Literature Review
for
Three Centres Antenatal Care Consensus Guidelines

Routine weighing

by: Clinical Practice Improvement Unit, The Royal Women's Hospital

Project team members

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Routine weighing

Conclusion and Recommendations

Does weighing pregnant women at every visit compared to weighing women at selective visits or weighing not at all have an effect on detection of pre-eclampsia/hypertensive disorders, macrosomia, FGR, and maternal perceptions of the procedure?

There is benefit to ascertaining BMI at the first antenatal visit as part of the risk categorization process, based on the outcomes delineated below.

Elevated body mass index (BMI) and excessive weight gain in pregnancy are associated with eclampsia/hypertensive disorders, macrosomia and fetal growth restriction. More specifically, elevated BMI in pregnancy is associated with preeclampsia, macrosomia, increased perinatal mortality rate and diabetes later in life. The evidence for these associations is primarily based on historical data with limited contemporary evidence. Evidence currently available is of poor quality and often in settings remote from Australian antenatal care provision.

Excessive weight gain in pregnancy is particularly associated with macrosomia, and diabetes later in life.

Low BMI is associated with low birth weight and fetal growth restriction. The evidence for association with preterm birth is conflicting.

Low maternal weight gain in pregnancy is particularly associated with low birth weight, fetal growth restriction and preterm birth.

There was no evidence identified regarding the benefit of weighing women at every visit compared with selective weighing in terms of intervention to prevent macrosomia or fetal growth restriction.

Recommendation (B)
The project team concurs with the RCOG recommendations:

- "Maternal weight and height should be measured at the first antenatal appointment, and the women's BMI calculated and recorded (weight [kg]/height[m^2]), and
- "Repeated weighing during pregnancy should be confined to circumstances where clinical management is likely to be influenced."

Contents

1. Introduction

The Three Centres Collaboration contracted the Royal Women's Hospital (RWH) Clinical Practice Improvement Unit to conduct a comprehensive search and critical appraisal of publications addressing the topic of routine weighing published between January 2000 and June 2005, to inform the proposed review of the 2001 Three Centres Consensus Guidelines on Antenatal Care.

2. Topics to be addressed

2.1 Does weighing pregnant women at every visit compared to weighing women at selective visits or weighing not at all have an effect on detection of pre-eclampsia/hypertensive disorders, macrosomia, FGR, and maternal perceptions of the procedure?

3. Methods

3.1 Search strategy

- The OVID interface was used to search the following electronic databases:
  MEDLINE: 2000 – May 2005
  CINAHL: 2000 – May 2005
  EBM Reviews: January 2000 – May 2005
- Cochrane Database: 2005 Issue 2
- Review of article citations and Cochrane Library references for additional citations
- Guidelines developed by specific Colleges of Obstetricians and Gynaecologists were searched including:
  Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG)
  Royal College of Obstetricians and Gynaecologists (RCOG)
  Society of Obstetricians and Gynaecologists Canada (SOGC), and
  American College of Obstetricians and Gynecologists.
- Guidelines developed by other groups were searched for via the internet, on the United States National Guidelines Clearinghouse.

3.2 Search terms

Terms used to identify relevant citations are outlined in Appendix I. The search included search terms for:

Pregnancy
Weighing
Visits / consultation

- Hypertension in pregnancy
- Macrosomia
- Fetal growth restriction
- Maternal perceptions
- Weight gain

4. Search findings

4.1 Initial search

Two guidelines/statements retrieved for antenatal weighing were considered, including application of the AGREE tool by the project team.

- Royal College of Obstetricians and Gynaecologists (RCOG). Clinical Guideline: Antenatal care: routine care for the healthy pregnant woman (2003)[1].
- Institute for Clinical Systems Improvement (ICSI). Health Care Guideline: Routine prenatal care. (2003)[2]

In addition to the guidelines, the initial search applied the following inclusion and exclusion criteria to retrieve 155 citations (Appendix II):

Inclusion criteria	Exclusion criteria
2000-2005	Exercise
BMI	Preexisting medical disorder
	Non-pregnant
	Specific supplementation (e.g. iron, Vitamins)
	Postpartum weight
	Birth / fetal weight without reference to maternal weigh$ search terms
	Lactation
	HIV
	Non human
	Biochemical assessment
	Ultrasound assessment

4.2 Key citation selection

The 157 citations (including guidelines) were triaged into those:

- Possibly containing relevant evidence or authoritative opinion (46 citations), and
- Unlikely to contain relevant evidence or authoritative opinion (111 citations). These citations were either too general or not relevant to the topics to be addressed and were not considered further.

The 46 citations (Appendix III) were retrieved and further screened to identify those studies with respect to quality of methodology and possible relevance to Australian obstetric practice. As a result of this exercise 17 articles were classified as key citations, and were subjected to systematic critical appraisal by the project team (Appendix IV) and those not meeting the criteria were discarded.

The evidence within these 17 key citations fell into the following levels (see Appendix IV for definitions):
Level I evidence: 0 publications
Level II evidence: 0 publications,
Level III evidence: 8 publications, and
Level IV evidence: 9 publications.

4.3 Grading recommendations

The project team has adapted the Scottish Intercollegiate Guidelines Network (SIGN) system applying the NHMRC Levels of Evidence, to grade recommendations as follows:

A At least one meta analysis, systematic review, or RCT directly applicable to the target population; or Levels I or II evidence.

B A body of evidence including studies rated as Level III-1 or III-2, directly applicable to the target population and demonstrating overall consistency of results.

C A body of evidence including studies rated as III-3 directly applicable to the target population and demonstrating overall consistency of results.

D Evidence Level IV.

5. Results of the critical appraisal process; Commentary on and interpretation of publications reviewed

5.1 Does weighing pregnant women at every visit compared to weighing women at selective visits or weighing not at all have an effect on detection of pre-eclampsia/hypertensive disorders, macrosomia, FGR, and maternal perceptions of the procedure?

- **Reference**

Royal College of Obstetricians and Gynaecologists (RCOG). Evidence based guidelines Antenatal care: routine care for the healthy pregnant woman. 2003. (Level IV)

Following consideration of the evidence the RCOG identified a correlation between maternal weight gain and infant birth weight. However, routine weighing was not considered effective for screening for small size (low birth weight) babies[1].

Authors conclude the measurement of maternal weight (or height) routinely during pregnancy should be abandoned as it may result in unnecessary anxiety for the woman with no added benefit. The exception is pregnant women in whom nutrition is of concern[1].

The RCOG recommend:

- "Maternal weight and height should be measured at the first antenatal appointment, and the women's BMI calculated (weight [kg]/height [m^2]).
- "Repeated weighting during pregnancy should be confined to circumstances where clinical management is likely to be influenced"[1].

- **Reference**

Institute for Clinical Systems Improvement (ICSI). Health Care Guideline: Routine prenatal care. 2003. (Level IV)

ICSI state there is a positive association between maternal pre-pregnant body mass index (BMI) and the risk of pre-eclampsia during pregnancy. In addition, evidence was identified that being obese leads to increased rates of dystocia and of primary caesarean section. Women who are underweight at the beginning of their pregnancy have higher birth weight babies if they have greater weight gains than generally have been recommended[2].

The amount of weight gained, either week to week or over the course of the entire pregnancy, is not associated with pregnancy-induced hypertension. However, underweight women are at higher risk for preterm labour, and overweight women are at risk for gestational diabetes and various forms of hypertension[2].

- **Reference**

Ehrenberg HM, Dierker L, Milluzzi C, Mercer BM. Low maternal weight, failure to thrive in pregnancy, and adverse pregnancy outcomes. *American Journal of Obstetrics & Gynecology* 2003;189(6):1726-30. (Level III-2)

This retrospective cohort study evaluated women according to pregravid weight and weight at delivery. Low weight or BMI at conception or delivery (pregravid BMI $\leq$ 19.8 kg/m^2) was significantly associated with an increased risk of intra uterine growth restriction and preterm labour (PTL) whereas a protective effect was seen in terms of caesarean delivery. In addition, poor maternal weight gain in pregnancy (<1.27kg/wk) was significantly associated with poor perinatal outcomes, including birth weight <1500g, low birth weight, PTL and preterm delivery[3].

Project team comment
The authors used the analysis of the rate of weight gain during the entire gestation to avoid the influence of length of gestation. This enabled them to conclude that weight gained in pregnancy can be considered a more potent predictor of adverse outcome than weight or BMI at delivery.

The study raises the possibility that aggressive management of maternal nutrition, during pregnancy will lead to improved perinatal outcomes in this population. However, the retrospective nature of the study precludes definitive conclusions of this nature.

- **Reference**

Brown JE, Murtaugh MA, Jacobs DR, Jr., Margellos HC. Variation in newborn size according to pregnancy weight change by trimester. *American Journal of Clinical Nutrition* 2002;76(1):205-9. (Level III-2)

This prospective cohort study evaluated whether the timing of maternal weight change in pregnancy may be an important determinant of the newborn's size. Maternal weight gain in the first and second trimesters predicted newborn weight (1kg weight gain in the first trimester predicted a 31g increase in newborn weight) but weight gain in the third trimester did not. Newborn weight was 211g lower and ponderal index 1.2 units lower in infants born to women who lost weight in the first trimester[4].

Project team comment
The prospective nature of the study prevented recall bias regarding prepregnancy weight.

The study team suggests that weight gain in the third trimester of pregnancy may play a role in preventing the birth of thin newborns and potentially decrease the risk later in life of certain chronic diseases that are associated with thinness at birth. However the lack of relation of trimester maternal weight gain to newborn length and head circumference may have been that the study sample consisted largely of white, middle income women with a reliable source of health care.

- **Reference**

Dawson SI, Smith WC, Watson MS, Wilson BJ, Prescott GJ, Campbell D, et al. A cohort study of reproductive risk factors, weight and weight change and the development of diabetes mellitus. *Diabetes, Obesity & Metabolism* 2003;5(4):244-50. (Level III-2)

This retrospective cohort study of 1257 women who had a first pregnancy between 1951 and 1970, found that parous women, higher BMI at index pregnancy, weight gain during follow-up and BMI in later life strongly predict diabetes risk[5].

Project team comment
This study suffers from the usual criticisms of retrospective cohort studies as in causation is difficult to assign, and confounders difficult to isolate.

- **Reference**

Schieve LA, Cogswell ME, Scanlon KS, Perry G, Ferre C, Blackmore-Prince C, et al. Prepregnancy body mass index and pregnancy weight gain: associations with preterm delivery. The NMIHS Collaborative Study Group. *Obstetrics & Gynecology* 2000;96(2):194-200. (Level III-2)

This prospective cohort study examined the association between rate of pregnancy weight gain and preterm delivery among women of varying prepregnancy BMI.

Women with low pregnancy weight gain were at increased risk of preterm delivery. The magnitude of risk varied according to a woman's prepregnancy BMI[6].

Project team comment
The strengths of this study included the use of a nationally representative sampling base; serial weight gain data to model rate of weight gain; ability to limit weight gain of interest to 14-28 weeks, which provided comparability between preterm and term deliveries; and availability of data on preterm etiology and antenatal maternal complications.

The limitations of the study include exclusion of large proportion of original respondents by the strict study criteria, which might have affected generalizability. However, the sample remained comparable to the original respondents on several key variables.

- **Reference**

Murakami M, Ohmichi M, Takahashi T, Shibata A, Fukao A, Morisaki N, et al. Prepregnancy body mass index as an important predictor of perinatal outcomes in Japanese. *Archives of Gynecology & Obstetrics* 2005;271(4):311-5. (Level III-2)

This retrospective cohort study of 633 women who gave birth to live singleton babies between 24 and 42 weeks gestation during 2001 in Japan found that obese women have a significantly increased risk of caesarean delivery, pre-eclampsia, and gestational diabetes compared with the control group. Women underweight before pregnancy had significantly increased risks of low birth weight infant and hospitalization of infant. However weight gain during pregnancy did not show any significant influence on the perinatal outcomes of the mother or infant[7].

Project team comment
This study was underpowered to evaluate significant associations between weight gain during pregnancy and perinatal outcomes of mother or infant.

- **Reference**

Neufeld LM, Haas JD, Grajeda R, Martorell R. Changes in maternal weight from the first to second trimester of pregnancy are associated with fetal growth and infant length at birth. *American Journal of Clinical Nutrition* Apr; 79(4): 646-52 (42 ref) 2004. (Level III-2)

The aim of the prospective cohort study was to explore the relation between maternal weight gain during different stages of pregnancy and linear growth (using femur length) of the fetus, by conducting ultrasound examinations on 200 women from 4 rural Guatemalan villages[8].

The study found that maternal weight gain from the second to the third trimester of pregnancy did not predict fetal linear growth or infant length at birth, but maternal weight change from the first to the second trimester of pregnancy is strongly associated with fetal growth. Maternal height was not a significant predictor of femur or tibia length[8].

The study reported a strong relationship between the rate of maternal weight gain and measures of fetal linear growth. The researchers postulate the association between weight gain from the first to the second trimester and fetal linear growth may actually reflect better placental nutrient transport and a better supply of endocrine growth factors in women who gain more weight. Early gestation may be a sensitive period for fetal linear growth[8].

Project team comment
This study was performed in rural Guatemala raising concerns regarding generalisability to the Australian setting. The exact nature of the relationship between maternal weight gain during pregnancy and fetal linear growth is difficult to assess in this cohort study, and further research is recommended.

- **Reference**

Lepercq J, Hauguel-De Mouzon S, Timsit J, Catalano PM. Fetal macrosomia and maternal weight gain during pregnancy. *Diabetes & Metabolism* 2002;28(4 Pt 1):323-8. (Level III-2)

This prospective cohort study evaluated the 'corrected maternal weight gain' (calculated as: maternal body weight at the last prenatal visit – [pregravid body weight + birth weight + placental weight]) against standard calculation of weight with respect to the effect on neonatal birth weight[9].

Weight gain was greater in mothers who delivered macrosomic infants but the difference was no longer significant when using corrected weight gain. This suggests that maternal weight gain during pregnancy has limited effects on fetal size[9].

Project team comment
The study authors conclude that corrected weight gain is a better estimate of true maternal weight gain in pregnancy. This should be accounted for in other studies on maternal weight gain in pregnancy.

Limitations of the study include the retrospective nature with respect to pregravid weight and the potential for recall bias on reported weight.

- **Reference**

Stephansson O, Dickman PW, Johansson A, Cnattingius S. Maternal weight, pregnancy weight gain, and the risk of antepartum stillbirth. *American Journal of Obstetrics & Gynecology* 2001;184(3):463-9. (Level III-2)

This case control study included 649 women with antepartum stillbirths and 690 control subjects among Swedish nulliparous women. Study variables included BMI and average weekly weight gain for early and late pregnancy within each BMI group. Authors found no clear association between body mass index and average weekly weight gain[10].

Early pregnancy weight gain was not significantly associated with risk of antepartum death. However, a nested case control study of term antepartum deaths ($\geq$37 completed gestational weeks) revealed that overweight and obese women faced an almost 3-fold increase in risk of term antepartum death relative to lean women[10].

Compared with risk of all antepartum deaths, the age-related risks were higher for term antepartum deaths, with a 4-fold risk increase observed for those aged $\geq$35 years, whereas cigarette smoking was no longer significantly associated with risk when term antepartum deaths were considered. There was no risk associated with weight gains during early or late pregnancy[10].

The overall risk of antepartum death was increased among overweight women, whereas the risk was no longer significant among obese women[10].

Project team comment
The study authors minimized the possibility of selection bias by their ability to retrieve 97% of the medical records. They accounted for possible confounders, such as maternal age, socioeconomic status, and smoking. The authors comment that the

relatively homogeneous population in Sweden and standardized antenatal care minimized these factors as confounders, but also may limit the external validity of the study.

- **Reference**

Catalano PM, Kirwan JP. Maternal factors that determine neonatal size and body fat. *Current Diabetes Reports* 2001;1(1):71-7. (Level IV)

This review identified a positive correlation between weight gain during pregnancy and maternal pregravid weight, and the birth weight in control subjects, but a negative correlation in subjects with gestational diabetes mellitus. As women with gestational diabetes have decreased insulin sensitivity compared with women with normal glucose tolerance, the correlation of maternal weight gain with birth weight is poorer in women with gestational diabetes. However, in women greater than 135% of weight for height before conception, there was no correlation between weight gain during pregnancy and birth weight. The strongest predictor of birth weight was gestational age, followed by maternal weight gain, pregravid weight, neonatal sex and parity[11].

Conversely, data from the Dutch famine of 1944 to 1945, demonstrated the time of gestation in which nutritional deprivation (less than 1500kcal/d) occurs has important consequences for the fetus. Nutritional deprivation in early gestation was associated with a higher rate of prematurity and very low birth weight, whereas deprivation in late gestation was associated with a 9% lower fetal weight but not length[11].

Project team comment

This is a comprehensive review of maternal factors that may contribute to neonatal biometric parameters.

- **Reference**

Honest H, Bachmann LM, Ngai C, Gupta JK, Kleijnen J, Khan KS. The accuracy of maternal anthropometry measurements as predictor for spontaneous preterm birth--a systematic review. *European Journal of Obstetrics, Gynecology, & Reproductive Biology* 2005;119(1):11-20. (Level IV)

This review aimed to assess the accuracy with which antenatal maternal anthropometric measurement predicts the risk spontaneous preterm birth[12].

Eight articles met the selection criteria which included a total of 122,647 asymptomatic women including studies on:

- Pre-pregnancy weight where five measured the body mass index (BMI) and one used an arbitrary measure.
- The adequacy of pregnancy weight gain, and
- Maternal height as a predictor for the risk of preterm birth[12].

Pre-pregnancy BMI is a poor predictor of preterm birth before 37 weeks' gestation as are the adequacy of pregnancy weight gain and short maternal height. The study therefore concluded that routine antenatal maternal anthropometric measurements are not useful in predicting the risk of preterm birth before 37 weeks' gestation[12].

Project team comment

None of the studies fulfilled the ideal test accuracy study criteria. There was heterogeneity in the accuracy results of pre-pregnancy BMI but not in the adequacy of weight gain.

Further studies are required to address the use of anthropometric measurements in combination with other tests with a focus on clinically appropriate reference standards

of preterm birth, such as birth before 32-34 weeks' gestation, and improve on the quality of study design."

- **Reference**

Abrams B, Altman SL, Pickett KE. Pregnancy weight gain: still controversial. *American Journal of Clinical Nutrition* 2000;71(5 Suppl):1233S-41S. (Level IV)

This study was a systematic review of fetal and maternal outcomes according to the Institute of Medicine (IOM) weight gain recommendations in women with a normal prepregnancy weight (11.5-16 kgs weight gain for BMI 19.8-26)[13].

After a variety of other risk factors were controlled for, women with a low rate of weight gain during the third trimester has a statistically significant higher risk of spontaneous preterm delivery than did women without a low weight gain in the third trimester[13].

The study found weight gain in pregnancy is also related to fetal growth. Too little gain is associated with reduced fetal growth, i.e., low birth weight (<2500g) or small-for-gestational-age infants (<10th percentile of weight for a given gestation). Excessive maternal weight gain is associated with large infants, i.e. macrosomia (defined as >4000 or >4500g) or large-for-gestational age infants (defined as >10th percentile of weight for a given gestation)[13].

The incidence of high birth weight (>4000g) and caesarean births increased with increasing maternal weight gains, but the increases were not statistically significant until the weight gain exceeded 16kg, the upper limit of the IOM's recommended ranges. Reviewers conclude there are no statistically significant differences in the incidence of low birth weight, macrosomia, or caesarean delivery between women with weight gains in the ranges of 7-11.5 and 11.5-16 kg and women with weight gains <7kg[13].

Project team comment

This study was essentially a literature review of current evidence around IOM's recommended pregnancy weight gain.

Statistical analysis was not applied to the collection of heterogeneous data. Validation of the IOM's recommendations was outside the scope of the article.

- **Reference**

Lederman SA. Pregnancy weight gain and postpartum loss: avoiding obesity while optimizing the growth and development of the fetus. *Journal of the American Medical Womens Association* 2001;56(2):53-8. (Level IV)

This review article also examined birth-weight rises with increased pregnancy weight gain, and perinatal and neonatal mortality fall as birth weight increases in both preterm and term infants in light of the IOM published recommendations for pregnancy weight gain[14].

The reviewer found that although often thought to be at high risk, infants termed "macrosomic" include infants of the lowest mortality rate. Therefore, restricting weight gain may be detrimental to the baby. However, pregnancy weight gain exceeding current recommendations is associated with increases in maternal fat gain, pregnancy complications, and delivery problems and should be discouraged[14].

Weight gain in overweight and obese women is associated with increased caesarean section risk and perinatal mortality is higher for infants of obese women than for infants of normal-weight women[14].

Project team comment
This review provides and opinion on the evidence surrounding obesity and birth outcome. It raises important points regarding evaluation of current evidence, particularly the difficulty in differentiating between poor outcomes due to obesity and poor outcomes due to excessive weight gain in pregnancy.

- **Reference**

Pinheiro A, David A, Joseph B. Pregnancy weight gain and its correlation to birth weight. *Indian Journal of Medical Sciences* 2001;55(5):266-70. (Level IV)

An audit of 2000 antenatal records in a rural hospital and health centre in India resulted in 935 records having a complete data set. Women were weighed at each antenatal visit. Weight gain in the second trimester was significantly associated with neonatal birth weight[15].

Project team comment
This study drew from 22 rural villages in India. The applicability to the Australian setting is restricted. In addition, the study identified significant limitations including irregular attendance at antenatal clinic and loss to follow-up which reduced the sample size. Height was never recorded therefore BMI could not be calculated.

- **Reference**

Marsoosi V, Jamal A, Eslamian L. Pre-pregnancy weight, low pregnancy weight gain, and preterm delivery. *International Journal of Gynaecology & Obstetrics* 2004;87(1):36-7. (Level IV)

This Iranian study of 2163 antenatal records found that antenatal weight gain was inversely related to pre-pregnancy BMI. The risk of preterm delivery was 7.72% among women who had an average BMI before pregnancy and had an average rate of weight gain during pregnancy[16].

Compared with that group, the risk of preterm delivery was increased for two groups: women with average pre-pregnancy BMI and low weight gain (17.14% preterm risk), and women with low pre-pregnancy BMI and high weight gain (14.29%). However, these results failed to achieve statistical significance[16].

Project team comment
This retrospective audit of antenatal records has limited applicability due to the methodology.

- **Reference**

Warriner S. Women's issues. Women's views on being weighed during pregnancy. *British Journal of Midwifery* Oct; 8(10): 620-3 (16 ref) 2000. (Level IV)

This qualitative analysis of 10 individual interviews plus a focus group of six women with the purpose of identifying themes and patterns around how women feel about being weighed in pregnancy[17].

The key points of the study include that most women reported regular and routine weighing throughout their pregnancies. For most women little information was made available regarding the process. The attitude of women to weight changes in pregnancy varied and was strongly influenced by their prepregnancy views. For some women pregnancy appears to absolve them of responsibility for their weight yet provokes fears of excessive weight gain[17].

The study authors conclude that in a tradition of weighing, health professionals endorse many women's' perceptions of its importance[17].

Project team comment

This was the only study identified regarding maternal perceptions of the weighing procedure.

The group was self selected and the study **very** small thereby limiting generalisability. The methodology was not described.

Project team overall conclusion

There is benefit to ascertaining BMI at the first antenatal visit as part of the risk categorization process, based on the outcomes delineated below.

Elevated BMI and excessive weight gain in pregnancy are associated with eclampsia/hypertensive disorders, macrosomia and fetal growth restriction. More specifically, elevated BMI in pregnancy is associated with preeclampsia, macrosomia, increased perinatal mortality rate and diabetes later in life. The evidence for these associations is primarily based on historical data with limited contemporary evidence. Evidence currently available is of poor quality and often in settings remote from Australian antenatal care provision.

Excessive weight gain in pregnancy is particularly associated with macrosomia, and diabetes later in life.

Low BMI is associated with low birth weight and fetal growth restriction. The evidence for association with preterm birth is conflicting.

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Recommendation (B)

The project team concurs with the RCOG recommendations:

- "Maternal weight and height should be measured at the first antenatal appointment, and the women's BMI calculated and recorded (weight [kg]/height[m^2]), and
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6. Conclusions and recommendations

There is benefit to ascertaining BMI at the first antenatal visit as part of the risk categorization process, based on the outcomes delineated below.

Elevated BMI and excessive weight gain in pregnancy are associated with eclampsia/hypertensive disorders, macrosomia and fetal growth restriction. More specifically, elevated BMI in pregnancy is associated with preeclampsia, macrosomia, increased perinatal mortality rate and diabetes later in life. The evidence for these associations is primarily based on historical data with limited contemporary evidence. Evidence currently available is of poor quality and often in settings remote from Australian antenatal care provision.

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Appendix I

Search framework

A structured approach was used to identify an appropriate search strategy for this topic. Using the Patient/Intervention/Compared with/Outcome (PICO) format search terms were listed and entered into the various electronic databases.

P All pregnant women
I Weighing at each visit
C Selective weighing or not weighing at all
O Detection of:
- Pre-eclampsia
- Hypertensive disorders
- IUGR
- Maternal perceptions

Search findings

Term	Medline	Premedline	CINAHL	EBM
Pregnan$ / pregnancy / prenatal diagnosis / prenatal care / antenatal / antenatal care + weigh$ + visit$ / consultation / referral & consultation / assess$	2460	10/95	30/463	0/80
Pregnan$ / pregnancy / prenatal diagnosis / prenatal care / antenatal / antenatal care + weigh$ + visit$ / consultation / referral & consultation / assess$ + preeclampsia / blood pressure / hypertens$ / gestational hypertension	18/248			
Pregnan$ / pregnancy / prenatal diagnosis / prenatal care / antenatal / antenatal care + weigh$ + visit$ / consultation / referral & consultation / assess$ + macrosomia / fetal macrosomia	6/59			
Pregnan$ / pregnancy / prenatal diagnosis / prenatal care / antenatal / antenatal care + weigh$ + visit$ / consultation / referral & consultation / assess$ + fetal growth restriction / fetal growth retardation	16/151			
Pregnan$ / pregnancy / prenatal diagnosis / prenatal care / antenatal / antenatal care + weigh$ + visit$ / consultation / referral & consultation / assess$ + perception / satisfaction	15/49			
Pregnan$ / pregnancy / prenatal diagnosis / prenatal care / antenatal / antenatal care + BMI / body mass index / anthropometr$ + visit$ / consultation / referral & consultation / assess$	1132			

Pregnan$ / pregnancy / prenatal diagnosis / prenatal care / antenatal / antenatal care + BMI / body mass index / anthropometr$ + visit$ / consultation / referral & consultation / assess$ + preeclampsia / blood pressure / hypertens$ / gestational hypertension	7/74			
Pregnan$ / pregnancy / prenatal diagnosis / prenatal care / antenatal / antenatal care + BMI / body mass index / anthropometr$ + visit$ / consultation / referral & consultation / assess$ + macrosomia / fetal macrosomia	1/18			
Pregnan$ / pregnancy / prenatal diagnosis / prenatal care / antenatal / antenatal care + BMI / body mass index / anthropometr$ + visit$ / consultation / referral & consultation / assess$ + fetal growth restriction / fetal growth retardation	2/24			
Pregnan$ / pregnancy / prenatal diagnosis / prenatal care / antenatal / antenatal care + BMI / body mass index / anthropometr$ + visit$ / consultation / referral & consultation / assess$ + perception / satisfaction	1/20			

Cochrane

	Systematic Review	Central	DARE
Pregnan* / antenatal* / prenatal	1099	13563	398
Pregnan* / antenatal* / prenatal + weigh* (in abstract)	3/89	10/237	

Appendix II
Results of Initial Search

1. Weight gain in pregnancy: how much is too much? *Nutrition & the M D* Jun*;* 2001;27(6):4-5.

2. Share with women. Weight gain during pregnancy. *Journal of Midwifery & Women's Health* May-Jun; 48(3): 229-30 2003.

3. Maternal characteristics, obstetric practice, and increases in cesarean delivery. *ACOG Clinical Review* Mar-Apr; 9(2): 3-4 2004.

4. Abraham S. Obstetricians and maternal body weight and eating disorders during pregnancy. *Journal of Psychosomatic Obstetrics & Gynecology* 2001;22(3):159-63.

5. Abrams B, Altman SL, Pickett KE. Pregnancy weight gain: still controversial. *American Journal of Clinical Nutrition* 2000;71(5 Suppl):1233S-41S.

6. Adair LS. Dramatic rise in overweight and obesity in adult filipino women and risk of hypertension. *Obesity Research* 2004;12(8):1335-41.

7. Alam DS, Van Raaij JM, Hautvast JG, Yunus M, Fuchs GJ. Energy stress during pregnancy and lactation: consequences for maternal nutrition in rural Bangladesh. *European Journal of Clinical Nutrition* 2003;57(1):151-6.

8. Allan J. Naturalistic weight reduction efforts predicted weight gain and onset of obesity in adolescent girls. commentary on Stice E, Cameron RP, Killen JD et al. Naturalistic weight-reduction efforts prospectively predict growth in relative weight and onset of obesity among female adolescents. J CONSULT CLIN PSYCHOL 1999 Dec;67:967-74. *Evidence-Based Nursing Jul; 3(3): 88 (2 ref)* 2000.

9. Barton JR, O'Nan JM, Bergauer NK, Jacques DL, Sibai BM. Does a lean prepregnancy body mass index influence outcome in pregnancies complicated by mild preeclampsia remote from term? *Hypertension in Pregnancy* 2001;20(3):283-90.

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Appendix III
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Appendix IV
Key Citations

Levels of Evidence Ratings

I Evidence obtained from a systematic review of all relevant randomised controlled trials.

II Evidence obtained from at least one properly-designed randomised controlled trial.

III-1 Evidence obtained from well-designed pseudorandomised controlled trials (alternate allocation or some other method).

III-2 Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomised, cohort studies, case-control studies, or interrupted time series with a control group.

III-3 Evidence obtained from comparative studies with historical control, two or more single arm studies, or interrupted time series without a parallel control group.

IV Evidence obtained from case series, either post-test or pretest/post test.

Source: NHMRC (1999)

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13. Abrams B, Altman SL, Pickett KE. Pregnancy weight gain: still controversial. *American Journal of Clinical Nutrition* 2000;71(5 Suppl):1233S-41S. (Level IV)

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17. Warriner S. Women's issues. Women's views on being weighed during pregnancy. *British Journal of Midwifery* 8(10): 620-3 (16 ref) 2000. (Level IV)

2.1 Does weighing pregnant women at every visit compared to weighing women at selective visits or weighing not at all have an effect on detection of pre-eclampsia/hypertensive disorders, macrosomia, FGR, and maternal perceptions of the procedure?

Study	Ref.	Population	Intervention	Outcomes	Results	Study type	EL
Ehrenberg HM, Dierker L, et al. 2003	3	MetroHealth Medical Centre, Cleveland, Ohio, USA. January 1997 – June 2001 15,196 women who had live births ≥20 weeks gestation with complete baseline maternal clinical information and outcome data.	Weight prior pregnancy and weight at delivery.	Low maternal weight (LMW) <100 pounds or BMI ≤ 19.8 kg/m. Low maternal weight gain was defined as <0.27 kg per week. Perinatal complication rates in these subjects were compared with those with weights of 100 to 200 pounds, normal BMI (>19.8, <26 kg/m(2)), and normal gestational weight gain (0.27-0.52 kg/wk).	• 2.6% had pregravid LMW • 0.15% had LMW at delivery, and • 13.2% had a pregravid BMI < or =19.8 kg/m. • Pregravid LMW was highly correlated with ethnicity (Asians, 8.6%; Hispanics, 4.3%; Caucasians, 2.5%; African Americans, 1.9%; P<.001). Those women with pregravid LMW were at increased risk for: • Intrauterine growth restriction (IUGR) (relative risk [RR], 2.3, 95% CI, 1.3-4.05), • Perineal tears (3rd-degree lacerations; RR, 1.8, 95% CI, 1.1-2.9), • Low birth weight ([LBW] <2500 g; RR, 1.8, 95% CI, 1.1-2.9). Those women with pregravid LMW had a lower risk of: • Caesarean section (RR, 0.72, 95% CI, 0.56-0.92), and • Preterm birth (RR, 1.1, 95% CI, 0.97-1.06). Pregravid BMI <19.8 kg/m(2) was associated with: • Preterm labor (PTL) (RR, 1.22, 95% CI, 1.02-1.46) • IUGR (RR, 1.67, 95% CI, 1.2-2.39) • LBW (<2500 g; RR, 1.13, 95% CI, 1.0-1.27), and • Protective against caesarean section (RR, 0.8, 95% CI, 0.71-0.91). Delivery LMW was associated with: • LBW (<2500 g; RR, 2.81, 95% CI, 1.62-4.84) • Active-phase arrest (RR, 5.07, 95% CI, 1.85-13.9) • PTL and PTD (RR, 2.5, 95% CI, 1.02-6.33, and RR, 2.45, 95% CI, 1.4-4.4, respectively) • Lower gestational age at delivery (36.8 vs 38.3 wks, P<.05), and • Mediolateral episiotomy (RR, 9.6, 95% CI, 1.9-48.0). A percentage (0.8%) of subjects had BMI <19.8 kg/m(2) at delivery associated with: • Birth weight <2500 g (RR, 1.74, 95% CI, 1.3-2.32) • PTL (RR, 2.16, 95% CI, 1.45-3.19), and • PTD (RR, 1.57, 95% CI, 1.18-2.11). Failure to thrive in pregnancy (weight gain <0.27 kg/wk) was associated with: • LBW (<1500 g; RR, 1.23, 95% CI, 1.03-1.45) • <2500 g; RR, 1.22, 95% CI, 1.13-1.33), and • PTL and PTD (RR, 1.2, 95% CI, 1.05-1.37, and RR, 1.11, 95%	Retrospective cohort study	III-2

					CI, 1.02-1.2, respectively). Authors conclude that "low weight and BMI at conception or delivery, as well as poor weight gain during pregnancy, are associated with LBW, prematurity, and maternal delivery complications."		
Brown JE, Murtaugh MA et al 2001	4	Group Health Inc, Minneapolis, Minnesota, USA. 1989 - 1992 389 women planning a pregnancy until birth.	Maternal weight. Prepregnancy. Weekly throughout pregnancy.	Maternal weight gain.	Maternal weight gain in the first and second trimesters predicted newborn weight (1kg weight gain in the first trimester predicted a 31g increase in newborn weight, P < 0.0007, and 1-kg weight gain in the second trimester predicted a 26-g increase in newborn weight, P < 0.007), however third trimester weight gain did not. Newborn weight was 211g less (P < 0.006) and ponderal index 1.2 units less (P < 0.02) in infants born to women who lost weight in the first trimester. Authors conclude that the "use of measured prepregnancy weight in tests of the effect on newborn size of weight gain by time in pregnancy produces different results than does the use of recalled prepregnancy weight. Maternal weight change in the first trimester of pregnancy more strongly influences newborn size than does weight change in the second or third trimester."	Prospective cohort study	III-2
Dawson SI, Smith WCS et al 2003	5	Aberdeen Maternity and Neonatal Databank, Aberdeen, UK. 3593 women had their first viable singleton pregnancy between 1951 and 1970. Follow up in 1997.	First pregnancy: • Reproductive history • Weight • Height. Questionnaire in 1997.	Independent risk of reproductive factors and body weight for diabetes later in life.	• 1257 women eligible for analysis • 60 developed diabetes • BMI at index pregnancy and after 28-48 years follow-up were both significantly associated with risk of diabetes, this increased with greater weight gain. Authors conclude that parous women with a high BMI at index pregnancy, weight gain during follow-up and BMI in later life strongly predict the risk of developing diabetes.	Retrospective cohort study	III-2
Schieve LA, Cogswell ME et al 2000	6	National Maternal and Infant Health Survey, USA. 3511 mother infant pairs	Prepregnancy BMI. Pregnancy weight gain.	Risk of preterm birth.	• Women with low pregnancy weight gain were at increased risk of preterm delivery. • The prepregnancy BMI influenced the magnitude of risk. • Following exclusions and adjustments for confounders, ORs, and 95% confidence intervals (CI) for low pregnancy weight gain were 6.7 (1.1, 40.6) for underweight women, 3.6 (1.6, 8.0) for average-weight women, and 1.6 (0.7, 3.5) for overweight women	Prospective cohort study	III-2

					compared with average-weight women with average pregnancy weight gain. Authors conclude that low weight gain in pregnancy was associated with increased risk of preterm birth, particularly if women were underweight or of average weight before pregnancy.		
Murakami M, Ohmichi M et al 2005	7	Yamagata Prefectural Nihonkai Hospital, Sakata, Japan. 633 women who gave birth to live singleton babies between 24 and 42 weeks gestation during 2001 in	Maternal prepregnancy BMI and weight gain during pregnancy.	Maternal and neonatal perinatal morbidity.	Women identified as obese before pregnancy had significantly elevated risks of caesarean delivery, preeclampsia, and gestational diabetes compared with the normal group. Women who were underweight before pregnancy had elevated risks of low birth weight infant and hospitalization of infant. Authors conclude weight gain during pregnancy did not show any significant influence on the perinatal outcomes of the mother or infant.	Retrospective cohort study	III-2
Neufeld LM, Haas JD et al 2004	8	Rural Guatemalan villages, South America. August 1996 – June 1999 All pregnant women between 19 and 34 years living in 4 rural villages in eastern Guatemala	Maternal weight four times during pregnancy. Two ultrasound examinations.	Linear growth of the fetus.	• The maternal weight gain from first to second trimester was found to be associated with fetal femur and tibia lengths measured at both means of 17 and 30 wk ($P < 0.05$) and infant length at birth ($P < 0.001$). • The maternal weight gain from the second to the third trimester of pregnancy did not predict fetal linear growth or infant length at birth. Authors conclude that maternal weight gain from the first to the second trimester of pregnancy is strongly associated with fetal growth. Therefore, the mid-gestation may be a sensitive period for fetal linear growth.	Prospective cohort study	III-2
Lepercq J, Hauguel-DeMouzon S et al 2002	9	Cochin Saint Vincent de Paul Hospital, Paris, France and MetroHealth Medical Centre, Cleveland, Ohio, USA. Pregnant women	'Corrected maternal weight gain' (calculated as: maternal body weight at the last prenatal visit – [pregravid body weight + birth weight + placental	Neonatal birth weight.	• In the type 1 diabetes group there was no significant difference between mothers of macrosomic and non macrosomic infants concerning age, parity, duration of diabetes. • In the gestational diabetes group, there was no significant difference in the incidence of macrosomia between the mothers who required insulin therapy versus diet alone • In the GDM group, there was significantly less maternal weight gain as compared with control patients. Differences in weight gain and corrected weight gain were not significant in women who delivered macrosomic infants. Pre gravid BMI was greater in	Prospective cohort study	III-2

		with diabetes.	weight]).		women with GDM compared to other groups. • Weight gain was greater in mothers who delivered macrosomic infants, but the difference was no longer significant when using corrected weight gain suggesting that maternal weight gain during pregnancy has limited effects on fetal size. • In non obese normal glucose tolerant women, maternal weight gain is not a major determinant of birth weight. The same conclusions can be drawn in type1 diabetic women. In GDM women, weight gain was smaller than in control patients, primarily because of greater pregravid BMI, and did not correlate with birth weight. • In lean GDM women, weight gain was smaller than in control patients, primarily because of greater pregravid BMI, and did not correlate with birth weight. • In lean GDM women, weight gain was not significantly greater in mothers of macrosomic infants. In women with GDM, no significant correlation has been observed between maternal weight gain and birth weight, irrespective of maternal pregravid BMI.		
Stephansson O, Dickman PW et al 2000	10	Central Sweden data from the Swedish Medical Birth Register, Sweden. 1987 to 1996 649 women who had an antepartum stillbirth.	BMI Average weekly weight.	Antepartum fetal death.	When compared with lean mothers (body mass index < or = 19.9 kg/m2), the odds ratios for risk of antepartum deaths were as follows: • Normal weight (body mass index, 20.0-24.9 kg/m2) odds ratio, 1.2 (95% confidence interval, 0.8-1.7); • Overweight (body mass index 25.0-29.9 kg/m2), odds ratio, 1.9 (95% confidence interval, 1.2-2.9); and • Obese (body mass index > or = 30.0 kg/m2) odds ratio, 2.1 (95% confidence interval, 1.2-3.6). Corresponding risks were even higher for term antepartum death, with odds ratios of: • 1.6 (95% confidence interval, 0.9-2.6) for normal weight, • 2.7 (95% confidence interval, 1.5-5.0) for overweight, and • 2.8 (95% confidence interval, 1.3-6.0) for obese women. Maternal weight gain during pregnancy was not associated with risk of antepartum stillbirth. Authors conclude that maternal overweight condition increased the risk of antepartum stillbirth, especially term antepartum stillbirth, whereas weight gain during pregnancy was not associated with risk.	Case control study	III-2

Catalano PM and Kirwan JP 2001	11		Maternal height, pregravid weight, weight gain during pregnancy, education, parity, paternal height and weight, neonatal sex, and gestational age.	• Nutritional deprivation in early gestation was associated with a higher rate of prematurity and very low birth weight, whereas deprivation in late gestation was associated with a 9% lower fetal weight but not length. • There was a progressively stronger correlation between maternal weight gain and birth weight in moderately overweight, ideal body weight and underweight women. • In women greater than 135% of weight for height before conception there was no correlation between weight gain during pregnancy and birth weight. • The strongest predictor of birth weight was gestational age, followed by maternal weight gain, pregravid weight, neonatal gender, and parity. Collectively, these variables explained 29% of the variance in birth weight. Reviewers found there was a positive correlation between weight gain and birth weight in control subjects but a negative correlation in subjects with gestational diabetes mellitus.	Review	IV
Honest H, Bachmann LM et al 2005	12	Antenatal maternal anthropometric measurements.	Spontaneous preterm birth.	Eight accuracy articles that met the selection criteria, which included a total of 122,647 asymptomatic women: • 6 studies on pre-pregnancy weight • 5 measured the body mass index (BMI) and one used an arbitrary measure. • 4 studies on the adequacy of pregnancy weight gain • 2 studies on maternal height as a predictor for the risk of preterm birth • 1 article contributed three studies, while two articles provided two studies each. • There was heterogeneity in the accuracy results of pre-pregnancy BMI but not in the adequacy of weight gain. • All three maternal anthropometric features were poor predictors of preterm labour. • Pre-pregnancy BMI is a poor predictor of preterm birth (LR+ that ranged from 0.96 (95% confidence interval (CI) 0.66-1.40) to 1.75 (95% CI 1.33-2.31)) as are the adequacy of pregnancy weight gain (summary LR+ of 1.81, 95% CI 1.45-2.30) and short maternal height (LR+ of 1.79 (95% CI 1.27-2.52). Authors conclude that routine antenatal maternal anthropometric measurements are not useful in predicting the risk of preterm birth (before 37 weeks' gestation).	Review	IV

Abrams B, Altman S et al 2000	13	IOM's weight gain recommendations.	Fetal and maternal outcomes.	• IOM recommend a gain of 11.5-16kg for pregnant women who start pregnancy with a normal prepregnant BMI (i.e. 19.8-26) • Studies showed that pregnancy weight gain within the IOM's recommended ranges is associated with the best outcome for both mothers and infants • Weight gain in most pregnant women is not within the IOM range. Preterm birth • There is some evidence that low rate of pregnancy weight gain was associated with preterm birth. • After control of risk factors, women with a low rate of weight gain during the third trimester had a statistically significantly higher risk of spontaneous preterm delivery • 11 of the 13 methodologically sound studies published between 1980 and 1996 showed an association between a low rate of pregnancy weight gain and an increased risk of preterm birth. Fetal growth • Too little weight gain is associated with reduced fetal growth or small for gestational age infants • Excessive maternal weight gain is associated with large infants • Steady decrease in the incidence of low birth weight as mean pregnancy weight gain increases. • One study provided evidence that the incidence of high birth weight, (>4500g) did not dramatically increase until pregnancy weight gains exceeded 16kg. • Another study demonstrated the incidence of macrosomia and caesarean section increased with increasing maternal weight gains, but not statistically significant until the weight gain exceeded 16kg.	Systematic Review	IV
Lederman SA 2001	14	Pregnancy weight gain.	Later maternal weight. Labor and delivery.	• Birth-weight rises with increased pregnancy weight gain • Perinatal and neonatal mortality fall as birthweight increases in both preterm and term infants. • Lowest mortality is observed at 3500 to 4500 g in infants of white women. • Infants termed "macrosomic" include infants of the lowest mortality rate. Thus, restricting weight gain may be detrimental to the baby. • Weight gain that is optimal for the mother and the baby differs according to the mother's prepregnancy weight. Pregnancy weight gain exceeding current recommendations is associated with increases in maternal fat gain, pregnancy complications, and delivery problems and should be discouraged.	Review	IV

Pinheiro A, David A, et al 2001	15	Community Health Centre, near Bangalore, India. ~2000 antenatal records between 1986-1999.	Audit	Pregnancy weight gain = weight at term – weight at the end of 12 weeks gestation.	• Second trimester weight gain significantly correlated to the birth weight. • Other factors that were found to significantly affect the birth weight were regular antenatal check ups, parity and maternal age. • Inadequate maternal weight gain during second trimester is associated with poor fetal growth and lower birth weight	Case series	IV
Marsoosi V, Jamal A et al 2004	16	University Hospital, Tehran, Iran. 2001-2003 2163 antenatal women.	Prepregnancy weight. Pregnancy weight gain.	Preterm birth.	• Pregnancy weight gain was found to be inversely related to pre-pregnancy BMI. • The risk of preterm delivery was 7.72% among women who had an average BMI before pregnancy and an average rate of weight gain during pregnancy compared with that group. • The risk of preterm delivery was markedly higher for two groups: women with average pre-pregnancy BMI and low weight gain (17.14% preterm risk), and women with low pre-pregnancy BMI and high weight gain (14.29%). • Lower risk (5%) was noted for women with a high BMI and high weight gain. • The odds of preterm delivery for those groups were more than twice and about 2.47 times higher than that of the reference group.	Retrospective audit	IV
Warriner S 2000	17	Stoke Mandeville Hospital, UK. Antenatal women	Weighing during pregnancy.	Attitudes toward weight, practicalities of being weighed and impact on eating habits, body image and self esteem.	Convenience sample of 10 women and focus group of 6 women identified: • Regular and routine weighing throughout their pregnancies, although none of the three maternity units used reported routine weighing as policy. • Very little or no information was made available to them on the reasons why weighing formed part of their antenatal care. Authors conclude that through weighing women, health professionals endorse many women's perceptions of its importance, adding to concerns over body weight and image.	Qualitative analysis	IV