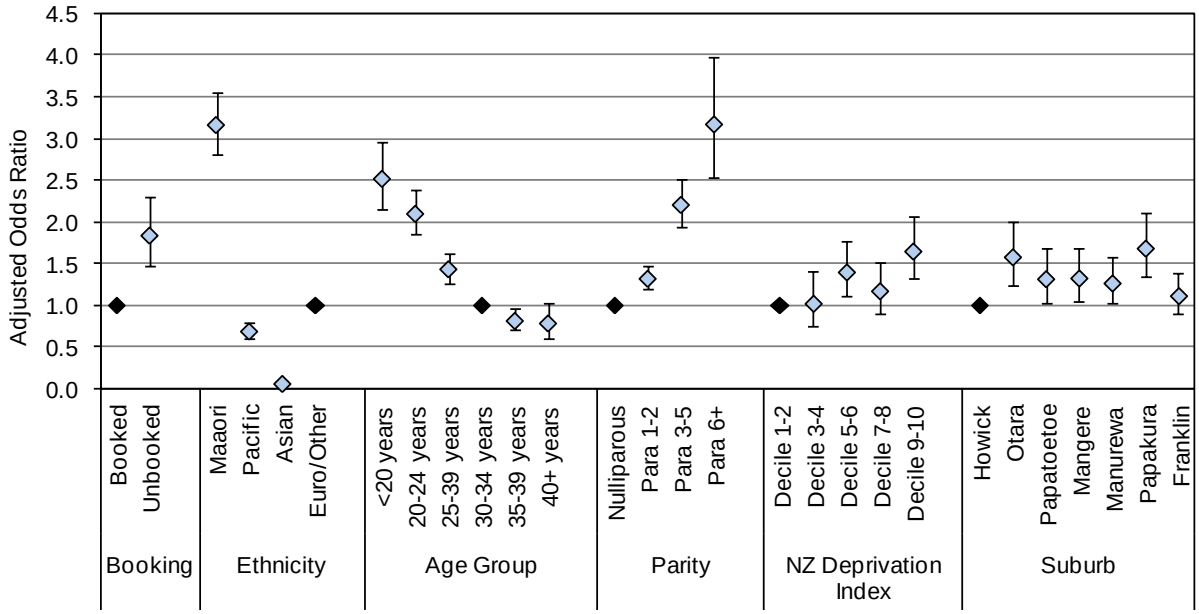


Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB had their smoking status recorded. Ethnicity is preferred. Error bars indicate 95% confidence intervals

In a multivariate analysis examining the odds of smoking in pregnancy after adjusting for the effects of ethnicity, age group, deprivation, residential suburb, parity and booking status all of these variables remained independently associated with the odds of smoking (p<0.0001 for all variables). After controlling for the effects of the other factors the following observations were made (Figure 28):

- The odds of smoking in pregnancy for Unbooked women were 1.8 times higher than the odds in women whose pregnancy was booked.
- Maaori women had 3.2 times higher odds of smoking during pregnancy, and Pacific and Asian women had lower odds of smoking in pregnancy (30% and 90% lower respectively), when compared to European/Other women.
- Compared with women aged 30-34 years, younger women had higher odds of smoking during pregnancy (p<0.0001) with women <20 years having 2.5 times higher odds, women aged 20-24 years having 2.1 times higher odds, and 25-29 year olds having 1.4 times higher odds. Women aged 35-39 had lower odds of smoking in pregnancy (20% lower, p=0.01), and women aged 40 years and older had the same odds of smoking compared to 30-34 year olds.
- Compared with nulliparous women, the odds of smoking during pregnancy increased with increasing parity, and were 1.3 times higher in para 1-2 women, 2.2 times higher in para 3-5 women, and 3.2 times higher in women with a parity of 6 or more.

Figure 28: Adjusted Odds Ratios for Smoking in Pregnancy in CMDHB Resident Women who Delivered in CMDHB, 2007-2009



Source: Healthware. Note: Only includes data for CMDHB resident women who delivered in CMDHB. Odds ratios are adjusted for ethnicity, age, parity, deprivation, suburb, and booking status. Black diamonds indicate reference groups; error bars indicate 95% CI and where these do not cross 1.0 indicate a statistically significant difference from the reference group. Ethnicity is preferred.

- Smoking in pregnancy was independently associated with the deprivation of the residential area. Compared with women living in the least deprived areas (decile 1-2), those living in decile 5-6 had 1.4 times higher odds of smoking, and those living in the most deprived areas (decile 9-10) had 1.6 times higher odds.

- In addition, women living in some suburbs had higher odds of smoking in pregnancy irrespective of their ethnicity, age group, parity, and the deprivation decile of the area. Compared with women living in Howick, women living in Papakura (1.7 times), and Otara (1.6 times) had the highest odds of smoking in pregnancy, followed by women living in Papatoetoe, Mangere, and Manurewa whose odds of smoking in pregnancy was 1.3 times higher than for women living in Howick.

3.9 Other Risk Factors in High Income Countries

3.9.1 Little or No Antenatal Care

Evidence for the Association

Observational studies have demonstrated an association between little or no antenatal care and increased odds of preterm birth, low birth weight, and maternal, fetal and neonatal death in both high-income and developing countries.[53-62] Despite this finding, a recent meta-analysis of stillbirths in high-income countries estimated that if all women accessed antenatal care, this would have a very small effect on the stillbirth rate because the population attributable risk of no antenatal care is low (<1%).[33]

Prevalence in CMDHB and New Zealand

An analysis of Healthware data for CMDHB resident women who delivered in a CMDHB facility during 2007-09 found that 2.6% had no antenatal care, while an additional 13.7% booked after 28 weeks gestation.[4] These women are described in more detail in the companion report.[4] After adjusting for the effects of ethnicity, age group, socioeconomic deprivation, suburb, year, delivery location, and parity, the odds of having no antenatal care in CMDHB was nearly 7 times greater in Maaori women and 4 times greater in Pacific women than in European/Other women. CMDHB Maaori and Pacific women also had the highest odds of booking after 18 weeks gestation after adjusting for the same factors. Similarly, women aged <25 years old and women with a parity of 3 or more had the highest adjusted odds of no antenatal care or booking after 18 weeks gestation. Living in an area of high relative socio-economic deprivation was not independently associated with having no antenatal care or booking late in pregnancy.

A higher proportion of CMDHB women had no antenatal care during 2007-09 than was reported in a national survey of women who used maternity services in New Zealand during 2007 (2.6% vs 1.6%).[4, 63] In contrast, the Growing Up in New Zealand Study that enrolled pregnant women living in the Auckland Region during 2010 reported that 2.2% had no antenatal care.[8]

3.9.2 Diabetes

Evidence for the Association

A woman may have pre-existing diabetes and become pregnant, be diagnosed with type II diabetes during pregnancy, or gestational diabetes that occurs as a result of endocrine changes during pregnancy. Which category a woman diagnosed with diabetes during pregnancy belongs to is not always known. Obesity increases the risk of a women developing type II diabetes or gestational diabetes.

A meta-analysis of five studies found an increased odds of stillbirth in women with pre-existing diabetes (adjusted OR 2·90 (95% CI: 2·05–4·09)) and estimated the population

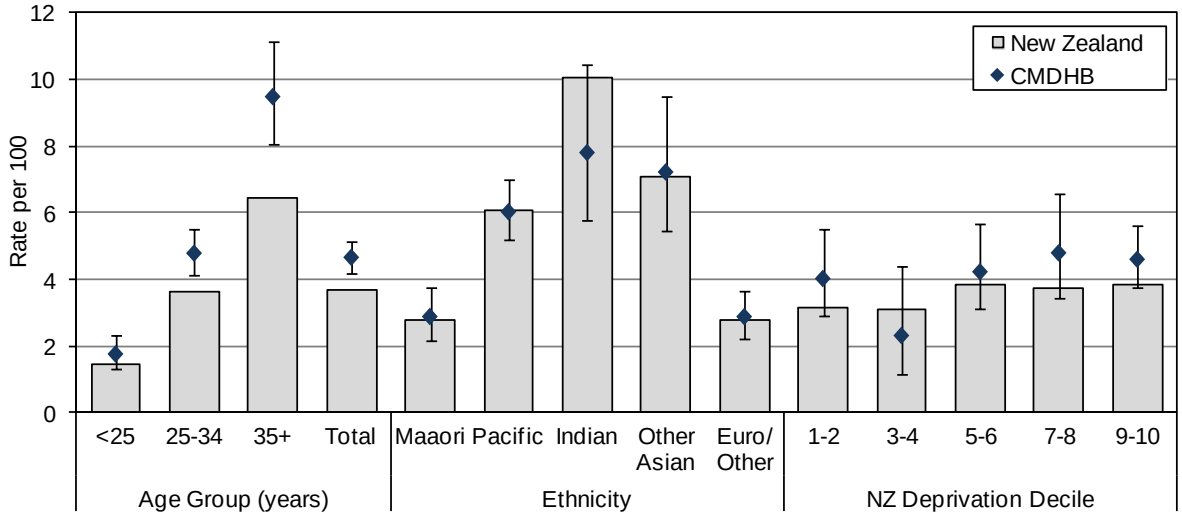
attributable risk at 3-5%.[33] In contrast, gestational diabetes was not associated with an increased risk of stillbirth.[33]

Prevalence in CMDHB and New Zealand

Screening for diabetes during pregnancy is recommended for all pregnant women in New Zealand but screening rates vary significantly by DHB.[64] A study in CMDHB during the mid-1990s reported that 51% of women were screened via a glucose tolerance test.[65] In this population the prevalence of gestational diabetes was 3.3% for European women, 7.9% for Maaori women, and 8.1% for Pacific women.[65]

The national hospital admission dataset (NMDS) has the capacity to record both pre-existing and gestational diabetes in pregnant women admitted to hospital during pregnancy and at the time of delivery. Data captured in the NMDS for women that gave birth during 2009, and NMDS data for their infants, were searched for ICD10 diagnostic codes consistent with a diagnosis of diabetes (see section 2.2.4.3). This analysis found a prevalence of pre-existing or gestational diabetes in pregnant women in CMDHB of 4.6% (95% CI: 4.2-5.1) which was significantly higher than the national prevalence at 3.7% (95% CI: 3.5-3.8). The higher prevalence of pre-existing or gestational diabetes in CMDHB women is driven by significantly higher rates in women aged 25-34 years and 35 years and older (Figure 29). In CMDHB, the prevalence of pre-existing or gestational diabetes was significantly higher in Pacific and Asian women than in Maaori and European/Other women. No significant differences were found by socio-economic deprivation.

Figure 29: Women with a History of Pre-existing or Gestational Diabetes during Pregnancy or in the Last 5 Years in CMDHB and New Zealand, 2009



Source: NMDS. Ethnicity is prioritised. Error bars indicate 95% confidence intervals.

ICD10 coding is likely to underestimate the prevalence of pre-existing or gestational diabetes. A study conducted in 1994-95 found that only 70% of women with pre-existing or gestational diabetes in CMDHB had been recorded as such in the NMDS.[65] This analysis was also limited by the extent to which maternal and infant records could be probabilistically matched, and the lack of infant records in the case of stillbirths.

A small number of CMDHB women that delivered in a CMDHB facility had a diagnosis of diabetes captured in Healthware, however the prevalence recorded here was 1.7% which appears to be a gross underestimation.

3.9.3 Hypertension in Pregnancy

Evidence for the Association

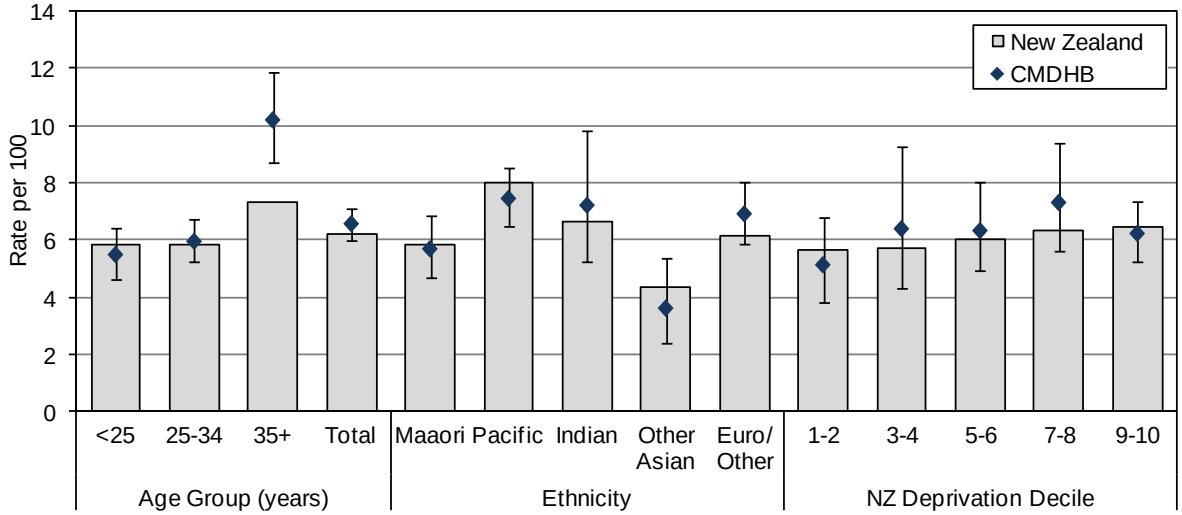
Pre-existing hypertension is associated with increased odds of stillbirth of 2.6 times, with a population attributable risk of 7-14% across five high income countries.[33] Pregnancy induced hypertension and its associated conditions are also associated with an increased odds of stillbirth with the odds increasing from 1.3 (95% CI: 1.1-1.6) for pregnancy induced hypertension, to 1.6(95% CI: 1.1-2.2) for pre-eclampsia, to 2.2 (95% CI: 1.5-3.2) for eclampsia.[33] The population attributable risk for pregnancy induced hypertension and pre-eclampsia was estimated at 1.9-3.1% for stillbirth, while for eclampsia the population attributable risk is much lower (0.1%) because of lower prevalence.

Prevalence in CMDHB and New Zealand

As part of this project, a search of the NMDS (hospital admission) data for women that gave birth in 2009, and the data of their infants, was undertaken to identify women who had an ICD10 diagnostic code indicating pre-existing or pregnancy induced hypertension (including pre-eclampsia and eclampsia) (see section 2.2.4.3). This analysis found a prevalence of pre-existing or pregnancy-induced hypertension in CMDHB mothers of 6.2% (95% CI: 6.0-7.1) which was not significantly higher than the national prevalence of 6.0% (95% CI: 6.4-6.2).

The prevalence of hypertension in pregnancy increased with increasing age and was highest in women aged 35 years and older; CMDHB women in this age group had a significantly higher prevalence than women nationally (Figure 29). Some differences were observed by maternal ethnicity, however in CMDHB there were no significant differences in the prevalence of hypertension in pregnancy for Maaori, Pacific, Indian, and European/Other women. A socio-economic gradient was evident in the prevalence of hypertension in pregnancy at a national level, although no significant differences in prevalence by NZ deprivation index decile were observed for CMDHB women.

Figure 30: Women with a History of Pre-Existing or Pregnancy-Induced Hypertension during Pregnancy or in the Last 5 Years in CMDHB and New Zealand, 2009



Source: NMDS. Ethnicity is prioritised. Error bars indicate 95% confidence intervals.

NMDS ICD10 coding is likely to underestimate the prevalence of pre-existing or pregnancy induced hypertension, the extent to which this is the case is unknown. This analysis was also limited by the extent to which maternal and infant records could be probabilistically matched, and the lack of infant records in the case of stillbirths.

A small number of CMDHB women that delivered in a CMDHB facility had a diagnosis of hypertension captured in Healthware, however the prevalence recorded here was 2.6% which appears to be a gross underestimation.

3.9.4 Antepartum Haemorrhage

Evidence for the Association

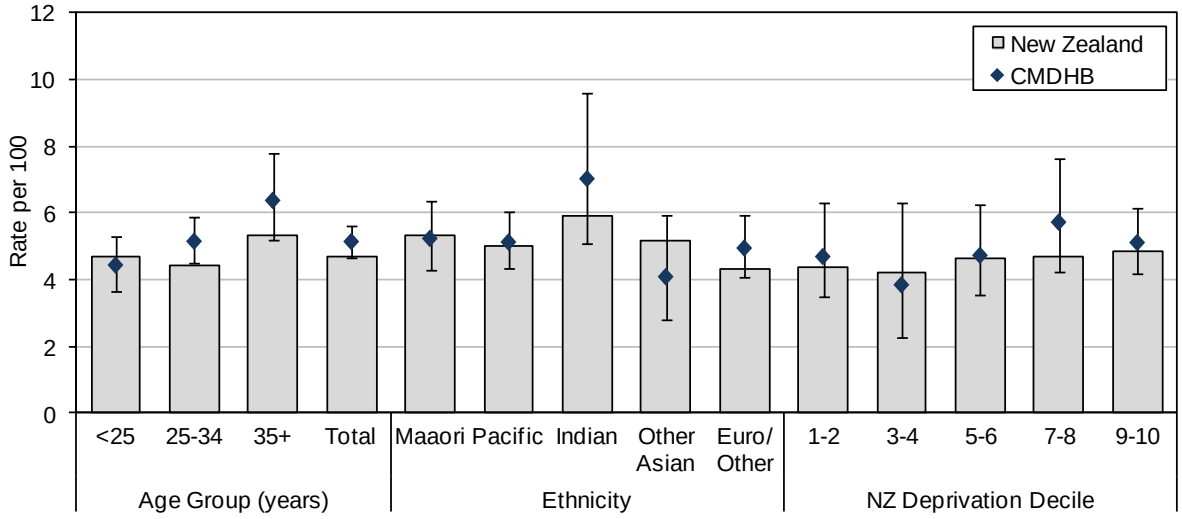
The PMMRC have identified antepartum haemorrhage as an important risk factor for stillbirth and recommend that all women with an antepartum haemorrhage be closely monitored for fetal growth and preterm birth.[3] While Flenady and colleagues did not include an analysis of antepartum haemorrhage from any cause in their systematic review, placental abruption was reviewed. A strong association between placental abruption and stillbirth was found, with two studies reported adjusted odds ratios of 11·4 (95% CI 10·6–12·2) and 18·9 (95% CI 16·9–20·8).[33] Because the risk of death is high following a placental abruption the population attributable risk is high even though prevalence is generally low; estimated to be 15% with a prevalence of 1%.[33]

Prevalence in CMDHB and New Zealand

A search of NMDS (hospital admission) data was undertaken for women in New Zealand that gave birth during 2009 to identify any woman who had an ICD10 code indicating antepartum haemorrhage, placental previa, or placental abruption during her current pregnancy and infants affected by placenta previa (see section 2.2.4.3). The prevalence of placental abruption was <1% nationally at 6.4 per 1,000 (95% CI: 5.7-7.1) and for CMDHB women was 2.7 per 1,000 (95% CI: 1.8-4.2).

Any antepartum haemorrhage includes all three conditions searched for. The prevalence of any antepartum haemorrhage nationally was 4.7% (95% CI: 4.5-4.9) and 5.1% (95% CI: 4.7-5.6) in CMDHB. This was not significantly higher, and no significant differences were seen between CMDHB and national rates when examined by age group, ethnicity, or socio-economic deprivation. In both NZ and CMDHB, the highest prevalence of any antepartum haemorrhage was been in women aged 35 years and older, Indian women, and women living in the most socio-economically deprived area.

Figure 31: Women with Antepartum Haemorrhage during Pregnancy in CMDHB and New Zealand, 2009



Source: NMDS. Ethnicity is prioritised. Error bars indicate 95% confidence intervals.

NMDS ICD10 coding is likely to underestimate the prevalence of antepartum haemorrhage because not all events result in hospital admissions, some women may not seek care, and it will only be captured if recorded in the clinical record. How well NMDS data reflects antepartum haemorrhage prevalence is unknown. This analysis was also limited by the extent to which maternal and infant records could be probabilistically matched, and the lack of infant records in the case of stillbirths.

3.9.5 Other Risk Factors

Other risk factors have been identified as contributing to stillbirth rates in high income countries.[33] These are described briefly here, with prevalence data presented where available.

Lethal Congenital Abnormalities

Congenital abnormalities contribute to the prevalence of late termination of pregnancy, stillbirth, and neonatal death.[3, 34] However, not all congenital abnormalities are lethal conditions, and the capacity to identify those that are likely to be lethal in hospital admission data is limited. In addition, some terminations are performed for congenital abnormalities that may not have been lethal in the perinatal period.

A search of the NMDS (hospital admission dataset) was undertaken for women in New Zealand that gave birth during 2009 to identify any woman with an ICD10 code indicating a pregnancy complicated by congenital abnormality and any infant diagnosed with a congenital abnormality at birth or during the first six weeks of life. The prevalence of any congenital abnormality in CMDHB was 5.4 per 100 (95% CI 4.9-6.0) which was not significantly different from the national rate at 5.5 per 100 (95% CI: 5.3-5.7). CMDHB Maaori had a higher prevalence of any congenital abnormality (5.9% (95% CI: 4.9-7.1)) than Maaori women across New Zealand (4.8% (955 CI: 4.4-5.2) in 2009 although the difference was not statistically significant. This analysis was unable to determine the prevalence of lethal congenital abnormalities in CMDHB or New Zealand.

Illicit Drug Use

A meta-analysis of two studies showed an increased adjusted odds of stillbirth of 1.95 (95% CI 1.24-3.02) for women using illicit drugs in pregnancy.[33] If the prevalence of illicit drug use was 2.4% this gives an estimated population attributable risk of stillbirth of 2%.[33] Population level data on the prevalence of illicit drug use in CMDHB were not found; however in case-control study conducted in the Auckland Region 8.4% of women with a late stillbirth (>28 weeks gestation) reported using recreational drugs during pregnancy.[66] A non-significant increase in the crude odds of stillbirth (2.8 (95% CI: 1.0-8.0) was observed in CMDHB women who reported recreational drug use in pregnancy.[66]

Previous Stillbirth

In a met-analysis of five studies, a previous stillbirth increased the adjusted odds of a stillbirth in the current pregnancy by 2.61 (95% CI 1.50-4.55).[33] However, as the prevalence of a history of previous stillbirth is thought to be low in high income countries, the population attributable risk was estimated at <1%. The prevalence of a previous stillbirth in CMDHB women was not found.

3.10 PMMRC Vulnerable Women

The PMMRC recommend the identification of vulnerable women at increased risk of perinatal related mortality, including women age <20 years or ≥40 years, obese women, women with a multiple pregnancy, women living in socio-economic deprivation, and women

with maternal mental health problems or medical conditions.[3] The maternal conditions that place a woman at greater risk are not described further. There is no guidance for what should be offered to these women beyond flagging them as high risk, how they should be managed, or by whom their care should be provided.

Prevalence in CMDHB and New Zealand

No national dataset was available for the estimation of the national prevalence of vulnerable women at risk of a perinatal death. As part of this project, Healthware data for CMDHB women that delivered in a CMDHB facility during 2007-09 were searched for these identifying characteristics. The following maternal risk factors were flagged, age at delivery <20 years or ≥40 years, BMI ≥30 (obese), fetal count ≥2 (multiple pregnancy), lived in an area with a NZ deprivation index decile of 8-10 (socio-economic deprivation), women with a perinatal death with an obstetric antecedent cause of diabetes or hypertension (including pre-eclampsia and eclampsia) and women with a medical history of diabetes or hypertension. Notably, the prevalence of these medical conditions was significantly lower when Healthware was used as the data source compared to the hospital admission dataset (see sections 3.9.2 and 3.9.3). Other important maternal conditions and maternal mental health problems were not able to be included in this analysis due to data availability.

The application of a "flag" based on these characteristics to the CMDHB women who delivered in a CMDHB facility during 2007-09 identified 6,075 (81%) as being high risk each year. The CMDHB women flagged as vulnerable during 2007-09 had an average 6,250 infants each year of which 83 died in utero or in the neonatal period; i.e. 98.7% of the infants born to these vulnerable women did not experience a perinatal death. This analysis highlights the limitations of a high risk approach in a population that is predominantly high risk, and illustrates the challenges of potentially providing augmented services to a large high risk population, particularly in the absence of convincing evidence that a different model of care will achieve the desired outcome.[4]

3.11 Chapter Summary

Flenady and colleagues identified the major risk factors for stillbirth in high income countries and recommended approaches for reducing stillbirths in such settings.[33, 34] The risk factors identified also make a significant contribution to neonatal deaths, the bulk of which are caused by obstetric antecedents e.g. preterm birth, antepartum haemorrhage, perinatal infection.[3] The most important potentially modifiable risk factors identified by Flenady were overweight and obesity, advanced maternal age, smoking, pre-existing hypertension, pre-existing diabetes, and placental abruption.[33] Other important risk factors were pregnancy-induced hypertension, fetal growth restriction, socio-economic status, no antenatal care, and post-term delivery.

These risk factors are summarised in Table 21, which shows the prevalence in high income countries used to calculate the population attributable risk of stillbirth. The quality of the data for determining the prevalence of these risk factors in New Zealand and CMDHB is variable, and described in the relevant sections in this Chapter. Where the New Zealand or CMDHB prevalence is higher than that seen in the reference high income countries, the population attributable risk will be higher assuming the effect measure (adjusted odds ratio) is applicable to the New Zealand and CMDHB setting.

For the risk factors examined in this Chapter, the prevalence in CMDHB was the same or higher than the national prevalence, with the exception of advanced maternal age. Those risk factors for which CMDHB had a higher prevalence included overweight and obesity, smoking, hypertension in pregnancy, diabetes in pregnancy, low socio-economic status, no antenatal care, and small for gestational age. The higher prevalence of these risk factors in CMDHB will contribute to the higher perinatal mortality rate observed.

The application of PMMRC identified "flags" of vulnerability identified 81% of the CMDHB maternity population (~6,500 women each year). A systematic review of risk assessment tools undertaken by the National Institute of Clinical Excellence failed to identify an ideal tool for reliably identifying women with a high risk of a poor pregnancy outcome.[32] This was not a surprising finding as perinatal deaths are relatively rare in comparison to the prevalence of perinatal mortality risk factors. A population-wide approach to reducing risk factors is more appropriate in a population that is predominantly high risk.

Table 21: Summary of Risk Factors for Stillbirth in High Income Countries

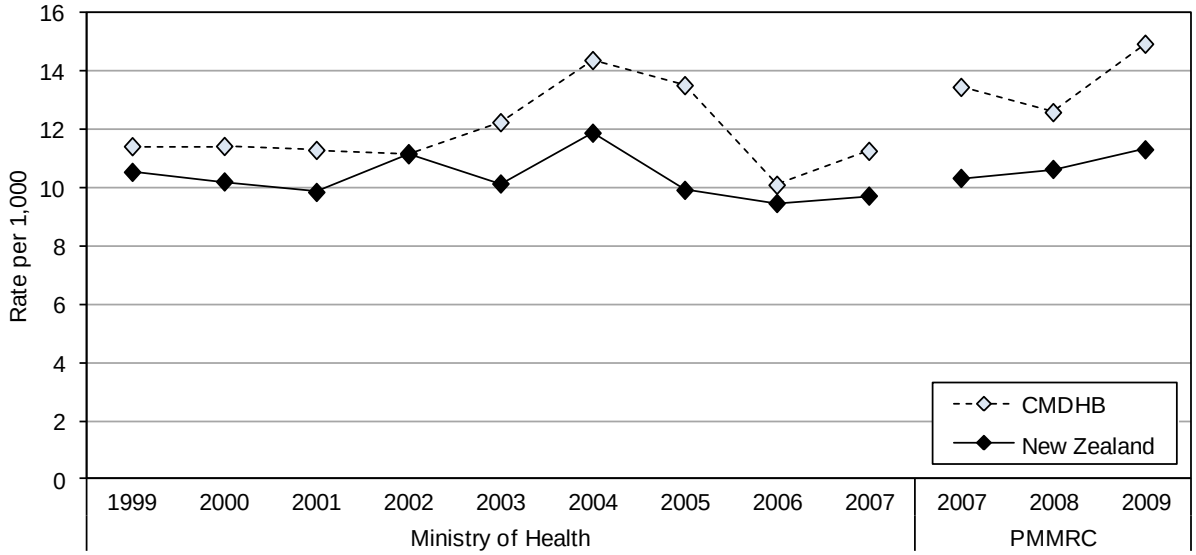
	High Income Countries			NZ Prevalence			
Risk Factor	**adjOR (95% CI)**	**Prev (%)**	**PAR (%)**	**NZ Total**	**CMDHB Total**	**CMDHB Maaori**	**CMDHB Pacific**
Body Mass Index							
Overweight	1·2 (1·1–1·4)	20.5-34.2	7.7%-17.6%	21-32%*	27%	31%	25%
Obesity	1·6 (1·4–2.0)	7.1-24.2		16-27%*	38%	38%	61%
Maternal Age							
35-39	1·5 (1·2–1·7)	11.6-19.0	7.5%-11.1%	18.0%	14.6%	9.9%	12.7%
40-44	1·8 (1·4–2·3)	2.4-3.5		3.6%	3.5%	2.2%	3.9%
45+	2·9 (1·9–4·4)	0.1-0.2		0.2%	0.1%	0.1%	0.1%
Lifestyle							
Any Smoking	1·4 (1·3–1·5)	10.0-19.0	3.9%-7.1%	15.8%	17.5%	43%	13%
Hypertension							
Pre-existing	2.6 (NR)	4.6-9.8	6.9-13.6%	6.0%	6.2%	5.7%	7.4%
In pregnancy	1·3 (1·1–1·6)	6·3	1·9				
Pre-Eclampsia	1·6 (1·1–2·2)	5·3	3·1				
Eclampsia	2·2 (1·5–3·2)	0·1	0·1				
Diabetes							
Pre-existing	2.9 (NR)	1.8-2.6%	3.3%-4.7%	3.7%	4.6%	2.9%	6.0%
Gestational	NR	NR	NR				
Socio-economic							
Low Education	1·7 (1·4–2·0)	6.9	2.1	6%	6%	11%	6%
Low SES (decile 8-10)	1·2 (1·0–1·4)	49.6	9.0	37%	60%	76%	89%
Other Pregnancy Related							
Placental Abruption	18.9 (NR)	1.0	15.2%	<1%	<1%	<1%	<1%
No antenatal care	3.3 (3.1-3.6)	0.3	0.7	1.6%	2.2%	5.2%	3.1%
Post-term (≥42 weeks)	1·3 (1·1–1·7)	0·9	0·3	2.9%	2.7%	2.1%	3.7%
Small for gestational age							
Population centiles	3·9 (3·0–5·1)	10.0	23.3	9.6%	10.1%	11.2%	9.7%
Customised centiles	NR	NR	NR	Unknown	15.9%	18.7%	18.2%

Note: Modified from Flenady[33]. NR: not reported. High income countries included were Australia, Canada, USA, UK, the Netherlands. *Overweight and obesity in NZ is for the child bearing population and not pregnant women.

Chapter 4. Perinatal Mortality in CMDHB

The Ministry of Health has published Fetal and Infant Death reports that include perinatal and neonatal mortality since the late 1990s. Although the data in these reports are subtly different from data reported by the PMMRC (see section 1.2.1.4), both demonstrate higher perinatal related mortality rates in CMDHB compared to the national rate persisting through the last decade (Figure 32).[1, 2, 12, 67] There are several potential reasons for this finding including differences in demography, the prevalence of risk factors, reporting of deaths, the quality of care, and access to maternity care. This Chapter examines perinatal related mortality in CMDHB compared to nationally, using data sourced from the PMMRC, before examining CMDHB rates in more detail using data collected locally (Healthware data).

Figure 32: Perinatal Related Mortality in CMDHB and New Zealand by Data Source, 1999-2009



Source: Ministry of Health[12], PMMRC[3]

4.1 Examination of PMMRC data for CMDHB women

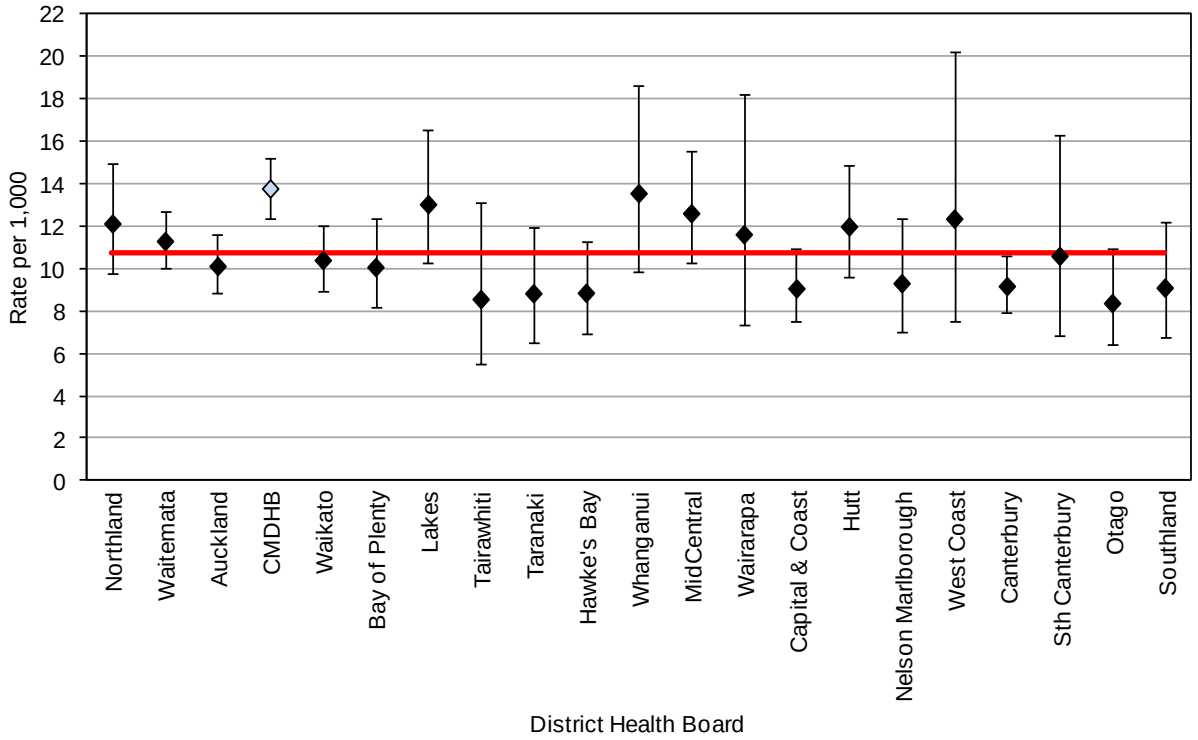
Patient level data to inform this project were requested from the PMMRC however only aggregated data were supplied limiting the extent of the analysis and the capacity to control for known confounders at a population level. This limitation should be kept in mind when interpreting the data presented here.

In 2007-09, the crude perinatal related mortality rate in Counties Manukau DHB was significantly higher than the national rate (Figure 33).[3] Crude rates in Whanganui, Lakes, MidCentral, West Coast, Northland and Hutt DHBs were also higher than the national rate during this time. CMDHB has a sufficiently large population of women giving birth each year for its crude perinatal mortality rate to be significantly higher than the national rate, as a larger denominator population results in narrower confidence intervals. If the current numbers of perinatal deaths in Lakes and MidCentral DHBs are maintained for another two years, the five year (2007-11) perinatal mortality rates in these DHBs will also be significantly higher than the national rate.

Age, ethnicity, and deprivation standardised DHB rates have not been reported to date, despite a multivariate analysis demonstrating that these variables influence perinatal related

mortality rates independent from each other[2], and the known variation in demography by DHB. It is likely that the demographic differences between DHBs in New Zealand account for most of the variation in perinatal mortality seen at a DHB level.

Figure 33: Crude Perinatal Related Mortality by District Health Board, New Zealand 2007-09



Source: PMMRC[3]. Note: Red line shows national perinatal mortality rate. Error bars indicate 95% confidence interval.

4.1.1 Categories of Perinatal Related Death

Perinatal related deaths can be broken down into deaths as a result of a late termination of pregnancy, a stillbirth (deaths that occur in-utero or during labour), or a neonatal death (death of a live born baby within the first 27 days of life). During 2007-09, a lower proportion of perinatal deaths were due to a termination of pregnancy in CMDHB (13.6%) compared to nationally (20.2%). Conversely, a higher proportion of perinatal deaths in CMDHB were neonatal deaths (39.6%) compared to nationally (25.0%) during this time (Table 22).

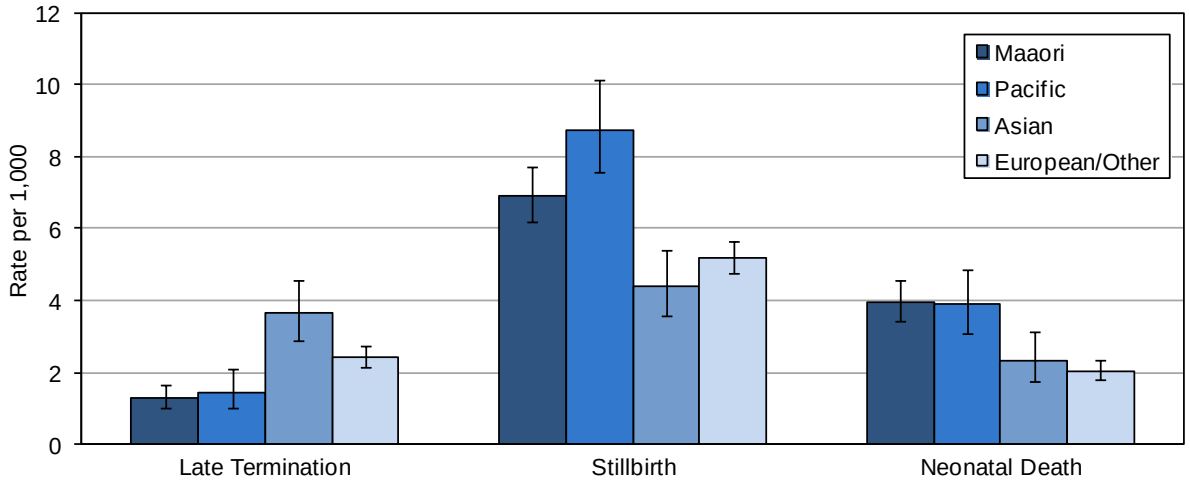
Table 22: Perinatal Deaths in CMDHB and New Zealand, 2007-09

CMDHB	Number 2007-09	Annual Average	Percent	Rate per 1,000
Late Termination	50	17	13.6	1.86
Stillbirths	209	70	56.8	7.78
Neonatal Death	109	36	29.6	4.10
Total	**368**	**123**	**100.0**	**13.70**
New Zealand	**Number 2007-09**	**Annual Average**	**Percent**	**Rate per 1,000**
Late Termination	425	142	20.2	2.18
Stillbirths	1,149	383	54.7	5.89
Neonatal Death	525	175	25.0	2.71
Total	**2,099**	**700**	**100.0**	**10.76**

Source: PMMRC[3]

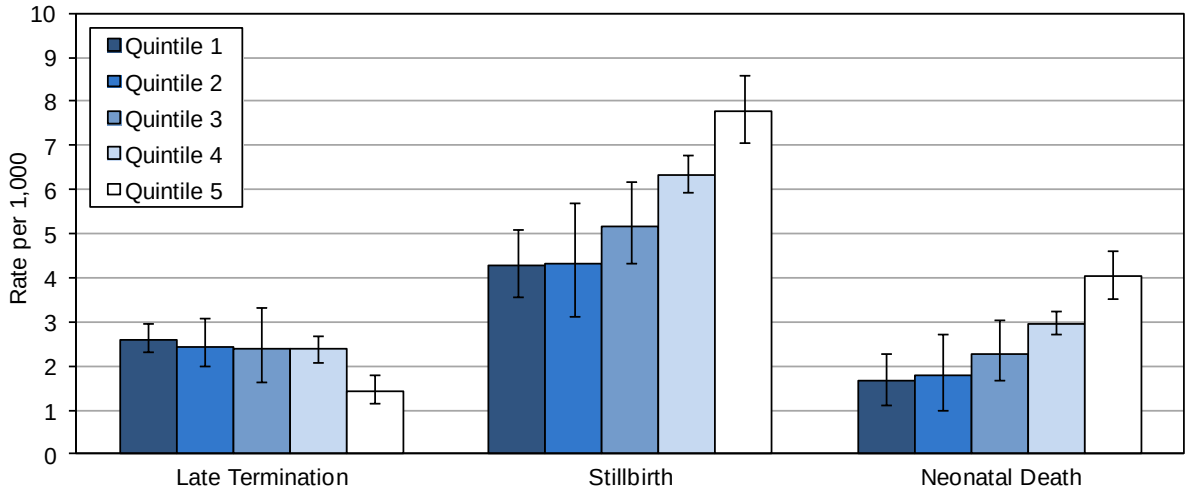
Late terminations, stillbirth, and neonatal mortality rates are confounded by differences observed in trends when further stratified by ethnicity and socio-economic status (Figure 34, Figure 35). These differences are also likely to influence the differences between rates observed in CMDHB and national rates.

Figure 34: Late Terminations, Stillbirths, and Neonatal Deaths by Maternal Ethnicity, New Zealand 2007-2009



Source: PMMRC[3]. Note: Ethnicity is prioritised. Error bars indicate 95% confidence interval.

Figure 35: Late Terminations, Stillbirths, and Neonatal Deaths by NZ Deprivation Index, New Zealand 2007-09



Source: PMMRC[2]. Note: Deprivation Index quintile is assigned at meshblock level. Error bars indicate 95% confidence interval.

In particular, the PMMRC notes that ethnic specific late termination rates have a marked effect on ethnic specific perinatal related mortality rates.[2] During 2007-09, late terminations accounted for 20% of all perinatal related deaths and 27% of fetal deaths in New Zealand but only 14% of perinatal related deaths in CMDHB. A lower late termination rate in CMDHB is to be expected as rates are highest in Asian and NZ European women and lowest in Maaori and Pacific women (Figure 34). Late termination rates are also significantly lower in woman living in the most socio-economically deprived areas (decile 9-10) than in those living in the least socio-economically deprived areas, a finding that will also contribute to lower late termination rates in CMDHB. The reasons for differences in late termination rates in different

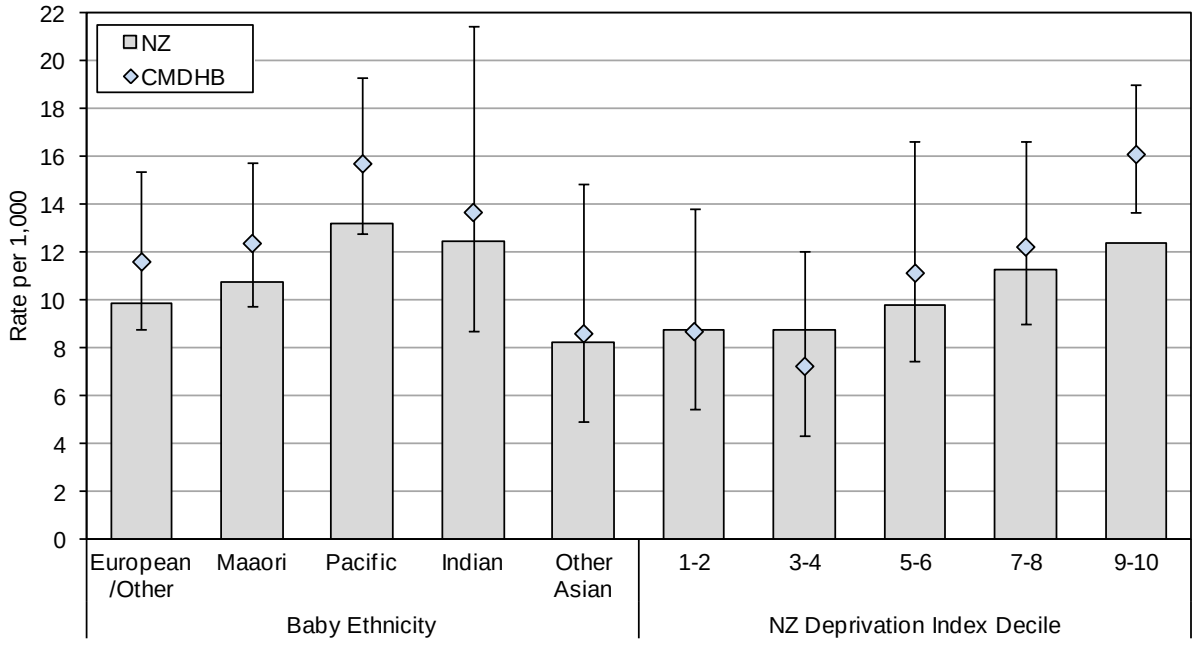
populations are unknown but may include differences in access to antenatal care or termination services, cultural and religious beliefs, and personal choice.

4.1.2 Ethnicity and Socio-economic Deprivation

While the total perinatal mortality rate was higher in CMDHB than nationally, during 2007-08 there were no significant differences observed by baby ethnicity between rates in CMDHB and New Zealand (Figure 36). This finding supports the hypothesis that demographic differences between the CMDHB maternity population and the national maternity population account for the difference in crude perinatal mortality observed.

During 2007-08, at both a CMDHB and national level, perinatal mortality increased with increasing socio-economic deprivation as measured by the NZ Deprivation Index at a meshblock level (Figure 36). CMDHB perinatal mortality rates were significantly higher only for babies born to women living in the most deprived area's (decile 9-10, quintile 5). However, almost all CMDHB women who delivered during this time who were living in decile 9-10 areas were Maaori or Pacific (79%) and this analysis was unable to take the influence of ethnicity into account.

Figure 36: Perinatal Related Mortality by Baby Ethnicity and NZ Deprivation Index, CMDHB and New Zealand 2007-08



Source: PMMRC (personal communication, L Sadler). Note: Ethnicity is of the infant and is prioritised. Deprivation index decile is assigned at meshblock level. Error bars indicate 95% confidence interval.

4.1.3 Cause of Death - Perinatal Death Classification

The PMMRC uses the Perinatal Society of Australia and New Zealand perinatal death classification system (PSANZ-PDC) to assign a primary obstetric antecedent cause of death to all fetal and neonatal deaths. One or more associated causes of death are assigned for 19% of perinatal deaths in 2009.[3] Neonatal deaths are also assigned a primary neonatal death classification (PSANZ-NDC), 16% were assigned one or more associated NDC causes of death in 2009. For all perinatal related deaths during 2007-09 in New Zealand the predominant obstetric antecedent causes of perinatal deaths were congenital abnormality and spontaneous preterm birth, however causes differ for late terminations of pregnancy, stillbirth, and neonatal deaths.[3] These will be described separately here and the causes of deaths in Counties Manukau compared with those seen nationally.

4.1.3.1 Obstetric Indications for Late Termination

Termination of pregnancy beyond 20 weeks gestation is legal under the *Crimes Act 1961* if *'necessary to save the life of the woman or girl or to prevent serious permanent injury to her physical or mental health'*.[68] The late termination rate in CMDHB was consistently lower than the national rate during 2007-09, and likely contributes in part to the higher stillbirth and neonatal death rate (Table 22). If CMDHB had the same late termination rate as the national rate, then an additional four late terminations would be performed annually.

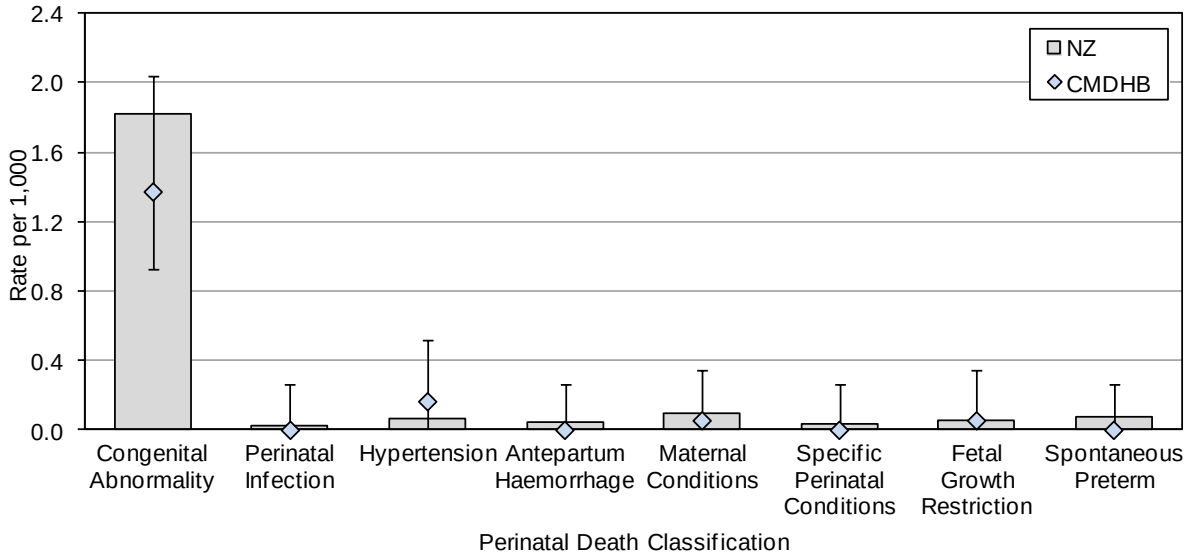
The most common indication for late termination in New Zealand during 2007-09 was congenital abnormality (83%), maternal conditions (4.2% these were for psychosocial indications, antiphospholipid syndrome, and other unspecified reasons), and spontaneous preterm labour (3.5%) (Table 23). In CMDHB during this time the indication specific perinatal mortality rates for late termination of pregnancy did not differ significantly, although numbers in CMDHB were small (Figure 37). In CMDHB, 83% of late terminations were also performed for congenital abnormality, with 10% performed for maternal hypertension.

Table 23: Late Termination by Primary Obstetric Antecedent Cause in New Zealand and CMDHB, 2007-2008

Perinatal Death Classification	New Zealand		CMDHB	
	Number	Percent	Number	Percent
Congenital Abnormality	239	82.7	25	83.3
Perinatal Infection	3	1.0	0	0.0
Hypertension	8	2.8	3	10.0
Antepartum Haemorrhage	6	2.1	0	0.0
Maternal Conditions	12	4.2	1	3.3
Specific Perinatal Conditions	4	1.4	0	0.0
Fetal Growth Restriction	7	2.4	1	3.3
Spontaneous Preterm	10	3.5	0	0.0
Total	289	100.0	30	100.0

Source: PMMRC[1, 2] and personal communication, L Sadler. Note: PMMRC data for CMDHB only available for 2007-08.

Figure 37: Late Termination Rates by Primary Obstetric Antecedent Cause in New Zealand and CMDHB, 2007-2008



Source: PMMRC[1, 2], personal communication, L Sadler. Note: Error bars indicate 95% confidence interval.

4.1.3.2 Primary Obstetric Antecedent Causes of Stillbirth

During 2007-09, the stillbirth rate in CMDHB (7.8 per 1,000 births) was higher than that seen nationally (5.9 per 1,000 births), with an annual average excess of 16 stillbirths above that which would be expected if CMDHB had the same stillbirth rate as New Zealand (Table 22).

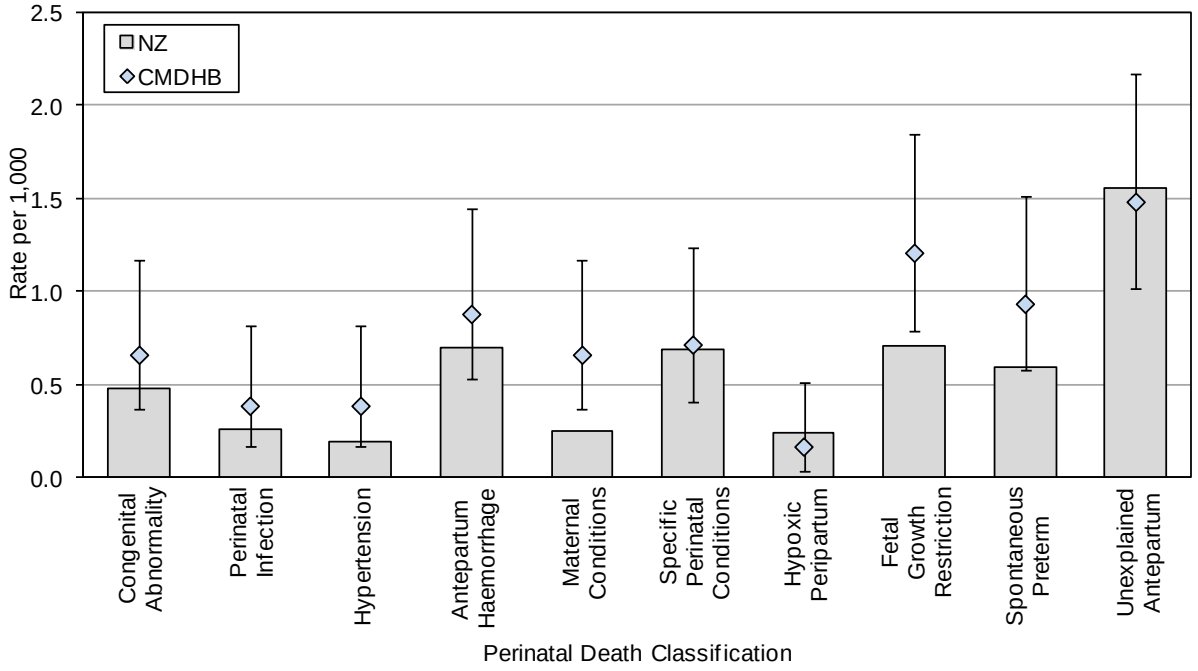
Nationally the most frequent primary maternal antecedent causes of stillbirth during 2007-08 were fetal growth restriction, antepartum haemorrhage, and other specific perinatal conditions (including twin-to-twin transfusion, fetomaternal haemorrhage, antepartum cord complications, uterine abnormalities, etc.) (Table 24).[1-3] In New Zealand during 2007-08, 28% of stillbirths were unexplained antepartum deaths compared with 20% in CMDHB.

Table 24: Stillbirths by Primary Obstetric Antecedent Cause in New Zealand and CMDHB, 2007-2008

Perinatal Death Classification	New Zealand		CMDHB	
	Number	Percent	Number	Percent
Congenital Abnormality	63	8.5	12	8.8
Perinatal Infection	34	4.6	7	5.1
Hypertension	25	3.4	7	5.1
Antepartum Haemorrhage	92	12.3	16	11.8
Maternal Conditions	33	4.4	12	8.8
Specific Perinatal Conditions	90	12.1	13	9.6
Hypoxic Peripartum	32	4.3	3	2.2
Fetal Growth Restriction	93	12.5	22	16.2
Spontaneous Preterm	78	10.5	17	12.5
Unexplained Antepartum	205	27.5	27	19.9
Total	**745**	**100.0**	**136**	**100.0**

Source: PMMRC[1, 2] and personal communication, L Sadler. Note: PMMRC data for CMDHB only available for 2007-08.

Figure 38: Stillbirth Rates by Primary Obstetric Antecedent Cause in New Zealand and CMDHB, 2007-2008



Source: PMMRC[1, 2], personal communication, L Sadler. Note: Error bars indicate 95% confidence interval.

During 2007-08, the stillbirth rate due to fetal growth restriction in CMDHB was significantly higher (1.2 per 1,000 (95% CI 0.8-1.8)) than that reported nationally (0.7 per 1,000) as was the rate of stillbirths due to maternal conditions (predominantly diabetes and maternal injury).

By applying the cause specific national stillbirth rates to CMDHB, 80% of the excess stillbirths observed within Counties Manukau DHB can be attributed to fetal growth restriction (28%), maternal conditions (23%), spontaneous preterm labour (19%) and hypertension (11%). Diabetes is the most frequently identified maternal condition.

4.1.3.3 Causes of Neonatal Death

During 2007-09, the neonatal mortality rate (<28 days old) in CMDHB (4.1 per 1,000 births) was higher than that seen nationally (2.7 per 1,000 births), with an annual average excess of 11 neonatal deaths above that which would be expected if CMDHB had the same rate as New Zealand (Table 22).

During 2007-08 in New Zealand, the most frequent primary obstetric antecedent causes of neonatal death were spontaneous preterm labour (31%), congenital abnormality (23%), and hypoxic peripartum (10%) (Table 25). The most frequent neonatal death classification nationally was extreme prematurity (32%) followed by congenital abnormality (24%) and neurological causes (19%) which include both hypoxic ischaemic encephalopathy / perinatal asphyxia and intracranial haemorrhage (Table 26).

The primary *obstetric antecedent* causes of neonatal death in CMDHB did not differ significantly from those observed nationally (Figure 39). By applying cause specific national neonatal mortality rates (using PDC) to CMDHB, 83% of the excess neonatal deaths observed within Counties can be attributed to the following causes: spontaneous preterm labour (21%), congenital abnormality (20%), antepartum haemorrhage (12%), specific perinatal conditions (10%), perinatal infection (10%), and hypoxic peripartum (9%) causes.

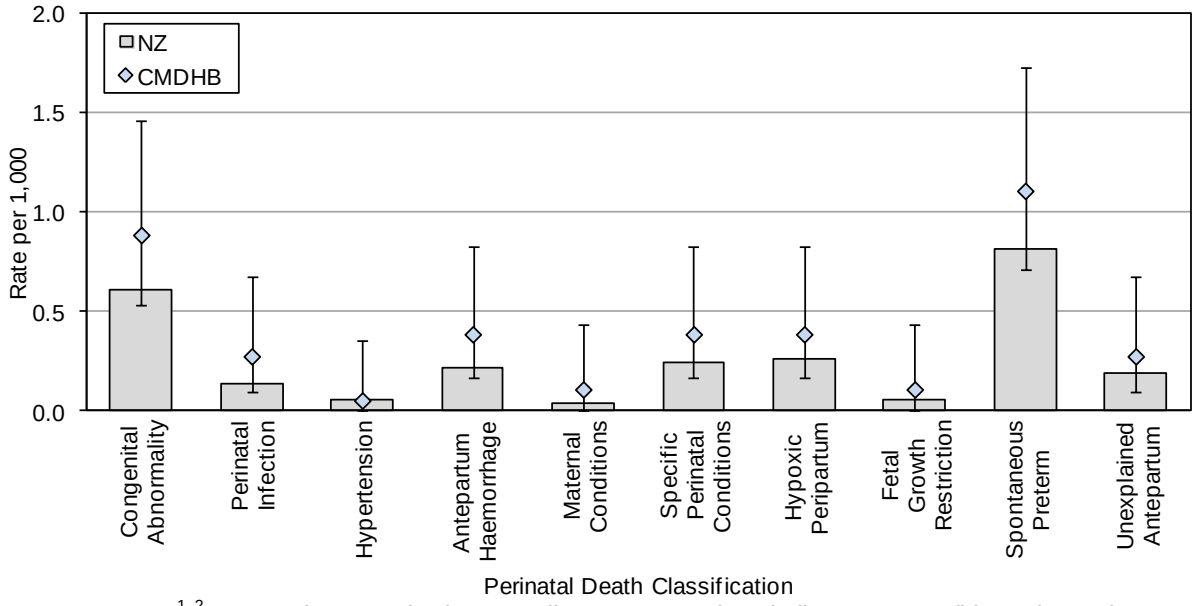
In contrast, the CMDHB neonatal mortality rates by primary *neonatal* death classification did differ significantly from national rates for deaths due to extreme prematurity (Figure 40). By applying cause specific national neonatal mortality rates (using NDC) to CMDHB, 83% of the excess neonatal deaths observed within Counties can be attributed to extreme prematurity (63%) and congenital abnormality (23%).

Table 25: Neonatal Deaths by Primary Obstetric Antecedent Cause in New Zealand and CMDHB, 2007-2008

Perinatal Death Classification	New Zealand		CMDHB	
	Number	Percent	Number	Percent
Congenital Abnormality	80	23.3	16	22.2
Perinatal Infection	18	5.2	5	6.9
Hypertension	8	2.3	1	1.4
Antepartum Haemorrhage	28	8.2	7	9.7
Maternal Conditions	5	1.5	2	2.8
Specific Perinatal Conditions	32	9.3	7	9.7
Hypoxic Peripartum	34	9.9	7	9.7
Fetal Growth Restriction	7	2.0	2	2.8
Spontaneous Preterm	106	30.9	20	27.8
No Obstetric Antecedent	25	7.3	5	6.9
Total	**343**	**100.0**	**72**	**100.0**

Source: PMMRC[1, 2] and personal communication, L Sadler. Note: PMMRC data for CMDHB only available for 2007-08.

Figure 39: Neonatal Mortality Rates by Primary Obstetric Antecedent Cause in New Zealand and CMDHB, 2007-2008



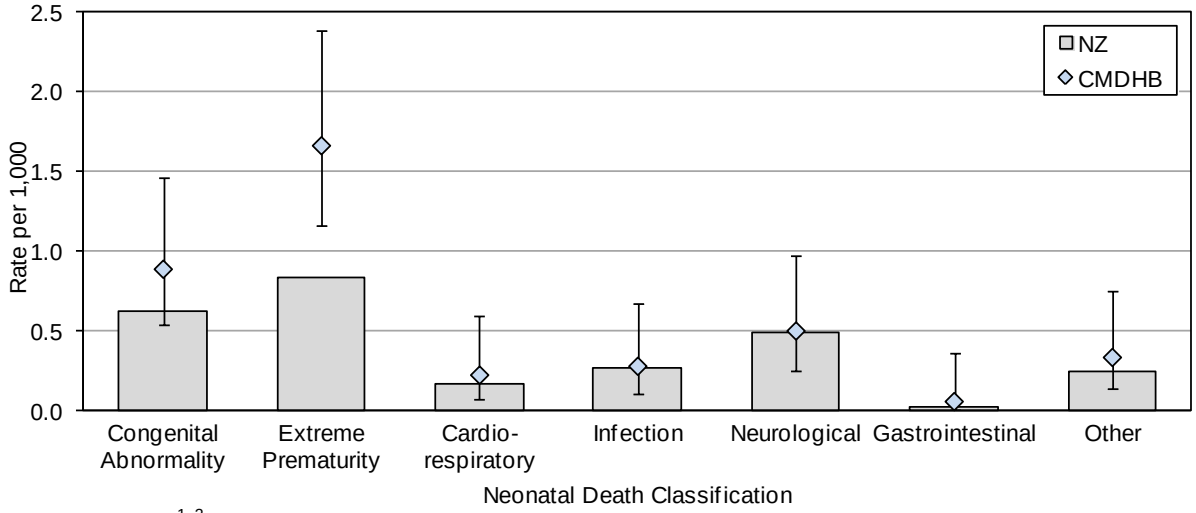
Source: PMMRC[1, 2], personal communication, L Sadler. Note: Error bars indicate 95% confidence interval.

Table 26: Neonatal Deaths by Neonatal Death Classification in New Zealand and CMDHB, 2007-2008

Neonatal Death Classification	New Zealand		CMDHB	
	Number	Percent	Number	Percent
Congenital Abnormality	81	23.6	16	22.2
Extreme Prematurity	108	31.5	30	41.7
Cardio-respiratory	22	6.4	4	5.6
Infection	35	10.2	5	6.9
Neurological	64	18.7	9	12.5
Gastrointestinal	2	0.6	1	1.4
Other	31	9.0	6	8.3
Total	**343**	**100.0**	**71**	**98.6**

Source: PMMRC[1, 2] and personal communication, L Sadler.

Figure 40: Neonatal Mortality Rates by Neonatal Death Classification Cause in New Zealand and CMDHB, 2007-2008



Source: PMMRC[1, 2], personal communication, L Sadler. Note: Error bars indicate 95% confidence interval.

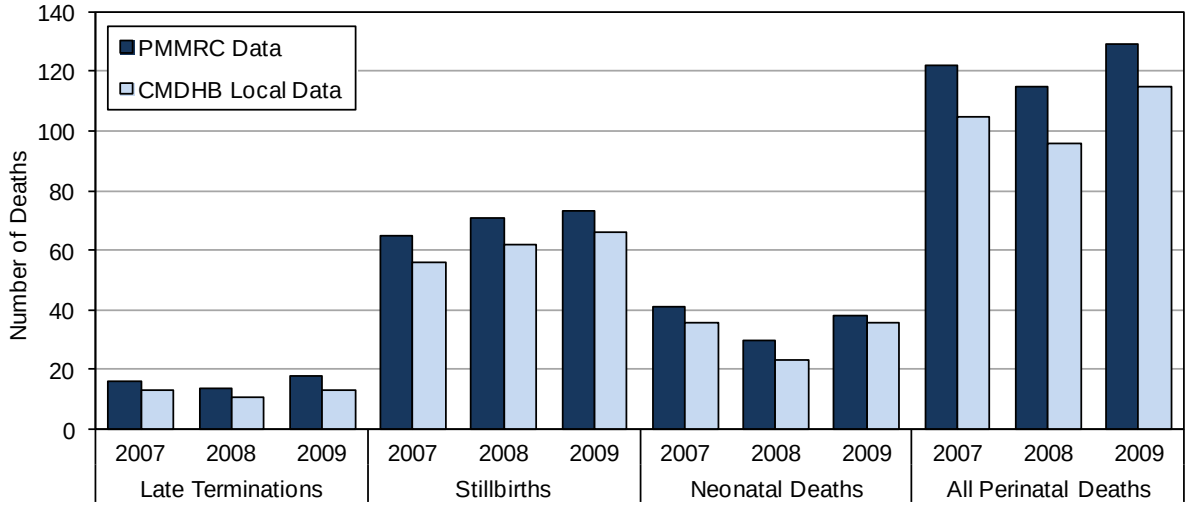
4.2 CMDHB Held Perinatal Mortality Data

The PMMRC has a network of local coordinators, located in each of the DHBs, who identify perinatal deaths that occur within the DHB and submit data to the Mortality Review Data Group at the University of Otago on each death.[1] Local coordinators are also responsible for initiating local clinical review of each case, including the assignation of perinatal death classification codes, and ensuring follow-up with parents. In CMDHB the local coordinators are currently Dr Sarah Wadsworth and Dr Nerida Titchiner who are both obstetricians.

Until recently, there was no CMDHB perinatal mortality database. CMDHB's local PMMRC coordinators recently established an access database into which they are entering data prospectively, with the intention to enter retrospective data when resourcing becomes available. However, since 2006 electronic records have been kept of all cases reviewed at the local review meetings in a series of excel spreadsheets. These contain limited data and are incomplete, particularly in the early years. While they provide a useful record of the review process, and can be used to identify perinatal deaths, they do not contain sufficient data to enable population level data analysis or to give an overview of perinatal mortality within the DHB. In order to facilitate this project, Sarah Wadsworth requested data from the PMMRC for CMDHB deaths, however the data provided only included deaths that CMDHB coordinators had reported to the PMMRC, was incomplete (missing ~15% of deaths), and was provided in paper form containing very limited information. In particular, late terminations, and stillbirths and neonatal deaths in infants born to CMDHB resident women who occurred outside of Counties DHB did not appear to be included.

In order to compile a single local perinatal dataset for analysis in this project, data was sought from numerous sources including the local coordinators, the PMMRC as described above, Healthware, the CMDHB patient management system (PIMs), and from individual patient records held in Concerto. Despite this wide search to identify perinatal deaths that occurred in infants born to CMDHB women, the resulting dataset was incomplete. For 2007-09, perinatal data from all sources available to CMDHB staff only included 86% of the deaths attributed to CMDHB women in the PMMRC dataset. Terminations of pregnancy were least likely to be captured in a local data set (77%), although 87% of neonatal deaths and 88% of stillbirths were captured during 2007-09. This finding is not unexpected, as deaths of babies born to CMDHB resident women who occur outside of the DHB are seldom notified to the local coordinators. In addition, Healthware did not identify all of the deaths in the compiled dataset, and so in and of itself it is not a reliable source of perinatal data.

Figure 41: Counties Manukau Perinatal Deaths Recorded in the Perinatal and Maternal Mortality Review Committee Dataset and Local Counties Manukau Datasets, 2007-09

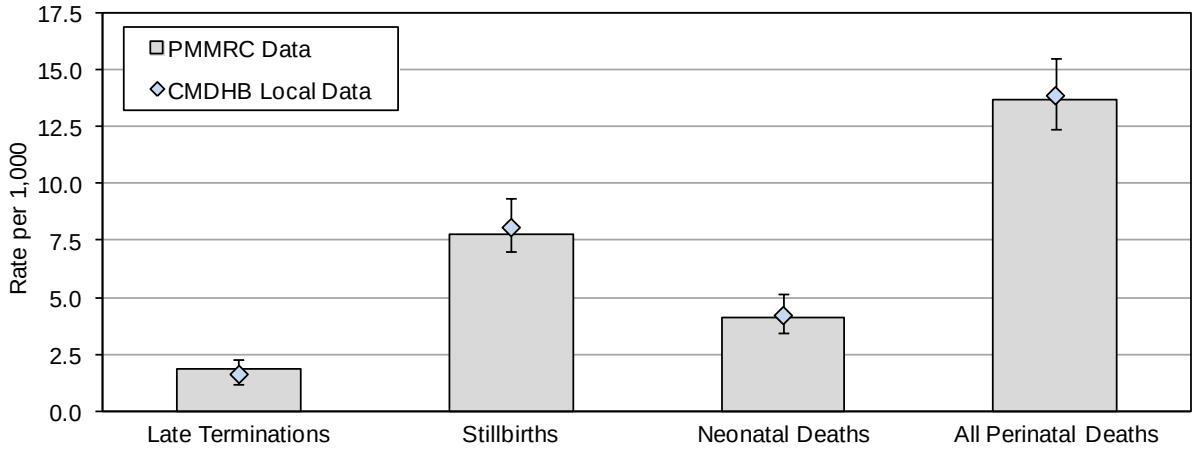


Source: PMMRC[1-3] and local CMDHB data sources

Perinatal Mortality in CMDHB Resident Women who Deliver in CMDHB

In order to fully utilise the data collected in CMDHB local datasets, further analysis of CMDHB perinatal mortality was restricted to deaths of babies that were born to CMDHB resident mothers that were delivered in, or on route to, a CMDHB facility. This allowed the identification of a defined denominator population. During 2007-09, perinatal mortality rates in CMDHB women who delivered in a CMDHB facility did not differ significantly from those reported for all CMDHB women by the PMMRC, even following stratification by type of perinatal death (Figure 42).[3]

Figure 42: Perinatal Mortality in CMDHB Resident Women by Data Source, 2007-09



Source: PMMRC[1-3] and local CMDHB data sources. Local data only include CMDHB women who delivered in a CMDHB facility. Late termination, stillbirth, and all perinatal mortality rates are per 1,000 total births. Neonatal mortality rates are per 1,000 live births. Error bars indicate 95% confidence intervals

This section presents local CMDHB perinatal mortality in two ways. The first follows the PMMRC report format and examines late terminations, stillbirths, and neonatal deaths separately. The use of CMDHB local data allows for a more detailed description and univariate and multivariate analyses where numbers allow.

The second method of analysis, Perinatal Periods of Risk (PPOR), was developed by the World Health Organization and refined for use in the united States.[5] The intent of this approach was to develop a simple method, based on a prevention framework, for use by community partners to engage with communities to set priorities for prevention.

IMPORTANT CAUTIONS: The cautions detailed here should be taken into account when interpreting the CMDHB local data presented in this section only include data for CMDHB resident women who delivered in a CMDHB facility during 2007-09. The demography of this group suggests they are a higher risk sub-group of the CMDHB maternity population although perinatal mortality rates during 2007-09 were not significantly different in this group than for CMDHB women as a whole.

Maternal data for all perinatal deaths has been audited for its accuracy; however limited data validation was undertaken for women who did not experience a perinatal death (see section 2.2.2.3). Some data were incomplete; particularly body mass index and smoking data, and data for women who did not book during their pregnancy. The demographic characteristics of women for whom data were missing suggests they are a higher risk population, therefore perinatal mortality analyses presented are likely to be conservative.

4.2.1 Late Terminations

During 2007-09, 77% of late terminations in CMDHB resident women were captured in local datasets. It is likely that terminations not recorded locally were performed in facilities outside of CMDHB, however this is not known for certain. Other potential reasons for under-reporting include misclassification of these deaths as stillbirths or neonatal deaths, failure by medical staff to notify these deaths to the local coordinator, lack of recognition that these deaths fulfil the criteria for a perinatal mortality event (i.e. gestation of 20 weeks of more, birth weight of at least 400g).

The broad indications for late terminations during 2007-09 in CMDHB women were described in section 4.1.3.1 using data supplied by the PMMRC. These did not differ significantly from the indications for late termination seen across New Zealand as a whole. More detail is available for 37 of the 48 fetal deaths that occurred as a result of a late termination of pregnancy in a CMDHB resident women during 2007-09 from local data sources. In 92% of these the late termination was performed for congenital abnormality, while the indications for the remaining three late terminations were spontaneous preterm labour, maternal hypertension, and psychosocial. Of the 34 late terminations for congenital abnormalities, 32% were for chromosomal abnormalities, 27% for abnormalities of the central nervous system, and 15% for multiple non-chromosomal abnormalities (Table 27).

Table 27: Late Termination Due to Congenital Abnormality in CMDHB Women who Delivered in CMDHB, 2007-09

	Number	Percent
Chromosomal		
Trisomy (13, 18, 21)	4 (11.8%)	11 (32.4%)
Triploidy	2 (5.9%)	
Sex chromosome abnormality	2 (5.9%)	
Other	3 (8.8%)	
Central Nervous System		
Anencephaly	4 (11.8%)	9 (26.5%)
Other	5 (14.7%)	
Other		
Multiple non-chromosomal	5 (14.7%)	12 (35.3%)
Urinary / GI	3 (8.8%)	
Cardio-vascular	1 (2.9%)	
Other	3 (14.7%)	

Source: CMDHB. Note: Only includes data for CMDHB women who delivered in a CMDHB facility, and accounts for only 77% of late terminations in CMDHB women during 2007-09.

While Maaori and Pacific women accounted for 60% of births to CMDHB women in a CMDHB facility during 2007-09, they only accounted for 32% of the late terminations (Table 28). Similarly, while 66% of CMDHB women living in the most socio-economically deprived deciles (66%) during this time, these women only accounted for 49% of the late terminations.

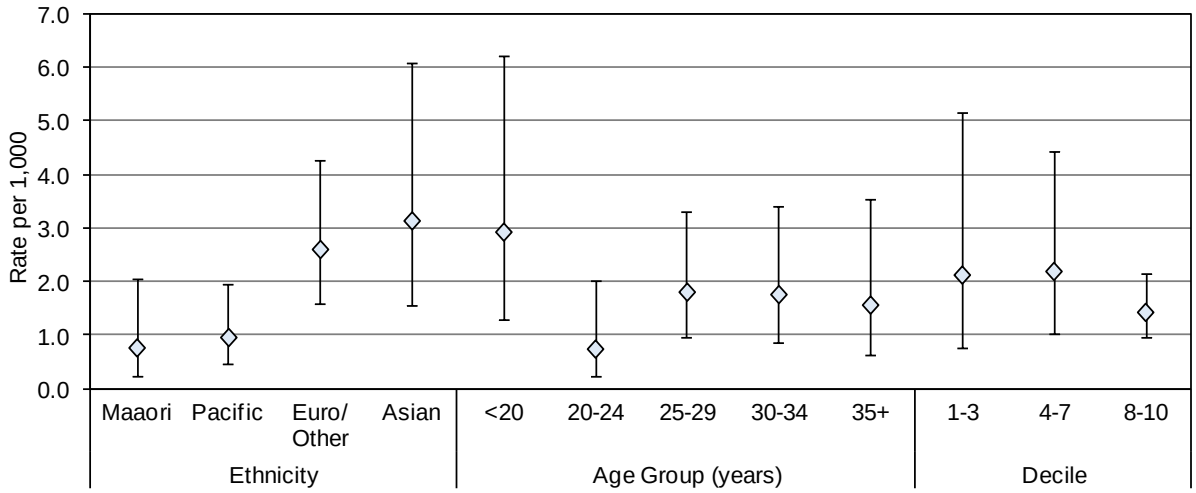
While small numbers precluded detailed analyses, and no statistically significant differences in late termination rates were observed by ethnicity, age group, or socioeconomic deprivation decile, trends were similar to those reported nationally by the PMMRC (Figure 43).[3] For CMDHB women who delivered in a CMDHB facility during 2007-09, late termination rates were highest for Asian and European/Other women and lowest for women living in the most deprived areas. In contrast to the national trend for late termination by age group, young women in CMDHB had a tendency to have the highest rate although differences by age group were not statistically significant.[3]

Table 28: Profile of CMDHB Women who had a Late Termination of Pregnancy, 2007-2009

Ethnicity	Num	Percent	Deprivation	Num	Percent
Maaori	4	10.8	Decile 1-2	5	13.5
Pacific	8	21.6	Decile 3-4	-	-
Asian	16	43.2	Decile 5-6	6	16.2
Euro/Other	9	24.3	Decile 7-8	8	21.6
Age Group	**Num**	**Percent**	Decile 9-10	18	48.7
<20 years	7	18.9	**Parity**	**Num**	**Percent**
20-24 years	4	10.8	Nulliparous	19	52.8
25-29 years	11	29.7	Para 1-2	12	33.3
30-34 years	9	24.3	Para 3-5	5	13.9
35+ years	6	16.2	Para 6+	-	-

Note: Only includes data for CMDHB women who delivered in a CMDHB facility, and accounts for only 75% of late terminations in CMDHB women during 2007-09. Ethnicity is preferred.

Figure 43: Late Termination Rates in CMDHB that Delivered in a CDMHB Facility by Ethnicity, Age Group, and Deprivation Decile, 2007-09



Note: Only includes data for CMDHB women who delivered in a CMDHB facility, and accounts for only 75% of late terminations in CMDHB women during 2007-08. Ethnicity is preferred. Error bars indicate 95% confidence intervals.

4.2.2 Stillbirths

During 2007-09, 88% of stillbirths in CMDHB resident women were captured in local datasets. It is likely that those stillbirths not recorded locally occurred in facilities outside of CMDHB, however this is not known for certain. Other potential reasons for under-reporting include misclassification of these deaths as neonatal deaths, failure by medical staff to notify these deaths to the local coordinator, lack of recognition that these deaths fit the criteria of a perinatal mortality event (i.e. gestation of 20 weeks of more, birth weight of at least 400g).

There is evidence that the drivers of stillbirth in babies with a birthweight of <1,500 grams differ from those for stillborn babies that weight 1,500 grams or more. This distinction is made in the Perinatal Periods of Risk method for analysing fetal-infant mortality based on the rationale that irrespective of whether the death is a stillbirth, neonatal or post-neonatal death, the causes of death in infants born weighing <1,500 grams are similar.[5] Furthermore, strategies to prevent deaths in infants weighing <1,500 grams are likely to be different and

are most likely to focus on maternal health, preconception care, and preventing prematurity. In contrast, strategies for preventing stillbirths in infants who weigh 1,500g or more are likely to focus on improving routine preventive care, screening, assessment, referral and high risk care.[5]

During 2007-09 there were 184 stillborn infants born to CMDHB mothers in a CMDHB facility, approximately half (95 (52%)) of whom weighed <1,500g at birth while 89 (48%) weighed 1,500g or more at birth. The stillbirth rate for very low birth weight babies (<1,500g) was 4.2 per 1,000 total births, while the rate for babies born weighing 1,500g or more was 3.9 per 1,000 total births, giving a total stillbirth rate for CMDHB infants of 8.1 per 1,000 total deliveries in a CMDHB facility.

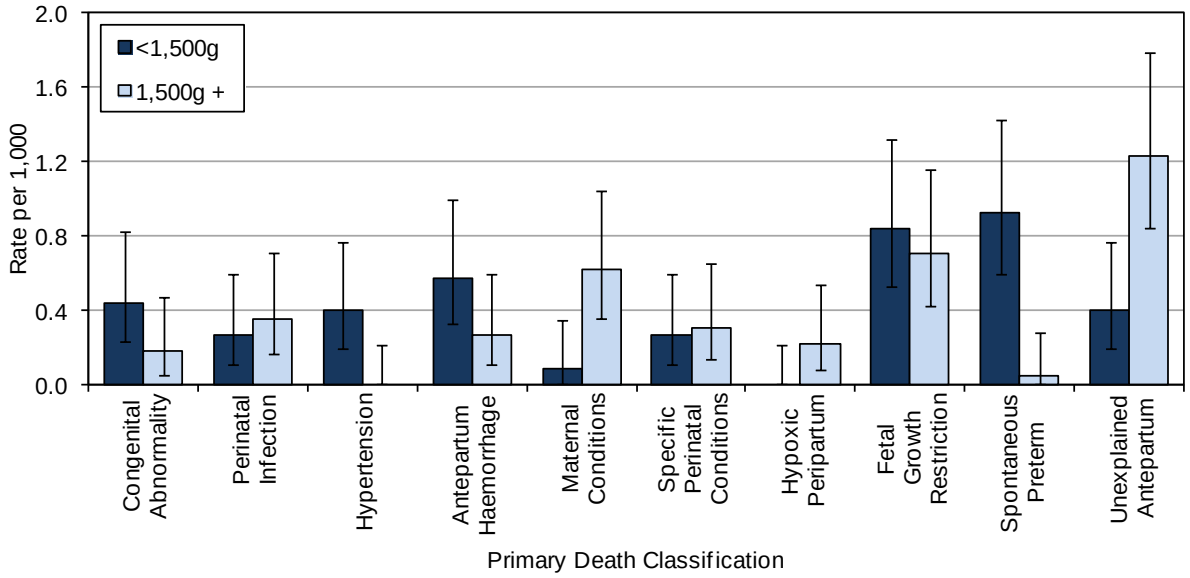
4.2.2.1 Causes of Stillbirth

PMMRC data for 2007-08 reveals significant differences in the causes of stillbirth in CMDHB compared with nationally (see 4.1.3.2). In particular, significantly higher rates of stillbirth in CMDHB were attributed to fetal growth restriction and maternal conditions that together account for approximately half of the excess stillbirths in CMDHB.

More detailed cause of death data were not available from the PMMRC, however local data were available for 2007-09 for 184 stillborn infants born to a CMDHB mother in a CMDHB facility. The primary obstetric antecedent causes of death differed significantly for infants that weighed <1.500g at birth compared to those that weighed 1,500g or more (Figure 44).

The most frequent cause of death in stillborn infants weighting <1,500g were spontaneous preterm labour (22%), fetal growth restriction (20%), antepartum haemorrhage (14%), and congenital abnormality (11%) while <10% were classified as an unexplained antepartum death. For stillborn infants weighing 1,500g or more at birth the most frequent cause of death was fetal growth restriction (18%), maternal conditions (16%) and perinatal infection (9%) while 31% were classified as an unexplained antepartum death.

Figure 44: Rates of Stillbirth by Birthweight and Primary Obstetric Antecedent Cause of Death in Infants, 2007-09



Note: Only includes data for stillborn CMDHB infants delivered in a CMDHB facility. Error bars indicate 95% confidence intervals.

During 2007-09, all of the maternal conditions identified as the antecedent cause of stillbirths infants weighing 1,500g or more were diabetes related (pre-existing or gestational). In

contrast, for stillborn infants weighing <1,500g both deaths were attributed to a maternal renal condition.

Congenital abnormalities were more frequently identified as a cause of stillbirth in very low birth weight infants (<1,500g). Of all the congenital abnormalities resulting in 14 stillbirths, 9 (64%) were chromosomal (Trisomy 21 (n=4); Trisomy 18 (n=2); Other (n=3)); 2 had multiple non-chromosomal abnormalities, and 3 had other congenital abnormalities.

Fourteen stillbirths were attributed to perinatal infection and these were caused by group B Streptococci (n=3), E. Coli (n=2), other bacteria (n=3), viral infection (n=2), toxoplasmosis (n-1), and other unspecified organisms (n=3).

4.2.2.2 Very Low Birth Weight (VLBW) Stillborn Infants (<1,500g)

Of the 368 CMDHB infants born in a CMDHB facility during 2007-09 weighing <1,500g, 95 (25.8%) were stillborn. If these 368 infants had the same stillbirth rate as infants born weighing <1,500g nationally during 2007-09 there would have been 17 fewer stillbirths in VLBW infants in CMDHB during this time.[3]

Of the 95 VLBW stillborn infants born in a CMDHB facility during 2007-09, 38% were born to a Pacific mother and 22% to a Maaori mother, 73% were born to a mother that lived in CMDHBs most socio-economically deprived areas (decile 9-10), 22% were born to a mother who smoked during pregnancy, 40% to a mother who was obese, and 18% to a mother who had no antenatal care during pregnancy (was Unbooked) (Table 29). Of these stillborn infants, 80% were born before 28 weeks gestation, 75% were small for gestational age (SGA using customised birthweight centiles[42]), and 3% were one of a multiple birth.

The overall stillbirth rate for infants weighing <1,500g was 4.2 per 1,000 total births during the three years examined. There were no significant differences in the crude stillbirth rates for VLBW infants by maternal age, the socio-economic deprivation decile of the area the mother lived in, maternal parity, smoking status, body size, or whether the infant was a singleton or one of a multiple birth.

Statistically significant differences in stillbirth rates in this group of infants were seen by maternal ethnicity, maternity provider, gestation at delivery, and whether the infant was SGA. The highest crude rates were seen in infants born to Indian mothers (7.4 per 1,000), mothers with no antenatal care (29.4 per 1,000) or who had Secondary Care (22.4 per 1,000), SGA infants (18.2 per 1,000), and infants born at 20-27 weeks (272.4 per 1,000) or 28-31 weeks gestation (56.9 per 1,000). In order to determine whether these factors were associated with the risk of stillbirth independent of each other, a multivariate analysis was performed with ethnicity, maternity provider, SGA (binary outcome), and gestation (as a continuous variable) as the explanatory variables. Only SGA, gestation, and maternity provider remained independently associated with the risk of stillbirth in this group. After controlling for the effects of these three variables on stillbirth rates, differences in VLBW stillbirth rates by ethnicity were no longer apparent ($p>0.05$).

Being SGA increased the adjusted odds of a VLBW stillbirth by 18 fold compared to not being SGA, independent of gestation or maternity provider ($p<0.0001$). For each additional week that a VLBW infant stayed in-utero, the adjusted odds of stillbirth decreased by 33%, independent of SGA or maternity provider ($p<0.0001$). The adjusted odds of a VLBW stillbirth was 4.2 (95% CI: 1.5-12.0; $p=0.008$) times higher in women under Secondary Care and 5.1 (95% CI: 1.7-16.1; $p=0.0048$) times higher for women who had no antenatal care compared to women with private LMC care, independent of gestation and SGA. Higher stillbirth rates in women receiving Secondary Care is to be expected as women under specialist care are high risk. No significant differences in the odds of a VLBW stillbirth was seen in women with private LMC care, CMDHB midwife care (Closed Unit or Caseloading care), or women with SharedCare.

Table 29: Crude Rate and Odds of Stillbirth in CMDHB Infants Weighing <1,500g, 2007-09

	Num	Percent	Crude Rate (95% CI)	Crude OR (95% CI)	p
Ethnicity					
Maaori	21	22.1	4.0 (2.6-6.2)	1.2 (0.6-2.2)	ns
Pacific	36	37.9	4.3 (3.1-6.0)	1.3 (0.7-2.2)	ns
Indian	12	12.6	7.4 (4.1-13.2)	2.2 (1.1-4.4)	0.032
Other Asian	5	5.3	4.0 (1.5-9.7)	1.2 (0.4-3.1)	ns
Euro/Other	21	22.1	3.4 (2.2-5.3)	ref	ref
Age Group					
<20 years	12	12.6	5.0 (2.8-8.9)	1.4 (0.7-2.8)	ns
20-24 years	19	20.0	3.5 (2.2-5.6)	1.0 (0.5-1.8)	ns
25-29 years	23	24.2	3.8 (2.5-5.7)	1.0 (0.6-1.9)	ns
30-34 years	19	20.0	3.7 (2.4-5.9)	ref	ref
35+ years	22	23.2	5.7 (3.8-8.8)	1.5 (0.8-2.9)	ns
NZ Deprivation Index 2006 (CAU)					
Decile 1-2	3	3.2	1.6 (0.3-5.0)	ref	ref
Decile 3-4	6	6.3	5.6 (2.3-12.5)	3.5 (0.9-13.9)	ns
Decile 5-6	9	9.5	3.4 (1.7-6.6)	2.1 (0.6-7.8)	ns
Decile 7-8	8	8.4	3.8 (1.8-7.7)	2.4 (0.6-8.9)	ns
Decile 9-10	69	72.6	4.6 (3.6-5.8)	2.8 (0.9-9.0)	ns
Parity					
Nulliparous	38	40.0	4.4 (3.2-6.0)	1.0 (0.7-1.6)	ns
1-2	41	43.2	4.2 (3.1-5.8)	ref	ref
3-5	13	13.7	3.5 (2.0-6.1)	0.8 (0.4-1.5)	ns
6+	3	3.2	4.4 (0.9-13.5)	1.0 (0.3-3.3)	ns
Smoking Status					
Yes	20	22.0	5.7 (3.6-8.8)	1.3 (0.8-2.2)	ns
No	71	78.0	4.3 (3.4-5.4)	ref	ref
Body Size					
Normal	29	37.7	4.5 (3.1-6.5)	ref	ref
Overweight	17	22.1	3.4 (2.1-5.5)	0.8 (0.4-1.4)	ns
Obese	31	40.3	4.4 (3.1-6.2)	1.0 (0.6-1.6)	ns
Maternity Provider					
Private LMC	36	37.9	3.2 (2.3-4.5)	ref	ref
DHB Midwife	17	17.9	3.3 (2.0-5.4)	1.0 (0.6-1.8)	ns
Shared Care	16	16.8	2.9 (1.8-4.8)	0.9 (0.5-1.6)	ns
Secondary	9	9.5	22.4 (11.3-42.9)	7.1 (3.4-14.9)	<0.0001
Unbooked	17	17.9	29.4 (18.2-47.0)	9.4 (5.2-16.8)	<0.0001
Gestation					
<28 weeks	76	80.0	272.4 (223.6-327.7)	5,304.0 (936.6->1,000)	<0.0001
28-31 weeks	12	12.6	56.9 (32.1-98.1)	1,107.0 (210.8->1,000)	<0.0001
32-36 weeks	6	6.3	3.8 (1.6-8.6)	74.9 (9.0-622.5)	<0.0001
37-41 weeks	1	1.1	0.1 (0.0-0.3)	ref	ref
42+ weeks	0	0.0	0.0 (0.0-3.8)	n/a	n/a
Small for Gestational Age (customised birthweight centiles)					
Yes	53	74.6	18.2 (13.9-23.8)	15.8 (9.3-27.1)	<0.0001
No	18	25.4	1.2 (0.7-1.9)	ref	ref
Multiple					
No	92	96.8	4.1 (3.4-5.1)	ref	ref
Yes	3	3.2	5.0 (1.1-15.5)	1.2 (0.4-3.8)	ns

Source: Healthware. Note: Only includes CMDHB infants delivered in a CMDHB facility. Rates are per 1,000 total births. See section 1.1 for a description of maternity providers. Ethnicity is preferred. OR: odds ratio; n/a: not applicable; ns: not significant; ref: reference group.

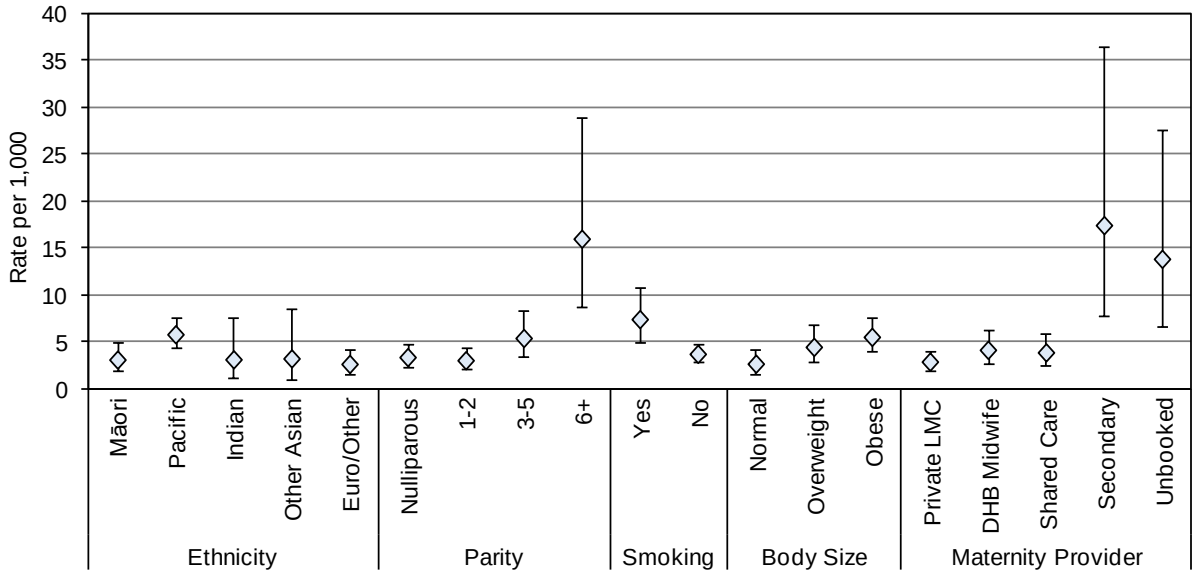
4.2.2.3 Stillborn Infants Weighing 1,500g or More

During 2007-09, 22,402 CMDHB infants were born weighing 1,500g or more of whom 89 were stillborn (0.4%). If these 22,402 infants had the same stillbirth rate as infants born weighing 1,500g or more nationally during 2007-09 there would have been 28 fewer stillbirths in infants weighing 1,500g or more in CMDHB during this time.[3]

Of the 89 CMDHB infants stillborn in a CMDHB facility during 2007-09, 54% were born to a Pacific mother and 18% to a Maaori mother, 73% were born to a mother that lived in CMDHBs most socio-economically deprived areas (decile 9-10), 30% were born to a mother who smoked during pregnancy, and 50% to a mother who was obese, and 9% to a mother who had no antenatal care during pregnancy (was Unbooked) (Table 30). Of these stillborn infants, 58% were born at term and 32% at 32-36 weeks gestation, 35% were small for gestational age (SGA using customised birthweight centiles[42]), and 3% were one of a multiple birth.

The overall stillbirth rate for infants weighing 1,500g or more was 3.9 per 1,000 total births during the three years examined. There were no significant differences in the crude stillbirth rates for this group of infants by maternal age, the socio-economic deprivation decile of the area the mother lived in, or whether the infant was a singleton or one of a multiple birth (Table 30). Statistically significant differences in crude stillbirth rates in this group of infants were seen by maternal ethnicity, parity, smoking status, body mass, maternity provider, gestation at delivery, and whether the infant was SGA (Figure 45). Infants who were stillborn weighing 1,500g were most likely to be born to Pacific mothers, mothers with a parity of 6 or more, who smoked during pregnancy, who were obese, and mothers with no antenatal care or under CMDHB Secondary Care, and to be born SGA (Table 30).

Figure 45: Crude Stillbirth Rates in CMDHB Infants Weighing 1,500g+ by Maternal Characteristics, 2007-09

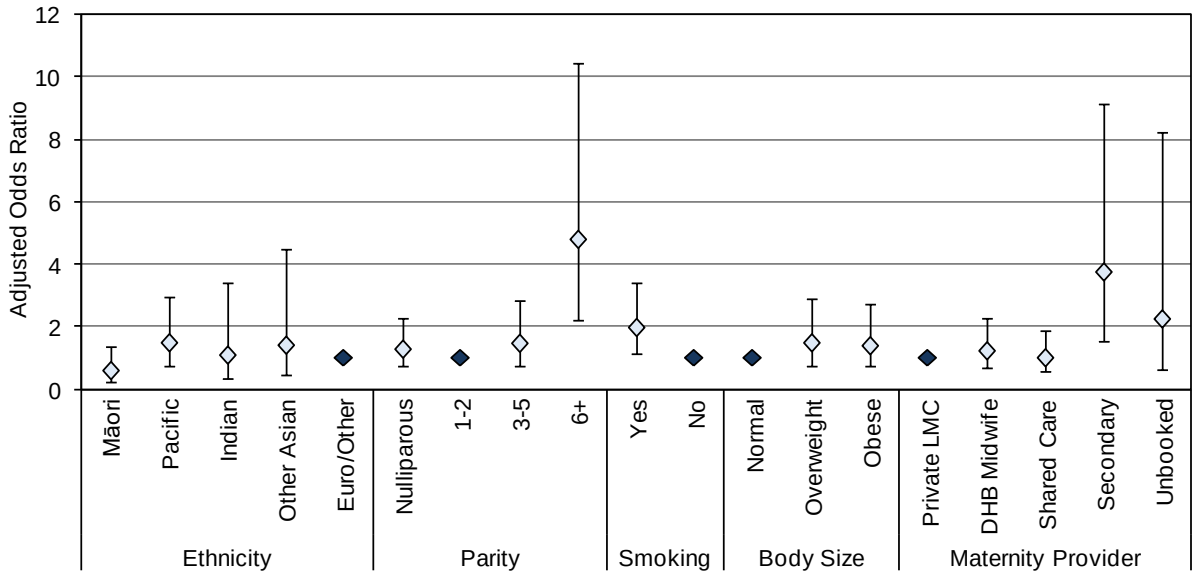


Source: Healthware. Note: Only includes CMDHB infants delivered in a CMDHB facility. Rates are per 1,000 total births. Ethnicity is preferred. See section 1.1 for a description of maternity providers. Error bars indicate 95% confidence intervals.

In order to determine whether ethnicity, parity, smoking, body size, maternity provider, gestation, and SGA were associated with the risk of stillbirth independent of each other, a multivariate analysis was performed. Only parity (p=0.0012), smoking status (p=0.0137), maternity provider (p= 0.0381), SGA (p=0.0012), and gestation (p= <0.0001) remained independently associated with a stillbirth at 1,500g or more (Figure 46). After controlling for

the effects of these variables on stillbirth rates for infants weighing 1,500g or more, differences in rates by ethnicity were no longer apparent (p>0.05).

Figure 46: Adjusted Odds of Stillbirth at 1,500g or more in CMDHB Infants, 2007-09



Source: Healthware. Note: Only includes CMDHB infants delivered in a CMDHB facility. Reference group shown by dark diamonds. Error bars indicate 95% CI. Odds ratios adjusted for the effects of maternal ethnicity, parity, smoking, body size, maternity provider, SGA, and gestation. Ethnicity is preferred. See section 1.1 for a description of maternity providers.

After adjusting for the effects of ethnicity, parity, smoking, body size, maternity provider, gestation, and SGA on the odds of having a stillborn infant weighing 1,500 or more the following observations were made (Figure 46):

- Women with a parity of 6 or more had 4.8 time higher adjusted odds of having a stillborn infant weighing 1,500g or more than women with a parity of 1-2 (p<0.0001). The adjusted odds in nulliparous women and women with a parity of 3-5 were not significantly different from those in women with a parity of 1-2.
- Women who smoked during pregnancy had 2 times higher adjusted odds of having a stillborn infant weighing 1,500g or more than women who did not smoke, independent of the effects of parity, maternity provider, SGA, and gestation (p=0.014).
- Infants born SGA had 2.2 times higher adjusted odds of being stillborn at a weight of 1,500g or more than infants who were not SGA (p=0.001). This was independent of maternal parity, maternity provider, and gestation.
- Women under CMDHB Secondary Care had 3.8 times higher adjusted odds of having a stillborn infant weighing 1,500g or more than women with a Private LMC (p=0.004) independent of the other factors in the model. This finding was not unexpected as women under Secondary Care are high risk. No significant differences in the adjusted odds of having such a stillbirth were observed for women with Shared Care, CMDHB midwife care, or women with no antenatal care compared to those with Private LMC care.
- The odds of an infant being stillborn at a weight of 1,500g or more decreased by 11% with every additional week in-utero after 20 weeks gestation (p<0.0001) independent of the other factors in the model.

Table 30: Crude Rate and Odds of Stillbirth in CMDHB Infants Weighing 1,500g+, 2007-09

	Num	Percent	Crude Rate (95% CI)	Crude OR (95% CI)	p
Ethnicity					
Maaori	16	18.0	3.1 (1.9-5.0)	1.2 (0.6-2.4)	ns
Pacific	48	53.9	5.8 (4.3-7.7)	2.2 (1.3-3.9)	0.006
Indian	5	5.6	3.1 (1.1-7.5)	1.2 (0.4-3.3)	ns
Other Asian	4	4.5	3.2 (1.0-8.6)	1.2 (0.4-3.7)	ns
Euro/Other	16	18.0	2.6 (1.6-4.3)	ref	ref
Age Group					
<20 years	5	5.6	2.1 (0.8-5.1)	0.5 (0.2-1.3)	ns
20-24 years	17	19.1	3.2 (1.9-5.1)	0.7 (0.4-1.4)	ns
25-29 years	19	21.3	3.1 (2.0-4.9)	0.7 (0.4-1.3)	ns
30-34 years	22	24.7	4.3 (2.8-6.6)	ref	ref
35+ years	26	29.2	6.8 (4.6-10.0)	1.6 (0.9-2.8)	ns
NZ Deprivation Index 2006 (CAU)					
Decile 1-2	4	4.5	2.2 (0.6-5.8)	ref	ref
Decile 3-4	3	3.4	2.8 (0.6-8.7)	1.3 (0.3-5.8)	ns
Decile 5-6	8	9.0	3.0 (1.4-6.1)	1.4 (0.4-4.7)	ns
Decile 7-8	9	10.1	4.3 (2.1-8.3)	2.0 (0.6-6.5)	ns
Decile 9-10	65	73.0	4.3 (3.4-5.5)	2.0 (0.7-5.5)	ns
Parity					
Nulliparous	29	32.6	3.3 (2.3-4.8)	0.0 (0.0-0.0)	ns
1-2	29	32.6	3.0 (2.1-4.3)	ref	ref
3-5	20	22.5	5.4 (3.4-8.4)	1.8 (1.0-3.2)	0.045
6+	11	12.4	16.0 (8.7-28.9)	5.4 (2.7-10.8)	<0.0001
Smoking Status					
Yes	26	29.9	7.4 (5.0-10.9)	2.0 (1.3-3.2)	0.003
No	61	70.1	3.7 (2.9-4.7)	ref	ref
Body Size					
Normal	17	21.8	2.6 (1.6-4.3)	ref	ref
Overweight	22	28.2	4.4 (2.9-6.7)	1.7 (0.9-3.2)	ns
Obese	39	50.0	5.5 (4.0-7.5)	2.1 (1.2-3.7)	0.011
Maternity Provider					
Private LMC	32	36.0	2.9 (2.0-4.0)	ref	ref
DHB Midwife	21	23.6	4.1 (2.7-6.3)	1.4 (0.8-2.5)	ns
Shared Care	21	23.6	3.8 (2.5-5.9)	1.3 (0.8-2.3)	ns
Secondary	7	7.9	17.4 (7.8-36.5)	6.2 (2.7-14.1)	<0.0001
Unbooked	8	9.0	13.8 (6.6-27.7)	4.9 (2.2-10.7)	<0.0001
Gestation					
<28 weeks	0	0.0	0.0 (0-16.8)	-	n/a
28-31 weeks	7	7.9	33.2 (15.1-68.6)	12.8 (5.8-28.6)	<0.0001
32-36 weeks	28	31.5	17.9 (12.3-25.9)	6.8 (4.3-10.8)	<0.0001
37-41 weeks	52	58.4	2.7 (2.0-3.5)	ref	ref
42+ weeks	2	2.2	1.6 (0.0-6.3)	0.6 (0.1-2.5)	<0.0001
Small for Gestational Age (customized birthweight centiles)					
Yes	27	35.1	9.3 (6.3-13.5)	2.9 (1.8-4.6)	<0.0001
No	50	64.9	3.2 (2.5-4.3)	ref	ref
Multiple					
No	86	96.6	3.9 (3.1-4.8)	ref	ref
Yes	3	3.4	5.0 (1.1-15.5)	1.3 (0.4-4.1)	ns

Source: Healthware. Note: Only includes CMDHB infants delivered in a CMDHB facility. Rates are per 1,000 total births. Ethnicity is preferred. See section 1.1 for a description of maternity providers. OR: odds ratio; n/a: not applicable; ns: not significant; ref: reference group.

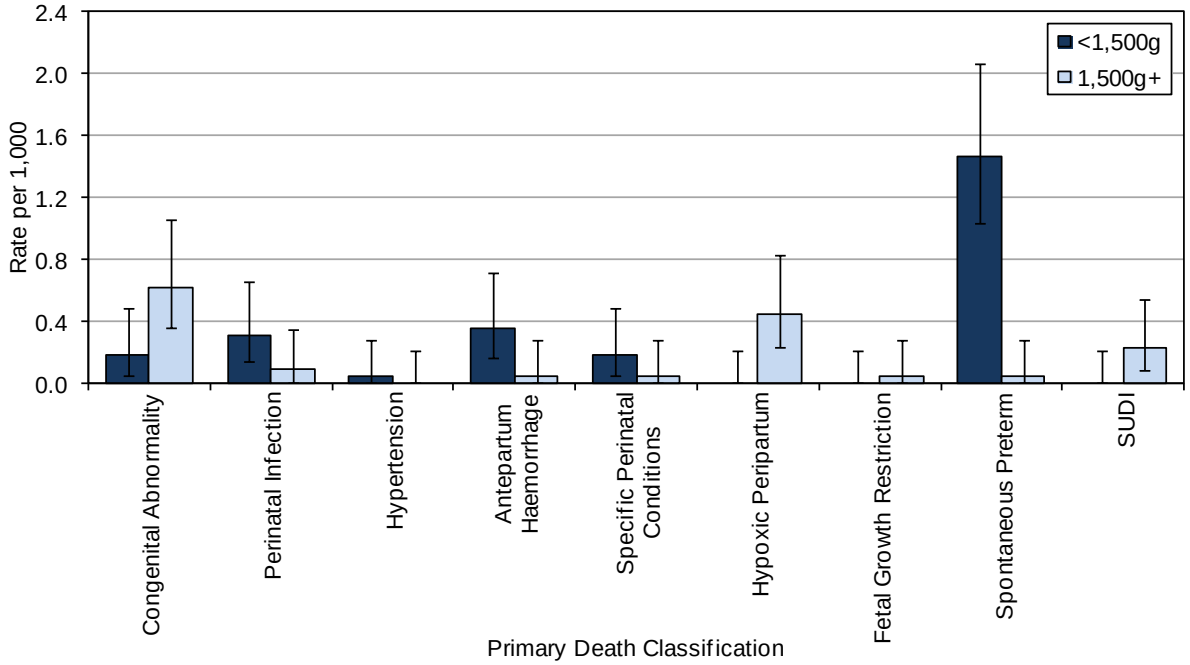
4.2.3 Neonatal Deaths

During 2007-09, 87% of neonatal in infants born to CMDHB resident women were captured in local datasets. It is likely that those deaths not recorded locally occurred in facilities outside of CMDHB or at home, however this is not known for certain. Other potential reasons for under-reporting include misclassification of these deaths as stillbirths, failure by medical staff to notify these deaths to the local coordinator, lack of recognition that these deaths fit the criteria of a perinatal mortality event (i.e. gestation of 20 weeks of more, birth weight of at least 400g).

During 2007-09, there were 22,549 live born CMDHB infants of whom 95 (0.4%) died in the neonatal period (<28 days old). If these 22,549 infants had the same neonatal mortality rate as live born infants nationally during 2007-09 there would have been 34 fewer neonatal deaths in CMDHB during this time (11 annually).[3]

Of the 95 neonatal deaths captured in the local CMDHB data, a primary obstetric antecedent cause of death was known for 92 (97%). Neonatal death classification of these deaths was not available from the local data source. While small numbers make differences difficult to detect, when comparing primary antecedent obstetric causes of neonatal death in infants who weighed <1,500g at birth (n=57) with those for infants weighing 1,500g or more (n=35) differences were seen (Figure 47). In VLBW infants who died in the neonatal period the primary drivers were spontaneous preterm labour, antepartum haemorrhage, and perinatal infection. In contrast, for infants who were 1,500g or more at birth the primary causes of neonatal death were congenital abnormality, hypoxic peripartum, and sudden unexplained death in infancy (SUDI). Small numbers preclude further analysis by birthweight groups.

Figure 47: Primary Obstetric Antecedent Cause of Neonatal Death by Birthweight, CMDHB 2007-09



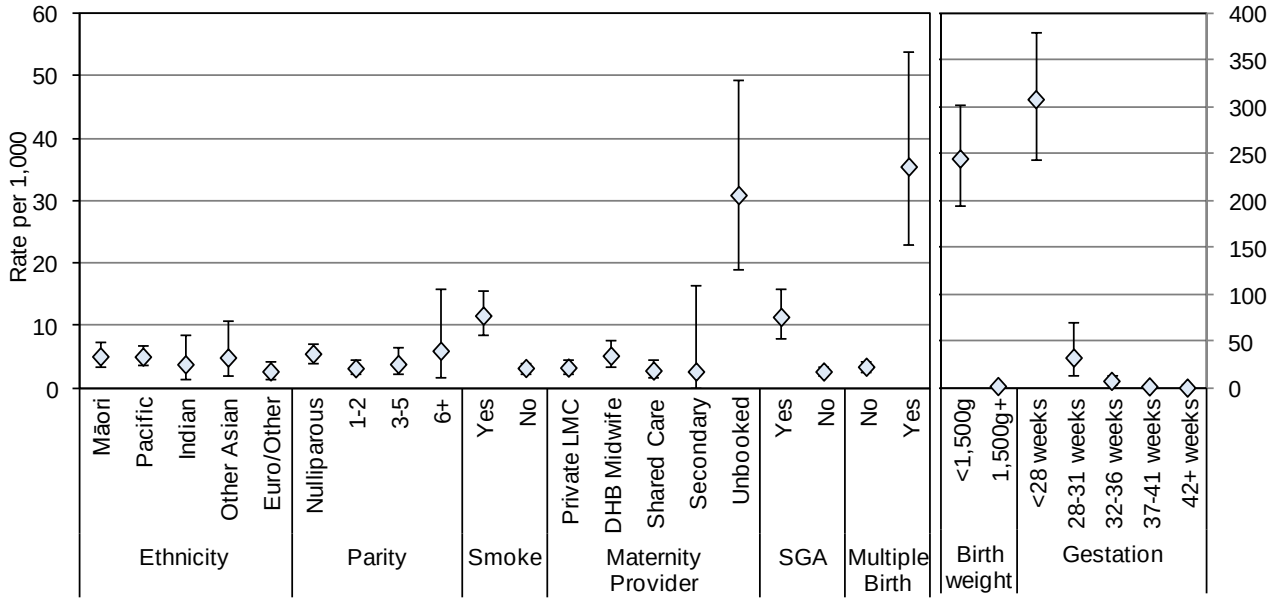
Source: Healthware. Note: Only includes CMDHB infants delivered in a CMDHB facility. Rates are per 1,000 live births. Error bars indicate 95% confidence intervals.

Of the 95 CMDHB infants born in a CMDHB facility that died in the neonatal period during 2007-09, 43% were born to a Pacific mother and 27% to a Maaori mother, 76% were born to a mother that lived in CMDHBs most socio-economically deprived areas (decile 9-10), 50% were born to a first time mother, 44% were born to a mother who smoked during pregnancy, and 18% to a mother who had no antenatal care during pregnancy (was Unbooked) (Table 31). Of these infants, 56% were born before 28 weeks gestation, 44% were SGA (using

customised birthweight centiles[42]), 61% weighed less than 1,500g, and 22% were one of a multiple birth (15 twins and 6 triplets).

The overall neonatal mortality rate was 4.2 per 1,000 live births during the three years examined. There were no significant differences in the crude stillbirth rates for this group of infants by maternal age, the socio-economic deprivation decile of the area the mother lived in, or maternal body size (not shown) (Table 30). Statistically significant differences in crude neonatal death rates were seen by maternal ethnicity, parity, smoking status, maternity provider, gestation, birthweight, SGA and by fetal count (Figure 48, Table 31).

Figure 48: Crude Neonatal Mortality Rates in CMDHB Infants by Maternal and Infant Characteristics, 2007-09



Source: Healthware. Note: Different scale used on the right graph. Only includes CMDHB infants delivered in a CMDHB facility. Rates are per 1,000 live births. Ethnicity is preferred. Small for gestation age based on customised birthweight centiles[42]. Error bars indicate 95% confidence intervals.

Mothers who had the highest crude rates of having their infant die in the neonatal period during 2007-09 were Pacific or Maaori, having their first child, smoked during pregnancy, and had no antenatal care (Figure 48). Infants who had the highest odds of dying in the neonatal period during this time were born very prematurely (<32 weeks and especially <28 weeks), had a birthweight <1,500g, were SGA, and were a twin or triplet. There was no difference in neonatal mortality in infants born to mothers who had Private LMC, DHB midwife, Shared Care, or Secondary Care.

In order to determine whether ethnicity, parity, smoking, maternity provider, gestation, SGA, birthweight, and multiple births were associated with the risk of neonatal death independent of each other, a multivariate analysis was performed. Only smoking (p=0.0009), SGA (p=0.0001), and gestation (p= <0.0001) remained independently associated with a neonatal death (Figure 46). After controlling for the effects of all of the other factors in the model; the odds of a neonatal death no longer varied by ethnicity, parity, maternity provider, multiple births, or birthweight.

The adjusted odds of a neonatal death in infants of women who smoked during pregnancy was 2.9 (95% CI: 1.5-5.5), the adjusted odds neonatal death in SGA infants was 3.2 (95% CI: 1.8-5.9), while the adjusted odds of a neonatal death decreased by 29% for each additional week in-utero beyond 20 weeks gestation.

Table 31: Crude Rate and Odds of Neonatal Death in CMDHB Infants, 2007-09

	Num	Percent	Crude Rate (95% CI)	Crude OR (95% CI)	p
Ethnicity					
Maaori	26	27.4	5.0 (3.4-7.4)	1.9 (1.0-3.6)	0.0408
Pacific	41	43.2	5.0 (3.7-6.8)	1.9 (1.1-3.4)	0.0297
Indian	6	6.3	3.8 (1.5-8.5)	1.4 (0.6-3.7)	ns
Other Asian	6	6.3	4.8 (2.0-10.9)	1.8 (0.7-4.7)	ns
Euro/Other	16	16.8	2.6 (1.6-4.3)	ref	ref
Age Group					
<20 years	12	12.6	5.1 (2.8-9.0)	1.5 (0.7-3.2)	ns
20-24 years	28	29.5	5.3 (3.6-7.6)	1.6 (0.9-2.9)	ns
25-29 years	27	28.4	4.5 (3.1-6.6)	1.3 (0.7-2.4)	ns
30-34 years	17	17.9	3.4 (2.1-5.4)	ref	ref
35+ years	11	11.6	2.9 (1.6-5.3)	0.9 (0.4-1.9)	ns
NZ Deprivation Index 2006 (CAU)					
Decile 1-2	4	4.2	2.2 (0.7-5.8)	ref	ref
Decile 3-4	2	2.1	1.9 (0.1-7.4)	0.9 (0.2-4.7)	ns
Decile 5-6	10	10.5	3.8 (2.0-7.2)	1.8 (0.6-5.6)	ns
Decile 7-8	7	7.4	3.4 (1.5-7.1)	1.6 (0.5-5.3)	ns
Decile 9-10	72	75.8	4.8 (3.8-6.1)	2.2 (0.8-6.1)	ns
Parity					
Nulliparous	47	49.5	5.5 (4.1-7.3)	1.7 (1.1-2.8)	0.0171
1-2	30	31.6	3.1 (2.2-4.5)	ref	ref
3-5	14	14.7	3.8 (2.2-6.5)	1.2 (0.6-2.3)	ns
6+	4	4.2	5.9 (1.8-15.9)	1.9 (0.7-5.4)	ns
Smoking Status					
Yes	40	43.5	11.6 (8.5-15.8)	3.7 (2.4-5.6)	<0.0001
No	52	56.5	3.2 (2.4-4.2)	ref	ref
Maternity Provider					
Private LMC	36	37.9	3.2 (2.3-4.5)	ref	ref
DHB Midwife	26	27.4	5.1 (3.5-7.6)	1.6 (1.0-2.6)	ns
Shared Care	15	15.8	2.8 (1.6-4.6)	0.9 (0.5-1.6)	ns
Secondary	1	1.1	2.6 (0.0-16.5)	0.8 (0.1-5.9)	ns
Unbooked	17	17.9	30.9 (19.1-49.4)	9.8 (5.5-17.6)	<0.0001
Gestation					
<28 weeks	53	55.8	308.1 (244.0-381.0)	345.5 (207.8-574.5)	<.0001
28-31 weeks	6	6.3	32.1 (13.5-70.3)	25.7 (10.4-63.4)	<.0001
32-36 weeks	11	11.6	7.2 (3.9-13.1)	5.6 (2.8-11.4)	<.0001
37-41 weeks	25	26.3	1.3 (0.9-1.9)	ref	ref
42+ weeks	0	0.0	0.0 (0.0-3.8)	n/a	n/a
Small for Gestational Age (customised birthweight centiles)					
Yes	32	44.4	11.3 (8.0-16.1)	4.4 (2.8-7.0)	<0.0001
No	40	55.6	2.6 (1.9-3.6)	ref	ref
Birthweight					
<1,500g	58	61.1	244.7 (194.4-303.6)	195.1 (125.9-302.2)	<.0001
1,500g+	37	38.9	1.7 (1.2-2.3)	ref	ref
Multiple					
No	74	77.9	3.4 (2.7-4.2)	ref	ref
Yes	21	22.1	35.4 (23.1-54.0)	10.9 (6.6-17.8)	<0.0001

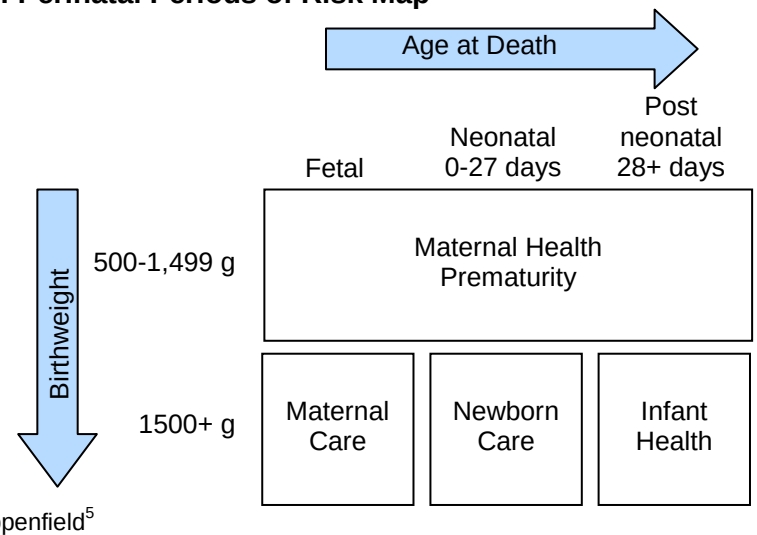
Source: Healthware. Note: Only includes CMDHB infants delivered in a CMDHB facility. Rates are per 1,000 live births. See section 1.1 for a description of maternity providers. Ethnicity is preferred. OR: odds ratio; n/a: not applicable; ns: not significant; ref: reference group.

4.2.4 Perinatal Periods of Risk

The Perinatal Periods of Risk (PPOR) approach provides a framework for investigating perinatal (and infant) mortality with a focus on identifying those factors that have the greatest impact on a community's perinatal mortality to allow better prevention planning.[5, 6] This approach has been used by communities to map excess perinatal mortality, and can be used to compare different time periods or populations.[59, 69-71] A minimum of around 60 perinatal deaths in each group is required to conduct a statistically reliable PPOR analysis.[5]

In a PPOR analysis, deaths are divided into four mutually exclusive periods of risk creating a feto-infant mortality map (Figure 49). The rationale for this division is that the main drivers of perinatal mortality vary in these groups therefore prevention strategies will vary, although some overlap is acknowledged.[5] For example, the potential approaches for addressing high perinatal mortality in the Maternal Health / Prematurity risk period include improving wellbeing in women of childbearing age (e.g. reduce smoking, improving nutrition, reducing obesity, planned pregnancy, sexually transmitted infection prevention), preconception care (e.g. folate to reduce the risk of neural tube defects), early engagement with antenatal care. For increased mortality in the Maternal Care risk period, actions include providing adequate antenatal care, screening, smoking cessation programmes, risk assessment and referral, availability and appropriate use of secondary maternity care. To address excess mortality in the Newborn care period, actions may include delivery in an appropriate facility, provision of neonatal intensive care, breast feeding and SUDI prevention.

Figure 49: Perinatal Periods of Risk Map



Source: Sappenfield[5]

The first step in the PPOR analysis uses the same data as has already been presented. Terminations are excluded from the analysis as access can vary and influence rates and the indications are generally limited and known. The next step is the identification of a reference population based on the premise that if one population can experience better perinatal mortality, then other populations should be able to attain the same rates. The reference population can be internal (e.g. the CMDHB population with the lowest mortality) or external (e.g. another DHB or the national rates). For the purposes of illustration, two reference populations have been used; 1) CMDHB women of European/Other ethnicity; and 2) the national non-CMDHB population.

The construction of the PPOR mortality map is considered Phase 1 of a PPOR analysis. Phase II analyses the findings from Phase 1 and investigates the areas which are contributing most to excess deaths in more detail in order to plan prevention strategies and interventions specifically tailored for the population. Community engagement is an important part of the PPOR process, but not undertaken in this project due to time constraints.

4.2.4.1 Perinatal Mortality by Period of Risk

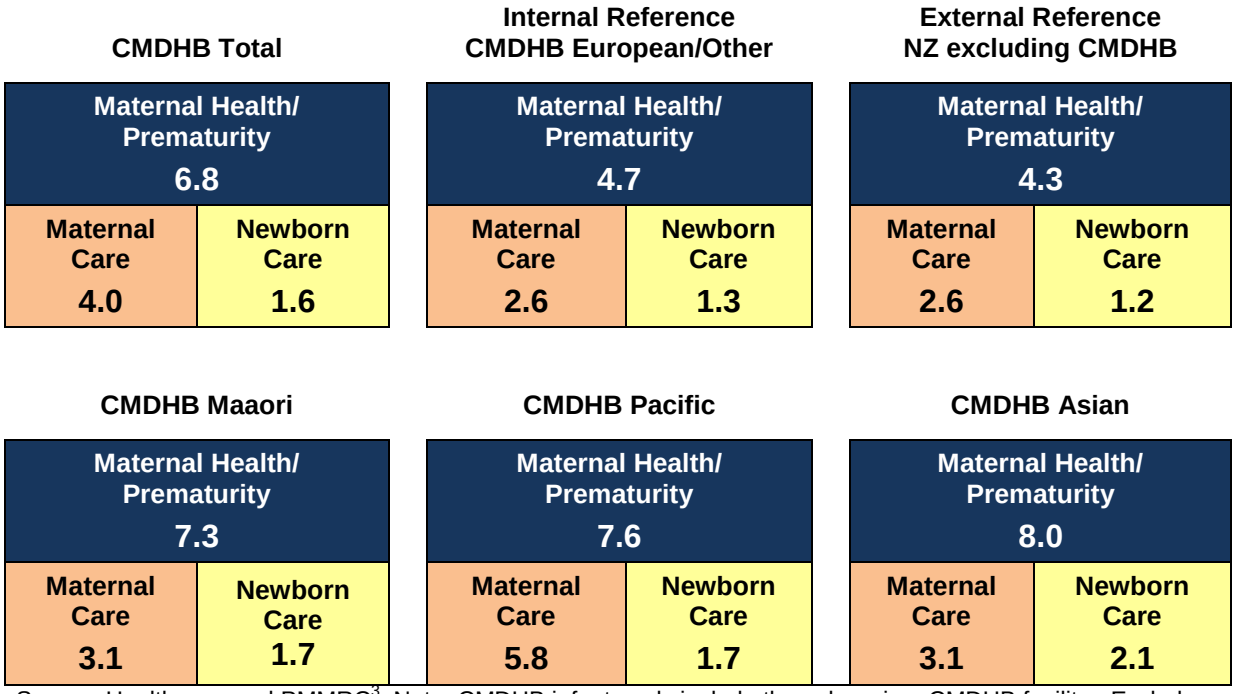
During 2007-09, the perinatal mortality rate for CMDHB infants born in CMDHB (12.3 per 1,000) was higher than the rate for NZ infants from the other 20 DHBs (8.6 per 1,000) excluding late terminations (Table 32). CMDHB had higher rates across all three perinatal risk periods. Within CMDHB during this time rates in infants born to European/Other women were lower in all three perinatal risk periods than that seen for infants born to Maaori, Pacific, or Asian women. Perinatal mortality rates for infants of European/Other women living in CMDHB were higher than rates for European/Other living elsewhere in New Zealand in the Maternal Health / Prematurity and Newborn Care risk periods. Rates in the two potential reference groups are shown in Table 32 and Figure 50.

Table 32: Perinatal Mortality by Perinatal Periods of Risk, CMDHB 2007-09

	Perinatal Mortality per 1,000				Numbers	
	Maternal Health /Prematurity	Maternal Care	Newborn Care	Total	Perinatal Deaths	Total Births
CMDHB						
Total	*6.8*	*4.0*	*1.6*	*12.4*	*279*	*22,501*
Maaori	7.3	3.1	1.7	12.1	63	5,207
Pacific	7.6	5.8	1.7	15.0	125	8,312
Asian	8.0	3.1	2.1	13.3	38	2,858
European/Other	4.7	2.6	1.3	8.7	53	6,124
Reference Groups						
CM Euro/Other	4.7	2.6	1.3	8.7	53	6,124
NZ excl CMDHB	4.3	2.6	1.2	8.1	1,394	172,370

Source: Healthware and PMMRC[3]. Note: CMDHB infants only include those born in a CMDHB facility. Excludes late terminations and infants with unknown ethnicity. CMDHB ethnicity is preferred; NZ ethnicity is prioritised.

Figure 50: Perinatal Periods of Risk Mortality Maps, 2007-09



Source: Healthware and PMMRC[3]. Note: CMDHB infants only include those born in a CMDHB facility. Excludes late terminations and infants with unknown ethnicity. CMDHB ethnicity is preferred; NZ ethnicity is prioritised.

4.2.4.2 Excess Perinatal Deaths by Period of Risk

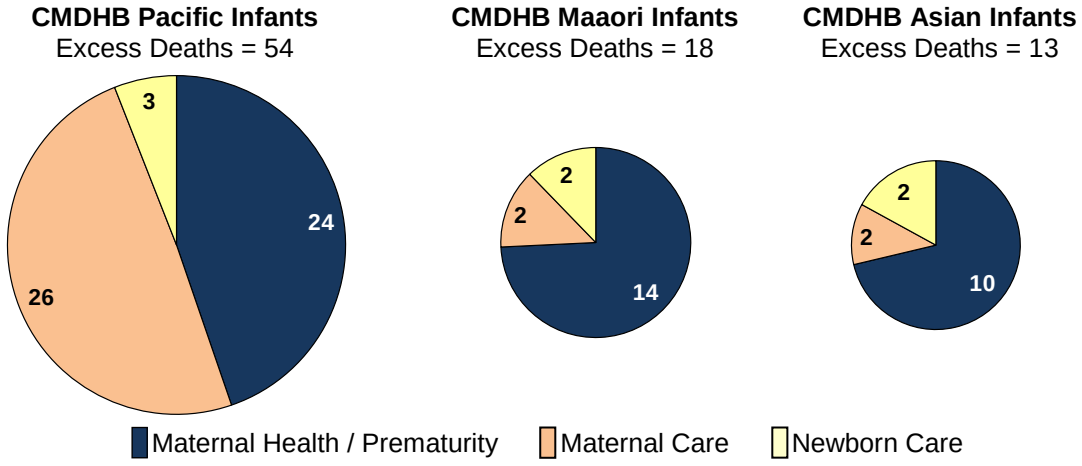
Perinatal mortality rates in the two reference groups can be used to calculate the excess number of perinatal deaths in CMDHB. This is done by applying the perinatal mortality rates of the reference group(s) to the CMDHB population to calculate the number of deaths you would expect and subtracting this from the number of deaths actually seen.

Excess Perinatal Deaths in CMDHB Maaori, Pacific, and Asian Infants vs. CMDHB European/Other Infants (Internal Reference Group)

If CMDHB Maaori, Pacific, and Asian infants had the same perinatal mortality rates as CMDHB European/Other (during 2007-09) there would have been 85 fewer perinatal deaths (28 per year) (Figure 51). CMDHB Pacific women experienced the greatest number of excess deaths during the three years examined (n=54) followed by Maaori (n=18) and Asian (n=13).

Notably, the distribution of excess deaths by perinatal period of risk differed significantly for Pacific women compared to Maaori and Asian women suggesting that different strategies for reducing perinatal mortality will be required. More than half of the excess deaths for CMDHB Pacific women occurred in the Maternal Care period which includes stillbirths in infants weighing 1,500g or more at birth. In contrast, the predominant period of risk for Maaori and Asian women was the Maternal Health / Prematurity period that includes stillbirths and neonatal deaths in infants weighing <1,500g at birth.

Figure 51 Excess Perinatal Deaths in CMDHB Maaori, Pacific, and Asian Infants Compared to CMDHB European/Other Infants by Period of Risk, 2007-09

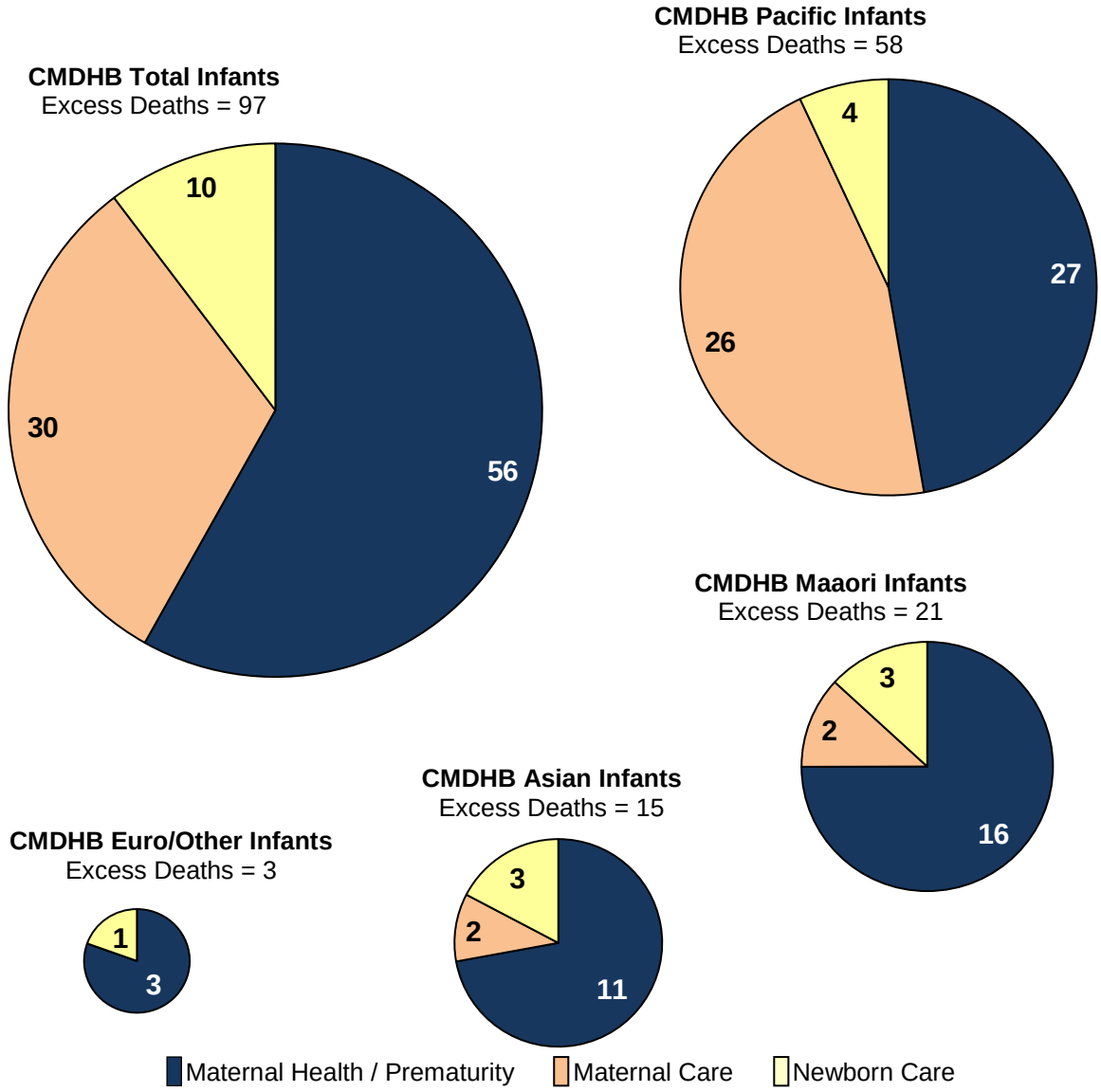


Source: Healthware. Note: CMDHB infants only include those born in a CMDHB facility. Excludes late terminations and infants with unknown ethnicity. Ethnicity is preferred. Numbers sum to more than the total in some cases due to rounding.

Excess Perinatal Deaths in CMDHB Infants vs. NZ Infants Outside CMDHB (External Reference Group)

If CMDHB women had the same perinatal mortality rates as New Zealand women living outside of CMDHB (during 2007-09) there would have been 97 fewer perinatal deaths (32 per year) excluding late terminations (Figure 51). Over half (58%) of the excess perinatal deaths occurred during the Maternal Health / Prematurity period, 31% during the Maternal Care period, and 10% during the Newborn Care period. However, there were marked differences in the distribution of perinatal deaths by risk period between different ethnic groups. Therefore, if new strategies for preventing perinatal deaths focussed solely on the Maternal Health / Prematurity period then large disparities would remain for CMDHB Pacific women, for whom almost half of the excess perinatal deaths occurred in the Maternal Care period.

Figure 52 Excess Perinatal Deaths in CMDHB Infants Compared to NZ Infants from Outside CMDHB, Total and by Ethnicity, 2007-09



Source: Healthware and PMMRC[3]. CMDHB infants only include those born in a CMDHB facility. Excludes late terminations and infants with unknown ethnicity. CMDHB ethnicity is preferred. Excess deaths are over the three year period. Numbers sum to more than the total in some cases due to rounding.

This analysis suggests that a total population focus on perinatal deaths in the Maternal Health / Prematurity category is appropriate and would address more than half (58%) of the excess perinatal mortality in CMDHB. In addition, a focus on the Maternal Care period of risk for Pacific women could address approximately half of the excess mortality in this group, and 27% of the total excess perinatal mortality in CMDHB. At this time, a focus on neonatal mortality in infants weighing 1,500g or more at birth (Newborn Care period) would not be considered a priority on the basis of this analysis. However, actions to reduce perinatal mortality in the Maternal Health / Prematurity category would also contribute to reduced mortality in the Newborn Care period (e.g. prenatal folate, reducing smoking in pregnancy).

4.2.4.3 Phase II Analyses for Maternal Health / Prematurity

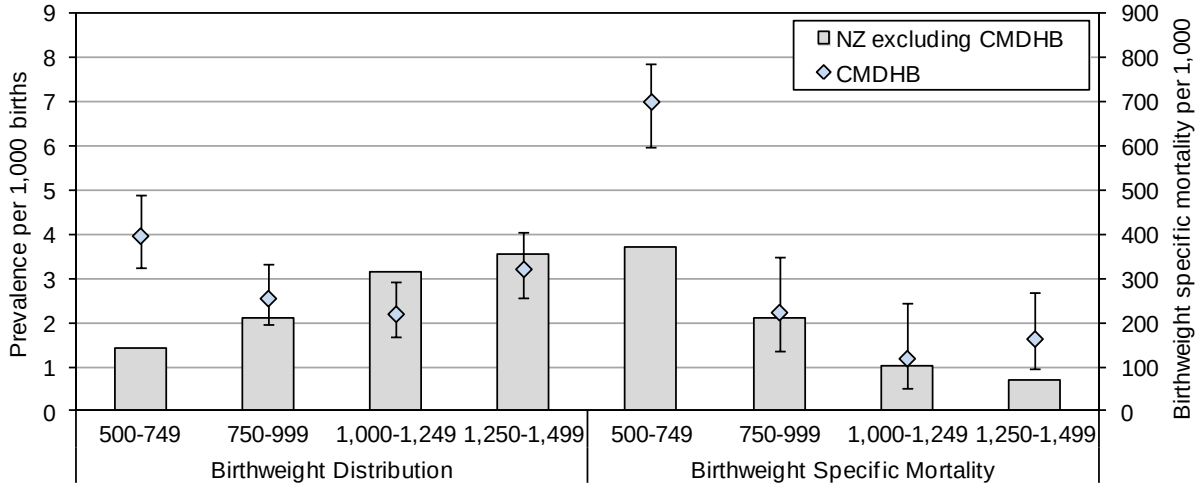
Phase II analyses use the results of Phase I to inform and prioritise the investigation of causes and risk factors in more detail with the aim of determining appropriate preventive strategies. The number of perinatal deaths required to identify important differences in risk depends on the prevalence of the risk factor in the study population, however a minimum of 90 is suggested for risk factors with a prevalence of 20% and 140 for risk factors with a prevalence of 10%.[6]

During 2007-09, there were 153 deaths in the Maternal Health / Prematurity period, with an excess of 56 above that which would be expected using non-CMDHB reference group rates. It should be noted that 62% of the deaths during this period occurred in-utero or during labour resulting in a stillbirth. For Maaori, European/Other, and Asian women, 72%-80% of the excess perinatal deaths experienced by these ethnic groups occurred during this period. In contrast, this risk period accounted for 47% of excess deaths in babies born to Pacific women.

In this risk period, prematurity is the predominant underlying cause of death; however this knowledge is not sufficient for planning preventive measures because different mechanism can be at play. For example, one population might have excess deaths because VLBW infants do not have access to appropriate care, and another may have excess deaths due to a higher prevalence of VLBW births. Kitagawa has developed a methodology for determining the relative contribution of birthweight-specific mortality rates and birthweight distribution.[6] During 2007-09, CMDHB women who delivered in a CMDHB facility had a higher prevalence of infants born weighing <1,000g, and a higher birthweight specific mortality for infants born weighing 500-750g and 1,250-1499g compared to infants born to NZ mothers that lived outside CMDHB (Figure 53).

Using the Kitagawa methodology[6], higher birthweight-specific mortality contributed to 59% to the excess Maternal Health / Prematurity deaths and while the birthweight distribution accounted for the remaining 41% of excess deaths. This ratio was reversed for the excess Maternal Health / Prematurity deaths in infants born to Pacific women.

Figure 53: Maternal Health / Prematurity Period Birthweight Distribution and Birthweight-Specific Mortality in CMDHB and the rest of NZ, 2007-09



Source: Healthware and PMMRC[3]. Includes CMDHB infants born in a CMDHB facility only. Deaths include stillbirths and neonatal deaths. Late terminations are excluded. Error bars indicate 95% confidence intervals.

A primary antecedent obstetric cause of death was assigned to all 153 of the deaths that occurred during this period. The most frequent primary cause was spontaneous preterm labour (38%) followed by antepartum haemorrhage (13.7%), and fetal growth restriction

(12.4%). Diabetes was not a strong feature of deaths that occurred during this risk period, and was not identified as a primary cause of death, although the mothers of 4 infants were noted to have diabetes. In addition to those infants for whom the primary obstetric cause was hypertension; an additional 4 mothers of infants that died during this time were noted to have hypertension, 2 whom the primary cause of death was an antepartum haemorrhage, 1 for whom the primary cause was fetal growth restriction, and 1 was spontaneous preterm labour.

Table 33: Primary Obstetric Antecedent Causes of Death in the Maternal Health / Prematurity Period, CMDHB 2007-09

Perinatal Death Classification	Number	Percent	Description
Congenital Abnormality	14	9.2	8 were chromosomal (Trisomy 13, 18, 21, Turners, translocation) 3 declined termination
Perinatal Infection	13	8.5	5 E coli; 2 group B strep; 2 CMV
Hypertension	10	6.5	
Antepartum Haemorrhage	21	13.7	12 were placental abruption
Maternal Conditions	2	1.3	Both were renal conditions
Specific Perinatal Conditions	7	4.6	4 cervical incompetence, 2 cord complications
Hypoxic Peripartum	0	0.0	
Fetal Growth Restriction	19	12.4	
Spontaneous Preterm	58	37.9	4 had APH, 3 had a past history of PTL, 2 had diabetes
Unexplained	9	5.9	
Total	153	100.0	

Source: Healthware. Note: Only includes Pacific CMDHB infants delivered in a CMDHB facility and who weighed 1,500g or more at birth.

Of the 153 deaths during the Maternal Health / Prematurity in 2007-09, nearly half occurred in women in their first pregnancy, 32% were experienced by women who smoked during pregnancy, and 11% were in women with no antenatal care (Unbooked) (Table 34). Of the infants weighing <1,500g that died in-utero or in the neonatal period, 82% were born before 28 weeks gestation, 67% were small for gestational age (customised centiles), and 13% were one of a multiple birth.

A univariate analysis found no statistically significant differences in the mortality rate during this period by age or body size (Table 34, Figure 54). The crude odds of a perinatal death in this period of risk were highest for extremely preterm infants, infants of women with no antenatal care (Unbooked), SGA infants, multiple births, infants of mothers under Secondary Care, infants of mothers that smoked during pregnancy, and infants of mothers that lived in the most socio-economically deprived areas. Infants born to Indian mothers had higher crude odds of a death in this risk period than infants of European/Other women.

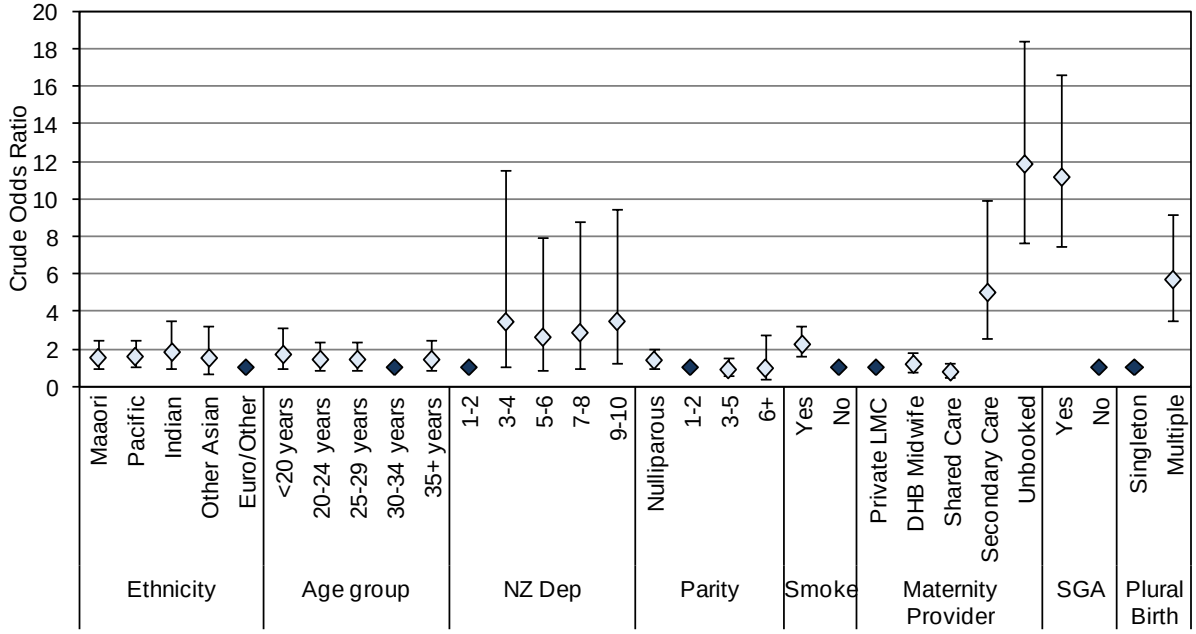
A multivariate analysis was performed to determine if death during this period was independently associated with ethnicity, socio-economic deprivation, parity, smoking, maternity provider, SGA, gestation, or multiple birth. Following this analysis, only SGA ($p<0.0001$), gestation ($p<0.0001$) and smoking during pregnancy ($p=0.0072$) were identified as independently associated with an increased odds of mortality during this period. Being SGA increased the adjusted odds of a death during the Maternal Health / Prematurity period of risk by 58.0 times (95% CI: 21.6-155.8), the adjusted odds of a death decreased by 52% for every increase in gestation after 20 weeks, while smoking during pregnancy increased the adjusted odds by 2.9 (95% CI: 1.2-6.9).

Table 34: Number, Crude Rate and Crude Odds of Maternal Health / Prematurity Period Mortality in CMDHB Infants, 2007-09

	Num	Percent	Crude Rate (95% CI)	Crude OR (95% CI)	p
Ethnicity					
Maaori	38	24.8	7.3 (5.3-10.0)	1.5 (1.0-2.5)	ns
Pacific	63	41.2	7.6 (5.9-9.7)	1.6 (1.0-2.5)	ns
Indian	14	9.2	8.7 (5.1-14.7)	1.8 (1.0-3.5)	0.0355
Other Asian	9	5.9	7.2 (3.6-14.0)	1.5 (0.7-3.2)	ns
Euro/Other	29	19.0	4.7 (3.3-6.8)	ref	ref
Age Group					
<20 years	20	13.1	8.4 (5.4-13.1)	1.7 (1.0-3.1)	ns
20-24 years	38	24.8	7.1 (5.1-9.8)	1.4 (0.9-2.4)	ns
25-29 years	43	28.1	7.1 (5.3-9.6)	1.4 (0.9-2.4)	ns
30-34 years	25	16.3	4.9 (3.3-7.3)	ref	ref
35+ years	27	17.6	7.1 (4.8-10.3)	1.4 (0.8-2.5)	ns
NZ Deprivation Index 2006 (CAU)					
Decile 1-2	4	2.6	2.2 (0.7-5.8)	ref	ref
Decile 3-4	8	5.2	7.4 (3.6-15.0)	3.5 (1.0-11.5)	ns
Decile 5-6	15	9.8	5.7 (3.4-9.5)	2.6 (0.9-8.0)	ns
Decile 7-8	13	8.5	6.2 (3.5-10.7)	2.9 (0.9-8.8)	ns
Decile 9-10	113	73.9	7.5 (6.2-9.0)	3.5 (1.3-9.5)	0.0143
Parity					
Nulliparous	72	47.1	8.3 (6.6-10.5)	1.4 (1.0-2.0)	0.0539
1-2	57	37.3	5.9 (4.6-7.7)	ref	ref
3-5	20	13.1	5.4 (3.4-8.4)	0.9 (0.5-1.5)	ns
6+	4	2.6	5.8 (1.8-15.6)	1.0 (0.4-2.7)	ns
Smoking Status					
Yes	47	32.2	13.4 (10.1-17.8)	2.3 (1.6-3.2)	<0.0001
No	99	67.8	6.0 (4.9-7.3)	ref	ref
Body Size					
Normal	42	36.2	6.5 (4.8-8.8)	ref	ref
Overweight	24	20.7	4.8 (3.2-7.2)	0.7 (0.4-1.2)	ns
Obese	50	43.1	7.0 (5.3-9.3)	1.1 (0.7-1.6)	ns
Maternity Provider					
Private LMC	36	23.5	5.1 (3.9-6.6)	ref	ref
DHB Midwife	17	11.1	6.1 (4.3-8.7)	1.2 (0.8-1.9)	ns
Shared Care	16	10.5	4.0 (2.6-6.1)	0.8 (0.5-1.3)	ns
Secondary	9	5.9	25.1 (13.2-46.4)	5.0 (2.5-9.9)	<0.0001
Unbooked	17	11.1	57.3 (41.0-79.7)	11.9 (7.7-18.4)	<0.0001
Gestation					
<28 weeks	125	81.7	512.3 (449.9-574.3)	204.4 (97.7-427.9)	<0.0001
28-31 weeks	19	12.4	90.5 (58.3-138.0)	19.4 (8.4-44.8)	<0.0001
32-36 weeks	8	5.2	5.1 (2.4-10.3)	ref	ref
37-41 weeks	1	0.7	0.1 (0.0-0.3)	0.01 (0.00-0.08)	<0.0001
42+ weeks	0	0.0	0.0 (0.0-3.8)	n/a	n/a
Small for Gestational Age (customised birthweight centiles)					
Yes	74	67.3	25.5 (20.4-32.0)	11.2 (7.5-16.7)	<0.0001
No	36	32.7	2.3 (1.7-3.2)	ref	ref
Multiple					
No	133	86.9	6.0 (5.1-7.1)	ref	ref
Yes	20	13.1	33.4 (21.5-51.4)	5.7 (3.5-9.2)	<0.0001

Source: Healthware. Note: Only includes CMDHB infants delivered in a CMDHB facility. Rates are per 1,000 live births. Ethnicity is preferred. OR: odds ratio; n/a: not applicable; ns: not significant; ref: reference group.

Figure 54: Crude Odds Ratios for Perinatal Mortality in CMDHB Infants During the Maternal Health / Prematurity Period, 2007-09



Source: Healthware. Note: Only includes CMDHB infants delivered in a CMDHB facility. Reference groups shown by dark diamonds. Ethnicity is preferred. SGA: Small for gestation age using customised birthweight centiles[42]. Error bars indicate 95% confidence intervals.

Impact of Smoking in Pregnancy

Smoking during pregnancy was found to be a driver of mortality during the Maternal Health / Prematurity risk period in CMDHB infants (infants born weighing <1,500g), with an adjusted odds ratio of 2.9 (95% CI: 1.2-6.9) when compared to the odds of a death in women that did not smoke. Smoking during pregnancy is associated with a number of adverse pregnancy outcomes in addition to stillbirth and neonatal death including miscarriage, placental abruption, intrauterine growth restriction, premature delivery, and stillbirth.[51] Around 1,100 women in CMDHB smoked during pregnancy each year during 2007-2009.

Given the odds of a perinatal death in this risk period associated with smoking, and the prevalence of smoking during pregnancy, the population attributable risk of a death in this risk period 18% in this CMDHB population. That is, if no CMDHB women smoked during pregnancy, the mortality rate in the Maternal Health / Prematurity risk period could be expected to decrease by 18%. Maaori women that delivered in a CMDHB facility during 2007-09 had a much higher prevalence of smoking during pregnancy (43%) than seen for the total population (17.5%). The population attributable risk of smoking to deaths in this risk period for Maaori women is consequently much higher at 29%. That is, if no CMDHB Maaori women smoked during pregnancy, the perinatal mortality rate in the Maternal Health / Prematurity risk period could be expected to decrease by 29% in infants born to these women.

Gains are likely to be achieved in other risk periods from a focus on smoking during pregnancy, particularly for Maaori women living in CMDHB. Smoking in pregnancy was also associated with increased odds of a stillbirth in infants weighing 1,500g or more at birth (see 4.2.2.3) and increased odds of any neonatal death (see 4.2.3). The population attributable risk of smoking with respect to all perinatal deaths during 2007-09 was 21.1% for all CMDHB infants and 67% for CMDHB infants born to Maaori mothers (excluding late terminations).

4.2.4.4 Phase II Analyses for Maternal Care for Infants born to Pacific Women

The Maternal Care period includes stillbirths in infants weighing 1,500g or more. Deaths during this period accounted for 31% of all excess perinatal deaths in CMDHB and 56% of excess deaths in infants born to Pacific mothers when compared to a non-CMDHB reference group. Stillbirths in infants weighing 1,500g or more were examined in more detail in section 4.2.2.3 for the population of CMDHB infants born to CMDHB resident mothers. The PPOR Phase I analysis suggests that a focus on deaths in the Maternal Care period for Pacific women is appropriate; therefore these deaths are examined in more detail here.

During 2007-09, there were 48 deaths during this risk period in infants born in a CMDHB facility to a Pacific mother who lived within the DHB. The primary obstetric antecedent cause of death was recorded for 46 of these infants (Table 35). The most frequent cause reported was unexplained (30%) followed by maternal conditions (17% all diabetes), fetal growth restriction (17%), and perinatal infection (11%). Several infants had more than one associated obstetric antecedent cause.

Because of the relatively small number of deaths in this analysis, caution should be taken with interpreting the results presented. In addition, important influences of stillbirth in this cohort may not be detected as confidence will be wide. Of the 48 stillbirths that occurred in infants weighing 1,500g or more born to Pacific women, all occurred after 28 weeks gestation, 35% were to women aged 35 years and older, 92% to women living in the most socio-economically deprived areas (decile 8-10), 96% to women who were overweight or obese, 21% to a women with a parity of 6 or more, and 21% to women who smoked (Table 36).

Table 35: Primary Obstetric Antecedent Causes of Death in the Maternal Care Period, Infants born to Pacific Mothers, CMDHB 2007-09

Perinatal Death Classification	Number	Percent	Description
Congenital Abnormality	2	4.3	Chromosomal (1 declined TOP)
Perinatal Infection	5	10.9	1 group B strep, 1 corynebacterium proteus, 1 viral, 1 unspecified
Hypertension	0	0.0	
Antepartum Haemorrhage	4	8.7	All placental abruption (1 had eclampsia, 1 had hypertension and diabetes)
Maternal Conditions	8	17.4	All diabetes or gestational diabetes (1 had a lethal congenital abnormality and declined TOP)
Specific Perinatal Conditions	2	4.3	1 feto-maternal haemorrhage, 1 antenatal cord complication (true knot)
Hypoxic Peripartum	2	4.3	1 cord prolapsed, 1 unspecified
Fetal Growth Restriction	8	17.4	1 had diabetes, 1 had placental abruption
Spontaneous Preterm	1	2.2	Assoc with group B strep
Unexplained	14	30.4	
Total	46	100.0	

Source: Healthware. Note: Only includes Pacific CMDHB infants delivered in a CMDHB facility and who weighed 1,500g or more at birth.

The crude odds of a stillbirth during the Maternal Care period was highest for Pacific women aged 35 years and older, women with a parity of 6 or more, women under Secondary Care and women that had no antenatal care (Unbooked), infants born at 28-31 weeks gestation, and infants that were small for gestational age as measured using customised centiles. As discussed previously, higher rates are expected in women under Secondary Care as they are high risk. No differences in the crude odds were observed by socio-economic deprivation in these women.

Although crude rates were 1.7 times higher in women that smoked in pregnancy compared to those who didn't, this finding did not reach statistical significance. In addition, the crude odds of a stillbirth in this period were increased by 3.2-3.6 times in Pacific women who were overweight or obese compared to those in a normal weight range, however this finding also did not reach statistical significance. These are not surprising findings as the number of deaths is relatively small, the numbers of Pacific women who smoke and who are of normal weight are also relatively small, resulting in wide confidence intervals for both the reference groups and the groups of interest.

Table 36: Number, Crude Rate and Crude Odds of Maternal Care Period Mortality in CMDHB Infants born to Pacific Mothers, 2007-09

	Num	Percent	Crude Rate (95% CI)	Crude OR (95% CI)	p
Age Group					
<20 years	1	2.1	1.2 (0.0-7.8)	0.3 (0.0-2.4)	ns
20-24 years	10	20.8	4.5 (2.4-8.5)	1.1 (0.4-2.9)	ns
25-29 years	13	27.1	5.9 (3.3-10.1)	ref	ref
30-34 years	7	14.6	4.1 (1.8-8.6)	1.4 (0.6-3.6)	ns
35+ years	17	35.4	12.5 (7.7-20.1)	3.1 (1.3-7.5)	0.0124
NZ Deprivation Index 2006 (CAU)					
Decile 1-7	4	8.3	6.8 (2.1-18.1)	ref	ref
Decile 8-10	44	91.7	5.7 (4.2-7.7)	0.8 (0.3-2.3)	ns
Parity					
Nulliparous	14	29.2	5.0 (2.9-8.5)	1.3 (0.6-2.9)	ns
1-2	12	25.0	3.8 (2.1-6.7)	ref	ref
3-5	12	25.0	6.1 (3.4-10.8)	1.6 (0.7-3.6)	ns
6+	10	20.8	26.3 (13.8-48.7)	7.1 (3.1-16.6)	<0.0001
Smoking Status					
Yes	10	20.8	10.1 (5.3-18.8)	1.7 (0.9-3.4)	ns
No	38	79.2	5.9 (4.3-8.1)	ref	ref
Body Size					
Normal	2	4.5	2.0 (0.1-8.1)	ref	ref
Overweight	11	25.0	6.4 (3.5-11.7)	3.2 (0.7-14.3)	ns
Obese	31	70.5	7.3 (5.1-10.4)	3.6 (0.9-15.0)	ns
Maternity Provider					
Private LMC	13	27.1	4.3 (2.4-7.4)	ref	ref
DHB Midwife	11	22.9	6.2 (3.4-11.3)	1.5 (0.7-3.3)	ns
Shared Care	13	27.1	4.2 (2.4-7.3)	1.0 (0.5-2.1)	ns
Secondary	4	8.3	22.1 (6.9-58.0)	5.3 (1.7-16.3)	0.004
Unbooked	7	14.6	27.0 (12.2-56.2)	6.5 (2.6-16.4)	<0.0001
Gestation					
<28 weeks	0	0.0	0.0 (0.0-45.6)	-	-
28-31 weeks	5	10.4	62.5 (24.2-142.4)	3.0 (1.0-8.7)	0.0454
32-36 weeks	12	25.0	21.9 (12.2-38.4)	ref	ref
37-41 weeks	30	62.5	4.3 (3.0-6.1)	0.2 (0.1-0.4)	<0.0001
42+ weeks	1	2.1	1.8 (0.0-11.6)	0.1 (0.0-0.6)	0.0165
Small for Gestational Age (customised birthweight centiles)					
Yes	16	37.2	12.7 (7.7-20.8)	2.7 (1.4-5.0)	0.0019
No	27	62.8	4.8 (3.3-7.0)	ref	ref

Source: CMDHB. Note: Only includes CMDHB infants delivered in a CMDHB facility to a Pacific mother. Rates are per 1,000 live births. Ethnicity is preferred. OR: odds ratio; n/a: not applicable; ns: not significant; ref: reference group.

A multivariate analysis was performed to determine if death during this period was independently associated with age group, parity, smoking, maternity provider, SGA,

gestation, or body size in infants born to Pacific women. The results of this analysis should be interpreted with caution as the numbers of deaths were small. Following this analysis, only SGA (p=0.0087), gestation (p=0.0017) and parity (p=0.007) were identified as being associated with an increased odds of mortality independent of the other factors during this risk period. Being SGA increased the adjusted odds of a death during the Maternal Care period of risk by 2.4 times (95% CI: 1.2-4.6), the adjusted odds of a death decreased by 10% for every increase in gestation after 20 weeks, while a parity of 6 or more increased the adjusted odds by 4.8 times (95% CI: 1.7-13.1) in infants born to Pacific Women.

Impact of Overweight and Obesity

Overweight and obesity in pregnancy have been associated with increased odds of urinary tract infection, pre-eclampsia, gestational diabetes, preterm and post-term birth, induction of labour, caesarean section, and macrosomia in addition to increased odds of stillbirth, neonatal and maternal death.[44-48] Flenady recently identified pre-pregnancy overweight and obesity as the top ranking modifiable risk factor for stillbirth in five high income countries including Australia, the UK, USA, Canada, and the Netherlands.[33] Obesity during pregnancy in CMDHB is most prevalent in Pacific women at 61% during 2007-09, whilst 25% were overweight.

Given the odds of a perinatal death in this risk period associated with being overweight or obese, and the prevalence of overweight and obesity during pregnancy in Pacific women, the population attributable risk of a death in this risk period was 68% in this CMDHB population during 2007-09. That is, if all Pacific women in CMDHB were in the normal weight range, the mortality rate in the Maternal Care risk period could be expected to decrease by 68% for infants born to Pacific women. In contrast, for all CMDHB women the population attributable risk of overweight and obesity for a death in this risk period was 37%.

Because overweight and obesity have the greatest influence on perinatal mortality late in pregnancy[72], a focus on this issue will have a smaller effect on the total perinatal mortality rate. Excluding late termination, if all CMDHB women were in the normal weight range during pregnancy the total perinatal mortality rate could be expected to decrease by 12%, whilst in infants born to Pacific women a 26% decrease in total perinatal mortality could be expected.

4.2.5 Role of Antenatal Care

A recent meta-analysis of stillbirths in high-income countries estimated that if all women accessed antenatal care, this would have a very small effect on the stillbirth rate because the population attributable risk of no antenatal care is low (<1%).[33] This was determined based on a adjusted odds of a stillbirth of 3.3 in women who had no antenatal care, compared to those with care, and a prevalence no antenatal care of 0.3%. The prevalence of no antenatal care was considerably higher in the CMDHB population examined (2.6%), therefore the population attributable risk would be expected to be higher.

CMDHB women with no antenatal care had the highest crude rates of stillbirth, irrespective of birthweight, and neonatal death. After controlling for those factors found in univariate analyses to influence mortality rates, having no antenatal care was not independently associated with an increased odds of stillbirth in infants weighing 1,500g or more, or of neonatal death. This finding suggests that infants born to women who have had no antenatal care are at increased risk of stillbirth (once ≥1,500g) or neonatal death because they were born to women with a higher prevalence of other risk factors rather than because these women had no antenatal care per se. This finding suggests that these women are an important group to engage with antenatal care so as to work with them to address their other risk factors.

In contrast, no antenatal care was found to be an independent risk factor for stillbirth in infants with a very low birth weight (VLBW <1,500g) in a multivariate analysis with an adjusted odds ratio of 5.1 (95% CI: 1.7-16.1). In VLBW infants the population attributable risk of no maternal antenatal care was 15.8%. Because having no antenatal care was only associated with an increased risk in this population independently of other risk factors, a focus on this issue will have a smaller effect on the total perinatal mortality rate. Therefore, the population attributable risk of no antenatal care for all perinatal deaths (excluding late terminations) was 5% for CMDHB women that delivered in a CMDHB facility during 2007-09.

Achieving a reduction of this magnitude in the overall perinatal mortality rate through improving engagement with antenatal care also assumes that these deaths can be prevented versus being reclassified as a death in a woman who accessed care. Of the 17 deaths that occurred in VLBW infants born to mothers with no antenatal care, 5 were intra-uterine deaths at ≤26 weeks gestation with no cause found, 4 occurred as a result of spontaneous preterm labour at 20 weeks, one had a lethal congenital abnormality, and one had an antepartum cord complication as the primary causes of death. Of the remaining 6, four had hypertension and presented with either an antepartum haemorrhage or an intrauterine death, and two presented following an antepartum haemorrhage in the absence of hypertension. The degree to which these deaths were preventable is unknown.

4.3 Chapter Summary

Two different approaches were taken to analysing CMDHB perinatal mortality. The perinatal periods of risk analysis is useful for providing a simple visual representation of the periods of risk when deaths are occurring, where the excess deaths are, and who carries the burden. This analysis can be used to guide the development of prevention strategies, and to prioritise the focus. An analysis using a more traditional framework was also presented.

Perinatal Mortality in CMDHB and New Zealand

The perinatal mortality rate in CMDHB has been higher than the national rate for many years. It is likely that most, if not all, of the difference can be accounted for by differences in maternal population demographics for CMDHB compared to the rest of New Zealand. This hypothesis should be tested by determining age, ethnicity, and deprivation standardised rates of perinatal mortality by DHB across New Zealand; a task best suited to the PMMRC who hold the most complete perinatal dataset. The high perinatal mortality rate in CMDHB remains a concern, whether or not it is driven by population demographics and warrants further consideration.

CMDHB Perinatal Mortality Data

Perinatal mortality rates in CMDHB women who live within CMDHB determined using local data sources did not differ significantly from those determined by the PMMRC for the entire CMDHB maternity population, either overall or by type of death. If CMDHB women (delivering in CMDHB) had the same perinatal mortality rates as New Zealand women living outside of CMDHB there would have been 95 fewer stillbirths and neonatal deaths (32 per year) during 2007-09. This suggests that the perinatal mortality rate in CMDHB is modifiable.

The late termination rate in CMDHB has been consistently lower than that seen nationally. Almost all late terminations were for lethal congenital abnormalities. While the decision to have a termination of pregnancy is one of personal choice, and may be influenced by cultural and religious beliefs, interventions for preventing congenital abnormalities should be considered (e.g. preconception folate, good glucose control at the time of conception). This

is particularly relevant as congenital abnormalities were also responsible for a significant proportion of stillbirths and neonatal deaths.

Healthware is a good source of maternity data for CMDHB; however the data collected could be strengthened. The addition of inbuilt validity checks (e.g. for weight, height, dates) would reduce the amount of data processing required prior to analysis. Feedback to maternity providers regarding data completeness may increase compliance. Consideration should be given to expanding the data collection to include date of first antenatal visit, completion of screening events during pregnancy (i.e. yes, no, declined), presence of important risk factors (e.g. pre-existing hypertension, pregnancy induced hypertension, pre-existing diabetes, diabetes diagnosed in pregnancy, antepartum haemorrhage). Unbooked women should have height and weight data at the time of delivery recorded. Consideration should also be given to removing screens/data fields from Healthware that are currently not being used so that a core dataset remains with the expectation that all fields are completed.

Drivers of CMDHB Perinatal Mortality

After controlling for the effects of factors shown in univariate analyses to influence perinatal mortality (socio-economic status, gestation, SGA, smoking, obesity, multiple birth, parity, maternity provider (proxy for risk)), ethnicity and socio-economic status were not independently associated with perinatal mortality. This finding supports the hypothesis that women in these different groups have different exposures to risk factors and these different exposures result in different rates of perinatal mortality. Insufficient local data were available to examine the effects of maternal medical conditions known to influence perinatal outcomes (e.g. diabetes and hypertension). However, this analysis did identify several important risk factors that are influencing perinatal mortality in CMDHB. These include smoking during pregnancy, obesity, premature labour, and fetal growth restriction.

Smoking was independently associated with an increased adjusted odds of perinatal death in the Maternal Health / Prematurity period of risk (adjusted OR 2.9), in the Maternal Care period of risk (adjusted OR 2.0), and for all neonatal deaths (adjusted OR 2.9). Maaori women that delivered in a CMDHB facility during 2007-09 had a much higher prevalence of smoking during pregnancy (43%) than seen for the total population (18%). The population attributable risk of smoking with respect to all perinatal deaths during 2007-09 was 21% for all CMDHB infants and 67% for CMDHB infants born to Maaori mothers (excluding late terminations). That is, if no CMDHB women smoked during pregnancy, the total perinatal mortality rate (excluding late terminations) could be expected to decrease by 21% overall and by 67% in infants born to Maaori mothers.

In this analysis an association between overweight and obesity with stillbirth was only demonstrated for stillbirths in infants weighing 1,500g or more. This finding is not surprising as the odds of a stillbirth in overweight and obese women has been shown to increase dramatically after 30 weeks gestation.[72] The association demonstrated here was weak and there are several possible reasons for this; small numbers mean confidence intervals in the multivariate analysis were wide, missing BMI data were for women who were most likely to be overweight and obese and excluded these women and any deaths experienced from the analysis. When outcomes are rare, case-control studies are more appropriate. The Auckland Stillbirth Study was a case-control study of late stillbirths (after 28 weeks gestation) which demonstrated a dose response relationship between BMI and the odds of a late stillbirth.[66, 73] In Pacific women in CMDHB, the population attributable risk of being overweight or obese was 68% for stillbirths in infants weighing 1,500g or more. That is, if all Pacific women in CMDHB were in the normal weight range, the mortality rate in the Maternal Care risk period could be expected to decrease by 68% for infants born to Pacific women. In addition, a focus on this issue for Pacific women in CMDHB could be expected to reduce the total perinatal mortality rate (excluding late terminations) in infants born to Pacific women by 26% if all were able to attain a weight in the normal range prior to conception.

Gestation was independently associated with the odds of a perinatal death in all analyses, and reduced significantly with each additional week in-utero after 20 weeks gestation. Fetal growth restriction, evidenced by an infant being small for gestational age assessed using customised birthweight centiles at delivery, was strongly associated with perinatal mortality. SGA was independently associated with an increased adjusted odds of perinatal death in the Maternal Health / Prematurity period of risk (adjusted OR 58.0), in the Maternal Care period of risk (adjusted OR 2.2), and for all neonatal deaths (adjusted OR 3.2).

CMDHB Perinatal Mortality and the CMDHB Model of Care

Stillbirth and neonatal mortality did not differ significantly for women with Private LMC care, CMDHB midwife care, and Shared Care. Infants born to women under Secondary Care had higher stillbirth rates and rates of perinatal mortality in infants weighing <1.500g at birth. This finding was expected as Secondary Care provides maternity care to high risk women. Infants born to women under Secondary Care did not have a higher rate of neonatal death.

CMDHB women with no antenatal care had the highest crude rates of stillbirth, irrespective of birthweight, and neonatal death. After controlling for those factors found in univariate analyses to influence mortality rates, having no antenatal care was not independently associated with an increased odds of stillbirth in infants weighing 1,500g or more, or of neonatal death. This finding suggests that infants born to women who have had no antenatal care are at increased risk of stillbirth (once ≥1,500g) or neonatal death because they were born to women with a higher prevalence of other risk factors rather than because these women had no antenatal care per se.

In contrast, for women who had a stillborn infant that weighed <1,500g at birth, no antenatal care remained independently associated with stillbirth even after controlling for the effects of gestation and fetal growth restriction. The estimated population attributable risk of no antenatal care for all perinatal deaths (excluding late terminations) was 5% for CMDHB women that delivered in a CMDHB facility during 2007-09 via a reduction of stillbirths in the <1,500g infants. Achieving a reduction of this magnitude in the overall perinatal mortality rate through improving engagement with antenatal care assumes that these deaths can be prevented versus being reclassified as a death in a woman who accessed care. The extent to which this is possible through engagement with antenatal is unknown, however without engagement with antenatal care there is no potential for prevention.

Chapter 5. Discussion and Recommendations

This project was stimulated by a recommendation from the PMMRC that the higher rate of perinatal mortality in CMDHB be examined further. The first full report by the PMMRC on data from 2007 presented perinatal mortality rates by DHB and CMDHB was the only DHB with a rate that was statistically significantly higher than the national rate.[1] This finding was repeated for 2008 and 2009 data, and an analysis of data from all three years found one New Zealand DHB with a perinatal mortality rate higher than the national average, CMDHB, and one DHB that was lower, Canterbury DHB.[2, 3] This finding raised several issues which this project considered and which are summarised here.

5.1 Key Findings

Understanding How Perinatal Mortality is Measured Matters

In order to interpret differences in perinatal mortality rates reported by different organisations, an understanding of differences in methodology is important. The elements to consider when interpreting perinatal mortality statistics include, identifying the source of the data, the source population, and the definition of a fetal death (based on gestation and birth weight). The PMMRC provides the highest quality perinatal mortality data in New Zealand. It is the most accurate, complete (all deaths and not just in-hospital deaths), and timely (vs. Mortality Collection) data source.[1]

Perinatal Mortality in CMDHB is Higher

Crude rates of perinatal mortality are important because they describe what is happening in any given population. CMDHB really has more perinatal deaths per 1,000 births than is seen on average across New Zealand. The reason that the CMDHB rate is statistically significant is a function of the size of the maternity population. Given a few more years data it is highly likely that other smaller DHBs, whose perinatal mortality rates have also been consistently higher than the national average, will accrue enough data to show a statistically significant difference.

Population Structure is Important

It is likely that all, or most, of the variation in perinatal mortality across the DHBs in New Zealand can accounted for by differences in population structure. Crude rates are influenced by the distribution of risk factors within a population group, and differences between these groups may be caused by this different distribution. Most of the variation between DHBs is in their demographic makeup, for example CMDHB has a maternity population that is 57% Maaori and Pacific compared to Canterbury DHB whose population is 15% Maaori or Pacific. Because a greater proportion of the CMDHB population is women who carry a higher risk of perinatal mortality, its overall rate could be predicted to be higher.

What is not known is whether or not the different ethnic structure of the DHBs is enough to account for all of the variation in mortality. If it is not then other things need to be considered, for example other risk factors, access to specialist care, access to appropriate neonatal intensive care. Standardising perinatal mortality rates for CMDHB against the national population structure is important because it will tell us whether other important risk factors are likely to be at work.

While perinatal mortality rates vary between DHBs because of their population structure, this raises the very important question of why rates are higher for Maaori and Pacific. This

disparity suggests that there are modifiable factors still influencing perinatal mortality in Maaori and Pacific (and other groups with higher rates) that are amenable to change. If CMDHB women (delivering in CMDHB) had the same perinatal mortality rates as New Zealand women living outside of CMDHB there would have been 95 fewer stillbirths and neonatal deaths (31 per year) during 2007-09. What is reassuring is that perinatal mortality rates in CMDHB Maaori and Pacific were not significantly different from rates in Maaori and Pacific across New Zealand suggesting that there is nothing specific to living in CMDHB that increases perinatal mortality in these women.

Perinatal Mortality Risk Factors are Prevalent in CMDHB

Flenady and colleagues have identified the major risk factors for stillbirth in high income countries and recommended approaches for reducing stillbirths in such settings.[33, 34] The risk factors identified also make a significant contribution to neonatal deaths, the bulk of which are caused by obstetric antecedents e.g. preterm birth, antepartum haemorrhage, and perinatal infection.[3] The most important potentially modifiable risk factors identified by Flenady were overweight and obesity, advanced maternal age, smoking, pre-existing hypertension, pre-existing diabetes, and placental abruption.[33] Other important risk factors were pregnancy-induced hypertension, fetal growth restriction, socio-economic status, no antenatal care, and post-term delivery. With the exception of advanced maternal age, the prevalence of all of the other risk factors in CMDHB was similar to or higher than the prevalence nationally. In addition, the prevalence for CMDHB Maaori and Pacific were generally higher again.

Local CMDHB maternity datasets collect data on many of these risk factors and in addition to demographic data collect data on antenatal care, smoking status, height and weight allowing BMI calculation and the calculation of customised birthweight centiles. This allowed univariate and multivariate analyses to be undertaken. Some CMDHB specific data were also available from the PMMRC for 2007-08. An analysis of these data suggests that the prevalence of key risk factors are contributing to the high perinatal mortality rates observed in CMDHB. In particular the effects of smoking, obesity, premature labour, and fetal growth restriction can be seen.

Many important findings have been detailed throughout this report, and a summary of the key messages are listed here:

Key Risk Factors for Perinatal Mortality in CMDHB

- PMMRC data on the primary antecedent causes of perinatal death in CMDHB infants suggest that diabetes and hypertension during pregnancy are contributing to the increased stillbirth rate in CMDHB.
- Extreme prematurity is the leading risk factor for stillbirth and neonatal death.
- Fetal growth restriction contributes to perinatal mortality independently of smoking.
- Smoking during pregnancy contributes significantly to perinatal mortality in CMDHB independent of any other risk factors. If no CMDHB women smoked during pregnancy the total perinatal mortality rate (excluding terminations) could be expected to decrease by 21% for all infants and by 67% for infants born to Maaori women.
- Obesity in CMDHB is contributing to stillbirths in infants born weighing 1,500g or more. If all CMDHB women had a weight in the normal range at conception, the total perinatal mortality rate (excluding terminations) could be expected to decrease by 12% for all infants and by 26% for infants born to Pacific women.

- After controlling for the effects of identified risk factors, perinatal mortality did not vary by ethnicity and socio-economic status. Supporting the hypothesis that perinatal mortality rates are higher in Maaori and Pacific women and women living in the most deprived area due to higher exposure to risk factors.

- Teenage women delivering in a CMDHB facility were **not** at higher risk of stillbirth or neonatal death.

Impact of Maternity Care on Perinatal Mortality in CMDHB

- Perinatal mortality does not differ by primary maternity provider in CMDHB.

- Being under Secondary Care is independently associated with increased odds of stillbirth but not neonatal death. This finding was expected as Secondary Care provides specialist care to women with high risk pregnancies.

- Women who have no antenatal care have the highest crude perinatal mortality.

- Having no antenatal care does **not** increase the odds of having a stillborn infant weighing ≥1,500g or a neonatal death independently of other risk factors, suggesting that women with no antenatal care have greater exposure to other risk factors than women who engage with antenatal care.

- Having no antenatal care was an independent risk factor for having a stillborn infant weighing <1.500g. However, the number of stillbirths <1,500g in women that did not access antenatal care was very small (17 in three years).

- Reducing perinatal mortality via improving engagement with antenatal care assumes that these deaths can be prevented versus being reclassified as deaths in women who accessed care. However without engagement with antenatal care there is little potential for prevention.

5.2 The Limitations of The Project

Several limitations were identified in the course of this project. Most of these were related to the availability and the quality of data and have described elsewhere in this report. Detailed here are those that influence the results and interpretation of the data presented.

- *Perinatal deaths are relatively rare*: When an outcome is rare large studies are need to detect important differences. The number of perinatal deaths experienced by CMDHB women each year is relatively small because only 8,500 women have a baby each year out of a child bearing population of 120,000 women. Therefore, several years of data are required in order for a useful analysis to be done. Even with three years of data, numbers are small and therefore relationships may not have been demonstrated even when they really exist. The addition of further years of data will increase the capacity to identify important relationships. This issue also has important implications for the capacity to detect change if new approaches or interventions are implemented.

- *Important risk factors have no data:* Local data does not adequately capture high risk maternal conditions (e.g. diabetes, hypertension, antepartum haemorrhage) and past obstetric history which are important perinatal mortality risk factors. This limited the capacity to investigate the influence and prevalence of important risk factors, and to control for the influence of these known risk factors in analyses.

- *Results are not generalisable:* Local data for CMDHB women and infants who delivered in a facility outside of CMDHB were excluded allowing the identification of a defined denominator population for whom the same data variables were collected. However, this population differs significantly from the population of CMDHB women who deliver outside of CMDHB and so results are unlikely to be *generalisable* to these women. It is unknown how well these results can be generalised to other women who deliver in CMDHB but do not reside there.

- *Missing data*: The data required for calculating BMI and smoking data were the most incomplete in this analysis and were 81.4% and 88.2% complete respectively. The most likely impact of this missing data would be an underestimate of the impact of BMI and smoking on perinatal mortality because the demographic characteristics of women with missing data suggests they are at higher risk of a perinatal death. For example, the neonatal mortality rate in infants with sufficient maternal data to determine their customised birthweight centile was 4.0 per 1,000 compared with 5.2 per 1,000 in infants without sufficient data to determine their customised birthweight centile.

In summary, locally collected CMDHB data allows a more detailed analysis of perinatal mortality, and while this analysis may miss identifying some important associations, any associations found are likely to be conservative estimates of effect.

5.3 Recommendations

The Perinatal Periods of Risk analysis suggests that a total population focus on deaths in the Maternal Health / Prematurity risk period is appropriate and would address more than half (58%) of the excess perinatal mortality in CMDHB. In addition, a focus on the Maternal Care period of risk for Pacific women could address approximately half of the excess mortality in this group, and 27% of the total excess perinatal mortality in CMDHB. A focus on neonatal mortality in infants weighing ≥1,500g (Newborn Care risk period) could be considered a lower priority on the basis of this analysis, as the number of excess deaths in this risk period was lower. In addition, actions focussing on the other two risk periods are likely to contribute to reduced mortality in the Newborn Care risk period also (e.g. reducing smoking in pregnancy).

This project and the companion antenatal care project have identified several areas that should be explored with a view to making population wide changes that will positively influence perinatal mortality in CMDHB. These echo the recommendations made by Flenady and colleagues in a recent publication and are summarised here.[34]

Improvement of the general health of women before, during, and after pregnancy

Preconception Care: Flenady and colleagues recommend culturally appropriate preconception care for all women of child bearing age to ensure adequate folic acid intake, optimum weight and diet, cessation of smoking, education about the harms of alcohol, and risk reduction for women with substance use.[34] Growing Up in New Zealand recently reported that 40% of pregnancies are unplanned, with the prevalence increasing with decreasing education.[8] This suggests that a programme designed to offer a pre-pregnancy counselling and assessment service may not target women at high risk of a poor pregnancy outcome. A population level approach delivered to all women of child bearing age would be more appropriate in CMDHB. This approach is supported by the work of Moos and colleagues who recommend that an assessment of a woman's reproductive risks be integrated into her routine care, irrespective of her pregnancy intentions.[74] This recommendation is based on a review of the literature which concludes that such an approach is likely to decrease the chances of women experiencing unintended pregnancies,

and increase the odds of women entering pregnancy with higher levels of preconception wellness, thereby increasing the odds of a healthy pregnancy and infant.[74, 75]

Planning Parenthood: Preconception health interventions should include a focus on planning parenthood. A US study demonstrated that the receipt of preconception health promotion interventions that included an assessment of reproductive plans in low-income women attending family planning clinics reduced the proportion of subsequent pregnancies that were unplanned in the intervention compared to the control group.[75] The strongest barrier to initiating and engaging with antenatal care is having an unwanted or unplanned pregnancy.[76-80] If unwanted/unplanned pregnancies were prevented this would lessen the exposure of infants to risk factors that increase the odds of a poor outcome. Of interest were the findings of a US study that reported that nearly half of all unintended pregnancies occurred in a month in which contraception was used.[81]

Barriers to accessing effective contraception and planning pregnancy in CMDHB are appropriate areas for research, particularly in Maaori and Pacific women as these groups have the highest prevalence of having inadequate antenatal care.[4] A review of programmes within the DHB aimed at reducing unwanted pregnancy through the provision of appropriate reproductive advice and contraception would be timely. The free provision of longer-term or permanent contraception options for CMDHB women (e.g. mirena, tubal ligation, vasectomy) is recommended. Improving access to more effective contraception options may help with the spacing of children and reduce the number of high parity women, and may help reduce the pressures on family resources, particularly for young mothers, during the first few years of their infant's lives. These issues should be explored with communities within CMDHB.

A recent New Zealand study of contraceptive use post first-trimester termination of pregnancy demonstrated that women who had an intrauterine contraceptive device (IUD) placed prior to leaving the clinic were 70% less likely to return for a repeat termination over the 3 year follow-up period than women who left with a contraceptive pill prescription.[82] Implementation of a routine discussion of IUDs has increased the uptake from 25% pre-study to 49%, and in women aged <19 years from 10% to 42%, in one Auckland clinic.[82] In an Australian study the use of a long-acting contraceptive in teenager mothers reduced the odds of a subsequent pregnancy within 2 years by 73%.[83] In contrast, a US study that used a computer assisted motivational intervention provided in quarterly sessions in conjunction with a home visit for 2 years post delivery in a teenage population reduced the odds of a subsequent birth within 2 years by 55% compared to usual management.[84]

Nutritional Programmes: Consideration should be given to nutritional programmes. There is increasing evidence that what a women eats during pregnancy influences outcomes for her infants, particularly with respect to preterm delivery and SGA.[85] In a review of interventions for improving pregnancy outcomes, Hollowell and colleagues found a number of interventions that were considered promising for reducing preterm birth.[86] These are described in more detail in the companion antenatal care report.[4] Two of these programmes involved a focus of improving nutrition in teenage pregnant women[87] and in women with low-calorie diets with modest reductions in preterm births and were provided as an adjunct to routine antenatal care. In a study of barriers to accessing antenatal care in disadvantaged women in the US, one study reported that participation in a Food Stamp Program[88] (supplying cheques/debit cards for purchasing specified nutritional foods e.g. milk, fruit and vegetables, tinned fish) reduced the odds of inadequate antenatal care.[89]

Detection and management of women at increased risk

Routine Antenatal Care: In order for risk assessment and appropriate referral to occur, pregnant women need to participate in antenatal care. To optimise the potential for antenatal care to improve outcomes, the National Institute for Health and Clinical Excellence recommend antenatal care start before 10 weeks gestation.[32] The companion report on antenatal care in CMDHB reviewed interventions for increasing early initiation and engagement with antenatal care and made several recommendations. Barriers to accessing antenatal care in CMDHB are currently the focus of a local research project which will further inform the selection of appropriate interventions.

Diabetes or Overweight and Obesity: Diabetes in CMDHB women is having an impact on perinatal mortality rates for the DHB. Flenady and colleagues recommend diabetes screening and an individualised pregnancy care plan, including dietician counselling (exercise and diet) and post-partum weight management; and routine weighing at the first antenatal visit.[34] Screening for diabetes in pregnancy is a recommended practice. Consideration should be given to auditing diabetes screening, further testing, and referral within CMDHB to identify gaps in service provision and access.

Routine weighing at first visit is currently being undertaken for ~85% of women. Efforts should be made to increase this practice, in particular for women who book late in pregnancy and Unbooked women who should be routinely weighed on first contact with maternity services. Weighing women at first contact and informing them of their recommended weight gain during pregnancy has been shown to increase the likelihood of appropriate weight gain.[90]

NICE guidelines for healthy weight management before, during, and after pregnancy have been developed.[91] Weight management during pregnancy has been trialled, particularly with a focus of limiting weight gain during pregnancy. Reviews of such interventions for overweight and obesity in pregnancy have highlighted a lack of evidence for effective antenatal interventions, and raised concerns regarding the potential for harm from such interventions during pregnancy.[92, 93] NICE guidelines recommend that women with a BMI of 30 or above be referred to a dietician for advice on healthy eating and activity during pregnancy.[91] Weight loss during pregnancy is not recommended.[91] Each year in CMDHB approximately 1,640 overweight and 2,300 obese women have a delivery. Provision of, for example, four sessions with a dietician lasting 1 hour each during the first and second trimesters, available for 48 weeks of the year, with each dietician scheduled to have 30 hours of patient contact time per week would require 6.4 full time equivalent dieticians. Post-partum weight management initiatives are an option, with the aim of achieving a weight in the normal range prior to a subsequent pregnancy. A review of the literature to identify effective programmes should be considered. Implementation of such programmes could be prioritised, for example for post-partum obese nulliparous women (~600-650 per year) as these women are likely to go on to have more children. However, most successful weight-loss programmes involve weekly participant contact, and the resource to provide this would be significant. Partnering with private weight-loss programmes could be considered.

As the evidence for a safe intervention during pregnancy is unclear, population level programmes may be more appropriate however challenging in the CMDHB setting. If the age and ethnic specific overweight and obesity rates in the maternity population are applied to the CMDHB population of child bearing women (15-44 year olds) then there are an estimated 29,600 overweight and 33,300 obese women who have the potential to become pregnant each year. This includes an estimated 10,600 women aged 15-24 years who are obese and very likely to experience a pregnancy in the future.

Smoking, Alcohol, and Illicit Drug Use: Flenady and colleagues recommend screening for substance use in pregnancy and offering intervention.[34] Brief interventions for smoking are already in place in CMDHB with auditing of the implementation of this initiative in process. An assessment of the effectiveness of current smoking cessation programmes within the DHB is recommended. In particular those targeting smoking in young Maaori, as smoking rates are maintained though all age groups of Maaori women in CMDHB suggesting that reducing the initiation of smoking in young Maaori women should be a priority. Two new smokefree services prioritising Maaori will be important to monitor, particularly the .specific pregnancy related service. Brief interventions targeting alcohol and illicit drug use should also be considered.[34]

Placental insufficiency and fetal growth restriction: Fetal growth restriction as evidenced by the high prevalence of SGA infants in CMDHB is an important risk factor for stillbirth and neonatal death. The PMMRC recommend screening for fetal growth restriction using regular fundal height measurement on customised growth charts.[3] The implementation of this recommendation should be audited in CMDHB; implementation also has the secondary benefit of requiring maternal height and weight measurement be performed. Flenady and colleagues also recommend doppler for high-risk pregnancies; monitoring and treatment with low-dose aspirin for those at risk.[34]

Improving Information Systems

Improvements in the CMDHB collection of maternity data have been recommended in the companion antenatal care report.[4] These include the review of current variables collected and the development of a core data set of mandatory fields, with little other data collected. All data should be collected with a clear understanding of its utility, the process for determining this would be enhanced by the development of a CMDHB maternity data collection data dictionary. This document would also standardise definitions, standardise data entry, inform staff training and facilitate research. The development of a web-based system is supported and consideration should be given to how private LMCs and Shared Care providers can be incentivised to submit data.

In order to inform future CMDHB perinatal research, important data elements should be added. These should include date of first antenatal visit, completion of screening events during pregnancy (i.e. yes, no, declined), and the presence of important risk factors (e.g. pre-existing hypertension, pregnancy induced hypertension, pre-existing diabetes, diabetes diagnosed in pregnancy, antepartum haemorrhage). Consideration should be given to ways of increasing the completeness of smoking and body mass data.

Community Engagement

While it is clear that reducing perinatal mortality in CMDHB is a priority for the Ministry of Health, it is not clear that it is a recognised priority in the lives of women living in CMDHB. The actions required for improving perinatal mortality in CMDHB primarily involve behavioural changes that are often challenging - planning pregnancy, weight management, improving nutrition, smoking cessation, engagement in antenatal care. A review of barriers to antenatal care in high-income countries concluded that for women with stressful or chaotic lifestyles, the motivation to attend antenatal care was overwhelmed by basic survival requirements.[94] Community engagement is recommended as a major part of the Perinatal Periods of Risk approach for precisely these reasons.[5, 6] Flenady and colleagues also recommend community engagement in their paper on the way forward for stillbirth in high income countries, although their focus is primarily on raising awareness and creating community champions.[34]

A population wide (universal) approach is recommended as the “flags” for identifying women at high risk for a poor perinatal outcome recommended by the PMMRC are applicable to the majority of the CMDHB maternity population (see section 3.10). If preventing perinatal deaths is a priority for communities these changes may be easier to achieve, and community groups may be able to be mobilised to support women and whaanau during pregnancy. Practical and material support from whaanau/friends/communities could include help with transport to antenatal clinics, smoking cessation in all whaanau / marae / church members, community fruit and vegetable gardens. As part of community engagement, research exploring attitudes and understanding of perinatal mortality in Maaori and the main Pacific groups in CMDHB is recommended.

References

1. PMMRC. *Perinatal and Maternal Mortality in New Zealand 2007: Third Report to the Minister of Health July 2008 - June 2009.* Wellington: Ministry of Health; 2009.

2. PMMRC. *Perinatal and Maternal Mortality in New Zealand 2008: Fourth Report to the Minister of Health July 2009 - June 2010.* Wellington: Ministry of Health; 2010.

3. PMMRC. *Fifth Annual Report of the Perinatal and Maternal Mortality Review Committee: Reporting mortality 2009.* Wellington: Health Quality & Safety Commission 2011; 2011.

4. Jackson C. *Antenatal Care in Counties Manukau DHB: A focus on primary antenatal care.* Auckland: Counties Manukau District Health Board; 2011.

5. Sappenfield WM, Peck MG, Gilbert CS, Haynatzka VR, Bryant T, 3rd. Perinatal Periods of Risk: Analytic Preparation and Phase 1 Analytic Methods for Investigating Feto-Infant Mortality. *Matern Child Health J.* Jun 20 2010.

6. Sappenfield WM, Peck MG, Gilbert CS, Haynatzka VR, Bryant T, 3rd. Perinatal Periods of Risk: Phase 2 Analytic Methods for Further Investigating Feto-Infant Mortality. *Matern Child Health J.* Jun 18 2010.

7. Mohsin M, Bauman AE, Jalaludin B. The influence of antenatal and maternal factors on stillbirths and neonatal deaths in New South Wales, Australia. *J Biosoc Sci.* Sep 2006;38(5):643-657.

8. Morton S, Atatoa Carr P, Bandara D, et al. *Growing Up in New Zealand: A longitudinal study of New Zealand children and their families. Report 1: Before we are born.* Auckland: Growing Up in New Zealand; 2010.

9. Ministry of Health. *Fetal and Infant Deaths 2006.* Wellington: Ministry of Health; 2010.

10. Counties Manukau DHB. *Women's Health Annual Clinical Report 2009.* Manukau City: Counties Manukau District Health Board; 2010.

11. Births, Deaths, Marriages, and Relationships Registration Act 1995. New Zealand Government, trans; 1995.

12. Ministry of Health. Fetal and Infant Deaths: Annual statistical publication series. http://www.moh.govt.nz/moh.nsf/indexmh/fetal-infant-deaths-series. Accessed July, 2010.

13. Ministry of Health. Data and Statistics: National systems and collections. http://www.moh.govt.nz/moh.nsf/indexmh/dataandstatistics-collections. Accessed July, 2010.

14. Ministry of Health. Data and Statistics: Maternity and newborn. http://www.moh.govt.nz/moh.nsf/indexmh/dataandstatistics-subjects-maternity. Accessed August, 2010.

15. Statistics New Zealand. Infoshare Births - VSB: Live births, stillbirths by District Health Board (Maori and total population) (Annual-Dec) http://www.stats.govt.nz/infoshare/. Accessed July, 2010.

16. PMMRC. *First Report to the Minister of Health June 2005 - June2007.* Wellington: Perinatal and Maternal Mortality Review Committee; 2007.

17. PMMRC. Guidelines for the completion of mother and baby forms following perinatal death. Version 5:http://www.pmmrc.health.govt.nz/moh.nsf/pagescm/350/$File/guidelines-mother-baby-forms-perinatal-death-v5.pdf. Accessed August, 2010.

18. Flenady V, King J, Charles A, et al. *PSANZ Clinical Practice Guideline for Perinatal Mortality Version 2.2*: Perinatal Society of Australia and New Zealand 2009.

19. Chan A, King JF, Flenady V, Haslam RH, Tudehope DI. Classification of perinatal deaths: development of the Australian and New Zealand classifications. *J Paediatr Child Health.* Jul 2004;40(7):340-347.

20. World Health Organization. *Neonatal and Perinatal Mortality: Country, Regional and Global Estimates.* Geneva: World Health Organization; 2006.

21. Baghurst P, Ellwood D, Holt J. *Benchmarking Maternity Care 2006-2008.* Canberra, Australia: Women's Hospitals Australasia; 2009.

22. Ministry of Health. *Ethnicity Data Protocols for the Health and Disability Sector.* Wellington: Ministry of Health; 2004.

23. Statistics New Zealand. Information About the Births. http://www2.stats.govt.nz/domino/external/omni/omni.nsf/outputs/births. Accessed May, 2011.

24. Department of Internal Affairs. Register a Birth, Death, Marriage, Civil Union or Name Change. http://www.dia.govt.nz/Births-deaths-and-marriages. Accessed May, 2011.

25. National Center for Health Statistics. 2003 Revisions to the US Standard Certificates of Live Birth and Death and the Fetal Death Report. 27 April 2011; http://www.cdc.gov/nchs/nvss/vital_certificate_revisions.htm. Accessed May, 2011.

26. National Center for Health Statistics. *Report to the Panel to Evaluate the US Standard Certificates.* Maryland: National Center for Health Statistics; 2000.

27. Kotelchuck M. An evaluation of the Kessner Adequacy of Prenatal Care Index and a proposed Adequacy of Prenatal Care Utilization Index. *American Journal of Public Health.* 1994;84:1414-1420.

28. McCowan LM, George-Haddad M, Stacey T, Thompson JM. Fetal growth restriction and other risk factors for stillbirth in a New Zealand setting. *Aust N Z J Obstet Gynaecol.* Dec 2007;47(6):450-456.

29. Facchinetti F, Alberico S, Benedetto C, et al. A multicenter, case-control study on risk factors for antepartum stillbirth. *J Matern Fetal Neonatal Med.* Jun 29 2010.

30. Huang L, Sauve R, Birkett N, Fergusson D, van Walraven C. Maternal age and risk of stillbirth: a systematic review. *CMAJ.* Jan 15 2008;178(2):165-172.

31. Silver RM, Varner MW, Reddy U, et al. Work-up of stillbirth: a review of the evidence. *Am J Obstet Gynecol.* May 2007;196(5):433-444.

32. National Institute for Health and Clinical Excellence. *Antenatal care routine care for the healthy pregnant woman.* London: National Institute for Health and Clinical Excellence; 2008.

33. Flenady V, Koopmans L, Middleton P, et al. Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis. *Lancet.* Apr 16 2011;377(9774):1331-1340.

34. Flenady V, Middleton P, Smith G, et al. Stillbirths: the way forward in high-income countries. *Lancet.* 2011;First Online.

35. Craig E, Anderson P, Jackson C. *The Health Status of Children and Young People in Counties Manukau.* Auckland: New Zealand Child and Youth Epidemiology Service; 2008.

36. Craig E, McDonald G, Reddington A, Wicken A. *The Determinants of Health for Children and Young People in Counties Manukau.* Dunedin: Child and Youth Epidemiology Service; 2009.

37. Gardosi J, Clausson B, Francis A. The value of customised centiles in assessing perinatal mortality risk associated with parity and maternal size *British Journal of Obstetrics & Gynaecology.* 2009;116(10):1356-1363.

38. Bai J, Wong F, Bauman A, Mohsin M. Parity and pregnancy outcomes. *American Journal of Obstetrics and Gynaecology.* 2002;186(AJOG):274-278.

39. Gardosi J, Francis A. Adverse pregnancy outcome and association with small for gestational age birthweight by customized and population-based percentiles. *Am J Obstet Gynecol.* Jul 2009;201(1):28 e21-28.

40. Qiu X, Lodha A, Shah PS, et al. Neonatal Outcomes of Small for Gestational Age Preterm Infants in Canada. *Am J Perinatol.* Nov 30 2011;First Online.

41. van Wassenaer A. Neurodevelopmental consequences of being born SGA. *Pediatr Endocrinol Rev.* Mar 2005;2(3):372-377.

42. Gestation Network. Growth Charts. www.gestation.net/fetal_growth/fetal_growth.htm, 2011.

43. Rowan JA, Luen S, Hughes RC, Sadler LC, McCowan LM. Customised birthweight centiles are useful for identifying small-for-gestational-age babies in women with type 2 diabetes. *Aust N Z J Obstet Gynaecol.* Apr 2009;49(2):180-184.

44. Kerrigan AM, Kingdon C. Maternal obesity and pregnancy: a retrospective study. *Midwifery.* Feb 2010;26(1):138-146.

45. McDonald SD, Han Z, Mulla S, Beyene J, on behalf of the Knowledge Synthesis Group. Overweight and obesity in mothers and risk of preterm birth and low birth weight infants: systematic review and meta-analyses. *BMJ.* July 20, 2010 2010;341(jul20_1):c3428-.

46. Nohr EA, Vaeth M, Bech BH, Henriksen TB, Cnattingius S, Olsen J. Maternal obesity and neonatal mortality according to subtypes of preterm birth. *Obstet Gynecol.* Nov 2007;110(5):1083-1090.

47. Nohr E, Timpson N, Andersen C, Davey Smith G, Olsen J, et al. Severe Obesity in Young Women and Reproductive Health: The Danish National Birth Cohort. *PLoSONE.* 2009;4(12):e8444.

48. Lewis G. *The Confidential Enquiry into Maternal and Child Health (CEMACH). Saving Mothers' Lives: Reviewing Maternal Deaths to Make Motherhood Safer.The Seventh Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom.* London: CEMACH; 2007.

49. Villamor E, Cnattingius S. Interpregnancy weight change and risk of adverse pregnancy outcomes: a population-based study. *Lancet* 2006;368:1164-1170.

50. Ministry of Health. *New Zealand Health Survey 2006/07.* Wellington: Ministry of Health; 2010.

51. Rogers J. Tobacco and pregnancy. *Reprod Toxicol.* 2009;28(2):152-160.

52. Smith G, Shah I, White I, Pell J, Crossley J, Dobbie R. Maternal and biochemical predictors of antepartum stillbirth among nulliparous women in relation to gestational age of fetal death. . *BJOG* 2007;114:705-714.

53. Raatikainen K, Heiskanen N, Heinonen S. Under-attending free antenatal care is associated with adverse pregnancy outcomes. *BMC Public Health.* 2007;7:268.

54. Cantwell R, Clutton-Brock T, Cooper G, et al. Saving Mothers' Lives: Reviewing maternal deaths to make motherhood safer: 2006-2008. The Eighth Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. *BJOG: An International Journal of Obstetrics & Gynaecology.* Mar 2011;118 Suppl 1:1-203.

55. Nga NT, Malqvist M, Eriksson L, et al. Perinatal services and outcomes in Quang Ninh province, Vietnam. *Acta Paediatrica.* Oct 2010;99(10):1478-1483.

56. Mohsin M, Bauman AE, Jalaludin B. The influence of antenatal and maternal factors on stillbirths and neonatal deaths in New South Wales, Australia. Sep 2006.

57. Vintzileos AM, Ananth CV, Smulian JC, Scorza WE, Knuppel RA. Prenatal care and black-white fetal death disparity in the United States: heterogeneity by high-risk conditions. Mar 2002.

58. Debiec KE, Paul KJ, Mitchell CM, Hitti JE. Inadequate prenatal care and risk of preterm delivery among adolescents: a retrospective study over 10 years. Aug 2010.

59. Chao SM, Donatoni G, Bemis C, et al. Integrated approaches to improve birth outcomes: perinatal periods of risk, infant mortality review, and the Los Angeles Mommy and Baby Project. *Maternal & Child Health Journal.* Nov 2010;14(6):827-837.

60. Bhutta ZA, Lassi ZS, Blanc A, Donnay F. Linkages among reproductive health, maternal health, and perinatal outcomes. *Seminars in Perinatology.* Dec 2010;34(6):434-445.

61. Kothari CL, Wendt A, Liggins O, Overton J, Sweezy LdC. Assessing maternal risk for fetal-infant mortality: a population-based study to prioritize risk reduction in a healthy start community. *Maternal & Child Health Journal.* Jan 2011;15(1):68-76.

62. Gao W, Paterson J, Carter S, Percival T. Risk factors for preterm and small-for-gestational-age babies: a cohort from the Pacific Islands Families Study. *J Paediatr Child Health.* Dec 2006;42(12):785-792.

63. Health Services Consumer Research. *Maternity Services Consumer Satisfaction Survey Report 2007.* Auckland: Ministry of Health; 2008.

64. Simmons D, Rowan J, Reid R, Campbell N. Screening, diagnosis and services for women with gestational diabetes mellitus (GDM) in New Zealand: a technical report from the National GDM Technical Working Party. *N Z Med J.* Mar 4 2008;121(1270):74-86.

65. Yapa M, Simmons D. Screening for gestational diabetes mellitus in a multiethnic population in New Zealand. *Diabetes Res Clin Pract.* Jun 2000;48(3):217-223.

66. Stacey T, Thompson JM, Mitchell EA, Ekeroma AJ, Zuccollo JM, McCowan LM. Relationship between obesity, ethnicity and risk of late stillbirth: a case control study. *BMC Pregnancy Childbirth.* 2011;11(3).

67. Ministry of Health. *Fetal and Infant Deaths 2007.* Wellington: Ministry of Health; 2010.

68. New Zealand Government. Crimes Act 1961. *Public Act 1961, No. 43*. Wellington: New Zealand Government; 1961.

69. Besculides M, Laraque F. Racial and ethnic disparities in perinatal mortality: applying the perinatal periods of risk model to identify areas for intervention. *J Natl Med Assoc.* Aug 2005;97(8):1128-1132.

70. Cai J, Hoff GL, Archer R, Jones LD, Livingston PS, Guillory VJ. Perinatal periods of risk analysis of infant mortality in Jackson County, Missouri. *J Public Health Manag Pract.* May-Jun 2007;13(3):270-277.

71. Cai J, Hoff GL, Dew PC, Guillory VJ, Manning J. Perinatal periods of risk: analysis of fetal-infant mortality rates in Kansas City, Missouri. *Matern Child Health J.* Jun 2005;9(2):199-205.

72. Nohr EA, Bech BH, Davies MJ, Frydenberg M, Henriksen TB, Olsen J. Prepregnancy obesity and fetal death: a study within the Danish National Birth Cohort. *Obstet Gynecol.* Aug 2005;106(2):250-259.

73. Stacey T, Thompson JM, Mitchell EA, Ekeroma AJ, Zuccollo JM, McCowan LM. The Auckland Stillbirth study, a case-control study exploring modifiable risk factors for third trimester stillbirth: methods and rationale. *Aust N Z J Obstet Gynaecol.* Feb 2011;51(1):3-8.

74. Moos M, Dunlop A, Jack BW, et al. Healthier women, healthier reproductive outcomes: recommendations for the routine care of all women of reproductive age. *American Journal of Obstetrics and Gynaecology.* 2008;199(6):S280-S289.

75. Moos MK, Bangdiwala SI, Meibohm AR, Cefalo RC. The impact of a preconceptional health promotion program on intendedness of pregnancy. *Am J Perinatol.* Feb 1996;13(2):103-108.

76. Delvaux T, Buekens P, Godin I, Boutsen M. Barriers to prenatal care in Europe. *Am J Prev Med.* Jul 2001;21(1):52-59.

77. Low P, Paterson J, Wouldes T, Carter S, Williams M, Percival T. Factors affecting antenatal care attendance by mothers of Pacific infants living in New Zealand. *N Z Med J.* Jun 3 2005;118(1216):U1489.

78. Quelopana AM, Champion JD, Salazar BC. Factors predicting the initiation of prenatal care in Mexican women. *Midwifery.* Jun 2009;25(3):277-285.

79. Johnson AA, El-Khorazaty MN, Hatcher BJ, et al. Determinants of late prenatal care initiation by African American women in Washington, DC. *Matern Child Health J.* Jun 2003;7(2):103-114.

80. Sunil TS, Spears WD, Hook L, Castillo J, Torres C. Initiation of and barriers to prenatal care use among low-income women in San Antonio, Texas. *Matern Child Health J.* Jan 2010;14(1):133-140.

81. Finer L, Henshaw S. Disparities in rates of unintended pregnancy in the United States, 1994 and 2001. *Perspect Sex Reprod Health.* 2006 38(2):90-96.

82. Roberts H. Post-abortion contraception and its effect on repeat abortions in New Zealand. *ADHB Healthcare Excellance Awards*. Auckland; 2011.

83. Lewis LN, Doherty DA, Hickey M, Skinner SR. Predictors of sexual intercourse and rapid-repeat pregnancy among teenage mothers: an Australian prospective longitudinal study. *Med J Aust.* Sep 20 2010;193(6):338-342.

84. Barnet B, Liu J, DeVoe M, Duggan AK, Gold MA, Pecukonis E. Motivational intervention to reduce rapid subsequent births to adolescent mothers: a community-based randomized trial. *Ann Fam Med.* Sep-Oct 2009;7(5):436-445.

85. McCowan LM, Roberts CT, Dekker GA, et al. Risk factors for small-for-gestational-age infants by customised birthweight centiles: data from an international prospective cohort study. *BJOG.* Dec 2010;117(13):1599-1607.

86. Hollowell J, Kurinczuk JJ, Oakley L, Brocklehurst P, Gray R. *The effectiveness of antenatal care programmes to reduce infant mortality and preterm birth in socially disadvantaged and vulnerable women.* Oxford: National Perinatal Epidemiology Unit, University of Oxford; 2009.

87. Dubois S, Coulombe C, Pencharz P, Pinsonneault O, Duquette MP. Ability of the Higgins Nutrition Intervention Program to improve adolescent pregnancy outcome. *J Am Diet Assoc.* Aug 1997;97(8):871-878.

88. Food and Nutrition Service. WIC Food Packages. 2011; http://www.fns.usda.gov/wic/benefitsandservices/foodpkg.HTM. Accessed May, 2011.

89. Johnson AA, Hatcher BJ, El-Khorazaty MN, et al. Determinants of inadequate prenatal care utilization by African American women. *J Health Care Poor Underserved.* Aug 2007;18(3):620-636.

90. Institute of Medicine and National Research Council. *Weight gain during pregnancy: reexamining the guidelines.* Washington, DC: National Academies Press; 2009.

91. National Institute for Health and Clinical Excellence. *NICE clinical guideline: Weight management before, during and after pregnancy. .* London: National Institute for Health and Clinical Excellence; 2010.

92. Dodd JM, Grivell RM, Crowther CA, Robinson JS. Antenatal interventions for overweight or obese pregnant women: a systematic review of randomised trials. *BJOG.* Mar 29 2010.

93. Thangaratinam S, Jollya K. Obesity in pregnancy: a review of reviews on the effectiveness of interventions. *BJOG.* 2010 117(11):1309-1312.

94. Downe S, Finlayson K, Walsh D, Lavender T. 'Weighing up and balancing out': a meta-synthesis of barriers to antenatal care for marginalised women in high-income countries. *BJOG.* Mar 2009;116(4):518-529.