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Data From Web-Based Questionnaires Were Valid for Gestational Diabetes and Preeclampsia, but Not Gestational Hypertension

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Abstract

Objectives: We aimed to validate Web-based questionnaires for the common pregnancy complications gestational diabetes, gestational hypertension, and preeclampsia.

Study Design and Setting: We included 1,809 women participating in the PRegnancy and Infant DEvelopment (PRIDE) Study who delivered in 2012−2017, for whom relevant data were complete. Sensitivity, specificity, and positive and negative predictive values of self-reported diagnoses of gestational diabetes, gestational hypertension, and preeclampsia were determined using obstetric records as reference standard. Furthermore, we assessed whether maternal characteristics affected disagreement between questionnaires and obstetric record.

Results: For gestational diabetes and preeclampsia, we observed very few false-positive and false-negative reports, yielding sensitivities of 93% (95% confidence interval [CI] 86−100) and 88% (95% CI 79−98), respectively, and specificities of 100%. Depending on the definition of gestational hypertension, sensitivity and positive predictive values ranged from 62% to 89% and 53% to 64%, respectively. Disagreement on gestational hypertension was associated with prepregnancy overweight and multiparity.

Conclusion: Self-reports of gestational diabetes and preeclampsia in Web-based questionnaires were valid, but the validity of gestational hypertension seemed to be lower because of relatively high numbers of false-positive reports. However, it is questionable whether an appropriate reference standard exists to validate this pregnancy complication.

Keywords: Epidemiologic methods; Gestational diabetes; Gestational hypertension; Preeclampsia; Pregnancy; PRIDE Study

1. Introduction

Studies focusing on pregnancy complications often use methods of self-report to collect data, including questionnaires and interviews. These methods rely on the mother's ability to accurately recall and report the occurrence of these events. However, evidence on the accuracy of self-report on pregnancy complications is conflicting [1−11]. Validity measures including sensitivity and specificity vary greatly among studies on pregnancy complications, such as preeclampsia, gestational hypertension, and gestational diabetes, using paper-based questionnaires or interviews. This variation may be because of methodological variation between studies in terms of different research designs, including time from delivery until assessment and different definitions of complications.

In addition to interviews and paper-based questionnaires, Web-based questionnaires are being used

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What is new?

Key findings

- Self-reports of gestational diabetes and preeclampsia in Web-based questionnaires are valid, but the validity of gestational hypertension seemed to be lower because of relatively high numbers of false-positive reports.

What this adds to what was known?

- This study confirmed that data from questionnaires are accurate for gestational diabetes and preeclampsia, even when collected online. For gestational hypertension, validity measures were lower, but it is questionable whether obstetric records can be considered as a true gold standard for this complication.

What is the implication and what should change now?

- Data on gestational diabetes and preeclampsia collected through maternal self-report are very suitable for use in clinical studies.
- When incorporating self-reported data on the diagnosis of gestational hypertension, sensitivity analyses are recommended to estimate the degree of bias due to misclassification.

increasingly in large-scale studies within the field of reproductive epidemiology [12−14]. Web-based questionnaires have been reported to be more efficient in terms of costs and time compared with traditional data collection methods [15]. Despite the increasing use of this method of data collection, no studies have evaluated the validity of Web-based questionnaires for pregnancy complications. Therefore, this study aimed to validate Web-based questionnaires for gestational diabetes, gestational hypertension, and preeclampsia using data from the PRegnancy and Infant DEvelopment (PRIDE) Study.

2. Methods

2.1. Study population and data collection

The PRIDE Study is an ongoing prospective cohort study in the Netherlands collecting data on health outcomes of mother and child and factors potentially affecting these outcomes. Participants are recruited as early in pregnancy as possible through participating midwives, gynecologists, and general practitioners around the first prenatal care visit (usually in gestational weeks 8−12). Women can also sign up for participation directly on the website of the PRIDE Study without being approached by prenatal care providers. Women aged <18 years are excluded from participation. Participants are asked to complete Web-based questionnaires at enrollment (Questionnaire 1), at 17 and 34 weeks of gestation (Questionnaires 2 and 3), at 2 and 6 months after the estimated date of delivery (Questionnaires 4 and 5), and biannually throughout childhood. Paper-based questionnaires are available for women who cannot or do not want to participate through the internet. At baseline, women are asked to give informed consent for participation and obstetric record review; the latter is not mandatory for participation. The PRIDE Study was approved by the Regional Committee on Research Involving Human Subjects (CMO 2009/305). More information on the PRIDE Study can be found elsewhere [14].

2.2. Ascertainment of pregnancy complications

Self-reported pregnancy complications, including gestational diabetes, gestational hypertension, and preeclampsia, were obtained from multiple-choice questions in Questionnaires 2 (gestational diabetes only), 3, and 4. For each of the pregnancy complications, the participants could indicate whether they experienced the particular complication (yes vs. no), followed by a question establishing the date of diagnosis. Self-reports of preeclampsia and gestational diabetes were defined as at least one report during pregnancy. Self-reported gestational hypertension was defined as at least one report of gestational hypertension without any report of preeclampsia.

Obstetric records were retrieved from midwives for participants who gave consent for obstetric record review. Trained research assistants abstracted information from the obstetric records into a standardized case report form that contained, among others, diagnosis of pregnancy complications and blood pressure readings. For women who were referred to hospital care for medical indications other than delivery, we retrieved obstetric records from electronic patient record systems from hospitals in the region of Nijmegen (Radboud University Medical Center and Canisius Wilhelmina Medical Center). Gestational hypertension was defined according to its clinical diagnosis as hypertension in the 20th week of gestation or later in the absence of proteinuria (Definition 1). To evaluate a stricter definition based on international guidelines, we created a second definition for gestational hypertension, in which gestational hypertension was defined as its clinical diagnosis and/or according to its diagnostic criteria (Definition 2): two subsequent measurements of elevated systolic ($\geq$140 mm Hg) or diastolic ($\geq$90 mm Hg) blood pressure in women who were normotensive before [16]. We defined preeclampsia and gestational diabetes according to their clinical diagnoses. For preeclampsia, it entails the presence of gestational blood pressure elevation accompanied by proteinuria (24-hour urinary protein >300 mg) [16]. Gestational diabetes was defined as a new onset of impaired glucose intolerance

in the second or third trimester, as indicated by a diagnostic oral glucose intolerance test [17]. The diagnostic criteria did not change over the study period.

2.3. Other variables

Information on maternal characteristics was obtained from the Web-based questionnaires, including maternal age at enrollment, country of birth, level of education, pre-pregnancy body mass index (BMI), and parity.

2.4. Inclusion and exclusion criteria

We included all PRIDE Study participants with an expected date of delivery (EDD) through December 31, 2017 (N = 5,826). We excluded women who did not give consent for obstetric record review or whose obstetric record data were not available for analysis on December 1, 2018, women whose pregnancy ended in a miscarriage or elective termination, women who completed paper-based questionnaires, and women who did not complete the first postpartum questionnaire. Furthermore, we excluded women with incomplete obstetric record information on pregnancy complications.

2.5. Statistical analysis

We considered the obstetric record as the reference standard in all analyses. For self-reported gestational diabetes, gestational hypertension, and preeclampsia, we computed sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), including 95% confidence intervals (CIs). In a sensitivity analysis, we analyzed the subsample of women residing in the Nijmegen region, for whom hospital records were available in case of referral from midwife to hospital at any point during pregnancy, as

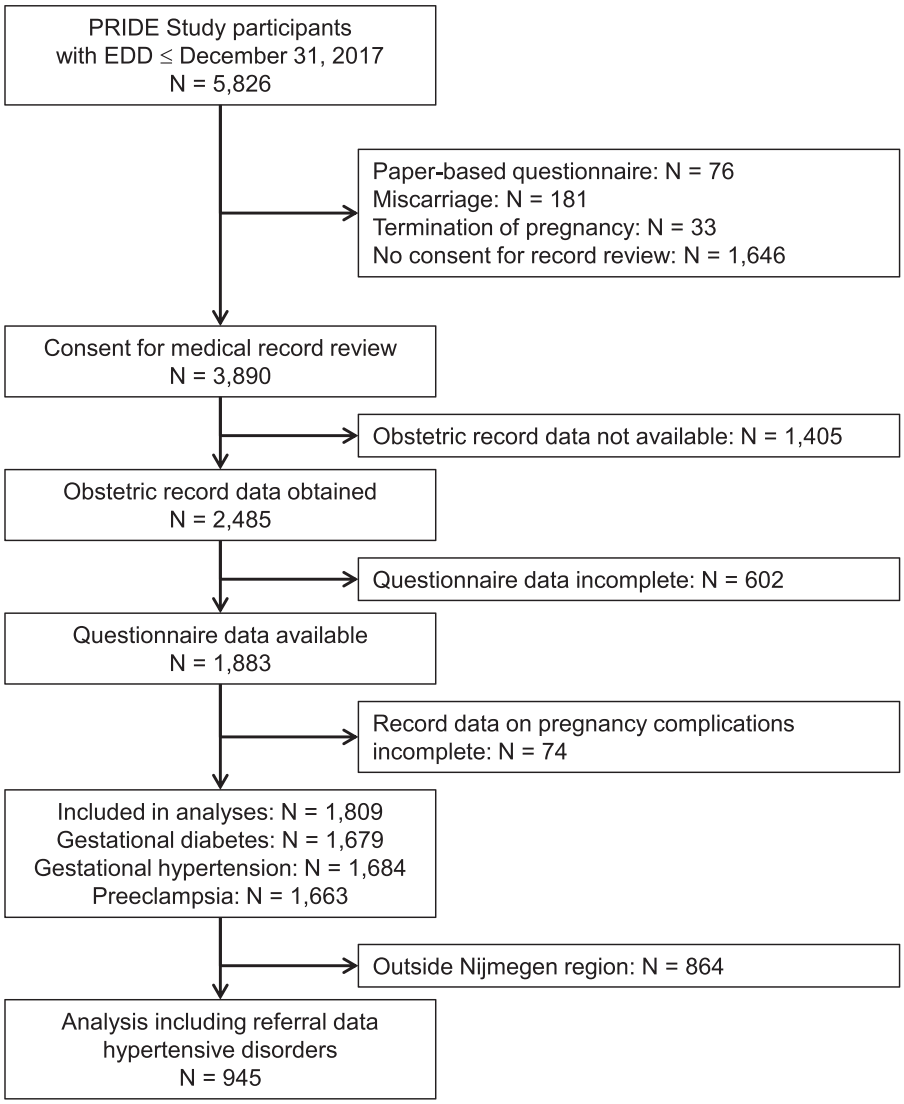

Fig. 1. Flow chart of participation.

Table 1. Characteristics of PRIDE Study participants by eligibility status

	Included in validation study				
	Total (*N* = 1,809)	Subsample (*N* = 945)[a]	No consent record review (*N* = 1,646)	Record data unavailable (*N* = 1,405)	WBQ incomplete (*N* = 602)
Characteristic	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**
Maternal age (y)					
<25 y	70 (3.9)	20 (2.1)	90 (5.5)	72 (5.1)	37 (6.1)
25–29 y	654 (36.2)	308 (32.6)	610 (37.1)	476 (33.9)	226 (37.5)
30–34 y	830 (45.9)	470 (49.7)	714 (43.4)	650 (46.3)	249 (41.4)
≥35 y	255 (14.1)	147 (15.6)	232 (14.1)	207 (14.7)	90 (15.0)
Country of birth					
The Netherlands	1,726 (95.4)	897 (94.9)	1,481 (90.0)	1,303 (92.7)	506 (84.1)
Other	70 (3.9)	40 (4.2)	58 (3.5)	49 (3.5)	29 (4.8)
Missing	13 (0.7)	8 (0.8)	107 (6.5)	53 (3.8)	67 (11.1)
Level of education					
Low/intermediate	406 (22.4)	156 (16.5)	409 (24.8)	372 (26.5)	199 (33.1)
High	1,390 (76.8)	780 (82.5)	1,132 (68.8)	982 (69.9)	338 (56.1)
Missing	13 (0.7)	9 (1.0)	105 (6.4)	51 (3.6)	65 (10.8)
Prepregnancy BMI					
Underweight	60 (3.3)	34 (3.6)	53 (3.2)	42 (3.0)	14 (2.3)
Normal weight	1,287 (71.1)	689 (72.9)	1,137 (69.1)	887 (63.1)	409 (67.9)
Overweight	323 (17.9)	151 (16.0)	300 (18.2)	296 (21.1)	116 (19.3)
Obese	123 (6.8)	61 (6.5)	113 (6.9)	149 (10.6)	43 (7.1)
Missing	16 (0.9)	10 (1.1)	43 (2.6)	31 (2.2)	20 (3.3)
Parity					
0 previous births	1,009 (55.8)	554 (58.6)	922 (56.0)	804 (57.2)	292 (48.5)
≥1 previous birth	794 (43.9)	387 (41.0)	711 (43.2)	594 (42.3)	307 (51.0)
Missing	6 (0.3)	4 (0.4)	13 (0.8)	7 (0.5)	3 (0.5)
Pregnancy complications[b]					
Gestational diabetes	44 (2.6)	10 (1.1)	NA	NA	15 (2.7)
Gestational hypertension	81 (4.8)	51 (5.6)	NA	NA	22 (4.0)
Preeclampsia	44 (2.6)	28 (3.1)	NA	NA	5 (0.9)
Pregnancy complications[c]					
Gestational diabetes	46 (2.6)	13 (1.4)	41 (3.7)	38 (3.7)	NA
Gestational hypertension	142 (7.9)	88 (9.4)	107 (9.5)	95 (9.1)	NA
Preeclampsia	44 (2.5)	27 (2.9)	45 (4.0)	34 (3.3)	NA

Abbreviations: BMI, body mass index; NA, not applicable; WBQ, Web-based questionnaire.

[a] Women residing in the Nijmegen region, for whom hospital records were available in case of referral from midwife to hospital at any point during pregnancy.

[b] According to the obstetric record, prevalence among those without missing information.

[c] According to the Web-based questionnaire, prevalence among those without missing information.

the data on pregnancy complications may not be fully captured in the records obtained from midwifery practices when women are referred to hospital.

To determine whether maternal characteristics were associated with disagreement between the Web-based questionnaires and obstetric records, we used univariable logistic regression analyses. All analyses were performed using IBM SPSS Statistics for Windows, version 25 (IBM Corp, Armonk, NY, USA).

3. Results

In total, 1,809 women were included in this validation study (Fig. 1). The characteristics of the PRIDE Study participants by eligibility status are shown in Table 1. The mean age of the women included was 30.5 years (standard deviation 3.6), 76.8% had a high level of education, and 56.0% had not given birth previously. For the women in the subsample with complete referral data, these figures were slightly higher.

In Table 2, sensitivity, specificity, PPV, and NPV are shown for gestational diabetes, gestational hypertension, and preeclampsia. In the total sample, we observed very few false-positive and false-negative reports for gestational diabetes and preeclampsia, resulting in sensitivities exceeding 88% and specificities of 100%. The PPVs for gestational diabetes and preeclampsia were approximately 90%, and the NPVs were 100%.

The validity measures for gestational hypertension differed between the two definitions. Depending on the definition used as reference standard, sensitivity was higher for Definition 1 (i.e., clinical diagnosis only) because of a lower number of false-negative reports, whereas the PPV was higher for Definition 2 (i.e., clinical diagnosis and/or according to diagnostic criteria) because of a lower number of false-positive reports. Specificity and NPV did not differ substantially between the two definitions. Sensitivity and specificity were in the range of 62–89% and 96–97% for gestational hypertension. The results in the subsample of women with complete referral information were comparable with those in the total sample, except for a lower PPV for gestational diabetes (69% vs. 91%).

The number of disagreements between questionnaires and obstetric records for gestational diabetes ($n = 7$) and preeclampsia ($n = 10$) was too small to estimate associations with maternal characteristics. Therefore, Table 3 only shows the odds ratios (ORs) with 95% CIs for the associations of maternal characteristic with disagreement between Web-based questionnaires and obstetric records for the diagnosis of gestational hypertension. Using Definition 1, we observed lower odds of disagreement among women aged 25–29 years (OR 0.6, 95% CI 0.3–1.0), with a low/intermediate level of education (OR 0.6, 95% CI 0.3–1.1), and/or with ≥1 previous births (OR 0.5, 95% CI 0.3–0.9). Prepregnancy overweight (OR 1.7, 95% CI 1.1–2.8) and ≥1 previous births (OR 0.6, 95% CI 0.4–0.9) were associated with disagreement when using Definition 2 for gestational hypertension. Maternal country of birth did not seem to be associated with disagreement on gestational hypertension between questionnaires and obstetric record irrespective of the definition for gestational hypertension applied.

4. Discussion

4.1. Main findings

Maternal report of preeclampsia and gestational diabetes in Web-based questionnaires administered during pregnancy and 2 months after the EDD seemed to be accurate with very few false-positive and false-negative reports. For gestational hypertension, however, we observed a substantial number of misclassified women, which differed greatly depending on the definition of gestational hypertension applied. When gestational hypertension was based on its clinical diagnosis in the obstetric record, we observed a substantial proportion of false-positive maternal reports. When hypertension diagnostic criteria were applied along with the clinical diagnosis, we observed a decrease in the number of false-positive reports but an increase in false-negative reports. Women were often hypertensive according to the diagnostic criteria, but no official diagnosis was recorded in the obstetric record. Therefore, this increase in false-negatives might be because of underdiagnosis of gestational hypertension rather than to poor maternal self-report. Nevertheless, substantial overreporting of gestational hypertension was seen for both definitions.

4.2. Strengths and limitations

The main strength of this study is the large number of participants in combination with the detailed data on

Table 2. Comparison of the diagnosis of gestational diabetes, gestational hypertension, and preeclampsia based on self-report in Web-based questionnaires and obstetric records

	Number of subjects				Validity			
Complication	**TP**	**FP**	**FN**	**TN**	**Se (95% CI)**	**Sp (95% CI)**	**PPV (95% CI)**	**NPV (95% CI)**
Total sample ($N = 1,809$)								
Gestational diabetes	41	4	3	1,631	93 (86–100)	100 (100–100)	91 (90–92)	100 (99–100)
Gestational hypertension (1)[a]	72	64	9	1,532	89 (82–96)	96 (95–97)	53 (50–55)	99 (98–100)
Gestational hypertension (2)[b]	88	49	54	1,493	62 (54–70)	97 (96–98)	64 (62–67)	97 (93–100)
Preeclampsia	38	5	5	1,615	88 (79–98)	100 (99–100)	88 (87–90)	100 (98–100)
Subsample ($N = 945$)								
Gestational diabetes	9	4	1	891	90 (71–100)	100 (99–100)	69 (66–72)	100 (98–100)
Gestational hypertension (1)[a]	44	40	7	816	86 (77–96)	95 (94–97)	52 (49–56)	99 (97–100)
Gestational hypertension (2)[b]	55	31	36	788	60 (50–70)	96 (95–98)	64 (61–67)	96 (91–100)
Preeclampsia	24	3	3	875	89 (77–100)	100 (99–100)	89 (87–91)	100 (97–100)

Abbreviations: CI, confidence interval; FN, false-negative; FP, false-positive; NPV, negative predictive value; PPV, positive predictive value; Se, sensitivity; Sp, specificity; TN, true-negative; TP, true-positive.

[a] Definition 1: clinical diagnosis only.

[b] Definition 2: clinical diagnosis and/or according to diagnostic criteria.

Data from the PRIDE Study, 2012–2017.

Table 3. Associations between selected maternal characteristics and disagreement of the Web-based questionnaire and obstetric record for diagnosis of gestational hypertension

	Gestational hypertension (1)[a]			Gestational hypertension (2)[b]		
Characteristic	**Total *N***	**Disagreement, *n* (%)**	**OR (95% CI)**	**Total *N***	**Disagreement, *n* (%)**	**OR (95% CI)**
Maternal age (y)						
<25 y	64	3 (4.7)	0.9 (0.3–2.9)	64	4 (6.3)	1.0 (0.3–2.7)
25–29 y	601	18 (3.0)	0.6 (0.3–1.0)	602	31 (5.1)	0.8 (0.5–1.2)
30–34 y	775	41 (5.3)	Reference	780	51 (6.5)	Reference
≥35 y	237	11 (4.6)	0.9 (0.4–1.7)	238	17 (7.1)	1.1 (0.6–1.9)
Country of birth						
The Netherlands	1,600	69 (4.3)	Reference	1,606	97 (6.0)	Reference
Other	67	2 (3.0)	0.7 (0.2–2.8)	67	4 (6.0)	1.0 (0.4–2.8)
Level of education						
Low/intermediate	370	10 (2.7)	0.6 (0.3–1.1)	371	17 (4.6)	0.7 (0.4–1.2)
High	1,296	61 (4.7)	Reference	1,301	84 (6.5)	Reference
Prepregnancy BMI						
Underweight	54	2 (3.7)	0.9 (0.2–3.8)	54	2 (3.7)	0.7 (0.2–2.8)
Normal	1,202	49 (4.1)	Reference	1,204	65 (5.4)	Reference
Overweight	295	17 (5.8)	1.4 (0.8–2.5)	298	27 (9.1)	1.7 (1.1–2.8)
Obese	112	5 (4.5)	1.1 (0.4–2.8)	113	8 (7.1)	1.3 (0.6–2.9)
Parity						
0 previous births	942	51 (5.4)	Reference	945	71 (7.5)	Reference
≥1 previous births	730	22 (3.0)	0.5 (0.3–0.9)	734	32 (4.4)	0.6 (0.4–0.9)

Abbreviations: BMI, body mass index; CI,confidence interval; OR, odds ratio.
[a] Definition 1: clinical diagnosis only.
[b] Definition 2: clinical diagnosis and/or according to diagnostic criteria.
Data from the PRIDE Study, 2012–2017.

pregnancy complications and covariates. Because of the availability of data on blood pressure readings in the obstetric records, we were also able to define hypertension according to its diagnostic criteria. However, this study also had some limitations. The study population mainly represented highly educated women, which may have affected the results and their generalizability. Furthermore, obstetric records were not or not yet available for a substantial proportion of PRIDE Study participants, but we did not identify major differences in maternal characteristics between participants with and without obstetric records available (Table 1).

4.3. Interpretation

This is the first study to validate data collection on a number of commonly studied pregnancy complications using Web-based questionnaires. Validity of maternal self-report of pregnancy complications was studied before for paper-based questionnaires or interviews only [2,5–8,10,11]. These studies reported conflicting results on the validity of hypertensive disorders of pregnancy in general [8,9], preeclampsia [2,5–8,10,11], gestational hypertension [2–4,11], and gestational diabetes [2–4,9,11]. Generally, we found higher values for the validity measures for preeclampsia and gestational diabetes than most previous studies. Validity measures for both definitions of gestational hypertension were within the range of results of previous studies.

In addition, we assessed whether maternal characteristics were associated with disagreement between maternal reports and the obstetric record for gestational hypertension, as this could lead to differential misclassification. Although results are inconsistent, multiparity has been associated with improved recall of pregnancy-related events in several studies [6,11,18,19], in accordance to this study. Thus, primiparous women may report hypertensive disorders during pregnancy less accurately than multiparous women, which may yield biased effect estimates in epidemiologic studies. Furthermore, we observed associations between disagreement and maternal age, level of education, and prepregnancy BMI, but no clear pattern for differential maternal recall associated with these characteristics is apparent in the literature.

The results of this study may have implications for epidemiologic studies focusing on pregnancy complications using data obtained through questionnaires. We confirmed that data from questionnaires are accurate for preeclampsia and gestational diabetes, even when collected online. For gestational hypertension, validity measures were lower, but it is debatable whether diagnoses in obstetric records can be considered as a true gold standard for this complication. We observed a substantial proportion of women who met the diagnostic criteria for this outcome but were not

officially diagnosed with gestational hypertension. The diagnosis in clinical practice might be less stringent in case of mild hypertension or among women who became normotensive at the next visit. More research is required to determine for what reasons these women were not classified as hypertensive. For now, studies using self-reported diagnoses of gestational hypertension may face a substantial number of false-positive reports, mainly because of women reporting a diagnosis of gestational hypertension based upon a single increased blood pressure reading only. Analyses of individual blood pressure trajectories originating from obstetric records may be more reliable to assess gestational hypertension than a clinical diagnosis but may be infeasible in large-scale studies.

5. Conclusion

In this study, we showed that maternal self-reports of preeclampsia and gestational diabetes in Web-based questionnaires are valid. Gestational hypertension seemed to be of lower validity because of relatively high numbers of false-positive reports, but it is questionable whether an appropriate reference standard is available to validate this outcome.

CRediT authorship contribution statement

Pim Beekers: Conceptualization, Data curation, Formal analysis, Writing - original draft. **Hussein Jamaladin:** Conceptualization, Data curation, Writing - review & editing. **Joris van Drongelen:** Data curation, Methodology, Writing - review & editing. **Nel Roeleveld:** Conceptualization, Funding acquisition, Methodology, Writing - review & editing. **Marleen M.H.J. van Gelder:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Writing - review & editing.

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