Author's response to reviews

Title: Do parental heights influence pregnancy length?: A Population-based prospective study, HUNT 2

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Author's response to reviews: see over
COVER LETTER to BMC Pregnancy and Childbirth

Dear Editor,

Please find a revised version of the Manuscript 8436058217961360, entitled "Do parental heights influence pregnancy length? A population-based prospective study, HUNT 2. In this revision we have taken into account the comments made by the reviewers. We would like to express our sincere gratitude for relevant and precise comments and for the opportunity to improve the readability and quality of our manuscript. Please note that the changes made in the revised version of the manuscript are indicated with yellow high-lighting ("Revised manuscript, including abstract and tables, changes highlighted") and attached at the end of this cover-letter. A revised manuscript version without high-lighting of the changes is uploaded to BMC pregnancy and Childbirth ("Revised abstract, manuscript and tables").

We hope that we have addressed the comments to your satisfaction, and that the manuscript now is acceptable for publication.

Reviewer's report 1

Title: Do parental heights influence pregnancy length?: A Population-based prospective study, HUNT 2

Version: 1 Date: 16 November 2012

Reviewer 1: Alkistis Skalkidou

Reviewer's report:

Comments
The authors use data from a population-based study in Norway (HUNT2) linked with Register data in order to examine the association of parental height with pregnancy length and risk for pre- and post-term pregnancy.

**Major Compulsory Revisions**

**Abstract**

1. **The sentence in the Results**

**Reviewer’s comment:**

“Shorter women …. had higher risk of pre-term delivery” is not entirely correct, as the p-value for the association when EDD is based on LMP is 0.32.

**Answer:**

This statement has been corrected in the revised abstract; line 19 and line 22, and in the discussion section, page17,line 8.

2. **Reviewer’s comment:**

I believe that the adjustment for cardiovascular risk factors in the analyses must be stressed in the abstract, for it is this which is unique about the study design.

**Answer:**

We agree. The adjustment for cardiovascular risk has now been thoroughly described throughout the revised abstract; see highlighted text.

**Introduction**

3. **Reviewer’s comment:**
The authors state that fetal growth has been shown to influence pregnancy length, but do not later do not adjust for it in the analyses, nor do they comment on the possible ways to do that.

**Answer:**

Access to longitudinal ultrasound data would have given us an opportunity to assess whether fetal growth influence pregnancy length. Birth weight (as a proxy for fetal growth) could be a mediator and a common consequence of maternal height and gestational age, but is less likely a confounder. Therefore, adjustment for birth weight would probably introduce a bias of the association between maternal height and gestational length and we decided not to perform analyses adjusted for birth weight. This is now described in the revised manuscript on page 8 (statistical methods) and on page 15 (discussion).

**4. Reviewer’s comment:**

The second paragraph introduces the hypothesis that unfavorable cardiovascular risk factors might underlie a possible association between maternal height and pregnancy length. In the analyses, later, the authors adjust for such factors in the third model used. Has the possibility of an interaction between height and cardiovascular profile been considered? Have you considered analyzing using a multi-level approach or path analysis?

**Answer:**

We have now assessed possible interactions between height and cardiovascular risk profiles by studying inclusion of interaction terms between maternal height and systolic blood pressure, BMI, glucose, lipids and pregestational cardiovascular disease. We did not find indication of substantial interaction between height and cardiovascular risk profile of the mother. This is now described on page 9 (statistical section) on page 11 (results section), and on page 16 (discussion) in the revised manuscript.
We considered using mixed models in our analyses. This provided similar results as using the cluster option in STATA and we chose to use the cluster option to account for the fact that some pregnancies are parented by the same parents. See page 7 (statistical methods).

5. Reviewer`s comment:
The authors might want to check the exact positioning of the references, for example reference nr 6.

Answer:
Thank you for this comment. This reference (6) refer to an original study, but do not describe the original study in detail or leave a reference of this, and has been omitted from the revised manuscript.

Methods

6. Reviewer`s comment:
It is understandable that the HUNT2 study participation rates and results are presented elsewhere. What the reader does need to know, on the other side, is whether a non-response analysis was made (participation rate at 70%) and in that case, if there is something that would bias the results in this sub-study.

Answer:
A follow up study of 685 (2.5 %) of the non-participants of HUNT 2 was performed to assess whether the participants are representative for the source population. We have now added this information on page 13 (discussion) in the revised manuscript.

7. Reviewer`s comment:
On page 5, the authors state that “… singleton births were recorded” and then “Among these births, 1022 were excluded either due to multiple pregnancies (n=252)…” Do the authors mean that there were 252 multiple pregnancies that resulted in singleton births?

**Answer:**

We are sorry for this mistake. The word *singleton* should not have been included, and has been omitted in the revised manuscript; page 7, line 3.

**8. Reviewer’s comment:** The authors present multivariate analyses results both for all births as well as only for spontaneous deliveries only what pregnancy length is concerned. It would be very useful for the readers to also see results for spontaneous deliveries for pre- and post-term pregnancy risk. Bearing in mind that clinical routines influence inductions, and thereafter rates of post-term deliveries, as well as the lack of statistical significance in the association between maternal height and risk of pre-term delivery when LPM is used, the reader is lacking this separate analysis. Please include it.

**Answer:**

We have included analyses of risks of spontaneous pre- and post-term births according to maternal height in *revised table 7*. The results are described on page 11 (results) in the revised manuscript. Additionally, to be consistent, we made a minor change to table 4: Only induced births (medically induced and by caesarian sections) were excluded from the analyses. Previously both induced births and pregnancy complications (SGA, preeclampsia and stillbirths) were excluded from the analyses. In the revised manuscript *table 4* shows associations of maternal height with pregnancy length restricted to spontaneous births, similarly *table 7* shows associations of maternal height with risk of pre-and post-term births restricted to spontaneous births. The additional exclusion of pregnancy complications (SGA,
preeclampsia, and stillbirth) has been commented separately on page 8 (statistical methods), and on page 11 (results) in the revised manuscript.

9. Reviewer’s comment:
As far as the possible confounders that were adjusted for in the models, could the authors provide an explanation about the lack of including spontaneous onset of delivery in Model 2? The authors might have thought about stratifying, like they did in Table 4. But this should be clearly stated. Short women were shown to have a higher rate of elective caesarean delivery. Could the authors comment on this and why this could be a possible confounder or effect modifier?

Answer:
Spontaneous onset of delivery/induced onset of delivery have been regarded to be a possible intermediate factor of the association between maternal height and pregnancy length, and less likely a confounder. We therefore did separate analyses restricted to spontaneous deliveries instead of adjustments (table 4 and 7). This is now more clearly stated on page 8 (statistical methods) in the revised manuscript.

All elective caesarian sections were included in the term “induced onset of labour by caesarian section”, regarded to be intermediate factors of the association between maternal height and pregnancy length, and handled by stratification as described above (Page 8, statistical methods). Description of elective sections are additionally expanded on page 6 (methods), 10(results), and page 16 (discussion).

10. Reviewer’s comment:
No information is provided about the extra tables, additional tables 1 and 2. Why are these analyses performed and what do they contribute to the results? Please expand.
**Answer:**

Additional file 1: We have removed the table in additional file 1, and left the comment of the sensitivity analysis on page 13 (discussion) unchanged in the revised manuscript.

Additional file 2 has been changed to additional file 1. In the revised manuscript we have expanded the description of the additional file on page 8 (statistical methods) and on page 11 (results) and on page 15 (discussion) to clarify why the analyses were performed.

**11. Reviewer’s comment:**

Table 2. The authors did not comment on how they chose 163 cm as a cut-off point.

**Answer:**

The categorization of maternal height was based on quintiles. The first quintile was defined by a cut off value of 163 cm. We have made a new table 2 in the revised manuscript in which pregnancy characteristics are stratified by all the quintiles of maternal height instead of the previous stratification by the upper value of the lowest quintile (163 cm). This was done to stress that evaluation of trends across quintiles could give other information than selecting the lower height quintile as a “high-risk” reference group.

We have also changed the text on page 9 (results) in accordance with the new table 2.

**12. Reviewer’s comment:**

Table 2. The readers could benefit from a measure of statistical significance of the presented associations (no information on p-value and statistical tests used when the authors discuss the results).

**Answer:**

P-values are now presented in the new table 2; as p-values for trend over maternal height quintiles. See above.
13. Reviewer’s comment:

The description of some Table 2 results is misleading. Short mothers do not have a higher rate of medically induced deliveries, but do not have higher rates of elective and acute caesarean deliveries. Please rephrase.

This difference in rates of elective caesarean deliveries has not at all been discussed and considered in the following analyses, despite the fact that it affects rates of post-term deliveries and pregnancy length (please describe guidelines for planning of elective caesarean deliveries in Norway during the study period. At week 38 or 39 ?) Please discuss in the discussion the possible reasons for this association. Was it more due to humanitarian reasons (anxiety for vaginal delivery, depression?) Mothers with depression are reported to have shorter duration of gestation and are at risk for pre-term labor. Does the author have such information in the HUNT 2 data that they can include as a confounder?

Answer

The misleading description in table 2 is rephrased in the description of the revised table 2 in the result section, see comment 11 above.

Elective caesarian sections are defined as caesarian sections planned and performed more than 8 hours prior to the operation. All elective caesarian sections are included in the group “onset of labour by caesarian section” and we did separate analyses of births with spontaneous onset of labour (eg. excluding all elective caesarian sections + acute caesarian sections before onset of labour + medically induced births).

This has been clarified in the revised manuscript on page 6 (methods), page108 results), footnotes of Table 2, and on page 15 (discussion).

The recommendation for performing elective caesarian sections in Norway during the study period was around 38 gestational weeks (ultrasound-based). Unfortunately, data on
indications for the elective caesarian sections are insufficient in the Medical Birth Registry of Norway. Still, a study from Norway reported that the main indication for elective caesarian section in Norway in the period of 1998-1999 was previous caesarian section and maternal request (Kolaas T, AJOG 2003- see reference in the revised manuscript), and from other studies (E. Scheiner et al- see reference in the manuscript) we know that shorter women have increased risk of acute caesarian section and other pregnancy and labour complications. About 85% of the women delivered by elective caesarian section were multipara women in our data material. Thus, the reason for the higher frequency of elective caesarian sections in shorter women could be a higher frequency of previous caesarian sections and traumatic labour experiences resulting in a maternal request or a medical recommendation of an elective CS.

This is commented in the revised manuscript on page 6 (methods) and on page 16 (discussion).

14. Reviewer’s comment:

The definition of SGA involves the use of duration of gestation as this is calculated from the EDD derived from US examination. The authors very well describe possible problems arising from the introduction of systematic misclassification of gestational length from US examination, but do not do so in the case of SGA. Please expand even here. How this bias influence could rates of SGA in short vs long mothers?

Answer: SGA was defined as z-score of birth weight below the 2.5th percentile adjusted for gestational age and sex. The z-scores used are estimated from data in the Norwegian Medical Birth registry from 1967 to 1998 and gestational age is LMP-derived. This information is now added on page 6, line 12 (methods).
15. Reviewer’s comment:
Table 6 analyses should be repeated for deliveries after spontaneous onset of labour, both because of the higher rate of elective cesareans among short women, and because of the systematic misclassification due to US guided definition of gestational duration. The fact that clinical induction protocols are based on the US derived EDD leads to biased definition of post-term pregnancies. The inclusion of just spontaneous deliveries could partly help overcoming this.

Answer
We agree. Table 7 in the revised manuscript shows analyses of deliveries restricted to spontaneous onset of labour, See comment 8 above.

16. Reviewer’s comment:
Another possible strategy which might help eliminating the systematic misclassification caused by US determination of EDD is analyzing just those pregnancies without mismatch between the US derived EDD and the LPM derived EDD (ie, +2 days).

Answer
As you suggested we restricted the analyses associations of maternal height with gestational length to pregnancies with similar US and LMP –derived EDD (n=1310), and unexpectedly found that the associations became stronger; the difference between shortest and highest maternal height group was now 5.7 days (95 % CI = 3.4, 8.1).

17. Reviewer’s comment:
The readers might benefit more if the plausible explanation between the observed results between LPM and US derived EDD were presented directly after the first discussion in the paragraph (now included as paragraph nr 4 AND Implications of these findings). Much of the
information included under “implication of these findings” should be changed to the
beginning of the discussion, along with information on the misclassification issue in
paragraph nr4. A Swedish study by Skalkidou et al, Epidemiology 2010 is discussed (“A large
population based study in Sweden reported that to replace LMP…. Pg 13”) but not included
in the references.

**Answer**

We appreciate this suggestion and have now moved the text as advised, please see the
discussion section of the revised manuscript.

We apologize for the mistake of losing this important reference from the manuscript. This has
now been corrected in the revised manuscript on page 14 (discussion), reference 38.

**18. Reviewer’s comment:**

The difference in gestational length based on LMP derived data is no more than 2 days. This
is being discussed in paragraph nr 5. According to LMP, there was no difference in rates of
pre-term births. Could the authors discuss other possible bias in their findings i.e. could it be
that shorter women have shorter/longer cycles or irregular cycles which is not being
considered when determining EDD by LMP and Naegel’s rule and could explain this 2-day
difference?

**Answer**

In separate analyses, we adjusted the association of maternal height with pregnancy length for
irregular cycles without finding any substantial changes to the results. This point has been
added to the revised manuscript on page 13 (discussion).

**19. Reviewer’s comment:**
The sentence on pg 10 “Both methods have limitations, but the fact that robust positive associations were obtained by both methods” is not true when considering pre-term deliveries by LMP in Table 6. The same might be true if the analyses are repeated on for spontaneous onset. Please rephrase.

**Answer**

We agree. The sentence has been excluded and replaced by another (page 13, line 19) in the discussion section of the revised manuscript.

**20. Reviewer`s comment:**

Bearing in mind the above mentioned bias introduced by the US examination, which the authors explain in the discussion, the reader might expect the other studies discussed to be presented in the light of clinical routines around EDD in the country-time period performed. How was the EDD determined in each of those studies?

**Answer:**

See comment 5. We have removed reference no 6 and descriptions of that study in the text. The other studies discussed, include information of whether EDD was estimated by ultrasound or LMP at the time of study, see page 10 (discussion).

**21. Reviewer`s comment:**

When discussing the parental contribution in pregnancy length, the authors might want to consider including references on correlates of intrauterine growth, which affects gestational length and is affected much more by maternal IGF levels, while growth after delivery is affected also by paternal genes.

**Answer:**
Unfortunately, we have not been able to find references on correlates of intrauterine growth which affect gestational length and at the same time disentangle maternal and paternal (fetal) contribution to gestational length. We are, however, uncertain about whether we have interpreted the reviewer’s comment correctly.

**Minor Essential Revisions**

**Reviewer’s comment:**

The use of the English language could be improved. For example, on pg. 13 “the rate of post-term pregnancies was reduced more among short women….” or on pg. 10 “LMP method is limited by uncertain maternal memory….”, pg. 9 “associations with pregnancy length for unfavorable pre-pregnancy levels of common cardiovascular risk factors….”

**Answer**

These sentences, as well as others, have hopefully been improved in the revised manuscript.

**Discretionary Revisions**

The authors use this study design combining data from the HUNT2 study and the MBR in order to control for metabolic and other known risk factors on an individual basis. Otherwise, a more plausible design would be to use population-based data from MBR. I would suggest that the authors stress this in their work.

**Answer:**

Unfortunately there is no data on maternal height in the medical birth registry of Norway. The benefits of combining HUNT data with data from MFR have been stressed more clearly in the revised manuscript on page 13 (discussion).
Discretionary Revisions

One usually sets the group considered as “normal” or “not as risk” as the Reference category. In this study, short women, they ones considered at risk, are presented as the Reference category. The authors might want to consider this.

Answer

We agree, and have now tried to be more precise in describing trends across quintiles, rather than comparing maternal quintile height groups with the shortest mothers as a “reference” group. See page 7 (statistical methods), results describing revised table 2 and the answers to comment 11 and 12 above.

Level of interest: An article of importance in its field

Quality of written English: Needs some language corrections before being published

Statistical review: Yes, and I have assessed the statistics in my report.

Declaration of competing interests:

I declare that I have no competing interests

Reviewer's report 2

Title: Do parental heights influence pregnancy length?: A Population-based prospective study, HUNT 2

Version: 1 Date: 18 October 2012

Reviewer: Ida Kirkegaard
Reviewer's report:

This manuscript is a comprehensive evaluation of the influence of maternal and paternal height on pregnancy length and the risk of pre- and post-term pregnancies. The study uses data from another population-based study (HUNT 2 study), and data from the Medical Birth Registry in Norway, and included 5010 pregnancies, provided by 3497 women, and 2798 pregnancies provided by 2005 men. They find a significant positive association between maternal height and pregnancy length, an increased risk of preterm delivery in short women and an increased risk of post-term pregnancies in taller women, whereas no association between paternal height and pregnancy length was found. The analyses are adequately adjusted for potential confounders, and have additionally provided analyses according to whether pregnancy was dated by LMP or ultrasound, and according to whether there was a spontaneous onset of labor, or if labor was induced.

It is a very important topic and indeed a well-done study. I applaud the authors for their data collection and the thoroughly analyses.

The manuscript certainly deserves publication and I only have very few concerns.

Discretionary revisions:

1. **Background, Paragraph 2:**

Please describe what you mean by unfavorable cardiovascular risk profile.

**Answer:** In the revised manuscript we have described unfavorable common cardiovascular risk factors more clearly on page 3, line 19 (background).

2. **Paragraph 4:** Why have you chosen not to investigate the cardiovascular risk profile in pregnant women in association with pregnancy length and maternal height? It would be
interesting to explore whether the short women delivering preterm had unfavorable cardiovascular risk profiles.

**Answer:** We agree. See answer to comment 4 of reviewer 1 above.

**3. Methods:**

Paragraph 2: What was the primary aim of the HUNT study? Do you have any information about non-participants?

**Answer:**

The primary aim of the HUNT Study was to survey current public health issues like cardiovascular disease, diabetes, obstructive lung disease, osteoporosis and mental health. However, additional scientific questions were presented by different research groups and resulted in a comprehensive health study covering a wide range of topics. The primary aim of the study has now been described on, page 4 (methods) in the revised manuscript.

A study among non-participants in HUNT 2 has been done, see answer above to comment 6 by reviewer 1.

**4. Discussion:**

The finding that taller women had higher odds of post-term pregnancies may be due to the fact that taller women have more 'healthy' pregnancies, and are thus not induced earlier because of pregnancy complications, such as FGR and preeclampsia, meaning that it is not their height per se, but the healthy pregnancy, that causes the post-term pregnancy. The same accounts for the short women and preterm deliveries. Please comment on that.
**Answer**

We agree. This is commented in the discussion on page 16 and 17 (discussion) in the revised manuscript.

5. Discussion

Regarding the discussion about BPD and underestimation of gestational age for short women and the implications of the findings, I figured if you had access to a first trimester CRL measurement in some of the women? It would be interesting to compare the associations using second trimester BPD vs with first trimester CRL. In many countries pregnancies are now dated in the first trimester, how would you expect first trimester dating to influence the results?

**Answer:**

Unfortunately, we do not have first trimester CRL measurements of any of the women registered in MBR of Norway.

Most likely first trimester US would be less biased by fetal growth and maternal height than early second trimester ultrasound. Thus, we expect that first trimester dating may have resulted in attenuation of the second trimester US-based associations of maternal height with pregnancy length.
Do parental heights influence pregnancy length?
: A Population-based prospective study, HUNT 2

Abstract

Background: The objective of this study was to examine the association of maternal and paternal height with pregnancy length, and with the risk of pre- and post-term birth. In addition we aimed to study whether cardiovascular risk factors could explain possible associations.

Methods: Parents who participated in the Nord-Trøndelag Health Study (HUNT 2; 1995-1997) were linked to offspring data from the Medical Birth Registry of Norway (1997-2005). The main analyses included 3497 women who had delivered 5010 children, and 2005 men who had fathered 2798 pregnancies. All births took place after parental participation in HUNT 2. Linear regression was used to estimate crude and adjusted differences in pregnancy length according to parental heights. Logistic regression was used to estimate crude and adjusted associations of parental heights with the risk of pre- and post-term births.

Results: We found a gradual increase in pregnancy length by increasing maternal height, and the association was essentially unchanged after adjustment for maternal cardiovascular risk factors, parental age, offspring sex, parity, and socioeconomic measures. When estimated date of delivery was based on ultrasound, the difference between mothers in the lower height
quintile (<163 cm cm) and mothers in the upper height quintile (≥ 173 cm) was 4.3 days, and when estimated date of delivery was based on last menstrual period (LMP), the difference was 2.8 days. Shorter women (< 163 cm) had lower risk of post-term births, and when estimated date of delivery was based on ultrasound they also had higher risk of pre-term births. Paternal height was not associated with pregnancy length, or risks of pre- and post-term births.

Conclusions: Women with shorter stature had shorter pregnancy length and lower risk of post-term births than taller women, and when EDD was based on ultrasound, they also had higher risk of preterm births. The effect of maternal height was generally stronger when pregnancy length was based on second trimester ultrasound rather than last menstrual period. The association of maternal height with pregnancy length could not be explained by cardiovascular risk factors. Paternal height was not associated with pregnancy length or with the risk of pre- and post-term birth.

Keywords:
Cardiovascular risk factors, maternal height, paternal height, pregnancy length, pre-term birth.

Background
The mechanisms that trigger onset of delivery and determine pregnancy length are poorly understood. Offspring sex, fetal growth, parity, and genetic factors may influence biological variation of pregnancy length, and various obstetric complications, including maternal and fetal disease may shorten length of pregnancy [1-4]. It is not clear if maternal height is a determinant of the length of pregnancy, and studies of maternal height and pregnancy length have shown conflicting results [5, 6].
 Nonetheless, it has been suggested that women of short stature are at increased risk of preterm births and other pregnancy complications that may shorten pregnancy length [5, 7-13]. Short women are also at increased risk of cardiovascular disease later in life, and an unfavorable cardiovascular risk profile prior to pregnancy (increased blood pressure and body mass index (BMI), and unfavorable serum lipids and glucose) have been associated with increased risk of preterm birth, low offspring birth weight and preeclampsia [14-17]. Thus, factors associated with cardiovascular risk may underlie a possible association between maternal height and pregnancy length.

Among men, short stature is also associated with increased risk of cardiovascular disease [17], but in contrast to the risk among women [14], it is not known whether unfavorable and common paternal cardiovascular risk factors may influence length of the fathered pregnancy. Neither is it known whether paternal height per se is associated with length of pregnancy. Still, results of large intergenerational studies suggest that paternal factors may contribute to the variation in pregnancy length [1, 2, 18, 19].

Therefore, the main aims of this study were to assess maternal and paternal height in relation to pregnancy length, and to examine whether parental height is associated with risk for pre- or post-term birth. We have also assessed whether any association of parental height could be attributed to cardiovascular risk factors, and whether common paternal cardiovascular risk factors, including blood pressure, BMI, serum glucose and lipids, are associated with pregnancy length.

**Methods**

Data on parental height and cardiovascular risk factors were retrieved from the second wave of a large population based study in Norway (HUNT 2) that was conducted between 1995 and
1997. By individual linkage to the Medical Birth Registry of Norway, we identified all births that occurred between 1997 and 2005 and had been parented by participants in the HUNT 2 Study.

The primary aim of the HUNT 2 Study was related to studies of major public health issues, such as cardiovascular disease, diabetes, obstructive lung disease, osteoporosis and mental health. The HUNT 2 Study has been described in detail elsewhere [20]. Briefly, all residents of Nord-Trøndelag County 20 years or older were invited, and 66,140 of the 94,194 eligible adults (71%) attended the study, that included a clinical examination carried out by specially trained nurses and technicians. Standardized measurements of height, weight, waist circumference, blood pressure, and non-fasting serum lipids and glucose were performed. Additionally, the participants responded to a comprehensive medical and lifestyle-related questionnaire.

Body height was measured to the nearest 1.0 cm and weight to the nearest 0.5 kg. Body-mass index (BMI) was calculated as weight in kilograms (kg) divided by the squared value of height in meters (m²). Blood pressure measurements were repeated three times with one minute intervals and measured by an automatic oscillometric method (Dinamap 845 XT; Critikon, Tampa, Florida). The mean of the second and third measurements was recorded and cuff size was adjusted to arm circumference. Venous blood sampling was done non-fasting at attendance, but with the registration of time since last meal. Serum lipids were analyzed on a Hitachi 911 Auto analyzer (Hitachi, Mito, Japan) with reagents from Boehringer Mannheim (Mannheim, Germany). Total cholesterol and HDL cholesterol were measured by an enzymatic colorimetric cholesterol esterase method, and HDL cholesterol was measured after precipitation with phosphotungsten and magnesium ions. Triglycerides were also measured with an enzymatic colorimetric method, and glucose was measured by an enzymatic hexokinase method.
All live- and stillbirth after 16 weeks of gestation are compulsory notified to the Medical Birth Registry (MBR) of Norway. The registration is based on a standardized form completed by midwives or doctors at the delivery units, and contains information related to maternal health before and during pregnancy, complications of pregnancy and delivery and perinatal data of the newborn.

Last menstrual period (LMP) was used to estimate expected date of delivery (EDD) from 1967 until ultrasound (US) became the national standard dating method in 1999. LMP has still been recorded for all women after 1999 and is used to estimate ultrasound data is missing. In the current study, LMP was available for nearly all births and ultrasound data was available for more than 80% of the births.

In Norway, one routine ultrasound examination is offered to all pregnant women between 17-19 weeks of gestation, and the offer accepted by more than 98% of the women [21]. In 1997-2005 EDD was based on measurement of the outer-outer border of fetal biparietal diameter (BPD). Preterm deliveries were defined as occurring before 259 days (< 37 +0 weeks) of gestation, and post-term pregnancies as lasting 294 days or more (≥ 42 +0 weeks). The proportion of post-term pregnancies will be influenced by hospital guidelines for induction of labor. During the study period, the Norwegian official guidelines recommended assessment of all pregnancies at 296 days (42+2 weeks). Women at high risk of complications were offered induction of labor, whereas low-risk women were subject to expectant management until spontaneous delivery or induction at 43 +0 weeks.

We calculated z-scores of birth weight according to sex and gestational age, using estimated standards from births registered in MBR [22]. Estimates of gestational age were based on LMP [22]. Z-scores indicate the standard deviations of the offspring’s birth weight above or below the expected mean for gestational age and sex. In this study, small for gestational age offspring (SGA) was defined as z-score of birth weight adjusted for
gestational age and sex below the 2.5 percentile. Diagnoses of preeclampsia were based upon hospital medical records noted in the MBR, using the following diagnostic criteria: The onset of blood pressure increase to 140/90 mm Hg in combination with proteinuria (protein excretion of $\geq 0.3$ grams per 24 hours or $\geq +$ on dip stick) after 20 weeks of gestational age.

Onset of labour was categorized as either spontaneous or induced. Induction of labour was either by medication or by caesarian section. Induced caesarian sections included all elective sections (planned and performed more than 8 hours after the decision was made), and acute sections (planned and performed less than 8 hours after the decision was made) performed before labour. In 1997-2005 elective caesarian sections in Norway were recommended to be performed around 38 gestational weeks. Data on indications for caesarian sections are insufficient in the MBR of Norway.

Among women who participated in HUNT 2, a total of 6 122 births were recorded in MBR (gestational age $> 22.0$ weeks and birth weight $> 425$ grams) from 1995 to 2005. Among these births, 1 022 were excluded from the analysis because of either multiple pregnancies (n=252) or possible ongoing pregnancies at the time of data collection (n=770). In addition, 90 were excluded due to missing data on the following variables: maternal height (n=5), information on social benefits (n=49), information on diabetes or chronic hypertension prior to pregnancy (n=7), and information on cardiovascular risk factors prior to pregnancy (n=29). Thus, the main analyses included 5 010 births among 3 497 mothers.

For the paternal analyses, 2 210 of 5 010 pregnancies were excluded because the father did not participate in HUNT 2, and 2 births had missing data on paternal height, thus leaving a total of 2 798 fathered pregnancies among 2 005 men to be analyzed.

**Statistical methods**

We used linear regression analyses to estimate crude and adjusted differences in pregnancy length according to parental heights, and logistic regression to estimate crude and adjusted
associations of parental heights with the risk of pre- and post-term deliveries. Separate analyses were done for mothers and fathers and for ultrasound and LMP dating. To account for more than one delivery by the same woman, we used the cluster option with robust standard errors in STATA for Windows which is recommended to obtain variance estimates with adjustments for within-cluster correlation [23]. Parental heights were categorized into quintiles in order to evaluate trends across quintiles. Tests for trend across quintiles were performed by scoring categories from 1 to 5, and by including the scores as a continuous variable in the models.

In multivariable analyses we adjusted for potentially confounding factors in three steps. In the first model, we adjusted for the parents’ age at enrollment in the HUNT 2 Study. In the second model, we additionally adjusted for offspring sex, time interval between parental participation in HUNT 2 until birth (continuous), maternal age at delivery (continuous), parity (0, 1, and 2 or more previous births), maternal smoking status in HUNT 2 (no / yes), educational level (< 10 years/ 10-12 years/ > 12 years), and socioeconomic position (employed, student or housewife / unemployed or receiving social security benefits), and partner’s height. In the third model, we additionally adjusted for cardiovascular risk factors of the mother prior to pregnancy; i.e. body mass index (continuous), systolic and diastolic blood pressure (continuous), serum glucose, total serum cholesterol, HDL cholesterol and triglycerides (continuous), prevalent diabetes mellitus, chronic hypertension, and kidney disease.

For fathers, we additionally conducted multivariable analyses of blood pressure, BMI, serum lipids and glucose with pregnancy length.

We evaluated the results of adjusting for intermediate factors that could lie on the causal pathway of the association between maternal height and pregnancy length or, alternatively; could be confounders. Induction of labour (by medication or by caesarian section), and
pregnancy complications were regarded as possible intermediate factors. To assess the role of induction, we restricted the main analyses to spontaneous onset of delivery (excluding medically induced deliveries plus all elective caesarian sections plus acute caesarian sections before onset of labour). Separately, we excluded pregnancy complications such as SGA (offspring below the 2.5 percentile), preeclampsia, and stillbirth) in addition to the induced deliveries.

We did linear regression analyses to assess associations between parental height and offspring birth weight in a similar way as was done for pregnancy length. This was done with the purpose of comparing associations between parental height and birth weight, with that of parental height and pregnancy length.

Possible effect modification by cardiovascular risk factors was also assessed in separate analyses. We included an interaction term between maternal height and the cardiovascular risk factors (systolic blood pressure, BMI, glucose, lipids, pregestational metabolic and cardiovascular disease) and a likelihood ratio test was used to compare the fit of models with and without the interaction term.

Stata for Windows (version 12.1, Stata Corporation, College Station, Texas) was used for all statistical analyses. The study was approved by the Norwegian Data Inspectorate, the Norwegian Board of Health, and by the Regional committee for medical research ethics. All the participants of the study assigned an informed consent to participate in the HUNT 2 Study and also approved that data could be linked to the Medical Birth Registry of Norway.

**Results**

Descriptive characteristics of the parents participating in HUNT 2 are presented in table 1. Mean maternal age at participation was 25.9 years. Pregnancy length was associated with
maternal age at delivery, maternal smoking and maternal systolic blood pressure, whereas no association with pregnancy length was found for parity, maternal educational status, maternal BMI, paternal BMI and paternal systolic blood pressure (table 1).

Table 2 describes pregnancy and offspring characteristics, stratified by quintiles of maternal height. Information on LMP was available for nearly 97% of the pregnant women, and 81% had EDD based on ultrasound. Shorter maternal height was associated with lower mean birth weight, lower frequency of spontaneous onset of labour, and higher frequency of onset of labour by caesarian section (elective and acute caesarian sections before onset of labour). Shorter women also had higher frequency of total number of caesarian sections, including acute caesarian sections after onset of labour. Shorter women had higher rates of SGA offspring below the 2.5 percentile than taller women.

Table 3 shows age-adjusted and multivariable adjusted differences in mean pregnancy length according to quintiles of maternal height. In the age-adjusted analyses gestational age increased by increasing maternal height, and women in the upper quintile (≥ 173 cm) had on average 4.3 days longer pregnancies than women in the reference group (< 163 cm) when EDD was based on ultrasound, and 2.7 days longer when EDD was LMP based. Additional adjustments for obstetric and socioeconomic measures (maternal age at delivery, time between baseline at HUNT 2 and delivery, parity, offspring sex, maternal smoking, educational status, and receiving social benefits or not) did not influence the effect estimates. Neither did additional adjustment for levels of maternal cardiovascular risk factors prior to pregnancy (systolic and diastolic blood pressure, BMI, concentration of glucose and lipids, hypertension, diabetes mellitus, kidney disease and coronary artery disease (Table 3). Additional adjustment for paternal height did not change the results (results not shown).

Table 4 shows age-adjusted and multivariable adjusted differences in pregnancy length according to quintiles of maternal height after restriction of the analysis to births with
spontaneous onset of delivery. For deliveries with spontaneous onset, the difference in pregnancy length between the upper and lower maternal height group was reduced from 4.3 days (95% CI 3.0, 5.7) to 3.5 days (95% CI 2.2, 4.8), according to ultrasound dating, and from 2.8 days (95% CI 1.4, 4.2) to 1.9 days (95% CI 0.4, 3.4) according to LMP dating (Table 4). Additional exclusion of pregnancy complications (SGA, preeclampsia, and stillbirth) did not substantially change these results (results not shown).

Paternal height showed no association with pregnancy length of the partner in age-adjusted and fully adjusted models (Table 5). Neither did we find any association with pregnancy length for common paternal cardiovascular risk factors, including levels of blood pressure, BMI, serum lipids and glucose (results not shown).

The risk of post-term deliveries (≥ 42.0 weeks) increased with maternal height (Table 6). In the crude analysis, taller women (≥ 173 cm) had 90% higher odds of post-term pregnancy compared to the reference group when gestational age was estimated by ultrasound (OR 1.9, 95% CI 1.3, 2.9), and 50% higher when gestational age was based on LMP (OR 1.5, 95% CI 1.0, 1.9). The risk was slightly increased after adjustment for obstetric factors, socioeconomic measures and cardiovascular risk factors prior to pregnancy. The risk of preterm delivery was lower in taller women when gestational length had been estimated by ultrasound, whereas only weak associations were observed when EDD was determined by LMP.

After restricting the analysis of maternal height with risks of pre- and post-term birth to deliveries with spontaneous onset (Table 7), the effect estimates were not substantially changed in relation to preterm births, but precision was lower due to the fewer numbers of pregnancies. The associations with post-term delivery were slightly weaker for deliveries with spontaneous onset than for unselected deliveries.
We found no association between paternal height and risks of pre- or post-term births (Table 8). Paternal height was, however, positively associated with z-score of fetal birth weight (Table 9), and the strength of the association among fathers was similar to the corresponding association for the mothers.

In separate analyses, we assessed potential effect modification between maternal height and cardiovascular risk factors, but found no consistent evidence of any interaction (all P-values above 0.10, except for HDL cholesterol with p=0.03) (results not shown).

**Discussion**

We found a positive association of maternal height with pregnancy length per se, and the effect was stronger when EDD was estimated by ultrasound than by LMP. Women with shorter stature had lower risk of post-term deliveries, and when EDD was based on ultrasound, they also had higher risk of preterm births. Paternal height and common cardiovascular risk factors of the father showed no association with length of pregnancy or with the risk of pre-and post-term births.

A Norwegian study among women with low risk pregnancies, spontaneous start of delivery, and EDD estimated by LMP found no association of maternal height with length of pregnancy[4]. However, the authors of a Swedish study among 952,630 unselected pregnant women whose gestational length was estimated by ultrasound in early second trimester, reported that unadjusted mean gestational length was 2 days shorter in mothers of short stature (< 160 cm) compared to those who were taller than 160 cm [5].

We assessed paternal height and levels of paternal cardiovascular risk factors such as blood pressure, BMI, serum glucose and lipids, in relation to pregnancy length and risk of pre- and post-term birth. In contrast to previously reported associations between unfavorable
cardiovascular risk factors among mothers and pregnancy length [14], no such associations were observed for the fathers. Intergenerational studies have suggested that fathers may be of importance in determining pregnancy length in term and post-term pregnancies [2, 18, 19], but there has been little evidence for a paternal contribution to the risk of preterm birth [24, 25]. In this study, paternal height was neither associated with pregnancy length nor with the risk of pre- and post-term birth. To our knowledge, these relations have not been reported previously. In line with a recent review [26], however, we found a positive association of paternal height with offspring birth weight.

The population based prospective design of the present study makes it unlikely that selection or recall bias can explain our findings. The attendance to HUNT 2 was 71%, and in a follow-up study of 685 (2.5%) non-responders it was concluded that practical reasons such as time constraints and moving out of the county were the main reasons for young people not to attend [20]. Thus, the participants at fertile age in our study are likely to be representative for the source population. The relatively large sample size and the standardized measurements of height and other clinical measures in HUNT 2 ensure high precision of the effect estimates, and comprehensive information from self-administered questionnaires provides access to a range of possible confounders. By combining data from the HUNT 2 Study and the MBR it was possible to control for metabolic factors and other known risk factors on an individual basis. A potential limitation in this study is that smoking status was sampled before rather than during pregnancy. This was due to lack of registration of smoking status in MBR until 1999. We performed sensitivity analyses restricted to pregnancies with available information on smoking during pregnancy from 1999 to 2005, and the estimates did not differ substantially from the main results.

The MBR in Norway is a nationwide registry that includes information about virtually all births that have occurred in the country since 1967. Almost all pregnant women in Norway
receive antenatal care, and hospital deliveries are free of charge, which minimizes any potential selection bias [21]. EDD was estimated by two different methods for most of the women (ultrasound and last menstrual period), and the use of both methods was standardized throughout the study period. The internal validity of our results is regarded as good. Generalization of the results to other populations must still be done with caution, since the population under study was rather homogenous with less than 3% of Caucasian women.

The LMP method is limited by inaccurate maternal recall, uncertain time of conception and implantation, irregular menses/oligomenorrhea and pre-pregnancy use of hormonal contraceptives. If shorter women have higher risk of hormonal disturbances with delayed ovulation, this could have biased our findings by underestimating EDD in LMP-based analyses. Adjustment for menstrual disturbances in the statistical analyses did not substantially alter the results.

It is generally agreed that ultrasound biometry in early second trimester gives a more accurate prediction of date of delivery (EDD) and reduces the rate of post-term deliveries compared to LMP dating [27, 28]. However, the ultrasound method is based on the assumption that the size of all fetuses is similar at a given gestational age during the first half of pregnancy, whereas several studies suggest that fetal size (BPD) may differ substantially during the first half of pregnancy according to fetal sex, fetal growth restriction, and maternal smoking[29-31]. If fetal size (BPD) in early second trimester also differ according to maternal height, ultrasound dating may induce a biased estimate of EDD [32]. Femur length of the fetus at 18-19 gestational weeks has been reported to correlate with maternal height, [33]maternal height is a known determinant of offspring birth weight [5, 34, 35], and fetal size in early second trimester is positively associated with offspring birth weight [36, 37]. Thus, it is not unlikely that ultrasound in 17-19 weeks of gestation may underestimate the true gestational age of a short woman and shift the EDD to a later date due to her smaller than
average sized fetus, and vice versa for taller women. As a result, shorter women may have
more severe post-term pregnancies than taller women and may therefore be at higher risk of
adverse perinatal outcomes as well [32]. Taller women, on the other hand, may risk labor
 inductions on false post-term indications. A large population-based study reported that the
replacement of LMP-dating with second trimester ultrasound dating in Sweden resulted in an
increased risk of post-term perinatal morbidity and mortality for female fetuses [38]. The
smaller size of female fetuses compared to males at time of ultrasound measurement most
likely resulted in an underestimation of the true gestational age and more severely post term
pregnancies among mothers of female fetuses. Whether the rate of post-term adverse perinatal
outcomes may differ between short and tall women is not known, and unfortunately we did
not have sufficient analytical power to investigate this in our data.

The observation that small fetuses grow slower and have longer pregnancies than average-sized fetuses, and vice versa for large fetuses, applies to low risk/non-pathological
pregnancies for humans, and are also observed for some other mammals [2, 4, 39, 40]. The
opposite is documented for pathological pregnancies; i.e. women with slow intrauterine fetal
growth have increased risk of both spontaneous and iatrogenic preterm births compared to
other women [41, 42]. Since maternal height is a predictor of offspring birth size [34, 35] and
fetal growth may influence pregnancy length, fetal growth could be an intermediate factor for
the association of maternal height with gestational length. We did not have access to data on
serial ultrasound measurements of fetal size to assess fetal growth. Offspring birth weight
could serve as an indicator of fetal growth. However, birth weight was not regarded as a
confounder, but as an intermediate factor or a common consequence of maternal height and
gestational length. Thus, to avoid introducing a bias to the results, we chose not to adjust the
analyses for birth weight. As an alternative approach, we separately assessed associations of
parental heights with birth weight z-scores, and found that paternal height was positively
The association of paternal height with birth weight was of similar strength to that of maternal height, and contrasted the finding of no association between paternal height and pregnancy length. This different effect of parental height may suggest that gestational length and offspring birth weight are determined by different parental factors, and that the positive association of maternal height with gestational length cannot solely be explained by fetal growth.

Short women are at increased risk of cardiovascular disease compared to tall women, and length of pregnancy tends to be shorter in women who are at increased cardiovascular risk [14, 17]. According to the fetal insulin hypothesis, poor nutritional conditions in utero may program both slow intrauterine growth and increased risk of later cardiovascular disease [43]. If the short stature of the woman has an intrauterine origin, their higher cardiovascular risk may also have originated in utero, and could possibly explain the observed association of short maternal height with short gestational length. However, adjustment for maternal cardiovascular risk factors did not change the effect estimates in the present study, and is therefore an unlikely explanation of the results. Possible effect modification of cardiovascular risk factors was also assessed, but we found no evidence of any interaction. Similarly, unfavorable socioeconomic conditions of the mother could be a common cause for short maternal stature and short pregnancy length, but adjustment for socioeconomic measures did not influence the results.

In line with other research, our descriptive data suggest that shorter women experience pregnancy complications such as SGA offspring, and acute and elective Caesarian section more frequently than taller women [5, 7]. Preeclampsia, stillbirth and perinatal deaths have also been reported to be associated with short stature of the mother [5, 8, 10]. After excluding induced births (by medication or by caesarian sections), and preeclampsia, SGA and stillbirths, the associations between maternal height and length of pregnancy became weaker.
in our study. This indicates that some of the association between maternal height and gestational length may be explained by a higher incidence of pregnancy complications and caesarian sections before labour among shorter women than among taller. Their higher frequency of elective caesarian sections may further reflect a higher risk of previous complications, including previous caesarian section and/or traumatic labour experience [12, 44].

We cannot rule out that the observed association of maternal height with gestational length may have some biological basis. Blacks and Asians have shorter average gestational length and higher risk of preterm birth than white Americans and Europeans, and teenage mothers have shorter length of pregnancy and higher risk of preterm birth compared to adult mothers[45, 46]. A smaller or more constricted female pelvis of teenage and Asian mothers has been suggested to facilitate shorter duration of pregnancy to minimize complications from cephalopelvic disproportion. In evolutionary terms similar mechanisms may explain that shorter women benefit from shorter duration of pregnancy [45]. The population in the present study is ethnically fairly homogenous and without teenage pregnancies [20].

**Conclusion**

Women with shorter stature had shorter pregnancy length and lower risk of post-term pregnancies than taller women. The associations were stronger when pregnancy length was based on ultrasound, and shorter women only had increased risk of preterm births in ultrasound-based analyses. The associations between maternal height and pregnancy length could partly be explained by a higher risk of elective caesarian sections and more pregnancy complications among shorter women. Cardiovascular risk factors did not explain the associations.

Early second trimester ultrasound is the method of choice for estimating EDD in many areas of the world and gestational age is a crucial determinant of perinatal outcome. Thus, it
remains to be clarified whether the observed association between maternal height and gestational length may have any clinical consequences.

**Competing interests**

There are no conflicts of interest to be declared by the authors.

All researchers are independent from funders.

**Author`s contribution**

KM and PRR had full access to all of the data in the study and take full responsibility for the integrity of the data and the accuracy of the data analysis. PRR conceived and planned the study. KM wrote the first draft of the paper and performed the statistical analyses together with PRR and EBM. LJV, KÅS, and EBM participated in the interpretation of the analyses, and the revising and writing of the article.

**Acknowledgements**

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References


### Tables

Table 1. Associations of maternal and paternal covariates with pregnancy length assessed as differences in days.

<table>
<thead>
<tr>
<th>Prepregnancy parental covariate</th>
<th>Number of births</th>
<th>Difference in gestational length(days)</th>
<th>95% CI</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age at delivery (per 5-years)</td>
<td>4038</td>
<td>-0.5</td>
<td>-1.1, 0.0</td>
<td>0.04</td>
</tr>
<tr>
<td>Parity</td>
<td>0.46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1107</td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1502</td>
<td>0.5</td>
<td>-0.5, 1.5</td>
<td></td>
</tr>
<tr>
<td>2 or more</td>
<td>1429</td>
<td>-0.4</td>
<td>-1.4, 0.7</td>
<td></td>
</tr>
<tr>
<td>Maternal education</td>
<td>0.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 10 years</td>
<td>190</td>
<td>0</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td>10-12 years</td>
<td>2214</td>
<td>3.6</td>
<td>0.7, 6.6</td>
<td></td>
</tr>
<tr>
<td>&gt;12 years</td>
<td>1587</td>
<td>3.9</td>
<td>0.9, 6.9</td>
<td></td>
</tr>
<tr>
<td>Maternal smoking</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no</td>
<td>2911</td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td>1036</td>
<td>-0.6</td>
<td>-1.6, 0.5</td>
<td></td>
</tr>
<tr>
<td>Maternal unemployment and/or receiving social benefits</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3305</td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>733</td>
<td>-1.1</td>
<td>-1.8, 0.5</td>
<td></td>
</tr>
<tr>
<td>Maternal BMI (quintiles)</td>
<td>0.82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 21.3</td>
<td>878</td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>21.4-22.9</td>
<td>859</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.0-24.7</td>
<td>817</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.8-27.1</td>
<td>810</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 27.2</td>
<td>674</td>
<td>-0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal systolic blood pressure, in mmHg (quintiles)</td>
<td>0.002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 111</td>
<td>863</td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>112-117</td>
<td>838</td>
<td>-0.1</td>
<td>-1.4, 1.2</td>
<td></td>
</tr>
<tr>
<td>118-122</td>
<td>712</td>
<td>-1.0</td>
<td>-2.4, 0.3</td>
<td></td>
</tr>
<tr>
<td>123-130</td>
<td>862</td>
<td>-1.1</td>
<td>-2.5, 0.2</td>
<td></td>
</tr>
<tr>
<td>Paternal age at delivery (per 5 years)</td>
<td>763</td>
<td>-2.0</td>
<td>-3.4, -0.6</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-----</td>
<td>------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Paternal BMI (quintiles)</td>
<td>0.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 22.9</td>
<td>388</td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>23.0-24.3</td>
<td>436</td>
<td>2.2</td>
<td>0.3, 4.1</td>
<td></td>
</tr>
<tr>
<td>24.4-25.8</td>
<td>445</td>
<td>1.2</td>
<td>-0.8, 3.3</td>
<td></td>
</tr>
<tr>
<td>25.9-27.8</td>
<td>463</td>
<td>0.9</td>
<td>-1.2, 2.9</td>
<td></td>
</tr>
<tr>
<td>≥ 27.9</td>
<td>421</td>
<td>0.1</td>
<td>-2.1, 2.2</td>
<td></td>
</tr>
<tr>
<td>Paternal systolic blood pressure, in mm Hg (quintiles)</td>
<td>0.63</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 122</td>
<td>437</td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>123-129</td>
<td>399</td>
<td>-1.3</td>
<td>-3.2, 0.7</td>
<td></td>
</tr>
<tr>
<td>130-135</td>
<td>440</td>
<td>-0.3</td>
<td>-2.2, 1.6</td>
<td></td>
</tr>
<tr>
<td>136-142</td>
<td>428</td>
<td>0.4</td>
<td>-1.5, 2.3</td>
<td></td>
</tr>
<tr>
<td>≥ 143</td>
<td>449</td>
<td>-0.3</td>
<td>-2.1, 1.5</td>
<td></td>
</tr>
</tbody>
</table>

1 Parental covariates were measured prior to pregnancy, at the HUNT 2 Study, Norway, 1995-1997.  
2 EDD (Expected Date of Delivery) estimated by ultrasound measurement in 17-19 weeks of gestation.  
3 Parity = previous births.  
4 Missing data on educational status for 47 women.  
5 Missing data on smoking status for 91 women.
Table 2. Pregnancy and offspring characteristics stratified by maternal height in quintiles

<table>
<thead>
<tr>
<th>Pregnancy characteristics</th>
<th>Maternal height by quintiles(cm)</th>
<th>n=1192</th>
<th>n=930</th>
<th>n=1032</th>
<th>n=1053</th>
<th>n=803</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age at delivery, years (SE)</td>
<td></td>
<td>30.3(0.2)</td>
<td>30.5(0.2)</td>
<td>30.3(0.2)</td>
<td>30.2(0.2)</td>
<td>30.6(0.17)</td>
<td>0.83</td>
</tr>
<tr>
<td>Mean time from baseline to delivery, years (SE)</td>
<td></td>
<td>4.2(0.1)</td>
<td>4.3(0.1)</td>
<td>4.3(0.1)</td>
<td>4.4(0.1)</td>
<td>4.4(0.1)</td>
<td>0.01</td>
</tr>
<tr>
<td>Mean pregnancy length, days, LMP-based (SE)(^2)</td>
<td></td>
<td>279.3(0.5)</td>
<td>280.2(0.5)</td>
<td>281.5(0.6)</td>
<td>281.5(0.5)</td>
<td>282.0(0.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mean pregnancy length, days, US-based (SE)(^3)</td>
<td></td>
<td>276.7(0.5)</td>
<td>277.9(0.5)</td>
<td>279.2(0.6)</td>
<td>280.1(0.5)</td>
<td>280.9(0.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Primiparous mother (%)(^4)</td>
<td></td>
<td>327(27)</td>
<td>241(26)</td>
<td>300(29)</td>
<td>309(29)</td>
<td>236(29)</td>
<td>0.06</td>
</tr>
<tr>
<td>Mean birth weight, grams (SE)(^5)</td>
<td></td>
<td>3490(20)</td>
<td>3618(21)</td>
<td>3655(22)</td>
<td>3692(20)</td>
<td>3803(25)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Male fetal sex (%)</td>
<td></td>
<td>626(52.5)</td>
<td>495(53.2)</td>
<td>531(51.5)</td>
<td>574(54.5)</td>
<td>402(50.1)</td>
<td>0.61</td>
</tr>
<tr>
<td>Onset of labour (%)</td>
<td>Spontaneous</td>
<td>873(73.2)</td>
<td>740(79.6)</td>
<td>835(80.9)</td>
<td>868(82.4)</td>
<td>624(77.7)</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>Medically induced</td>
<td>144(12.1)</td>
<td>111(11.9)</td>
<td>137(13.3)</td>
<td>127(12.1)</td>
<td>114(14.2)</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>CS before labour(^6)</td>
<td>175(14.7)</td>
<td>79(8.5)</td>
<td>60(5.8)</td>
<td>58(5.5)</td>
<td>65(8.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>CS, total number (%)(^7)</td>
<td>302(25)</td>
<td>162(17)</td>
<td>133(13)</td>
<td>100(9.5)</td>
<td>100(12.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Acute CS (^8)</td>
<td>154(17.9)</td>
<td>64(6.9)</td>
<td>52(5.0)</td>
<td>48(4.6)</td>
<td>49(6.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Condition</td>
<td>Elective CS&lt;sup&gt;9&lt;/sup&gt;</td>
<td>SGA &lt; 2.5 percentile (%)&lt;sup&gt;10&lt;/sup&gt;</td>
<td>Preeclampsia (%)</td>
<td>Stillbirth (%)&lt;sup&gt;11&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
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<td>-------------------------------</td>
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<td>------------------</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>148(12.4)</td>
<td>41(3.4)</td>
<td>50(4.2)</td>
<td>4(0.3)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>98(10.5)</td>
<td>12(1.3)</td>
<td>27(2.9)</td>
<td>3(0.3)</td>
<td></td>
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</tr>
<tr>
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<td>81(7.9)</td>
<td>18(1.8)</td>
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<tr>
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<td>52(4.9)</td>
<td>13(1.2)</td>
<td>31(2.9)</td>
<td>4(0.4)</td>
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</tr>
<tr>
<td></td>
<td>51(6.4)</td>
<td>9(1.1)</td>
<td>30(3.7)</td>
<td>2(0.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CS = Caesarian section, SE = Standard Error, LMP = last menstrual period, US = ultrasound early second trimester, SGA = small for gestational age

1 Data from 5010 singleton pregnancies of 3497 mothers, registered in the Medical Birth Registry of Norway 1995-2005. 2 Missing data on LMP for 164 pregnancies. 3 Missing data on US for 972 pregnancies. 4 Primiparous = woman with no previous birth. 5 Missing data on birth weight for 1 woman. 6 Elective and acute caesarian section before labour. 7 Elective and acute caesarian sections before and after onset of labour. 8 Planned and performed less than 8 hours after decision was made. 9 Planned and performed more than 8 hours after decision was made. 10 Missing data on SGA for 5 pregnancies. 11 Missing data on stillbirth for 1 woman.
Table 3. Mean differences in length of pregnancy by maternal height\(^1\).

<table>
<thead>
<tr>
<th>Maternal height (in quintiles)</th>
<th>N</th>
<th>Mean difference</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p for trend</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;163</td>
<td>957</td>
<td>0</td>
<td>0</td>
<td>Ref</td>
<td></td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>163-165</td>
<td>751</td>
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<td>1.3</td>
<td>-0.1,2.6</td>
<td>1.3</td>
<td>1.3</td>
<td>0.2,7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>166-168</td>
<td>811</td>
<td>2.6</td>
<td>2.6</td>
<td>1.2,4.0</td>
<td>2.6</td>
<td>2.6</td>
<td>1.2,4.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>169-172</td>
<td>856</td>
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<td>3.4</td>
<td>2.1,4.8</td>
<td>3.4</td>
<td>3.4</td>
<td>2.0,4.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>173+</td>
<td>663</td>
<td>4.3</td>
<td>4.3</td>
<td>2.9,5.6</td>
<td>4.3</td>
<td>4.3</td>
<td>3.0,5.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Estimated date of delivery based on US</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>Ref</td>
<td></td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>163-165</td>
<td>903</td>
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<td>1.0</td>
<td>-0.3,2.4</td>
<td>1.1</td>
<td>1.1</td>
<td>-0.2,2.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>166-168</td>
<td>997</td>
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<td>2.3</td>
<td>0.9,3.7</td>
<td>2.3</td>
<td>2.3</td>
<td>0.9,3.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>169-172</td>
<td>1021</td>
<td>2.2</td>
<td>2.2</td>
<td>1.0,3.6</td>
<td>2.3</td>
<td>2.3</td>
<td>1.0,3.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>173+</td>
<td>777</td>
<td>2.7</td>
<td>2.7</td>
<td>1.3,4.2</td>
<td>2.8</td>
<td>2.8</td>
<td>1.3,4.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Estimated date of delivery based on LMP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Pregnancy length according to estimated date of delivery (EDD) by ultrasound (US) (4038 pregnancies) and by first day of last menstrual period (LMP) (4846 pregnancies).\(^2\) Adjusted for maternal age at baseline (HUNT 2 participation).\(^3\) Additionally adjusted for maternal age at birth, duration between Hunt 2 participation and delivery, maternal education, parity, maternal smoking, receiving social security benefits or not, and fetal sex.\(^4\) Additionally adjusted for pre-pregnancy, hypertension, diabetes mellitus, kidney and heart disease, BMI; systolic and diastolic blood pressure, concentration of glucose and lipids.
Table 4. Mean differences in length of pregnancy by maternal height\textsuperscript{1}. Pregnancies restricted to spontaneous onset of delivery\textsuperscript{2}.

<table>
<thead>
<tr>
<th>Maternal height (in quintiles)</th>
<th>N</th>
<th>Mean difference</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p for trend</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated date of delivery based on US</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;163</td>
<td>687</td>
<td>0</td>
<td>0</td>
<td>Ref</td>
<td>0</td>
<td>0</td>
<td>Ref</td>
<td>0</td>
</tr>
<tr>
<td>163-165</td>
<td>593</td>
<td>0.5</td>
<td>0.5</td>
<td>-0.8, 1.8</td>
<td>0.5</td>
<td>0.5</td>
<td>-0.8, 1.8</td>
<td>0.5</td>
</tr>
<tr>
<td>166-168</td>
<td>654</td>
<td>1.8</td>
<td>1.9</td>
<td>0.5, 3.3</td>
<td>1.9</td>
<td>1.9</td>
<td>0.5, 3.3</td>
<td>1.9</td>
</tr>
<tr>
<td>169-172</td>
<td>703</td>
<td>1.8</td>
<td>1.9</td>
<td>0.5, 3.2</td>
<td>1.8</td>
<td>1.8</td>
<td>0.5, 3.2</td>
<td>1.8</td>
</tr>
<tr>
<td>173+</td>
<td>509</td>
<td>3.5</td>
<td>3.6</td>
<td>2.3, 4.8</td>
<td>&lt;0.001</td>
<td>3.5</td>
<td>2.2, 4.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Estimated date of delivery based on LMP</td>
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<td>Ref</td>
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<td>0</td>
<td>Ref</td>
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</tr>
<tr>
<td>163-165</td>
<td>723</td>
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<td>-1.0, 1.7</td>
<td>0.4</td>
<td>0.4</td>
<td>-1.0, 1.7</td>
<td>0.4</td>
</tr>
<tr>
<td>166-168</td>
<td>808</td>
<td>1.3</td>
<td>1.4</td>
<td>0.0, 2.9</td>
<td>1.4</td>
<td>1.4</td>
<td>0.0, 2.9</td>
<td>1.4</td>
</tr>
<tr>
<td>169-172</td>
<td>839</td>
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<td>-0.7, 2.0</td>
<td>0.6</td>
<td>0.6</td>
<td>-0.7, 2.0</td>
<td>0.6</td>
</tr>
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<td>0.02</td>
<td>1.9</td>
<td>0.4, 3.4</td>
<td>0.02</td>
</tr>
</tbody>
</table>

\textsuperscript{1} Pregnancy length according to date of delivery estimated by ultrasound (US) (3146 pregnancies) and by first day of last menstrual period (LMP) (3831 pregnancies).

\textsuperscript{2} Exclusion of pregnancies with induced onset of delivery (medically or by caesarean section).

\textsuperscript{3} Adjusted for maternal age at baseline (HUNT 2 participation).

\textsuperscript{4} Additionally adjusted for maternal age at birth, duration between Hunt 2 participation and delivery, maternal education, parity, maternal smoking, receiving social security benefits or not, and fetal sex.

\textsuperscript{5} Additionally adjusted for pre-pregnancy maternal hypertension, diabetes mellitus, kidney and heart disease, BMI; systolic and diastolic blood pressure, concentration of glucose and lipids.
Table 5. Mean differences in length of pregnancy by paternal height.\(^1\)

<table>
<thead>
<tr>
<th>Paternal height (in quintiles)</th>
<th>N</th>
<th>Mean difference</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p for trend</th>
<th>Mean difference</th>
<th>95% CI</th>
<th>p for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated date of delivery based on US</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 175</td>
<td>503</td>
<td>0</td>
<td>0</td>
<td>Ref</td>
<td></td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>176-178</td>
<td>397</td>
<td>0.2</td>
<td>-0.2</td>
<td>-2.0,1.7</td>
<td>179-181</td>
<td>448</td>
<td>-0.1</td>
<td>-2.4,1.3</td>
</tr>
<tr>
<td>179-181</td>
<td>448</td>
<td>-0.6</td>
<td>-0.6</td>
<td>-2.4,1.3</td>
<td>182-185</td>
<td>412</td>
<td>-0.5</td>
<td>-2.2,1.6</td>
</tr>
<tr>
<td>182-185</td>
<td>412</td>
<td>0.6</td>
<td>0.6</td>
<td>-2.4,1.3</td>
<td>≥186</td>
<td>399</td>
<td>-0.7</td>
<td>-2.5,1.0</td>
</tr>
<tr>
<td>≥186</td>
<td>399</td>
<td>0.5</td>
<td>-0.7</td>
<td>-2.5,1.0</td>
<td></td>
<td>0</td>
<td>-0.7</td>
<td>-2.5,1.0</td>
</tr>
<tr>
<td>Estimated date of delivery based on LMP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 175</td>
<td>642</td>
<td>0</td>
<td>0</td>
<td>Ref</td>
<td></td>
<td>0</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>176-178</td>
<td>496</td>
<td>0.2</td>
<td>0.0</td>
<td>-1.9,1.9</td>
<td>179-181</td>
<td>514</td>
<td>0.2</td>
<td>-1.9,1.6</td>
</tr>
<tr>
<td>179-181</td>
<td>514</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-1.9,1.6</td>
<td>182-185</td>
<td>552</td>
<td>-0.6</td>
<td>-3.0,0.7</td>
</tr>
<tr>
<td>182-185</td>
<td>552</td>
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<td>-1.2</td>
<td>-3.0,0.7</td>
<td>≥186</td>
<td>512</td>
<td>-0.3</td>
<td>-2.7,0.9</td>
</tr>
<tr>
<td>≥186</td>
<td>512</td>
<td>-0.3</td>
<td>-0.9</td>
<td>-2.7,0.9</td>
<td></td>
<td>-0.9</td>
<td>-2.7,0.9</td>
<td>0.16</td>
</tr>
</tbody>
</table>

\(^1\) Pregnancy length according to date of delivery estimated by ultrasound (US) (2159 pregnancies) and by first day of last menstrual period (LMP) (2716 pregnancies).\(^2\) Adjusted for paternal age at baseline (HUNT 2 participation). \(^3\) Additionally adjusted for maternal height, maternal age at birth, duration between Hunt 2 participation and delivery, maternal education, parity, maternal smoking, receiving social security benefits or not, and fetal sex. \(^4\) Additionally adjusted for pre-pregnancy hypertension, diabetes mellitus, kidney and heart disease, BMI; systolic and diastolic blood pressure, concentration of glucose and lipids and maternal height.
Table 6. Odds ratio (OR) for pre-term delivery and post-term delivery by maternal height.

<table>
<thead>
<tr>
<th>Maternal height (in quintiles)</th>
<th>Preterm delivery(&lt; 37.0) weeks</th>
<th>Post term delivery(&gt;42.0 weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases/non-cases</td>
<td>Crude Estimate&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>&lt;163</td>
<td>62/895</td>
<td>1.0</td>
</tr>
<tr>
<td>163-165</td>
<td>39/712</td>
<td>0.8</td>
</tr>
<tr>
<td>166-168</td>
<td>43/768</td>
<td>0.8</td>
</tr>
<tr>
<td>169-172</td>
<td>30/826</td>
<td>0.5</td>
</tr>
<tr>
<td>173+</td>
<td>28/635</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Estimated date of delivery based on US

| <163                          | 76/1072           | 1.0                          | 1.0                          | Ref     |           | 112/1036        | 1.0                          | 1.0                          | Ref     |           |
| 163-165                       | 41/862            | 0.7                          | 0.6                          | 0.4,1.0 |           | 91/812          | 1.0                          | 1.0                          | 0.8,1.4 |           |
| 166-168                       | 52/945            | 0.8                          | 0.8                          | 0.5,1.1 |           | 143/854         | 1.5                          | 1.5                          | 1.2,2.0 |           |
| 169-172                       | 42/979            | 0.6                          | 0.6                          | 0.4,0.9 |           | 129/892         | 1.3                          | 1.4                          | 1.0,1.8 |           |
| 173+                          | 45/732            | 0.9                          | 0.9                          | 0.6,1.3 | 0.32      | 105/672         | 1.5                          | 1.5                          | 1.1,2.0 | 0.001   |

<sup>1</sup> Pregnancy length according to date of delivery estimated by ultrasound (US) (4038 pregnancies) and by first day of last menstrual period (LMP) (4846 pregnancies).

<sup>2</sup> Adjusted for maternal age at HUNT participation.

<sup>3</sup> Additionally adjusted for maternal age at birth, duration between baseline (maternal participation in HUNT 2) and delivery, maternal education, parity, smoking, receiving social security benefits, pre-pregnancy maternal hypertension, diabetes mellitus, kidney and heart disease, BMI, systolic and diastolic blood pressure, blood concentration of glucose and lipids.
Table 7. Odds ratio (OR) for pre-term delivery and post-term delivery by maternal height\(^1\). Pregnancies restricted to spontaneous onset of delivery\(^2\)

<table>
<thead>
<tr>
<th>Maternal height (in quintiles)</th>
<th>Preterm delivery (&lt; 37.0) weeks</th>
<th></th>
<th></th>
<th></th>
<th>Post term delivery (&gt; 42.0 weeks)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases/non-cases</td>
<td>Crude Estimate(^3)</td>
<td>Adjusted Estimate(^4)</td>
<td>95% CI</td>
<td>p for trend</td>
<td>Cases/non-cases</td>
<td>Crude Estimate(^3)</td>
<td>Adjusted Estimate(^4)</td>
<td>95% CI</td>
</tr>
<tr>
<td>&lt;163</td>
<td>25/662</td>
<td>1.0</td>
<td>1.0</td>
<td>Ref</td>
<td>22/665</td>
<td>1.0</td>
<td>1.0</td>
<td>Ref</td>
</tr>
<tr>
<td>163-165</td>
<td>18/575</td>
<td>0.8</td>
<td>0.8</td>
<td>0.4, 1.5</td>
<td>15/578</td>
<td>0.8</td>
<td>0.8</td>
<td>0.4, 1.6</td>
</tr>
<tr>
<td>166-168</td>
<td>17/637</td>
<td>0.7</td>
<td>0.7</td>
<td>0.3, 1.3</td>
<td>36/618</td>
<td>1.8</td>
<td>1.8</td>
<td>1.0, 3.1</td>
</tr>
<tr>
<td>169-172</td>
<td>18/685</td>
<td>0.7</td>
<td>0.7</td>
<td>0.4, 1.3</td>
<td>29/674</td>
<td>1.3</td>
<td>1.4</td>
<td>0.8, 2.5</td>
</tr>
<tr>
<td>173+</td>
<td>12/497</td>
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<td>0.6</td>
<td>0.3, 1.4</td>
<td>27/482</td>
<td>1.7</td>
<td>1.9</td>
<td>1.0, 3.4</td>
</tr>
</tbody>
</table>

Estimated date of delivery based on US

<table>
<thead>
<tr>
<th>Cases/non-cases</th>
<th>Crude Estimate(^3)</th>
<th>Adjusted Estimate(^4)</th>
<th>95% CI</th>
<th>p for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;163</td>
<td>42/808</td>
<td>1.0</td>
<td>1.0</td>
<td>Ref</td>
</tr>
<tr>
<td>163-165</td>
<td>19/704</td>
<td>0.5</td>
<td>0.5</td>
<td>0.3, 0.9</td>
</tr>
<tr>
<td>166-168</td>
<td>25/783</td>
<td>0.6</td>
<td>0.6</td>
<td>0.3, 1.0</td>
</tr>
<tr>
<td>169-172</td>
<td>27/812</td>
<td>0.6</td>
<td>0.6</td>
<td>0.4, 1.1</td>
</tr>
<tr>
<td>173+</td>
<td>25/586</td>
<td>0.8</td>
<td>0.8</td>
<td>0.5, 1.4</td>
</tr>
</tbody>
</table>

\(^1\) Pregnancy length according to date of delivery estimated by ultrasound (3146 pregnancies) and by last menstrual period (3831 pregnancies). \(^2\) After exclusion of pregnancies with induced onset of delivery (medically or by Caesarean section). \(^3\) Adjusted for maternal age at HUNT participation. \(^4\) Additionally adjusted for maternal age at birth, duration between baseline (maternal participation in HUNT 2) and delivery, maternal education, parity, smoking, receiving social security benefits, pre-pregnancy maternal hypertension, diabetes mellitus, kidney and heart disease, BMI, systolic and diastolic blood pressure, blood concentration of glucose and lipids.
Table 8. Odds ratio (OR) for preterm delivery and post term delivery by paternal height.

<table>
<thead>
<tr>
<th>Paternal height (in quintiles)</th>
<th>Preterm delivery (&lt;37.0) weeks</th>
<th>Post term delivery (&gt;42.0 weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases/cases</td>
<td>Crude Estimate$^2$</td>
</tr>
<tr>
<td>≤175</td>
<td>24/479</td>
<td>1.0</td>
</tr>
<tr>
<td>176-178</td>
<td>26/371</td>
<td>1.4</td>
</tr>
<tr>
<td>179-181</td>
<td>24/388</td>
<td>1.2</td>
</tr>
<tr>
<td>182-185</td>
<td>18/430</td>
<td>0.8</td>
</tr>
<tr>
<td>≥186</td>
<td>21/378</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Estimated date of delivery based on US

<table>
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<tr>
<th></th>
<th>Cases/cases</th>
<th>Crude Estimate$^2$</th>
<th>Adjusted Estimate$^3$</th>
<th>95% CI</th>
<th>$p$ for trend</th>
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</thead>
<tbody>
<tr>
<td>≤175</td>
<td>33/609</td>
<td>1.0</td>
<td>1.0</td>
<td>Ref</td>
<td>87/555</td>
</tr>
<tr>
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<td>23/473</td>
<td>0.9</td>
<td>0.9</td>
<td>0.5,1.8</td>
<td>66/430</td>
</tr>
<tr>
<td>179-181</td>
<td>27/487</td>
<td>1.0</td>
<td>1.1</td>
<td>0.7,2.0</td>
<td>54/460</td>
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<tr>
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<td>1.1</td>
<td>0.7,2.1</td>
<td>67/485</td>
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<tr>
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<td>28/484</td>
<td>1.1</td>
<td>1.2</td>
<td>0.8,2.2</td>
<td>55/357</td>
</tr>
</tbody>
</table>

1 Pregnancy length according to date of delivery estimated by ultrasound (US) (2159 pregnancies) and by first day of last menstrual period (LMP) (2716 pregnancies).
2 Adjusted for paternal age at HUNT 2 participation.
3 Additionally adjusted for maternal height, maternal age at birth, duration between baseline (HUNT 2 participation) and delivery, maternal education, parity, smoking, receiving social security benefits or not, pre-pregnancy maternal hypertension, diabetes mellitus, kidney and heart disease, BMI, systolic and diastolic blood pressure, blood concentration of glucose and lipids.