





ORIGINAL RESEARCH

Hypertension in Pregnancy Among Immigrant and Swedish Women: A Cohort Study of All Pregnant Women in Sweden

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BACKGROUND: Little is known about risks of hypertensive disorders of pregnancy in both first- and second-generation immigrant women in Europe and other Western countries; such knowledge may help elucidate the influence of genetic versus social factors on such risks. We aimed to study both first- and second-generation immigrant women for the presence of all types of hypertension (preexisting hypertension, gestational hypertension, preeclampsia, and eclampsia) during pregnancy.

METHODS AND RESULTS: A cohort study was conducted using data derived from the Swedish National Birth Register, the National Patient Register, and the Total Population Register. We used Cox regression analysis to compute hazard ratios (HRs) and 99% CIs while adjusting for sociodemographic factors and comorbidities. The first-generation study included a total of 1 084 212 deliveries and 68 311 hypertension cases, and the second-generation study included 989 986 deliveries and 67 505 hypertension cases. The fully adjusted HR (with 99% CI) for hypertension in pregnancy among first-generation immigrant women was 0.69 (0.66–0.72), and among second-generation immigrant women, it was 0.88 (0.86–0.91), compared with Swedish-born women with 2 Swedish-born parents. Women born in Finland or with parent(s) from Finland had higher risks, with fully adjusted HRs (99% CIs) of 1.30 (1.18–1.43) and 1.12 (1.07–1.17), respectively.

CONCLUSIONS: Both first- and second-generation immigrant women had overall lower risks of hypertension in pregnancy compared with other Swedish women. However, the risk reduction was less pronounced in second-generation compared with first-generation immigrant women, suggesting that environmental factors in Sweden may have an important influence on risk of hypertension during pregnancy.

Key Words: diabetes ■ gestational diabetes ■ hypertension ■ immigrant women ■ socioeconomic factors

Hypertension or elevated blood pressure is considered to be the most important risk factor for developing cardiovascular diseases and chronic kidney disease.¹ In 2015, the age-adjusted global prevalence of elevated blood pressure (defined as systolic ≥ 140 mmHg, diastolic ≥ 90 mmHg, or both) was estimated at 20% among women and 24% among men.¹ The highest prevalence rates globally are currently found in Central and Eastern Europe, sub-Saharan Africa, and South Asia, with age-standardized prevalence rates

exceeding 35% in men in some countries in Central and Eastern Europe (Croatia, Latvia, Lithuania, Hungary, and Slovenia), and prevalence rates exceeding 33% among women in a few countries in West Africa.¹

Hypertension during pregnancy is 1 of the leading contributors to maternal morbidity and mortality.^{2,3} Hypertensive disorders of pregnancy (HDP) are often classified into the following: preeclampsia/eclampsia, preeclampsia superimposed on chronic hypertension, gestational hypertension, and chronic hypertension.⁴

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RESEARCH PERSPECTIVE

What Is New?

- What factors explain the lower risk of hypertension in pregnant women of foreign-born origin?

What Question Should Be Addressed Next?

- What lifestyle factors are important mediators of the less pronounced risk reduction that was observed in second-generation compared with first-generation immigrant women?

Nonstandard Abbreviations and Acronyms

HDP hypertensive disorders of pregnancy

Hypertensive disorders are the most common cardiovascular disorders during pregnancy, according to a US study, and cardiovascular disorders during pregnancy are associated with a higher all-cause mortality in hospital care.⁵ Recent Swedish studies have reported associations between adverse pregnancy outcomes, including gestational hypertension, and subsequent diagnosis of ischemic heart disease,⁶ or image-identified coronary artery disease⁷; this clearly suggests that women with HDP should be targeted for cardiovascular prevention.

At-risk populations may include those having risk factors for HDP, such as high blood pressure before pregnancy, diabetes, obesity, and being aged <20 years or >40 years.⁸ At-risk populations may also include immigrant women; the number of immigrants globally was estimated to be 230 million in 2013, or 3% of the global population, with almost half of them being women.⁹ Previous studies of HDP in immigrant women globally have yielded discrepant results. Some,⁹ but not all,^{10–12} studies have reported overall lower rates of HDP among immigrant women, with substantial global ethnic and racial differences.³ In Europe, the overall risk of HDP among immigrant women in Norway was lower than in the domestic population,¹³ and the same was true in Finland, except the risk of preeclampsia was higher among women of sub-Saharan origin.¹⁴ In 6 industrialized countries (Australia, Canada, Denmark, Sweden, Spain, and the United States), the risk of preeclampsia and eclampsia was found to be higher in women from sub-Saharan Africa, Latin America, and the Caribbean region than in the domestic population.¹⁰ However, other studies from Norway and Sweden reported lower risks of preeclampsia among immigrant women.^{11,12} In addition, the Swedish study found a

higher risk of preeclampsia associated with low socioeconomic status,¹¹ which is more common in both first- and second-generation immigrants. Elucidating risks in second-generation immigrants may help to clarify the influence of environmental factors on the risks of HDP. Studies on maternal health among immigrants are important because, despite having free maternal health care in Sweden, certain immigrant women may use these services to a lesser extent than native-born Swedish women.¹⁵ This may partly be related to lower education level among immigrants¹⁵; education and other socioeconomic factors are thus important to consider in studies on immigrant health.

The aim of this study was to examine the risk of all HDP among first- and second-generation immigrant women compared with Swedish-born women with 2 Swedish-born parents. On the basis of previous studies, we hypothesized that women from most non-European regions, particularly from Asia, Africa, and Latin America, may have a lower risk of all hypertensive disorders.

METHODS

Because of the sensitive nature of the data collected for this study, requests to access the data set from qualified researchers trained in human subject confidentiality protocols may be requested from the National Board of Health and Welfare and Statistics Sweden at registerservice@socialstyrelsen.se and scb@scb.se. We used data derived from several national Swedish registers (ie, the Swedish National Patient Register, the Swedish Total Population Register, and the Medical Birth Register).¹⁶ The National Patient Register includes diagnoses from all Swedish hospitals for inpatients since 1987 and for outpatients from 2001 and onwards. The Total Population Register includes data on country of origin and other sociodemographic factors for all Swedish people with a residence permit. The Swedish national registers are known to be of high quality,^{17,18} and the unique Swedish personal identity number, which is issued on birth or permanent immigration to Sweden, allows linkage of different registers,¹⁹ while preserving confidentiality (secured through the use of pseudonymized serial numbers). Numbers of cases in the sources used within this study are found in [Table S1](#).

Study Population

We included the first recorded pregnancy among all women with a live birth between 1998 and 2018. In the first-generation study, immigrant women were defined as being born outside Sweden. In the second-generation study, immigrant women were defined as having at least 1 parent born outside Sweden. The reference group for first- and second-generation

women was the same (ie, Swedish-born women with 2 Swedish-born parents).

Outcomes

The study outcome was a hypertension diagnosis during pregnancy based on *International Classification of Diseases, Tenth Revision (ICD-10)*, codes (Table S2): edema, proteinuria and HDP, childbirth, and the puerperium, with the following subgroups: preexisting hypertension complicating pregnancy, childbirth, and the puerperium; preeclampsia superimposed on chronic hypertension; gestational (pregnancy-induced) hypertension; preeclampsia; eclampsia; and unspecified maternal hypertension. We also subcategorized this outcome into 3 main groups: (1) preexisting hypertension in pregnancy; (2) gestational hypertension; and (3) preeclampsia and eclampsia. Only the first registered outcome diagnosis during the study period was considered. The numbers in the group unspecified maternal hypertension were too low, and none reached statistical significance.

Comorbidities

The following comorbid diagnoses were included as adjustment variables (for *ICD-10* codes, see Table S2): cancers, diabetes, diabetes in pregnancy, renal failure, and systemic connective tissue disorders (autoimmune disorders).

Demographic and Socioeconomic Variables

Age at delivery was modeled as a continuous variable. Educational attainment was categorized as ≤ 9 years (partial or complete compulsory schooling), 10 to 12 years (partial or complete secondary schooling), and >12 years (attendance at college or university). Marital status was categorized as married or not married. Geographic region of residence was included to adjust for possible regional differences in health care and was categorized as follows: (1) large cities (population $>200\,000$, which includes Stockholm, Gothenburg, and Malmö, each located in Southern Sweden); (2) elsewhere in Southern Sweden (ie, nonurban); and (3) Northern Sweden. Parity was categorized into 4 groups (ie, 1, 2, 3, and ≥ 4 children).

Body mass index levels were categorized as follows: unknown, <18.5 , 18.5 to 24.9, 25.0 to 29.9, and ≥ 30.0 kg/m².

The included covariates (ie, comorbidities and the demographic and socioeconomic variables) were selected on the basis of previous research.⁸

Neighborhood Deprivation Index

We used a neighborhood deprivation index,²⁰ which was derived from Small Area Market Statistics.

The average population in each Small Area Market Statistics neighborhood is ≈ 2000 people for Stockholm and 1000 people for the rest of Sweden. A summary index was calculated to characterize neighborhood-level deprivation that was categorized into 4 groups: >1 SD below the mean (low deprivation level or high socioeconomic status [SES]), within 1 SD of the mean (moderate deprivation level or moderate SES; used as the reference group), >1 SD above the mean (high deprivation level or low SES), or unknown neighborhood deprivation level/SES.²¹

Regions of the world were categorized by continent, European subregion, and specific countries that had sufficient numbers for analysis. Analyses of subtypes of hypertension during pregnancy included only regions or subregions of Europe because other groups had too few cases to conduct meaningful analyses.

Statistical Analysis

Baseline data are shown with categorical variables both as counts and percentages. Cox regression analysis was used to estimate relative rates of HDP, and the results were expressed as hazard ratios (HRs) and 99% CIs for total hypertension risk during the pregnancy, both overall and in different groups of first- and second-generation immigrant women, compared with Swedish-born women with 2 Swedish-born parents during the follow-up period. We tested the proportional hazard assumptions by plotting the incidence rates over time and by calculating Schoenfeld (partial) residuals, and these assumptions were fulfilled. Only 2.49% of the first-generation and 4.44% of the second-generation study population were lost to follow-up because of emigration, and they were censored in the follow-up analysis.

Three models were used: model 1 with adjustment for age and region of residence in Sweden; model 2 with adjustment for age, region of residence, educational level, marital status, parity, body mass index level, and neighborhood SES; and model 3 as model 2 but with the inclusion of relevant comorbidities (all cancers, prevalent diabetes, gestational diabetes, renal failure, and autoimmune disorders). Furthermore, we conducted subanalyses that stratified hypertension into 4 groups that were mutually exclusive (ie, preexisting hypertension, gestational hypertension, preeclampsia and eclampsia, and, finally, all other forms of hypertension). The HRs were calculated for the subgroups of hypertension in the same way as for hypertension overall. We performed a sensitivity analysis for nulliparous women, who were defined as a subgroup of the study population (ie, women with no previous live birth). We also performed a sensitivity analysis in which the main analyses were repeated using a robust variance estimator to account for small numbers of

events in certain country groups. We also performed an interaction test to evaluate whether the association between immigrant status and hypertension risk varied according to region of Sweden or neighborhood SES.

Compliance With Ethical Standards

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was not applicable, as the study was based on pseudonymized data from registers. Research data are not shared. The study was approved by the Regional Ethical Review Board in Lund (reference number 2008/471 and later amendments).

RESULTS

Descriptive Statistics

In total, 818 776 women who were Swedish born with 2 Swedish-born parents were included, with 57 260 hypertension cases (Table 1). A total of 265 346 women were foreign born, with 11 112 hypertension cases (Table S3), and 171 210 second-generation immigrant women with at least 1 foreign-born parent were included, with 10 245 hypertension cases (Table S3).

First-Generation Immigrant Women

Among first-generation immigrant women compared with Swedish-born women with 2 Swedish-born parents, the fully adjusted HR (with 99% CI) for any hypertension in pregnancy was 0.69 (0.66–0.72; Table 2). Stratified by country or region, most groups showed a lower risk among first-generation immigrant women, but those from Finland had a higher risk, with a fully adjusted HR (99% CI) of 1.30 (1.18–1.43).

In analyses of different types of hypertension, foreign-born women had a lower relative rate of pre-existing hypertension (adjusted HR, 0.64 [99% CI, 0.55–0.75]), gestational hypertension (adjusted HR, 0.57 [99% CI, 0.53–0.63]), and preeclampsia/eclampsia (adjusted HR, 0.75 [99% CI, 0.71–0.79]) (Table 3). However, women born in other Nordic countries had higher risks of these outcomes, with corresponding HRs of 1.13 (99% CI, 1.05–1.69), 1.33 (99% CI, 1.05–1.69), and 1.20 (99% CI, 1.04–1.38), respectively (fully adjusted model in Table 3, crude model in Table S4).

Second-Generation Immigrant Women

Among second-generation immigrant women, the fully adjusted HR for any hypertension during pregnancy

was 0.88 (99% CI, 0.86–0.89; Table 4). Stratified by country or region, most groups had lower risks compared with Swedish-born women with 2 Swedish-born parents, as in the first-generation study; however, women with at least 1 parent from Finland had a higher overall risk (fully adjusted HR, 1.12 [99% CI, 1.07–1.17]).

In analyses of different types of hypertension, second-generation immigrant women had, in general, a lower relative rate of gestational hypertension (fully adjusted HR, 0.87 [99% CI, 0.82–0.92]) and preeclampsia/eclampsia (fully adjusted HR, 0.87 [99% CI, 0.83–0.90]) (Table 5; crude model in Table S5). However, women with at least 1 parent from Nordic countries had higher risks for preexisting hypertension, gestational hypertension, and preeclampsia/eclampsia (Table 5).

Background Factors in Relation to Hypertensive Disorders

In secondary analyses, we analyzed background factors in relation to HDP (Tables S6 and S7). Among Swedish-born women with 2 Swedish-born parents and among second-generation immigrants, the highest educational level was associated with lower risks of hypertension (Table S7). For region in Sweden, both Southern and Northern Sweden were associated with a higher risk in all the studied groups compared with the 3 largest cities in Sweden (Stockholm, Gothenburg, and Malmö), except for foreign-born women living in Southern Sweden (Table S6). In regard to neighborhood deprivation, Swedish-born women with 2 Swedish-born parents living in middle- and high-deprivation areas had higher hypertension risk. However, first- and second-generation immigrant women living in high-deprivation areas had a lower risk (Tables S6 and S7). All groups with hypertension during pregnancy also had a higher risk of having prevalent diabetes and gestational diabetes. Higher parity was associated with a higher risk of hypertension during pregnancy, as were body mass index levels of ≥ 25.0 kg/m², whereas a body mass index level of < 18.5 kg/m² was associated with a lower risk. Renal failure was also associated with a higher risk of hypertension during pregnancy, whereas autoimmune disorders were associated with higher risks only in Swedish-born women with 2 Swedish-born parents (Tables S6 and S7).

Sensitivity Analyses

We also performed subanalyses of first- and second-generation women in the years 2002 to 2018 (Table S8), which yielded similar results as the main analyses for the entire cohort. The sensitivity analysis of nulliparous women yielded HRs that were similar to those from the main analyses but no longer statistically significant, attributable in part to smaller numbers of women

Table 1. Characteristics of 3 Study Groups: Native Swedes (Swedish-Born With 2 Swedish-Born Parents), First-Generation Immigrant Women (Foreign-Born), and Second-Generation Women (Swedish-Born With 1 or 2 Foreign-Born Parents)

Characteristic	Native Swedes		First-generation immigrant women		Second-generation immigrant women	
	No.	%	No.	%	No.	%
Total population	818776	...	265436	...	171210	...
Age, y						
<20	8133	1.0	2975	1.1	3399	2.0
20–29	364745	44.5	115969	43.7	83601	48.8
30–39	413904	50.6	131814	49.7	77842	45.5
≥40	31994	3.9	14678	5.5	6368	3.7
Educational level, y						
≤9	170106	20.8	208495	78.5	53363	31.2
10–12	404911	49.5	29986	11.3	74226	43.4
>12	243759	29.8	26955	10.2	43621	25.5
Region of residence						
Large cities	380550	46.5	62610	23.6	97030	56.7
Southern Sweden	288322	35.2	28570	10.8	47739	27.9
Northern Sweden	149904	18.3	174256	65.6	26441	15.4
Marital status						
Married	89527	10.9	203194	76.6	28337	16.6
Not married	729249	89.1	62242	23.4	142873	83.4
Neighborhood deprivation index						
Low	203040	24.8	13512	5.1	31237	18.2
Middle	506383	61.8	39957	15.1	80687	47.1
High	108311	13.2	46104	17.4	50360	29.4
Unknown	1042	0.1	165863	62.5	8926	5.2
Parity						
1	304443	37.2	129390	48.7	66909	39.1
2	383279	46.8	92642	34.9	73797	43.1
3	108444	13.2	31328	11.8	23660	13.8
≥4	22610	2.8	12076	4.5	6844	4.0
Body mass index, kg/m ²						
Unknown	82569	10.1	27095	10.2	16658	9.7
<18.5	15421	1.9	9232	3.5	4204	2.5
18.5–24.9	461307	56.3	139245	52.5	93534	54.6
25.0–29.9	178884	21.8	62667	23.6	38424	22.4
≥30	80595	9.8	27197	10.2	18390	10.7
Diagnosis of cancer	31516	3.8	5780	2.2	5315	3.1
Diagnosis of diabetes	10275	1.3	3830	1.4	2046	1.2
Diagnosis of gestational diabetes	14218	1.7	8998	3.4	3720	2.2
Diagnosis of renal failure	22276	2.7	7102	2.7	5602	3.3
Diagnosis of autoimmune disorders	7019	0.9	2111	0.8	1551	0.9

(Table S9). A sensitivity analysis that used a robust variance estimator yielded similar risk estimates as the main analyses, and the conclusions were unchanged. An interaction test showed that the association

between first-generation (but not second-generation) women and lower hypertension risk was more pronounced among those living in the south of Sweden or in low-SES neighborhoods (data not shown).

Table 2. HRs and 99% CIs for HDP Among First-Generation Immigrant Women

Country or region of origin	Cases	Model 1			Model 2			Model 3		
		HR	99% CI		HR	99% CI		HR	99% CI	
Sweden	57 260	1.00	...		1.00	...		1.00	...	
All foreign-born	11 051	0.62*	0.60*	0.63*	0.71*	0.68*	0.74*	0.69*	0.66*	0.73*
Nordic countries	1499	1.05	0.97	1.13	1.14*	1.05*	1.23*	1.15*	1.07*	1.25*
Denmark	244	0.86	0.72	1.03	0.97	0.81	1.17	0.97	0.80	1.16
Finland	923	1.21*	1.10*	1.33*	1.28*	1.16*	1.41*	1.30*	1.18*	1.43*
Iceland	67	0.95	0.67	1.35	1.09	0.77	1.55	1.17	0.83	1.66
Norway	265	0.84	0.70	1.00	0.92	0.77	1.09	0.93	0.78	1.11
Southern Europe	185	0.52*	0.42*	0.64*	0.61*	0.49*	0.75*	0.65*	0.52*	0.80*
France	38	0.44*	0.28*	0.70*	0.52*	0.33*	0.83*	0.58*	0.37*	0.92*
Greece	35	0.45*	0.28*	0.74*	0.53*	0.32*	0.85*	0.56*	0.34*	0.91*
Italy	34	0.55*	0.34*	0.90*	0.65	0.40	1.06	0.71	0.43	1.16
Spain	40	0.53*	0.34*	0.83*	0.63*	0.40*	0.99*	0.69	0.44	1.08
Other Southern European countries	38	0.69	0.43	1.09	0.77	0.48	1.22	0.73	0.46	1.16
Western Europe	338	0.67*	0.57*	0.78*	0.79*	0.67*	0.93*	0.84*	0.72*	0.99*
Netherlands	53	0.76	0.51	1.13	0.92	0.62	1.36	0.97	0.66	1.44
United Kingdom and Ireland	15	0.93	0.44	1.93	1.11	0.53	2.32	1.17	0.56	2.44
Germany	228	0.67*	0.55*	0.80*	0.78*	0.64*	0.95*	0.83	0.68	1.00
Austria	19	0.62	0.32	1.20	0.72	0.37	1.38	0.78	0.41	1.51
Other Western European countries	23	0.51	0.28	0.92	0.60	0.33	1.08	0.65	0.36	1.18
Eastern Europe	1285	0.53*	0.49*	0.58*	0.57*	0.52*	0.62*	0.59*	0.54*	0.64*
Bosnia	476	0.59*	0.52*	0.68*	0.61*	0.53*	0.69*	0.66*	0.58*	0.76*
Yugoslavia	459	0.58*	0.50*	0.66*	0.58*	0.51*	0.67*	0.56*	0.49*	0.64*
Croatia	45	0.57*	0.37*	0.87*	0.63*	0.41*	0.96*	0.70	0.46	1.07
Romania	122	0.42*	0.33*	0.55*	0.49*	0.38*	0.63*	0.52*	0.40*	0.68*
Bulgaria	32	0.37*	0.22*	0.61*	0.43*	0.26*	0.71*	0.48*	0.29*	0.79*
Other Eastern European countries	151	0.42*	0.33*	0.53*	0.52*	0.41*	0.65*	0.53*	0.42*	0.67*
Baltic countries	189	0.62*	0.50*	0.76*	0.76*	0.62*	0.94*	0.86	0.70	1.07
Estonia	67	0.70	0.50	0.99	0.85	0.60	1.21	0.92	0.65	1.31
Latvia	122	0.58*	0.45*	0.75*	0.72*	0.55*	0.93*	0.83	0.64	1.08
Central Europe	728	0.73*	0.65*	0.81*	0.84*	0.75*	0.94*	0.93	0.83	1.04
Poland	646	0.75*	0.67*	0.84*	0.87*	0.77*	0.98*	0.97	0.86	1.09
Other Central European countries	11	0.40*	0.17*	0.95*	0.41*	0.17*	0.97*	0.45	0.19	1.07
Hungary	71	0.63*	0.45*	0.89*	0.71*	0.51*	1.00*	0.77	0.55	1.08
Africa	1571	0.75*	0.70*	0.81*	0.87*	0.80*	0.95*	0.69*	0.63*	0.75*
North America	133	0.67*	0.52*	0.86*	0.79	0.61	1.01	0.78	0.61	1.01
Latin America	690	0.81*	0.72*	0.90*	0.86*	0.77*	0.96*	0.82*	0.73*	0.91*
Chile	368	1.03	0.89	1.19	1.02	0.88	1.19	0.88	0.76	1.03
Other South American countries	322	0.65*	0.55*	0.76*	0.72*	0.61*	0.85*	0.75*	0.64*	0.88*
Asia	4076	0.50*	0.47*	0.52*	0.57*	0.53*	0.60*	0.54*	0.51*	0.58*
Turkey	405	0.58*	0.50*	0.67*	0.62*	0.54*	0.72*	0.58*	0.50*	0.67*
Lebanon	222	0.47*	0.39*	0.57*	0.48*	0.40*	0.58*	0.40*	0.33*	0.48*
Iran	337	0.42*	0.36*	0.49*	0.45*	0.39*	0.53*	0.48*	0.41*	0.56*
Iraq	1060	0.53*	0.49*	0.58*	0.63*	0.57*	0.70*	0.52*	0.47*	0.57*
Other Asian countries	2052	0.48*	0.45*	0.52*	0.56*	0.52*	0.60*	0.58*	0.54*	0.63*
Russia	273	0.51*	0.43*	0.61*	0.61*	0.51*	0.73*	0.70*	0.59*	0.84*

Model 1: adjusted for age; model 2: adjusted for age, region of residence in Sweden, educational level, marital status, parity, body mass index level, and neighborhood deprivation; and model 3: model 2 plus comorbidities. HDP indicates hypertensive disorders of pregnancy; and HR, hazard ratio.

*Values are statistically significant.

Table 3. Fully Adjusted HRs and 99% CIs for Different Types of Hypertension in Pregnancy Among First-Generation Immigrant Women

Country or region of origin	Preexisting hypertension in pregnancy				Gestational hypertension				Preeclampsia and eclampsia			
	Cases	HR	99% CI		Cases	HR	99% CI		Cases	HR	99% CI	
Sweden	4003	1.00	...		17 420	1.00	...		35 191	1.00	...	
All foreign-born	940	0.64*	0.55*	0.75*	2787	0.57*	0.53*	0.63*	7168	0.75*	0.71*	0.79*
Nordic countries	168	1.13*	1.05*	1.69*	461	1.33*	1.05*	1.69*	847	1.20*	1.04*	1.38*
Southern Europe	26	0.63	0.53	1.67	49	0.94	0.53	1.67	108	0.55*	0.36*	0.84*
Western Europe	33	0.62	0.53	1.49	107	0.89	0.53	1.49	196	0.85	0.64	1.13
Eastern Europe	85	0.36*	0.32*	0.62*	296	0.45*	0.32*	0.62*	883	0.44*	0.37*	0.52*
Baltic countries	23	0.76	0.62	2.16	67	1.16	0.62	2.16	94	0.92	0.64	1.33
Central Europe	95	1.09	0.98	1.87	242	1.36	0.98	1.87	386	0.98	0.80	1.19
Africa	107	0.39*	0.35*	0.67*	290	0.49*	0.35*	0.67*	1152	0.40*	0.33*	0.49*
North America	10	0.31	0.23	1.45	38	0.58	0.23	1.45	81	0.72	0.45	1.16
Latin America	44	0.42*	0.36*	0.87*	152	0.56*	0.36*	0.87*	487	0.60*	0.47*	0.75*
Asia	313	0.38*	0.36*	0.54*	986	0.44*	0.36*	0.54*	2715	0.42*	0.37*	0.47*
Russia	28	0.51	0.43	1.32	82	0.75	0.43	1.32	161	0.66*	0.47*	0.92*

HR indicates hazard ratio.

*Values are statistically significant.

DISCUSSION

The main results of this study were that first- and second-generation immigrant women had a lower overall risk of hypertension during pregnancy, compared with the Swedish reference group. First-generation immigrant women had lower risks of all types of hypertension in pregnancy, whereas second-generation immigrant women had lower risks specifically of gestational hypertension and preeclampsia/eclampsia but not preexisting hypertension. The lower risks observed in second-generation women were not as pronounced as among first-generation women, thus suggesting that environmental factors may have an important influence on HDP. The only immigrant group with a higher overall risk of hypertension was women from Finland. Second-generation women with at least 1 parent from Nordic countries outside of Sweden also had higher risks of preexisting hypertension, gestational hypertension, and preeclampsia/eclampsia, which may have been driven by the women with parent(s) from Finland.

The lower risk of hypertension among first-generation immigrant women is consistent with findings from several prior studies.^{9,13,14} It also is in accordance with studies that showed a lower risk of hypertension among immigrants in Europe, including immigrants from Muslim countries residing in Europe²² or non-European immigrants in Sweden.²³ A systematic review suggested that the lower risk of hypertension in Muslim populations could be related to yet untapped lifestyle and behavioral habits, which may indicate some advantages in the risk of hypertension.²² An interesting result is that the lower overall risk of hypertension among immigrant women

was less pronounced in second-generation immigrants. A tendency for equalization in second-generation immigrants has also previously been shown for other outcomes, such as myocardial infarction.²⁴ This may imply that preventive measures during pregnancy may be needed especially among second-generation women. A lower risk of hypertension among pregnant immigrant women could be partly attributable to the healthy migrant effect,²⁵ as the risk of hypertension in many immigrant groups is known to be lower.^{23,26} The healthy migrant effect refers to a better health status among people who migrate compared with their compatriots in their region of origin,²⁷ or also compared with native-born individuals in their newly adopted country. Starting in the 1960s, many labor migrants came to work in the expanding Swedish economy and were likely to be healthier overall than the native Swedish-born population. Non-European immigrants in Denmark have also been reported to be healthier in regard to lower alcohol intake and higher vegetable consumption, but less healthy concerning leisure-time physical activity.²⁸ The risk for obesity is also higher in some non-European immigrant groups.²⁹

In contrast with our findings for hypertension, the risk of diabetes during pregnancy has been reported to be higher among first-generation immigrant women in Sweden,³⁰ and diabetes risk is also higher in certain non-European immigrant groups.^{29,31} The reasons for a lower risk of hypertension and a higher risk of diabetes among some immigrant groups of non-European origin are unclear. These contrasting findings could possibly be related to differences in alcohol intake, as high alcohol intake is 1 risk factor for hypertension,³²

Table 4. HRs and 99% CIs for HDP Among Second-Generation Immigrant Women

Country or region of origin	Cases	Model 1			Model 2			Model 3		
		HR	99% CI		HR	99% CI		HR	99% CI	
Sweden	57260	1.00	...		1.00	...		1.00	...	
All with foreign-born parents	10245	0.87*	0.84*	0.90*	0.88*	0.86*	0.91*	0.88*	0.86*	0.89*
Nordic countries	5533	1.11*	1.06*	1.15*	1.09*	1.05*	1.14*	1.06*	1.02*	1.10*
Denmark	609	0.91	0.81	1.02	0.91	0.81	1.02	0.87*	0.77*	0.98*
Finland	4302	1.17*	1.11*	1.22*	1.15*	1.10*	1.20*	1.12*	1.07*	1.17*
Iceland	29	0.72	0.42	1.22	0.75	0.44	1.27	0.75	0.44	1.28
Norway	593	1.00	0.89	1.12	0.98	0.87	1.10	0.96	0.86	1.08
Southern Europe	368	0.72*	0.62*	0.84*	0.73*	0.63*	0.84*	0.74*	0.64*	0.86*
France	35	0.58*	0.36*	0.94*	0.60*	0.37*	0.98*	0.64	0.40	1.04
Greece	98	0.60*	0.45*	0.80*	0.59*	0.44*	0.79*	0.60*	0.45*	0.80*
Italy	92	0.75	0.55	1.00	0.75	0.56	1.01	0.76	0.57	1.03
Spain	98	1.01	0.76	1.34	1.02	0.76	1.35	1.03	0.77	1.38
Other Southern European countries	45	0.69	0.45	1.05	0.70	0.45	1.06	0.70	0.46	1.07
Western Europe	723	0.85*	0.77*	0.95*	0.87*	0.78*	0.97*	0.89*	0.80*	0.99*
Netherlands	56	0.90	0.61	1.31	0.93	0.64	1.37	0.95	0.65	1.39
United Kingdom and Ireland	8	0.82	0.30	2.24	0.87	0.32	2.37	0.88	0.32	2.42
Germany	515	0.83*	0.73*	0.94*	0.85*	0.75*	0.96*	0.86*	0.76*	0.97*
Austria	114	0.96	0.73	1.25	0.98	0.75	1.28	1.01	0.77	1.32
Other Western European countries	30	0.82	0.48	1.37	0.85	0.51	1.43	0.87	0.51	1.46
Eastern Europe	980	0.65*	0.59*	0.71*	0.65*	0.59*	0.71*	0.67*	0.61*	0.73*
Bosnia	222	0.61*	0.50*	0.73*	0.60*	0.50*	0.73*	0.66*	0.54*	0.79*
Yugoslavia	649	0.68*	0.61*	0.76*	0.68*	0.60*	0.76*	0.68*	0.61*	0.76*
Croatia	28	0.61	0.36	1.05	0.61	0.36	1.05	0.65	0.38	1.11
Romania	44	0.57*	0.37*	0.88*	0.59*	0.38*	0.90*	0.60*	0.39*	0.92*
Bulgaria	18	0.56	0.29	1.10	0.57	0.29	1.11	0.61	0.31	1.18
Other Eastern European countries	19	0.56	0.29	1.08	0.59	0.31	1.14	0.60	0.31	1.16
Baltic countries	143	0.98	0.77	1.24	1.03	0.81	1.30	1.06	0.83	1.34
Estonia	120	0.99	0.76	1.28	1.03	0.80	1.34	1.06	0.81	1.37
Latvia	23	0.93	0.51	1.69	0.99	0.55	1.80	1.07	0.59	1.93
Central Europe	516	0.83*	0.73*	0.94*	0.85*	0.75*	0.96*	0.87*	0.76*	0.98*
Poland	311	0.88	0.75	1.03	0.91	0.77	1.06	0.94	0.79	1.10
Other Central European countries	59	0.68*	0.47*	0.99*	0.70	0.49	1.02	0.71	0.49	1.03
Hungary	146	0.79	0.62	1.00	0.81	0.64	1.02	0.81	0.64	1.02
Africa	265	0.75*	0.63*	0.90*	0.77*	0.64*	0.91*	0.73*	0.61*	0.87*
North America	132	0.97	0.76	1.25	1.02	0.79	1.30	1.05	0.82	1.34
Latin America	325	0.76*	0.65*	0.89*	0.76*	0.64*	0.89*	0.71*	0.60*	0.83*
Chile	252	0.87	0.73	1.05	0.85	0.71	1.02	0.77*	0.64*	0.92*
Other South American countries	73	0.53*	0.38*	0.74*	0.55*	0.39*	0.76*	0.56*	0.40*	0.78*
Asia	1179	0.55*	0.50*	0.59*	0.55*	0.50*	0.60*	0.54*	0.50*	0.59*
Turkey	344	0.60*	0.51*	0.70*	0.56*	0.48*	0.66*	0.56*	0.48*	0.65*
Lebanon	124	0.49*	0.38*	0.64*	0.47*	0.36*	0.61*	0.43*	0.33*	0.56*
Iran	133	0.48*	0.38*	0.62*	0.49*	0.38*	0.63*	0.52*	0.41*	0.67*
Iraq	235	0.50*	0.41*	0.60*	0.55*	0.45*	0.67*	0.52*	0.42*	0.63*
Other Asian countries	343	0.59*	0.50*	0.68*	0.59*	0.50*	0.69*	0.61*	0.52*	0.71*
Russia	53	0.94	0.63	1.39	1.01	0.68	1.50	1.09	0.74	1.62

Model 1: adjusted for age; model 2: adjusted for age, region of residence in Sweden, educational level, marital status, parity, body mass index level, and neighborhood deprivation; and model 3: model 2 plus comorbidities. HDP indicates hypertensive disorders of pregnancy; and HR, hazard ratio.

*Values are statistically significant.

Table 5. Fully Adjusted HRs and 99% CIs for Different Types of Hypertension Among Second-Generation Immigrant Women

Country or region of origin	Cases	Preexisting hypertension in pregnancy			Cases	Gestational hypertension			Cases	Preeclampsia and eclampsia		
		HR	99% CI			HR	99% CI			HR	99% CI	
Sweden	4003	1.00	...		17 420	1.00	...		35 191	1.00	...	
All with foreign-born parents	782	0.96	0.86	1.08	3069	0.87*	0.82*	0.92*	6269	0.87*	0.83*	0.90*
Nordic countries	484	1.13*	1.09*	1.43*	1752	1.25*	1.09*	1.43*	3233	1.13*	1.05*	1.21*
Southern Europe	25	0.48	0.41	1.27	98	0.72	0.41	1.27	236	0.64*	0.48*	0.86*
Western Europe	50	0.60	0.53	1.20	226	0.80	0.53	1.20	436	0.92	0.76	1.11
Eastern Europe	54	0.44*	0.39*	0.86*	251	0.58*	0.39*	0.86*	659	0.56*	0.46*	0.67*
Baltic countries	15	0.77	0.61	2.69	38	1.29	0.61	2.69	89	0.95	0.60	1.51
Central Europe	37	0.67	0.58	1.49	174	0.93	0.58	1.49	302	0.94	0.76	1.17
Africa	12	0.31	0.24	1.24	68	0.54	0.24	1.24	181	0.60*	0.42*	0.84*
North America	11	0.71	0.54	3.05	43	1.29	0.54	3.05	78	1.07	0.69	1.66
Latin America	15	0.30	0.23	1.03	84	0.49	0.23	1.03	221	0.59*	0.43*	0.80*
Asia	70	0.40*	0.36*	0.74*	314	0.51*	0.36*	0.74*	783	0.48*	0.40*	0.56*
Russia	7	0.96	0.69	5.97	11	2.03	0.69	5.97	35	0.75	0.32	1.76

HR indicates hazard ratio.

*Values are statistically significant.

whereas moderate alcohol intake of especially wine may be preventive for type 2 diabetes.^{33,34} There is, however, no consensus on whether this or other factors could explain the differences in risks for hypertension and diabetes among non-European immigrants. Immigrants from Middle Eastern countries in Sweden seem to have a different kind of type 2 diabetes, suggesting the importance of genetic factors,³⁵ which is consistent with an Indian study showing that gestational diabetes is associated with a genetic variant.³⁶ However, a Swedish study found that clinical factors were more important than genetic factors for the prediction of incident type 2 diabetes.³⁷ In addition, interactions between genes and environment are likely to play an important role,³⁸ and possibly epigenetic factors.

We found a higher risk of hypertension among Finnish immigrants in Sweden, consistent with a previous study.²³ In addition, in Finland, the risk of hypertension among pregnant women was lower in immigrant women compared with Finnish-born women.¹⁴ Furthermore, Finland also had the highest rate of coronary heart disease mortality in the 1970s, with a higher prevalence of hypertension as 1 of the main contributing factors.³⁹ The higher risk among immigrants from Finland was also less pronounced among second-generation compared with first-generation women. The higher risk of HDP in Finnish women calls for awareness and for preventive efforts in this group after pregnancy, to reduce their overall cardiovascular risk. The overall cardiovascular risk should also be monitored in women with other risk factors during pregnancy, such

as gestational diabetes,³⁰ which is more common in certain immigrant groups. Evidence suggests that cardiometabolic risk factors that appear during pregnancy may reappear in the years after pregnancy, which calls for further preventive efforts. In addition, prepregnancy public health efforts are needed to prevent hypertension in pregnancy.

For other potential risk factors for HDP, some findings were expected, such as a protective effect of higher educational level. However, neighborhood SES and risk of hypertension during pregnancy showed an opposite and unexpected pattern, with lower risks among first- and second-generation women living in the most deprived neighborhoods. A possible explanation for this paradoxical finding could be a lack of integration of these women into Swedish society. As all women in Sweden have free access to maternal health care, it seems unlikely that hypertension during pregnancy would have been undetected in certain groups. Furthermore, diabetes during pregnancy was associated with higher risks of hypertension in both Swedish-born women with 2 Swedish-born parents and in first- and second-generation immigrant women (Tables S5 and S6).

There are some limitations of this study. We used register-based data and had no possibility to confirm the clinical criteria for the reported diagnoses. Thus, we could not specify other types of hypertension, but these cases were few compared with the other subgroups. In general, Swedish registers, including the Medical Birth Register, are known to be of high standard and validity.^{16–18} We lacked information on severity

of hypertension. We also lacked information on lifestyle or other environmental factors that may underly the main findings, which would be useful to include in future studies. There is also a small risk of underdiagnosis of hypertension during pregnancy in immigrant women compared with Swedish women as previous studies have shown that certain immigrant women use maternal health care to a lesser extent than native-born Swedish women.¹⁵ However, we believe that this risk is minimal because our previous findings of higher risks of diabetes in immigrant women during pregnancy suggest that their lower risks of hypertension in the present study are unlikely to be explained by low health care use.

CONCLUSIONS

The overall risk of hypertension in pregnancy was lower in both first- and second-generation immigrant women compared with the Swedish reference group. The risk reduction was less pronounced in second-generation compared with first-generation immigrant women, thus suggesting that environmental factors in Sweden may have an important influence on the risk of hypertension during pregnancy. However, because there is a small risk that our findings could be related to lower use of maternal health care services by certain immigrant women, maternal health care should be encouraged in such women with attention to factors that promote good cardiovascular health.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Tables S1–S9.

REFERENCES

1. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1479 population-based measurement studies with 19.1 million participants. *Lancet*. 2017;389:37–55. doi: [10.1016/S0140-6736\(16\)31919-5](https://doi.org/10.1016/S0140-6736(16)31919-5)
2. Jung J, Karwal EK, McDonald S, Turner T, Chou D, Vogel JP. Prevention and control of non-communicable diseases in antenatal, intrapartum, and postnatal care: a systematic scoping review of clinical practice guidelines since 2011. *BMC Med*. 2022;20:305. doi: [10.1186/s12916-022-02508-9](https://doi.org/10.1186/s12916-022-02508-9)
3. Burger RJ, Delagrangé H, van Valkengoed IGM, de Groot CJM, van den Born BH, Gordijn SJ, Ganzevoort W. Hypertensive disorders of pregnancy and cardiovascular disease risk across races and ethnicities: a review. *Front Cardiovasc Med*. 2022;9:933822. doi: [10.3389/fcvm.2022.933822](https://doi.org/10.3389/fcvm.2022.933822)
4. Zamorski MA, Green LA. NHBPEP report on high blood pressure in pregnancy: a summary for family physicians. *Am Fam Physician*. 2001;64:263–270, 216.
5. Majmundar M, Doshi R, Patel KN, Zala H, Kumar A, Kalra A. Prevalence, trends and outcomes of cardiovascular diseases in pregnant patients in the United States: 2010 to 2019. *Eur Heart J*. 2023;44:726–737. doi: [10.1093/eurheartj/ehac669](https://doi.org/10.1093/eurheartj/ehac669)
6. Crump C, Sundquist J, McLaughlin MA, Dolan SM, Govindarajulu U, Sieh W, Sundquist K. Adverse pregnancy outcomes and long term risk of ischemic heart disease in mothers: national cohort and co-sibling study. *BMJ*. 2023;380:e072112. doi: [10.1136/bmj-2022-072112](https://doi.org/10.1136/bmj-2022-072112)
7. Sederholm Lawesson S, Swahn E, Pihlsgård M, Andersson T, Angeras O, Bacsovcics Brodin E, Bergdahl E, Blomberg M, Christersson C, Goncalves I, et al. Association between history of adverse pregnancy outcomes and coronary artery disease assessed by coronary computed tomography angiography. *JAMA*. 2023;329:393–404. doi: [10.1001/jama.2022.24093](https://doi.org/10.1001/jama.2022.24093)
8. Ying W, Catov JM, Ouyang P. Hypertensive disorders of pregnancy and future maternal cardiovascular risk. *J Am Heart Assoc*. 2018;7:e009382. doi: [10.1161/JAHA.118.009382](https://doi.org/10.1161/JAHA.118.009382)
9. Mogos MF, Salinas-Miranda AA, Salemi JL, Medina IM, Salihi HM. Pregnancy-related hypertensive disorders and immigrant status: a systematic review and meta-analysis of epidemiological studies. *J Immigr Minor Health*. 2017;19:1488–1497. doi: [10.1007/s10903-016-0410-6](https://doi.org/10.1007/s10903-016-0410-6)
10. Urquia ML, Glazier RH, Gagnon AJ, Mortensen LH, Nybo Andersen AM, Janevic T, Guendelman S, Thornton D, Bolumar F, Rio Sanchez I, et al. Disparities in pre-eclampsia and eclampsia among immigrant women giving birth in six industrialised countries. *BJOG*. 2014;121:1492–1500. doi: [10.1111/1471-0528.12758](https://doi.org/10.1111/1471-0528.12758)
11. Mattsson K, Juárez S, Malmqvist E. Influence of socio-economic factors and region of birth on the risk of preeclampsia in Sweden. *Int J Environ Res Public Health*. 2022;19:4080. doi: [10.3390/ijerph19074080](https://doi.org/10.3390/ijerph19074080)
12. Naimy Z, Grytten J, Monkerud L, Eskild A. The prevalence of pre-eclampsia in migrant relative to native Norwegian women: a population-based study. *BJOG*. 2015;122:859–865. doi: [10.1111/1471-0528.12978](https://doi.org/10.1111/1471-0528.12978)
13. Sole KB, Staff AC, Laine K. The association of maternal country of birth and education with hypertensive disorders of pregnancy: a population-based study of 960 516 deliveries in Norway. *Acta Obstet Gynecol Scand*. 2018;97:1237–1247. doi: [10.1111/aogs.13393](https://doi.org/10.1111/aogs.13393)
14. Bastola K, Koponen P, Skogberg N, Gissler M, Kinnunen TI. Hypertensive disorders of pregnancy among women of migrant origin in Finland: a population-based study. *Acta Obstet Gynecol Scand*. 2022;101:127–134. doi: [10.1111/aogs.14291](https://doi.org/10.1111/aogs.14291)
15. Liu C, Ahlberg M, Hjern A, Stephansson O. Perinatal health of refugee and asylum-seeking women in Sweden 2014–17: a register-based cohort study. *Eur J Pub Health*. 2019;29:1048–1055. doi: [10.1093/eurpub/ckz120](https://doi.org/10.1093/eurpub/ckz120)
16. Cnattingius S, Kallen K, Sandstrom A, Rydberg H, Mansson H, Stephansson O, Frisell T, Ludvigsson JF. The Swedish medical birth register during five decades: documentation of the content and quality of the register. *Eur J Epidemiol*. 2023;38:109–120. doi: [10.1007/s10654-022-00947-5](https://doi.org/10.1007/s10654-022-00947-5)
17. Ludvigsson JF, Almqvist C, Bonamy AK, Ljung R, Michaelsson K, Neovius M, Stephansson O, Ye W. Registers of the Swedish total population and their use in medical research. *Eur J Epidemiol*. 2016;31:125–136. doi: [10.1007/s10654-016-0117-y](https://doi.org/10.1007/s10654-016-0117-y)
18. Ludvigsson JF, Andersson E, Ekblom A, Feychting M, Kim JL, Reuterwall C, Heurgren M, Olausson PO. External review and validation of the

- Swedish national inpatient register. *BMC Public Health*. 2011;11:450. doi: [10.1186/1471-2458-11-450](https://doi.org/10.1186/1471-2458-11-450)
19. Ludvigsson JF, Otterblad-Olausson P, Pettersson BU, Ekblom A. The Swedish personal identity number: possibilities and pitfalls in health-care and medical research. *Eur J Epidemiol*. 2009;24:659–667. doi: [10.1007/s10654-009-9350-y](https://doi.org/10.1007/s10654-009-9350-y)
 20. Winkleby M, Sundquist K, Cubbin C. Inequities in CHD incidence and case fatality by neighborhood deprivation. *Am J Prev Med*. 2007;32:97–106. doi: [10.1016/j.amepre.2006.10.002](https://doi.org/10.1016/j.amepre.2006.10.002)
 21. Zoller B, Li X, Sundquist J, Sundquist K. Neighbourhood deprivation and hospitalization for atrial fibrillation in Sweden. *Europace*. 2013;15:1119–1127. doi: [10.1093/europace/eut019](https://doi.org/10.1093/europace/eut019)
 22. Modesti PA, Reboldi G, Cappuccio FP, Agyemang C, Remuzzi G, Rapi S, Perruolo E, Parati G; ESH Working Group on CV Risk in Low Resource Settings. Panethnic differences in blood pressure in Europe: a systematic review and meta-analysis. *PLoS One*. 2016;11:e0147601. doi: [10.1371/journal.pone.0147601](https://doi.org/10.1371/journal.pone.0147601)
 23. Carlsson AC, Wandell PE, de Faire U, Hellenius ML. Prevalence of hypertension in immigrants and Swedish-born individuals, a cross-sectional study of 60-year-old men and women in Sweden. *J Hypertens*. 2008;26:2295–2302. doi: [10.1097/HJH.0b013e32831391c3](https://doi.org/10.1097/HJH.0b013e32831391c3)
 24. van Oeffelen AA, Vaartjes I, Stronks K, Bots ML, Agyemang C. Incidence of acute myocardial infarction in first and second generation minority groups: does the second generation converge towards the majority population? *Int J Cardiol*. 2013;168:5422–5429. doi: [10.1016/j.ijcard.2013.08.046](https://doi.org/10.1016/j.ijcard.2013.08.046)
 25. Kennedy S, Kidd MP, McDonald JT, Biddle N. The healthy immigrant effect: patterns and evidence from four countries. *Int Migration & Integration*. 2015;16:317–332. doi: [10.1007/s12134-014-0340-x](https://doi.org/10.1007/s12134-014-0340-x)
 26. Modesti PA, Bianchi S, Borghi C, Cameli M, Capasso G, Ceriello A, Ciccone MM, Germano G, Maiello M, Muesan ML, et al; Societa' Italiana di Cardiologia (SIC); Societa' Italiana dell'Ipertensione Arteriosa (SIIA); Societa' Italiana di Medicina Interna (SIMI); Societa' Italiana di Nefrologia (SIN); Associazione Medici Diabetologi (AMD); Associazione Italiana Aritmia e Cardiostimolazione (AIAC); Societa' Italiana dell'Obesita' (SIO); Societa' Italiana di Prevenzione Cardiovascolare (SIPREC); Osservatorio Nazionale della Sanita' Elettronica e Telemedicina (ONSET). Cardiovascular health in migrants: current status and issues for prevention. A collaborative multidisciplinary task force report. *J Cardiovasc Med (Hagerstown)*. 2014;15:683–692. doi: [10.2459/JCM.0000000000000069](https://doi.org/10.2459/JCM.0000000000000069)
 27. Lu Y, Qin L. Healthy migrant and salmon bias hypotheses: a study of health and internal migration in China. *Soc Sci Med*. 2014;102:41–48. doi: [10.1016/j.socscimed.2013.11.040](https://doi.org/10.1016/j.socscimed.2013.11.040)
 28. Hansen AR, Ekholm O, Kjoller M. Health behaviour among non-Western immigrants with Danish citizenship. *Scand J Public Health*. 2008;36:205–210. doi: [10.1177/1403494807085065](https://doi.org/10.1177/1403494807085065)
 29. Wandell PE. Population groups in dietary transition. *Food Nutr Res*. 2013;57:10.3402/fnr.v57i0.21668. doi: [10.3402/fnr.v57i0.21668](https://doi.org/10.3402/fnr.v57i0.21668)
 30. Wandell P, Li X, Saleh Stattin N, Carlsson AC, Crump C, Sundquist J, Sundquist K. Diabetes during pregnancy among immigrants in Sweden: a national cohort study of all pregnant women in Sweden. *Diabetes Care*. 2023;46:e94–e96. doi: [10.2337/dc22-2180](https://doi.org/10.2337/dc22-2180)
 31. Wandell PE, Carlsson A, Steiner KH. Prevalence of diabetes among immigrants in the Nordic countries. *Curr Diabetes Rev*. 2010;6:126–133. doi: [10.2174/157339910790909404](https://doi.org/10.2174/157339910790909404)
 32. Aljuraiban GS, Gibson R, Chan DS, Van Horn L, Chan Q. The role of diet in the prevention of hypertension and management of blood pressure: an umbrella review of meta-analyses of interventional and observational studies. *Adv Nutr*. 2024;15:100123. doi: [10.1016/j.advnut.2023.09.011](https://doi.org/10.1016/j.advnut.2023.09.011)
 33. Huang J, Wang X, Zhang Y. Specific types of alcoholic beverage consumption and risk of type 2 diabetes: a systematic review and meta-analysis. *J Diabetes Investig*. 2017;8:56–68. doi: [10.1111/jdi.12537](https://doi.org/10.1111/jdi.12537)
 34. Knott C, Bell S, Britton A. Alcohol consumption and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis of more than 1.9 million individuals from 38 observational studies. *Diabetes Care*. 2015;38:1804–1812. doi: [10.2337/dc15-0710](https://doi.org/10.2337/dc15-0710)
 35. Glans F, Elgzyri T, Shaat N, Lindholm E, Apelqvist J, Groop L. Immigrants from the Middle-East have a different form of Type 2 diabetes compared with Swedish patients. *Diabet Med*. 2008;25:303–307. doi: [10.1111/j.1464-5491.2007.02366.x](https://doi.org/10.1111/j.1464-5491.2007.02366.x)
 36. Arora GP, Almgren P, Brons C, Thaman RG, Vaag AA, Groop L, Prasad RB. Association between genetic risk variants and glucose intolerance during pregnancy in north Indian women. *BMC Med Genet*. 2018;11:64. doi: [10.1186/s12920-018-0380-8](https://doi.org/10.1186/s12920-018-0380-8)
 37. Lyssenko V, Jonsson A, Almgren P, Pulizzi N, Isomaa B, Tuomi T, Berglund G, Altshuler D, Nilsson P, Groop L. Clinical risk factors, DNA variants, and the development of type 2 diabetes. *N Engl J Med*. 2008;359:2220–2232. doi: [10.1056/NEJMoa0801869](https://doi.org/10.1056/NEJMoa0801869)
 38. Huang N, Xiao W, Lv J, Yu C, Guo Y, Pei P, Yang L, Millwood IY, Walters RG, Chen Y, et al. Genome-wide polygenic risk score, cardiometabolic risk factors, and type 2 diabetes mellitus in the Chinese population. *Obesity (Silver Spring)*. 2023;31:2615–2626. doi: [10.1002/oby.23846](https://doi.org/10.1002/oby.23846)
 39. Jousilahti P, Laatikainen T, Peltonen M, Borodulin K, Mannisto S, Jula A, Salomaa V, Harald K, Puska P, Vartiainen E. Primary prevention and risk factor reduction in coronary heart disease mortality among working aged men and women in eastern Finland over 40 years: population based observational study. *BMJ*. 2016;352:i721. doi: [10.1136/bmj.i721](https://doi.org/10.1136/bmj.i721)