

## Online Appendix

This appendix has been provided by the authors to give readers additional information about their work.

**Supplement to:** Garovic, VD, White WM, Lisa Vaughan LE, et al.

**A population-based cohort study of incidence of hypertensive disorders of pregnancy, long-term outcomes, and multimorbidity**

Supplementary Appendix

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**Online Table 1.** Hospital International Classification of Diseases Adapted (HICDA) codes utilized to identify potential cases of HPD in the study population between 1976 and 1982

<b>HICDA Codes used</b>
0650-0664 Full-term delivery of livebirth or stillbirth and premature delivery of livebirth or stillbirth after 20 weeks of gestation
4000-4050 Hypertension, malignant, accelerated
06370-06379 Preeclampsia, eclampsia, HELLP, toxemia
06330-06339 Intrauterine death
06343-06344 Intrauterine growth retardation
06352 Infarction, placental
06353 Insufficiency, placental (mother's history)
07600-07603 Premature infant, preterm
07640 Fetal distress before labor
07649 Birth asphyxia, unspecified
07747 High blood pressure, labile blood pressure
07756 Edema, swelling fluid retention

07700 Coma
07703 Convulsion, seizure
07733 Hyperreflexia, abnormal reflexes
<b>Berkson codes used</b>
013502 Dead, fetus
013512 Maceration, fetus
013554 Still birth

**Online Table 2.** Definitions and diagnostic criteria of hypertensive disorders of pregnancy <sup>1</sup>

**Chronic hypertension.** Diagnosed based on data obtained at <20 weeks of gestation, chronic hypertension was diagnosed if any of these three criteria were met during non-Emergency room visits: (1) SBP>140 mm Hg or DBP>90 mm Hg on at least two occasions within one month, but at least 6 hours apart; (2) prescription of an anti-hypertensive medication or; (3) evidence of chronic hypertension prior to pregnancy AND one SBP>140 mm Hg or DBP>90 mm Hg prior to 20 gestational weeks. Women with chronic hypertension were eligible for the superimposed diagnoses of eclampsia or preeclampsia.

**Gestational hypertension.** Diagnosed based on data obtained at >20 weeks of gestation, gestational hypertension was diagnosed if any of these three criteria were met during non-Emergency room visits: (1) sustained SBP>140 mm Hg or DBP>90 mm Hg in a previously normotensive woman (occurred more than 50% of consecutive blood pressure readings from the first recorded elevated prenatal blood pressure through 24 hours postpartum); or (2) one SBP>140 mm Hg and/or DBP>90mm Hg in a patient who was also prescribed an anti-hypertensive medication for blood pressure control within

one week of the blood pressure elevation.; or (3) by expert physician review if the patient had one or more blood pressure elevations more than 48 hours after delivery, but was coded as normotensive by the algorithm. The latter definition was included in an effort to identify postpartum HDP.

**Preeclampsia.** Diagnosed based on data obtained at >20 weeks of gestation, preeclampsia was defined as gestational hypertension plus (1) new or worsening proteinuria; (2) administration of magnesium sulfate for seizure prophylaxis; or (3) new abnormal laboratory testing (AST/ALT>70 U/L, platelet count <100 x10<sup>9</sup>/L, or serum creatinine>1.1 mg/dL). If the only evidence, in addition to gestational hypertension, was subjective symptoms of persistent headache, epigastric pain or hyperreflexia, then a diagnosis of possible preeclampsia was assigned. Preeclampsia superimposed on chronic hypertension required worsening of BP control plus new onset or worsening proteinuria, new abnormal lab tests, or subjective symptoms.

**Eclampsia.** Defined as preeclampsia plus new onset seizures

**Online Table 3.** Chronic conditions recommended by the US-DHHS to study multimorbidity<sup>2</sup>

Description *	CCC+	CMS (ICD-9 codes) ‡
Hyperlipidemia	53	272.0, 272.1, 272.2, 272.3, 272.4
Hypertension	98,99	401.0, 401.1, 401.9, 402.00, 402.01, 402.10, 402.11, 402.90, 402.91, 403.00, 403.01, 403.10, 403.11, 403.90, 403.91, 404.00, 404.01, 404.02, 404.03, 404.10, 404.11, 404.12, 404.13, 404.90, 404.91, 404.92, 404.93, 405.01, 405.09, 405.11, 405.19, 405.91, 405.99, 362.11, 437.2
Depression	657	296.20, 296.21, 296.22, 296.23, 296.24, 296.25, 296.26, 296.30, 296.31, 296.32, 296.33, 296.34, 296.35, 296.36, 296.51, 296.52, 296.53, 296.54, 296.55, 296.56, 296.60, 296.61, 296.62, 296.63, 296.64, 296.65, 296.66, 296.89, 298.0, 300.4, 309.1, 311
Diabetes	49,50	249.00, 249.01, 249.10, 249.11, 249.20, 249.21, 249.30, 249.31, 249.40, 249.41, 249.50, 249.51, 249.60, 249.61, 249.70, 249.71, 249.80, 249.81, 249.90, 249.91, 250.00, 250.01, 250.02, 250.03, 250.10, 250.11, 250.12, 250.13, 250.20, 250.21, 250.22, 250.23, 250.30, 250.31, 250.32, 250.33, 250.40, 250.41, 250.42, 250.43, 250.50, 250.51, 250.52, 250.53, 250.60, 250.61, 250.62, 250.63, 250.70, 250.71, 250.72, 250.73, 250.80, 250.81, 250.82, 250.83, 250.90, 250.91, 250.92, 250.93, 357.2, 362.01, 362.02, 362.03, 362.04, 362.05, 362.06, 366.41
Arthritis	202,203	714.0, 714.1, 714.2, 714.30, 714.31, 714.32, 714.33, 715.00, 715.04, 715.09, 715.10, 715.11, 715.12, 715.13, 715.14, 715.15, 715.16, 715.17, 715.18, 715.20, 715.21, 715.22, 715.23, 715.24, 715.25, 715.26, 715.27, 715.28, 715.30, 715.31, 715.32, 715.33, 715.34, 715.35, 715.36, 715.37, 715.38, 715.80, 715.89, 715.90, 715.91, 715.92, 715.93, 715.94, 715.95, 715.96, 715.97, 715.98, 720.0, 721.0, 721.1, 721.2, 721.3, 721.90, 721.91
Cancer	11-43	Female breast cancer: 174.0, 174.1, 174.2, 174.3, 174.4, 174.5, 174.6, 174.8, 174.9, 175.0, 175.9, 233.0, V10.3. Colorectal cancer: 154.0, 154.1, 153.0, 153.1, 153.2, 153.3, 153.4, 153.5, 153.6, 153.7, 153.8, 153.9, 230.3, 230.4, V10.05. Prostate cancer: 185, 233.4, V10.46. Lung cancer: 162.2, 162.3, 162.4, 162.5, 162.8, 162.9, 231.2, V10.11.
Cardiac arrhythmia	105,106	427.31
Asthma	128	493.00, 493.01, 493.02, 493.10, 493.11, 493.12, 493.20, 493.21, 493.22, 493.81, 493.82, 493.90, 493.91, 493.92

Coronary artery disease	100,101	410.00, 410.01, 410.02, 410.10, 410.11, 410.12, 410.20, 410.21, 410.22, 410.30, 410.31, 410.32, 410.40, 410.41, 410.42, 410.50, 410.51, 410.52, 410.60, 410.61, 410.62, 410.70, 410.71, 410.72, 410.80, 410.81, 410.82, 410.90, 410.91, 410.92, 411.0, 411.1, 411.81, 411.89, 412, 413.0, 413.1, 413.9, 414.00, 414.01, 414.02, 414.03, 414.04, 414.05, 414.06, 414.07, 414.12, 414.2, 414.3, 414.8, 414.9
Substance abuse disorders (drug and alcohol)	660,661	Not applicable
Chronic obstructive pulmonary disease	127	490, 491.0, 491.1, 491.20, 491.21, 491.22, 491.8, 491.9, 492.0, 492.8, 494.0, 494.1, 496
Osteoporosis	206	733.00, 733.01, 733.02, 733.03, 733.09
Chronic kidney disease	158	016.00, 016.01, 016.02, 016.03, 016.04, 016.05, 016.06, 095.4, 189.0, 189.9, 223.0, 236.91, 249.40, 249.41, 250.40, 250.41, 250.42, 250.43, 271.4, 274.10, 283.11, 403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 440.1, 442.1, 572.4, 580.0, 580.4, 580.81, 580.89, 580.9, 581.0, 581.1, 581.2, 581.3, 581.81, 581.89, 581.9, 582.0, 582.1, 582.2, 582.4, 582.81, 582.89, 582.9, 583.0, 583.1, 583.2, 583.4, 583.6, 583.7, 583.81, 583.89, 583.9, 584.5, 584.6, 584.7, 584.8, 584.9, 585.1, 585.2, 585.3, 585.4, 585.5, 585.6, 585.9, 586, 587, 588.0, 588.1, 588.81, 588.89, 588.9, 591, 753.12, 753.13, 753.14, 753.15, 753.16, 753.17, 753.19, 753.20, 753.21, 753.22, 753.23, 753.29, 794.4
Stroke	109-112	430, 431, 433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.00, 434.01, 434.10, 434.11, 434.90, 434.91, 435.0, 435.1, 435.3, 435.8, 435.9, 436, 997.02
Congestive heart failure	108	398.91, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 404.03, 404.13, 404.93, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, 428.9
Dementia (including Alzheimer's and other senile dementias)	653	331.0, 331.11, 331.19, 331.2, 331.7, 290.0, 290.10, 290.11, 290.12, 290.13, 290.20, 290.21, 290.3, 290.40, 290.41, 290.42, 290.43, 294.0, 294.10, 294.11, 294.8, 797



CCC = Clinical Classification Codes; CMS = Centers for Medicare and Medicaid Services; ICD-9 = International Classification of Diseases, 9th revision; US-DHHS = US Department of Health and Human Services.

\* For this study we only considered 16 of the 20 conditions. The following 4 conditions were rare and not considered: human immunodeficiency virus infections, autism spectrum disorders, schizophrenia, and hepatitis. The 16 conditions were defined by the US-DHHS as detailed elsewhere.<sup>3</sup> Each condition is defined by having a code in either the CCC group of codes or the CMS group of codes. Conditions are listed in decreasing order of frequency (by overall age and sex standardized prevalence).

† We list the CCC chapters developed by the Agency for Healthcare Research and Quality (AHRQ). Each CCC chapter includes a list of ICD-9 codes as detailed elsewhere.<sup>4</sup>

‡ We list the ICD-9 codes defined in the Chronic Conditions Data Warehouse of the CMS.

**Online Table 4.** Denominators used for the results by calendar year in Online Table 7

<b>Age (years)</b>	<b>1976</b>	<b>1977</b>	<b>1978</b>	<b>1979</b>	<b>1980</b>	<b>1981</b>	<b>1982</b>	<b>TOTAL</b>
<b>&lt;20</b>	99	100	82	89	118	109	97	<b>694</b>
<b>20-24</b>	333	373	386	405	430	462	465	<b>2853</b>
<b>25-29</b>	517	544	530	563	612	581	614	<b>3961</b>
<b>30-34</b>	227	214	250	275	276	303	320	<b>1865</b>
<b>35+</b>	56	52	61	74	79	82	85	<b>489</b>
<b>TOTAL</b>	<b>1232</b>	<b>1283</b>	<b>1309</b>	<b>1406</b>	<b>1515</b>	<b>1536</b>	<b>1581</b>	<b>9862</b>

**Online Table 5.** Demographic and perinatal characteristics of women with 719 pregnancies which met criteria for hypertensive disorders of pregnancy during 1976-1982 for residents of Olmsted County, Minnesota

<i>Characteristic</i>	<b>Type of HDP</b>				
	<b>Preeclampsia (n=324)</b>	<b>Eclampsia (n=4)</b>	<b>Preeclampsia superimposed on chronic HTN</b>	<b>Gestational HTN (n=300)</b>	<b>Chronic HTN (n=69)</b>
			<b>(n=22)</b>		
<b>Age at delivery (years), mean(SD)</b>	24.94 (5.24)	30.50 (8.58)	26.14 (4.23)	26.79 (5.26)	29.23 (5.71)
<b>BMI (kg/m<sup>2</sup>), mean(SD)*</b>	24.76 (4.82)	23.39 (3.23)	27.16 (6.71)	25.71 (5.53)	27.44 (6.33)
<b>Parity prior to pregnancy, n (%) †</b>					
0	241 (74.4%)	2 (50.0%)	16 (72.7%)	151 (50.3%)	29 (42.0%)
1	50 (15.4%)	0 (0.0%)	3 (13.6%)	74 (24.7%)	17 (24.6%)
2	20 (6.2%)	0 (0.0%)	0 (0.0%)	42 (14.0%)	12 (17.4%)
3 or more	13 (4.0%)	2 (50.0%)	3 (13.6%)	33 (11.0%)	11 (15.9%)
<b>History of diabetes, n (%) ‡</b>	6 (1.9%)	0 (0.0%)	1 (4.5%)	5 (1.7%)	2 (2.9%)
<b>History of smoking, n (%) ‡</b>	141 (43.5%)	0 (0.0%)	9 (40.9%)	130 (43.3%)	17 (24.6%)
<b>Twin pregnancies, n (%)</b>	13 (4.0%)	1 (25.0%)	2 (9.1%)	8 (2.7%)	2 (2.9%)
<b>Gestational weeks, n (%)</b>					

<34 weeks (pre-term)	13 (4.0%)	0 (0.0%)	1 (4.5%)	1 (0.3%)	1 (1.4%)
34-36 weeks (pre-term)	29 (9.0%)	1 (25.0%)	4 (18.2%)	13 (4.3%)	5 (7.2%)
≥37 weeks (term)	282 (87.0%)	3 (75.0%)	17 (77.3%)	286 (95.3%)	63 (91.3%)
<b>Pregnancy Type, n (%)</b>					
Liveborn	316 (97.5%)	4 (100.0%)	20 (90.9%)	298 (99.3%)	69 (100.0%)
Stillborn	8 (2.5%)	0 (0.0%)	2 (9.1%)	2 (0.7%)	0 (0.0%)
<b>Fetal weight percentile, n (%) §</b>					
≥10%	254/323 (78.6%)	0 (0.0%)	14/21 (66.7%)	265/296 (89.5%)	61 (88.4%)
<10%	69/323 (21.4%)	4 (100.0%)	7/21 (33.3%)	31/296 (10.5%)	8 (11.6%)
<b>APGAR 1 minute, median(IQR) §</b>	8.0 (7.0, 9.0)	7.5 (7.0, 8.0)	8.0 (5.0, 8.0)	8.0 (7.0, 9.0)	8.0 (7.5, 9.0)
<b>APGAR 5 minute, median(IQR) §</b>	9.0 (9.0, 10.0)	9.0 (8.0, 9.0)	9.0 (8.0, 9.0)	9.0 (9.0, 10.0)	9.0 (9.0, 10.0)
<b>Education, n (%)</b>					
Less than high school graduate	31 (9.6%)	0 (0.0%)	0 (0.0%)	13 (4.3%)	2 (2.9%)
High school graduate	84 (25.9%)	1 (25.0%)	6 (27.3%)	83 (27.7%)	24 (34.8%)
GED/adult diploma	32 (9.9%)	1 (25.0%)	1 (4.5%)	32 (10.7%)	5 (7.2%)
Some college	69 (21.3%)	0 (0.0%)	7 (31.8%)	57 (19.0%)	10 (14.5%)
College graduate or more	83 (25.6%)	2 (50.0%)	6 (27.3%)	92 (30.7%)	25 (36.2%)
Unknown	25 (7.7%)	0 (0.0%)	2 (9.1%)	23 (7.7%)	3 (4.3%)

Abbreviations: APGAR, appearance, pulse, grimace, activity, and respiration; BMI, body mass index; GED, general equivalency diploma; HTN, hypertension.

\*BMI based on weight taken closest to conception date, within 6 months prior and up to 20 gestational weeks.

†Parity defined as number of pregnancies with a gestational age  $\geq 20$  weeks resulting in a live or still birth.

‡ Including during current pregnancy

§ Fetal weight considered small for gestational age was defined as  $< 10\%$  by the Brenner 1976 growth curve<sup>5</sup>

If twins, the fetal weight percentile and APGAR scores are based on the baby with the lowest birth weight.

**Online Table 6.** Comparison of exposed pregnancies from the per-woman cohort (n=269) compared to the pregnancies NOT in the per-woman cohort (n=450) from the n=719 total exposed pregnancies

<b>Characteristic</b>	<b>Not in per-woman cohort (N=450)</b>	<b>In per-woman cohort (N=269)</b>	<b>p value</b>
<b>Age at pregnancy, mean(SD)</b>	26.90 (5.88)	25.01 (4.38)	<b>&lt;0.001</b>
<b>Pregnancy Type, n (%)</b>			0.77
Live birth	442 (98.2%)	265 (98.5%)	
Still birth	8 (1.8%)	4 (1.5%)	
<b>Gestational weeks, n (%)</b>			0.31
<34 weeks (pre-term)	8 (1.8%)	8 (3.0%)	
34-36 weeks (pre-term)	29 (6.4%)	23 (8.6%)	
≥37 weeks (term)	413 (91.8%)	238 (88.5%)	
<b>BMI, mean (SD)</b>	26.16 (5.86)	24.42 (4.38)	<0.001
<b>History of smoking prior to pregnancy, y (%)</b>	174 (38.7%)	123 (45.7%)	0.037
<b>History of diabetes, y (%)</b>	12 (2.7%)	2 (0.7%)	0.071
<b>Education</b>			0.001
Less than high school graduate	34 (7.6%)	12 (4.5%)	
High school graduate	122 (27.1%)	76 (28.3%)	
GED/adult diploma	31 (6.9%)	40 (14.9%)	

<b>Characteristic</b>	<b>Not in per-woman cohort (N=450)</b>	<b>In per-woman cohort (N=269)</b>	<b>p value</b>
Some College	83 (18.4%)	60 (22.3%)	
College graduate or more	141 (31.3%)	67 (24.9%)	
Unknown	39 (8.7%)	14 (5.2%)	

P-values were derived from equal variance t-test for continuous variables and chi square tests for categorical variables.

**Online Table 7.** Age-specific per-pregnancy incidence (per 100 pregnancies) of hypertensive disorders of pregnancy among 9,862 pregnancies during 1976-1982 for residents of Olmsted County, Minnesota, overall and by calendar year

Hypertensive disorders of pregnancy /Age at delivery	Overall Incidence (95% CI) <sup>†</sup>	Incidence (95% CI) by calendar year of delivery*		
		1976-1977 (N=2,515)	1978-1980 (N=4,230)	1981-1982 (N=3,117)
<b>Preeclampsia</b>				
<20	6.5 (4.8, 8.6)	5.5 (2.8, 9.7)	7.3 (4.6, 10.9)	6.3 (3.4, 10.6)
20-24	4.4 (3.6, 5.2)	4.5 (3.1, 6.3)	4.3 (3.2, 5.6)	4.3 (3.1, 5.8)
25-29	2.6 (2.1, 3.1)	2.0 (1.2, 3.0)	2.5 (1.8, 3.4)	3.3 (2.3, 4.4)
30-34	1.9 (1.3, 2.6)	2.0 (0.94, 3.8)	1.6 (0.9, 2.8)	2.1 (1.1, 3.5)
≥35	3.5 (2.0, 5.5)	4.6 (1.5, 10.5)	3.7 (1.6, 7.2)	2.4 (0.66, 6.0)
<b>Eclampsia</b>				
<20	0 (0, 0.53)	0 (0, 1.8)	0 (0, 1.3)	0 (0, 1.8)
20-24	0.04 (0, 0.20)	0 (0, 0.52)	0 (0, 0.30)	0.11 (0, 0.60)
25-29	0.05 (0.01, 0.18)	0.09 (0, 0.52)	0 (0, 0.22)	0.08 (0, 0.47)
30-34	0 (0, 0.20)	0 (0, 0.83)	0 (0, 0.46)	0 (0, 0.59)
≥35	0.20 (0.01, 1.1)	0 (0, 3.4)	0.47 (0.01, 2.6)	0 (0, 2.2)
<b>Preeclampsia superimposed on chronic HTN</b>				
<20	0.43 (0.09, 1.3)	1.0 (0.12, 3.6)	0 (0, 1.3)	0.49 (0.01, 2.7)
20-24	0.07 (0.01, 0.25)	0 (0, 0.52)	0.16 (0.02, 0.59)	0 (0, 0.40)
25-29	0.33 (0.17, 0.56)	0.28 (0.06, 0.82)	0.47 (0.2, 0.92)	0.17 (0.02, 0.60)
30-34	0.16 (0.03, 0.47)	0.23 (0.01, 1.3)	0.12 (0, 0.69)	0.16 (0, 0.89)
35+	0.20 (0.01, 1.1)	0 (0, 3.4)	0 (0, 1.7)	0.6 (0.02, 3.3)
<b>Gestational HTN</b>				
<20	2.9 (1.8, 4.4)	3.5 (1.4, 7.1)	1.7 (0.56, 4.0)	3.9 (1.7, 7.5)
20-24	3.0 (2.4, 3.7)	2.4 (1.4, 3.8)	3.0 (2.1, 4.1)	3.5 (2.4, 4.8)
25-29	2.7 (2.2, 3.3)	1.8 (1.1, 2.8)	3.5 (2.6, 4.4)	2.4 (1.6, 3.5)
30-34	3.1 (2.3, 3.9)	1.1 (0.37, 2.6)	3.4 (2.2, 4.9)	4.0 (2.6, 5.9)
35+	6.3 (4.4, 8.9)	0.93 (0.02, 5.1)	7.9 (4.7, 12.4)	7.8 (4.2, 12.9)
<b>Chronic HTN</b>				
<20	0.29 (0.03, 1.0)	0 (0, 1.8)	0.35 (0.01, 1.9)	0.49 (0.01, 2.7)
20-24	0.49 (0.27, 0.82)	0.57 (0.15, 1.4)	0.57 (0.23, 1.2)	0.32 (0.07, 0.94)
25-29	0.45 (0.27, 0.72)	0.09 (0, 0.52)	0.65 (0.32, 1.2)	0.50 (0.18, 1.1)
30-34	1.1 (0.66, 1.7)	0.45 (0.05, 1.6)	1.5 (0.78, 2.6)	0.96 (0.35, 2.1)
≥35	3.1 (1.7, 5.0)	0.93 (0.02, 5.1)	3.3 (1.3, 6.6)	4.2 (1.7, 8.5)



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