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Maternal Recall of Hypertensive Disorders in Pregnancy: A Systematic Review

Jennifer J. Stuart, MSc,[1,2] C. Noel Bairey Merz, MD,[3] Sarah L. Berga, MD,[4] Virginia M. Miller, MBA, PhD,[5] Pamela Ouyang, MBBS,[6] Chrisandra L. Shufelt, MD, MS,[3] Meir Steiner, MD, PhD,[7] Nanette K. Wenger, MD,[8] and Janet W. Rich-Edwards, ScD, MPH[1,2]

Abstract

Background: Hypertensive disorders in pregnancy are risk markers for future maternal coronary heart disease (CHD). Clinical assessment of a woman's history of pregnancy complications relies on self-report, but the predictive value of maternal recall is unclear. A systematic review was conducted to comprehensively review and critically assess the available literature on maternal recall of hypertensive disorders in pregnancy.
Methods: The PubMed, EMBASE, and Web of Science databases were searched through August 2012. We included original research articles comparing maternal recall of hypertensive disorders in pregnancy with medical records.
Results: Ten studies met eligibility criteria for qualitative analysis and were independently reviewed by two investigators. Recall periods ranged from 48 hours to 30 years. Length of recall did not appear to uniformly affect recall quality. Sensitivity was generally lower and less consistent for gestational hypertension than for preeclampsia. Specificity was >90% for all hypertensive disorders. Determinants of recall accuracy included maternal education and parity.
Conclusions: Although maternal recall of hypertensive disorders of pregnancy is specific, low sensitivity and predictive values may limit the clinical utility of asking mothers to recall their history of hypertensive pregnancy complications. Future research on maternal recall of pregnancy complications should be designed to yield predictive values and test recall of disorder subtypes, recurrent complications, and changing recall over time in the same population. The utility of gestation length and offspring birth weight for clinical identification of women whose pregnancy history puts them at increased CHD risk should also be explored.

Introduction

Coronary heart disease (CHD) is the leading cause of death globally, and more women than men die from CHD.[1,2] Treatment and control of established cardiovascular risk markers, such as smoking, hypertension, and high cholesterol, have reduced cardiovascular mortality.[2–8] The success of primary prevention relies on our ability to identify individuals at high risk for CHD for targeted risk prevention.[9] However, up to 20% of all coronary events occur in individuals without any major risk markers and many women with traditional risk markers do not experience coronary events.[10,11] The biologic understanding of CHD has expanded over the past half-century, but cardiovascular risk prediction algorithms remain largely unchanged for women.[12–14]

A growing body of literature indicates that women with a history of hypertensive pregnancies are twice as likely as women with normotensive pregnancies to develop CHD.[15,16] In particular, women with a history of preterm preeclampsia appear to be at a 7–8-fold increased risk of CHD morbidity

[1]Department of Epidemiology, Harvard School of Public Health, Boston, Massachusetts.
[2]Connors Center for Women's Health and Gender Biology, Division of Women's Health, Brigham and Women's Hospital, Boston, Massachusetts.
[3]Women's Heart Center, Cedars-Sinai Heart Institute, Los Angeles, California.
[4]Department of Obstetrics and Gynecology, Wake Forest School of Medicine, Winston-Salem, North Carolina.
[5]Departments of Surgery and Physiology and Biomedical Engineering, Mayo Clinic, Rochester, Minnesota.
[6]Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, Maryland.
[7]Departments of Psychiatry & Behavioral Neurosciences and Obstetrics & Gynecology, McMaster University, Hamilton, Ontario, Canada.
[8]Emory Heart and Vascular Center, Emory University School of Medicine, Atlanta, Georgia.

and mortality.[17–19] Hypertensive complications may reveal subclinical CHD risk under the physiologic stress of pregnancy, providing an early warning of future CHD that could be exploited to identify high-risk women at a young age.[20,21]

Hypertensive disorders of pregnancy include preeclampsia-eclampsia, gestational hypertension, chronic hypertension, and preeclampsia superimposed on chronic hypertension (Fig. 1).[22] Over the course of reproductive life, approximately 10%–15% of parous U.S. women will have at least one pregnancy complicated by a hypertensive disorder.[35] Further research is needed to determine the extent to which a history of hypertensive disorders of pregnancy predicts future CHD beyond traditional CHD risk markers routinely screened in primary care. If the association between a history of hypertensive disorders of pregnancy and CHD is accounted for by traditional risk markers, pregnancy history may identify women suitable for early screening.

The clinical utility of pregnancy history as a CHD screen depends on a woman's ability to accurately recall if her pregnancies were hypertensive, as pregnancy records are rarely transferred to primary care clinicians as part of routine clinical practice. Accordingly, the positive predictive value (PPV) and negative predictive value (NPV) of maternal recall are crucial to its clinical relevance. Studies linking pregnancy complications with CHD events in maturity often rely on maternal recall of details about the course of pregnancies that occurred decades earlier, for which medical record collection may not be feasible. The sensitivity and specificity of maternal recall are important determinants of a study's ability to detect associations between hypertensive disorders and CHD events.

Given the increasing attention to the relationship of pregnancy complications with CHD and the challenges surrounding accurate report of these conditions, we conducted a systematic review of the literature to assess the accuracy of maternal recall of hypertensive disorders in pregnancy.

Materials and Methods

Relevant studies were identified through structured literature searches of three databases (PubMed, EMBASE, Web of Science) through August 2012. With guidance from a professional librarian, we developed individual search strategies for each database. Articles were identified through PubMed using the Medical Subject Headings (MeSH): mental recall, reproducibility of results, validity, validation, hypertension, pregnancy-induced, and obstetric labor complications. These were combined with keyword searches (Title and Abstract [TIAB] content) to capture recent articles not yet MeSH indexed and to collectively define a primary collection of relevant literature. Articles were identified in the EMBASE database through use of the EMTREE terms: recall, validation study, validation process, medical record, reliability, sensitivity and specificity, self report, pregnancy, preeclampsia, eclampsia and preeclampsia, and maternal hypertension. Similar search strategies were employed for Web of Science. References of relevant articles were hand searched to capture studies not previously identified.

Study selection

We included only original research articles and validation studies assessing maternal recall against medical records of at

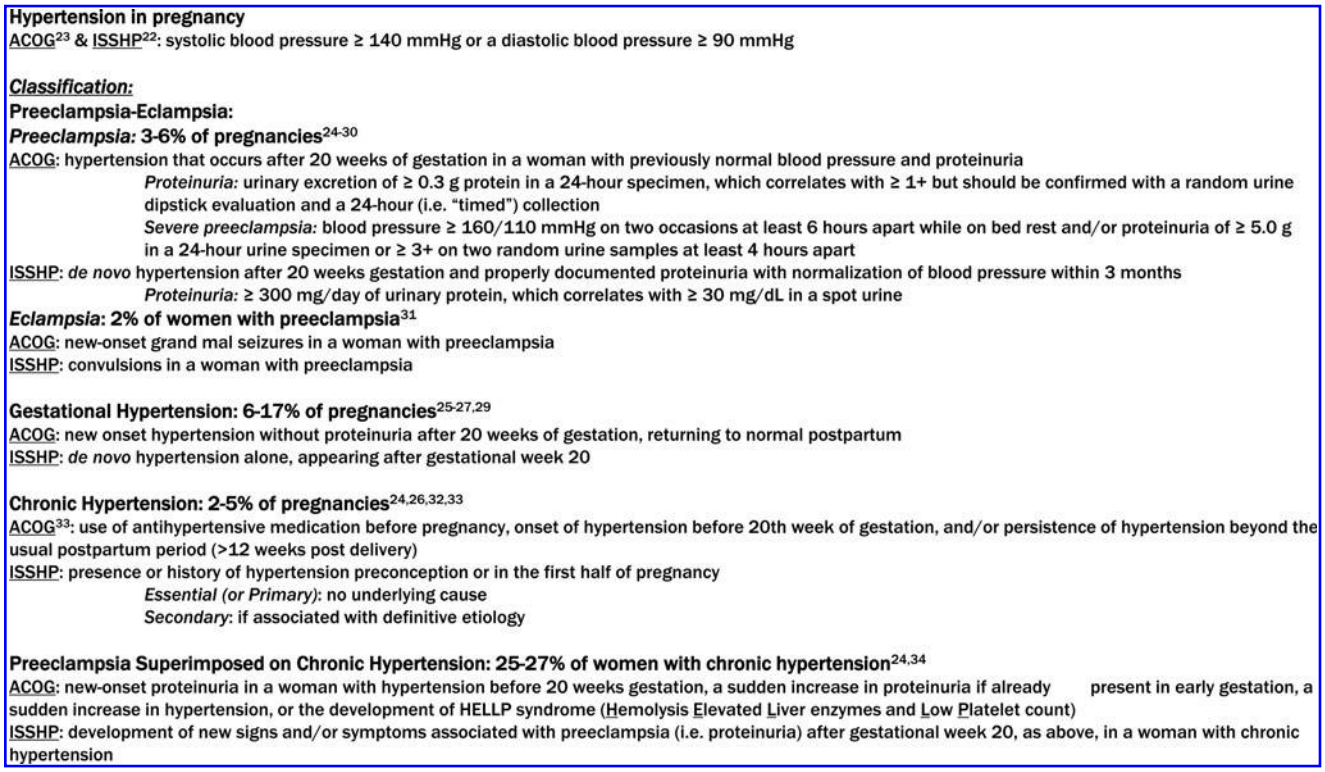

FIG. 1. Classification, prevalence, and diagnostic criteria of hypertension in pregnancy. ACOG, American College of Obstetricians and Gynecologists; ISSHP, International Society for the Study of Hypertension in Pregnancy.

least one of the hypertensive disorders of pregnancy: chronic hypertension, chronic hypertension with superimposed preeclampsia, preeclampsia, eclampsia, or gestational hypertension. Medical records served as the gold standard against which the accuracy of maternal recall was compared. Only English language studies were included. No restrictions were made about date of publication, journal, or country. Studies that did not separate or adequately define the hypertensive disorder of pregnancy, did not compare maternal report to medical records, or did not provide validity estimates (sensitivity, specificity) or predictive values (PPV, NPV) were excluded.

One investigator selected articles for review based on title. Two investigators then independently assessed studies for inclusion and completed data abstraction into an electronic database based on abstract and full text. Abstracted variables included sample size, length of recall, date and country of publication, recalled conditions of interest and their corresponding definitions, and diagnostic criteria applied to the medical records.

The limited number of studies and heterogeneity in the participants, outcome definitions, and study design precluded a meta-analysis of results; therefore, data were summarized qualitatively. Sensitivity, that is, the percentage of women with the hypertensive disorder who correctly recall having the hypertensive disorder in pregnancy, and specificity, that is, the percentage of women without the hypertensive disorder who correctly recall not having the hypertensive disorder in pregnancy, are important to the quality of studies reliant on maternal recall. The PPV, the proportion of positive maternal recalls that are accurate, and NPV, the proportion of negative maternal recalls that are accurate, are relevant to the clinician's assessment of a patient's self-reported history of disease. Where case-control studies assessed recall of hypertensive disorders by case mothers of offspring affected by other conditions (e.g., schizophrenia) vs. control mothers of unaffected offspring, our summary focused on the recall accuracy of the control mothers because of the heterogeneity of case conditions and the potential for case status to affect maternal recall quality.

Results

The electronic database search identified 1874 citations, of which 1794 were excluded on title review by one investigator (J.J.S.) because they were not about maternal recall of hypertensive disorders of pregnancy or were duplicates found in multiple databases (Fig. 2). Two independent investigators (J.J.S. and J.W.R.E.) reviewed the remaining 80 articles and excluded 70 because they did not assess recall of hypertensive disorders in pregnancy ($n=47$); did not compare maternal report to medical records ($n=4$); did not provide information on sensitivity, specificity, PPV, or NPV ($n=3$); did not separate or adequately define the hypertensive disorder of pregnancy ($n=10$); were commentaries ($n=4$); or for which full-text ($n=1$) or English versions ($n=1$) were not available. The remaining 10 articles, 8 from electronic databases and an additional 2 from references, were included in this systematic review. These studies represent validation studies across seven countries: Canada,[36] Denmark,[37] The Netherlands,[38] Spain,[39] Taiwan,[40] the U.K.,[41] and the United States.[42–45] Sample sizes ranged from 78[42] to 4330 mothers.[38] These studies provided validity estimates and predictive values only for gestational hypertension and preeclampsia; therefore, the subsequent review focuses on these two conditions. In the absence of validation data, statements about maternal recall of the other hypertensive disorders in pregnancy, namely, chronic hypertension, preeclampsia superimposed on chronic hypertension, and eclampsia, cannot be made at this time.

Of the 10 studies included, 7 validated maternal recall of gestational hypertension (Table 1) and 7 validated preeclampsia (Table 2). The majority ($n=7$) were case-control studies in which mothers of offspring with and without various conditions, including cancer,[36,45] schizophrenia,[42,43] or perinatal complications,[39,40] were asked to recall if their

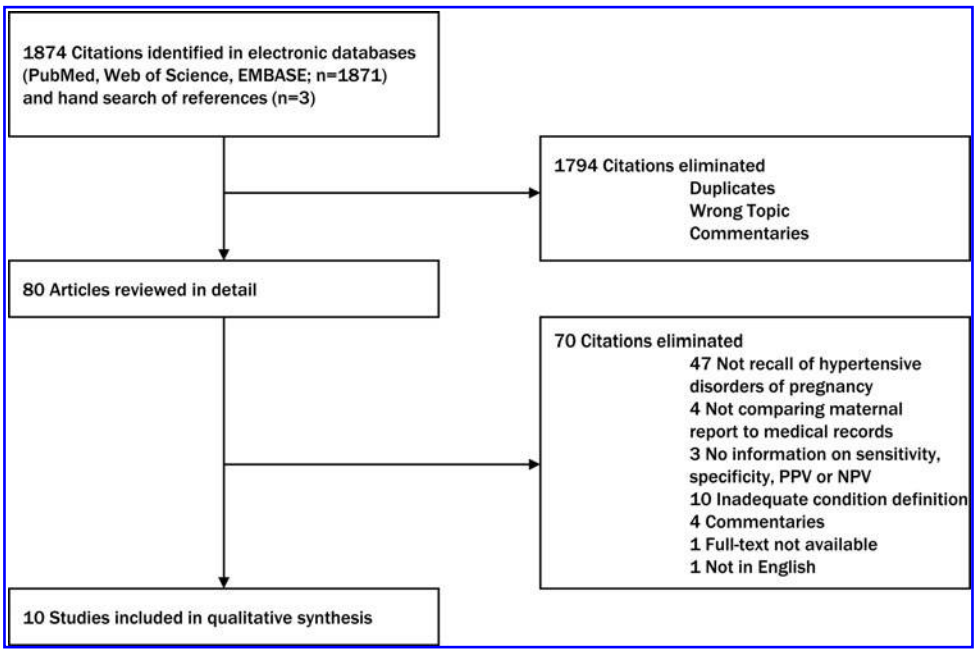

FIG. 2. Flow diagram of search strategy. NPV, negative predictive value; PPV, positive predictive value.

Table 1. Characteristics of Studies Comparing Report of Gestational Hypertension from Two Sources by Study Design and Length of Recall

Study	*Study design*	*Sample size & population characteristics*	*Mean recall period*	*Condition recalled*	*Prevalence (%)*	*Sensitivity (%)*	*Specificity (%)*	*PPV (%)*	*NPV (%)*
Cohort study									
Klemmensen et al., 2007[37]	Population-based validation study using a mandatory Danish national hospital discharge registry (Danish National Birth Cohort)	3039 women who gave birth at one of three hospitals (Denmark)	6 months	Gestational hypertension	3.0 (chart)[a] 8.6 (recall)[b]	58.5	92.6	18. 7	98.7*
Case-control studies									
Delgado-Rodriguez et al., 1995[39]	Case-control study of drug exposure and low birth weight at a tertiary hospital	169 mothers of low birth weight cases; 198 control mothers (Spain)	<48 hours	Gestational hypertension		33.3 (controls) 71.4 (cases)	98.9 (controls) 96.5 (cases)		
Olson et al., 1997[36]	Case-control study of childhood cancer	287 mothers of childhood cancer cases and 467 control mothers (U.S. and Canada)	2–3.9 years	Gestational hypertension		72.0 (criteria)[c] 65.0 (mention)[d]	90.0 (criteria)[c] 94.0 (mention)[d]		
Jurek et al., 2011[45]	Case-control study of infant leukemia diagnosed during first year of life	234 mothers of infant leukemia cases and 215 control mothers (Tennessee)	3 years	Gestational hypertension		90.0 (controls) 46.0 (cases)	92.0 (controls) 92.0 (cases)	56.0 (controls) 46.0 (cases)	99.0 (controls) 92.0 (cases)
Sou et al., 2006[40]	Case-control study of maternal recall for term, normal birth weight and preterm, low birth weight infants	101 mothers of preterm, low birth weight cases and 107 control mothers (Taiwan)	6 years	Gestational hypertension	Controls: 3.7 (chart)[a] 4.7 (recall)[b] Cases: 31.7 (chart)[a] 32.7 (recall)[b]	100.0 (controls) 90.6 (cases)	99.0 (controls) 94.2 (cases)		
Buka et al., 2004[43]	Case-control validation study of long-term recall of prenatal and perinatal events within a prospective cohort study	96 mothers with perinatal complications or offspring psychosis and corresponding controls (Boston and Providence)	30 years	High blood pressure	30.0 (chart)[a] 12.0 (recall)[b]	31.0	97.0		
Buka et al., 2000[42]	Case-control study of recall in mothers of adult offspring with schizophrenia or other psychoses within a prospective cohort study	39 mothers of offspring with psychosis and 39 mothers of control offspring (Boston and Providence)	33 years	High blood pressure	Controls: 41.0 (chart)[a] 18.0 (recall)[b] Cases: 21.0 (chart)[a] 4.0 (recall)[b]	17.0 (cases) 36.0 (controls)	100.0 (cases) 94.0 (controls)		

[a]Prevalence of gestational hypertension according to medical chart review (chart prevalence).
[b]Prevalence of gestational hypertension according to maternal recall (recall prevalence).
[c]Estimate obtained when requiring fulfillment of diagnostic criteria to validate gestational hypertension diagnosis.
[d]Estimate obtained when only requiring mention of gestational hypertension in the medical chart to validate gestational hypertension diagnosis.
*Value was hand calculated from available data.
NPV, negative predictive value; PPV, positive predictive value.

Table 2. Characteristics of Studies Comparing Report of Preeclampsia from Two Sources by Study Design and Length of Recall

Study	Study design	Sample size and population characteristics	Mean recall period	Condition recalled	Prevalence (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Cohort studies									
Coolman et al., 2010[38]	Validation study within a population-based prospective cohort study	4330 women enrolled in pregnancy in Generation R Study (The Netherlands)	2 months	Preeclampsia	2.1 (chart)[a] 3.5 (recall)[b]	84.0 (ACOG) 87.0 (ISSHP)	98.0 (ACOG) 98.0 (ISSHP)	57.0 (ACOG) 50.0 (ISSHP)	99.0 (ACOG) 99.0 (ISSHP)
				Severe preeclampsia		92.0			99.0
Klemmensen et al., 2007[37]	Population-based validation study using mandatory Danish national hospital discharge registry (Danish National Birth Cohort)	3039 women who gave birth at one of three hospitals (Denmark)	6 months	Preeclampsia	2.9 (chart)[a] 3.4 (recall)[b]	72.6	98.6	59.2	99.2[c]
Diehl et al., 2008[44]	Validation study of preeclampsia, eclampsia, and toxemia	103 women with a preeclampsia-related condition and 100 controls (Rochester, MN)	27 years	Preeclampsia		79.6	96.0	51.0	99.0
Case-control studies									
Olson et al., 1997[36]	Case-control study of childhood cancer	287 case and 467 control mothers (U.S. and Canada)	2–3.9 years	Preeclampsia		100.0 (criteria)[d,e] 65.0 (mention)[f]	96.0 (criteria)[d,e] 98.0 (mention)[f]		
				Proteinuria		47.0 (criteria)[d,e] 11.0 (mention)[f]	93.0 (criteria)[d,e] 98.0 (mention)[f]		
Jurek et al., 2011[45]	Case-control study of infant leukemia diagnosed during first year of life	234 mothers of infant leukemia cases and 215 control mothers (Tennessee)	3 years	Preeclampsia		57.0 (controls) 47.0 (cases)	98.0 (controls) 97.0 (cases)		
				Proteinuria		11.0 (controls) 12.0 (cases)	98.0 (controls) 95.0 (cases)		
Sou et al., 2006[40]	Case-control study of maternal recall for term, normal birth weight and preterm, low birth weight infants	101 mothers of preterm, low birth weight cases and 107 control mothers (Taiwan)	6 years	Preeclampsia	Controls: 2.8 (chart)[a] 1.9 (recall)[b] Cases: 28.8 (chart)[a] 22.8 (recall)[b]	66.7 (controls) 68.9 (cases)	100.0 (controls) 95.8 (cases)		
				Proteinuria		20.8 (controls) 59.3 (cases)	95.1 (controls) 86.5 (cases)		
Walshe et al., 2011[41]	Validation study of obstetric complications among a sample of mothers of subjects affected with psychosis and their unaffected relatives	30 mothers of subjects affected with psychosis and 40 mothers of unaffected relatives (England, Wales, Northern Ireland)	30 years	Severe preeclampsia		83.0	100.0		

[a]Prevalence of preclampsia according to medical chart review (chart prevalence).
[b]Prevalence of preclampsia according to maternal recall (recall prevalence).
[c]Indicates hand calculation from values provided in text.
[d]Estimate obtained when requiring fulfillment of diagnostic criteria to validate preclampsia diagnosis.
[e]Validity estimates obtained with diagnostic criteria are based on small cell counts. Among women with a positive medical record, only 3 women for preeclampsia and 7 women for proteinuria provided both a positive maternal report.
[f]Estimate obtained when only requiring mention of preclampsia in the medical chart to validate preclampsia diagnosis.
ACOG, American College of Obstetricians and Gynecologists; ISSHP, International Society for the Study of Hypertension in Pregnancy.

Table 3. Maternal Report Ascertainment and Diagnostic Criteria by Study

Study	Maternal report ascertainment	Diagnostic criteria	
Gestational hypertension			
Cohort study			
Klemmensen et al., 2007[37]	Telephone interview Query: not reported	SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg measured twice within an interval of at least 6 hours	
Case-control studies			
Delgado-Rodriguez et al., 1995[39]	In-person interview Query: not reported	Not reported	
Olson et al., 1997[36]	Telephone interview Query: not reported	DBP > 90 mm Hg on ≥ 2 occasions; Mention of "high blood pressure" in medical record	
Jurek et al., 2011[45]	Telephone interview Query: hypertension occurred in pregnancy	Mention of hypertension in medical record [No diagnostic criteria or defined values were used]	
Sou et al., 2006[40]	Questionnaire (Lewis-Murray Obstetric Complication Scale) Query: not reported	Not reported	
Buka et al., 2004[43]	Telephone interview Query: Did you have high blood pressure/ Pregnancy History Instrument[46]	SBP > 160 or DBP > 110	
Buka et al., 2000[42]	Telephone interview Query: Did you have high blood pressure/ Pregnancy History Instrument[46]	SBP > 160 or DBP > 110	
Preeclampsia			
Cohort studies			
		High blood pressure	*Proteinuria*
Coolman et al., 2010[38]	Questionnaire Query: Hypertension in combination with proteinuria (or using a lay term, translating to loss of protein in urine) (no, yes, or don't know)	SBP ≥ 140 mm Hg and/or DBP ≥ 90 mm Hg (ISSHP) SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg (ACOG) Severe preeclampsia: ≥ 180 mm Hg or DBP ≥ 110 mm Hg[47]	≥ 300 mg/day or spot urine protein/ creatinine ratio ≥ 30 mg/nmol (ISSHP) ≥ 0.3g /24-hour urine (≥ 300 mg /24-hour urine) (ACOG)
Klemmensen et al., 2007[39]	Telephone interview Query: Not reported	SBP ≥ 140 mmHg or DBP ≥ 90 mm Hg measured twice within an interval of at least 6 hours (ACOG) Severe: ≥ 160/110 mm Hg	≥ 0.3 g/24-hour urine or ≥ 1 + urine dipstick twice within an interval of at least 4 hours (ACOG) Severe: ≥ 5.0 g/24-hour urine or ≥ 3 + urine dipstick

(*continued*)

Table 3. (Continued)

Study	*Maternal report ascertainment*	*Diagnostic criteria*	
Diehl et al., 2008[44]	Questionnaire Query: Self-report of any of the following: 1. History of preeclampsia, eclampsia, or toxemia, with or without hypertension, during index pregnancy; 2. Hypertension and proteinuria during but not before index pregnancy; or 3. Hypertension and seizures during but not before index pregnancy.	SBP ≥ 140 mm Hg and DBP ≥ 90 mm Hg on measured twice at least 6 hours apart	≥ 0.3 g /24-hour urine or ≥ 1 + urine dipstick
Case-control studies			
Olson et al., 1997[36]	Telephone interview Query: Not reported	Mention of toxemia or preeclampsia in medical record	
Jurek et al., 2011[45]	Telephone interview Query: Yes/no response to whether toxemia or preeclampsia or hypertension and maternal protein or albumin in urine occurred in pregnancy	Mention of toxemia or preeclampsia or hypertension and maternal protein or albumin in urine in the medical record [No diagnostic criteria or defined values were used]	
Sou et al., 2006[40]	Questionnaire (Lewis-Murray Obstetric Complication Scale) Query: Not reported	Not reported	Not reported
Walshe et al., 2011[41]	In-person interview (Lewis-Murray Obstetric Complication Scale) Query: Not reported	Not reported	Not reported

DBP, diastolic blood pressure; SBP, systolic blood pressure.

pregnancies were complicated by gestational hypertension or preeclampsia. Four case-control studies provided recall estimates separately for case and control mothers; for these, we focus our review on the recall accuracy of the control mothers.[39,40,42,45] Specificity was high across both hypertensive disorders in pregnancy, ranging from 90%[36] to 99%[39,40] for gestational hypertension and from 96%[44] to 100%[40,41] for preeclampsia.

Sensitivity estimates varied greatly for gestational hypertension, ranging from 31%[43] to 100%.[40] Sensitivity estimates for preeclampsia were higher in cohort studies (73%–87%) than in case-control studies (57%–67%), with the exception of Olson et al.'s 100% sensitivity drawn from 747 women, only 3 of whom had medical records positive for preeclampsia who also provided positive self-report.[36] In the 2 studies validating recall of severe preeclampsia, sensitivity estimates were higher than for all preeclampsia across both study designs: 83%[41] and 92%[38] for case-control and cohort studies, respectively. Three studies examined recall of proteinuria, one of the criteria for preeclampsia.[36,40,45] Sensitivity estimates for proteinuria ranged from 11%[45] to 47%,[36] and specificity estimates ranged from 93%[36] to 98%.[45] Predictive values were 19% and 99% for PPV and NPV, respectively, from the 1 cohort study validating maternal recall of gestational hypertension.[37] PPV estimates for maternal recall of preeclampsia ranged from 50%[38] to 59%,[37] and NPV was ≥99%.

Length of recall ranged from <48 hours[39] to >30 years,[42] and only 5 of the 10 studies obtained recall >5 years after the index pregnancy. Across study designs, length of recall did not uniformly affect quality of report of gestational hypertension or preeclampsia. For example, the study with the shortest period of recall (<48 hours) had a sensitivity of 33% among the controls[39] compared with a sensitivity of 36% among controls in the study with the longest period of recall (33 years) for gestational hypertension.[42]

Assessment of maternal recall is highly dependent on the questions asked of the mother, which varied widely across studies (Table 3). Maternal report of hypertensive disorders of pregnancy was typically obtained through either telephone interview or questionnaire. Studies of gestational hypertension generally required a positive or negative response to whether a woman experienced hypertension or high blood pressure during pregnancy. There was great variability in the assessment of maternal recall of preeclampsia. Some studies directly asked women if they had experienced preeclampsia or toxemia, others used questions about the presence of individual symptoms to identify preeclampsia, and still others used multiple detailed questions to triangulate maternal responses into a positive or negative report.

The estimation of predictive values, sensitivity, and specificity also depends on the stringency of criteria applied in the medical records to confirm report of hypertensive disorder (Table 3). The American College of Obstetricians and Gynecologists (ACOG) and International Society for the Study of Hypertension in Pregnancy (ISSHP) definitions of preeclampsia require documentation of blood pressure and proteinuria above specified thresholds (Fig. 1).[22,23] Some studies cited criteria established by the National High Blood Pressure Education Program Working Group on High Blood Pressure in Pregnancy, which additionally require two determinations of elevated blood pressure at least 6 hours apart.[44,48] Still other studies used broader definitions, accepting medical record mention of the condition to confirm presence of disease, rather than requiring documentation of component diagnostic criteria.[45] Although medical records served as the gold standard in all studies reviewed, the information required from the records and the validation details provided by the study authors varied greatly. Some studies failed to report what was required from the records to constitute a positive history.

Three studies assessed potential modifying variables of the accuracy of maternal report.[37,38,43] These variables included maternal education, socioeconomic status, parity, ethnicity, previous disease (i.e., hypertensive disorders in a previous pregnancy), language quality, height, body mass index (BMI), and smoking status. Only 1 study found any statistically significant association. Coolman et al.[38] found higher maternal education and multiparity were positively associated with accurate self-reported diagnosis of preeclampsia, whereas a history of hypertensive disorder in a previous pregnancy lowered the accuracy of self-report for a given pregnancy.

Discussion

This systematic review of maternal recall of hypertensive disorders in pregnancy indicates that the current literature is inadequate to determine the overall quality of maternal report. Estimates of maternal recall accuracy are influenced by study design, selection criteria, population of interest, method of maternal assessment, and diagnostic criteria, all of which vary considerably across validation studies.

Of the 10 studies included in this review, the majority were conducted to validate recall within a particular study population, usually comparing the recall of pregnancy complications by case mothers of offspring with particular conditions to that of control mothers with unaffected offspring. Issues of recall bias may affect the accuracy of the recall of case mothers. To the extent that the prevalence of hypertensive disorder in a cohort more closely resembles that of the general population than the prevalence in a case-control study, cohort studies may provide PPV and NPV estimates superior to those in case-control studies. In the cohort studies, between 73% and 87% of mothers with a history of preeclampsia were able to recall the condition (sensitivity), and >95% of women without preeclampsia correctly denied the condition (specificity). Given the low prevalence of preeclampsia, these validity estimates should be suitable for research purposes.

There was little evidence that maternal recall accuracy was sufficient for clinical purposes. The imperfect specificity combined with the low prevalence of preeclampsia led to PPV estimates of 50%–60%, indicating that slightly more than half of women who report to a clinician they had a history of preeclampsia do, in fact, have evidence of the condition documented in their medical records. However, only 3 cohort studies reported the predictive values of maternal recall of preeclampsia, with a combined total of <350 preeclampsia cases.

Despite the fact that many traditional risk markers, such as family history, also rely on patient recall, this has not precluded their clinical use. Unlike in other screening contexts, the consequences of treating a false positive—a woman who incorrectly reports a history of hypertension in pregnancy—do not involve high costs or potential harm to the patient. Risk-reduction counseling and increased monitoring of

modifiable risk markers, such as blood pressure and cholesterol level, would benefit any individual. Although additional research is needed to identify specific interventions that would reduce morbidity for women with a history of hypertensive disorders in pregnancy, this group of high-risk women would likely benefit from general cardioprotective practices. Future research is needed to establish the role of hypertensive disorders in pregnancy as a risk marker, including whether or not it operates independent of other markers, such as diabetes mellitus, and with regard to the timing of increased cardiovascular risk, both of which may inform clinical application of this marker.

The manner of eliciting maternal report of hypertensive disorders and the diagnostic criteria applied to the medical records to confirm the presence or absence of disease are study design features that profoundly affect the estimates obtained in validation studies. For example, it is easier to report the diagnosis of preeclampsia correctly than to recall the individual criteria of proteinuria, as is evident in the 3 studies examining validity estimates for both preeclampsia and proteinuria (Table 2). Thus, maternal report of preeclampsia diagnosis would obtain a higher sensitivity and NPV than would maternal report of component diagnostic criteria for preeclampsia; this use of an easier maternal recall question would also lower specificity and PPV. When validation studies apply strict modern diagnostic criteria to the review of older medical records, they may conclude maternal recall accuracy is poor when the failure to validate might be more properly attributed to outdated diagnostic criteria or poor medical record documentation. Many studies failed to report either the method of maternal recall report or the diagnostic criteria applied to the medical records (Table 3). When the method used to obtain maternal recall and the criteria applied to the gold standard are not transparent, readers are unable to consider these factors in weighing the quality of maternal recall.

If the diagnostic criteria applied to the medical record are made more strict, more women who report preeclampsia will fail to meet the medical record criteria, decreasing the PPV. Conversely, it becomes more likely that the women identified by medical records as having the condition of interest will provide a positive maternal report, increasing the sensitivity. When more stringent criteria are applied, the specificity will also decrease while the NPV will increase. This impact of different clinical diagnostic criteria on validity estimates is demonstrated by Olson et al.[36] Strict diagnostic criteria for preeclampsia (diastolic blood pressure [DBP] >100 mm Hg on two occasions and $\geq 3+$ urine dipstick) yielded a higher sensitivity of 100% compared to 65% obtained when accepting clinician mention of toxemia or preeclampsia in the medical record. In contrast, strict diagnostic criteria yielded a lower PPV of 8.8% compared to 66.7% obtained by accepting clinician mention of toxemia or preeclampsia in the medical record (values were hand calculated from published data). In this instance, it is difficult to gauge whether maternal recall was flawed, obstetricians overdiagnosed preeclampsia, or the medical record was incomplete.

Validation studies of recall accuracy have inherent limitations tied to study design. Women who participate in studies may be more or less likely to recall specific pregnancy details than the general population. Validation study results rely on the availability, completeness, and accuracy of medical records. Measures of validity are only as valuable as the quality of the gold standard to which self-report is compared. Lack of a medical record or diagnostic details does not necessarily imply absence of the condition; where medical diagnosis or record keeping is incomplete, it is possible the true prevalence of conditions may be underestimated. In situations where medical records are incomplete, especially in the setting of emergency delivery, a woman's report may be more accurate than her medical record.

Only 1 of the 3 studies evaluating predictors of recall quality identified statistically significant relationships, namely, positive associations between higher maternal education and multiparity with accurate self-report and a negative association between history of hypertensive disorder in a previous pregnancy and accurate self-report. Experience of a hypertensive disorder in a previous pregnancy other than the index pregnancy may be inversely associated with accuracy of maternal report as a result of confusion over which pregnancy is being recalled, the woman's desire to share her pregnancy complication even if it took place outside the pregnancy in question, lack of clarity in ascertainment, or some other factor. When evaluating the relationship between a woman's history of hypertensive pregnancy and her cardiovascular disease risk, however, her ability to recall complications in an individual pregnancy may be less important than her ability to recall ever having the complication.

The length of recall period did not uniformly affect quality of maternal report. Our summary focused on recall periods ranging from <48 hours to >30 years after delivery of the index pregnancy. Although longer recall periods may be more relevant in the context of CHD risk prediction in clinical practice, the quality of maternal report shortly after delivery is still important. If a woman is unable to accurately recall her experience of a hypertensive disorder in pregnancy shortly after delivery, she likely cannot be expected to accurately recall the experience decades after the delivery. Further research should be conducted to improve clinician-patient communication strategies after delivery to improve recall shortly after delivery and, in turn, improve long-term recall.

As the severity of hypertensive disorder increased from gestational hypertension to preeclampsia to severe preeclampsia, the accuracy of maternal recall appeared to increase. Although this suggests that recall of acute cases can be trusted in future studies, it further suggests that other markers of disease severity may be combined with maternal recall of hypertensive pregnancy to increase its accuracy. For example, severe preeclampsia is often accompanied by low birth weight or preterm delivery. It is possible that maternal recall of an infant weighing <2500 g or delivered before 37 weeks of gestation may be used to refine or even replace maternal recall of hypertensive disorders. The accuracy of such a combined clinometric recall algorithm should be tested against medical records to determine if it would enhance the PPV and sensitivity of maternal recall of hypertensive pregnancies. The combined recall of hypertensive pregnancy with preterm or low birth weight delivery may yield higher PPV and identify a group of women at highest risk of future CHD, suggested by the 7–8-fold increased risk of CHD in women with a history of preterm preeclampsia.[19–21] Future research should also evaluate recall of chronic hypertension in pregnancy, preeclampsia superimposed on chronic hypertension, recurrent complications, recall over time within the same population, and changes in recall quality obtained through application of different clinical diagnostic criteria.

If studies continue to indicate that the PPV of maternal recall is low, its collection as part of routine clinical history may not

prove useful as a screen for future CHD. Studies designed specifically to test the predictive value of preeclampsia recall are necessary to fully understand its clinical utility. Qualitative research with mothers and clinicians may help further elucidate the factors that affect maternal recall. It is possible both PPV and NPV could be improved with better communication by, for example, including a pregnancy complication summary that could accompany a woman as she transits from the obstetric to primary care setting. Ultimately, however, the clinical utility of pregnancy history may require linkage of prenatal medical records to primary care records.

Women with a history of hypertensive disorders in pregnancy may benefit from risk-reduction counseling, but only if providers are aware of the association and of their patients' pregnancy history. A recent study by Young et al.[49] found that although 95% of internists and 70% of obstetrician-gynecologists routinely counseled their patients about cardiovascular risk, the majority of providers did not include preeclampsia as part of the medical history. Of those providers who collected information on preeclampsia, the majority (91% of internists and 62% of obstetrician-gynecologists) did not counsel women with a positive report of preeclampsia about their increased cardiovascular risk.[49] The American Heart Association 2011 guidelines recommend clinicians evaluate cardiovascular risk by screening women for a history of pregnancy complications.[50] However, few data exist on which risk markers should be screened or the frequency and timing of screening after a complicated pregnancy. Improved clarity in published guidelines about the association between hypertensive disorders in pregnancy and cardiovascular disease is needed to better inform providers.

Conclusions

The quality of maternal recall of hypertensive disorders in pregnancy remains inconclusive with regard to sensitivity and predictive values. Given the heterogeneity present across validation studies of maternal recall of hypertensive disorders in pregnancy, we recommend large, population-based studies designed to examine maternal recall validity among women with documented histories of hypertensive pregnancy of varying severity. Information on birth weight and gestation length should be collected to evaluate potential refinement of recall through the combined use of these variables. The utility of the relationship between hypertensive disorders in pregnancy and CHD remains in question until an increased understanding of the validity of maternal report of pregnancy complications is determined.

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Address correspondence to:
Jennifer J. Stuart, MSc
1620 Tremont Street, 3rd Floor
Boston, MA 02120

E-mail: jstuart@mail.harvard.edu