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Chaohua Li Date

Effect of Parity on Pregnancy-Associated Hypertension among Asian American Women in the United States

By

Chaohua Li

MPH, Emory University, 2017

Department of Epidemiology

_____

Vijaya Kancherla, PhD.
Committee Chair

_____

Jose Binongo, PhD.

Committee Member

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By

Chaohua Li

Master of Medicine

Liaoning University of Traditional Chinese Medicine, China

2015

Thesis Committee Chair: Vijaya Kancherla, PhD

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Abstract

Effect of Parity on Pregnancy-Associated Hypertension among Asian American Women in the United States

By Chaohua Li

BACKGROUND: Asian Americans in the U.S. are a fastest-growing racial group. Despite having a higher socio-economic status, Asian Americans are observed to experience higher rates of maternal morbidity and mortality compared to other races. Pregnancy-associated hypertension (PAH) includes gestational hypertension, preeclampsia and eclampsia. Although a protective effect of multi-parity on PAH has been observed in previous studies, the association is not well-understood among Asian American women in the U.S.

METHODS: Using live births data from 2014 U.S. National Vital Statistics System, we examined whether higher parity reduces the risk of PAH and whether the association is different across Asian ethnic groups among Asian American mothers who had singleton live births (N=235,303). We estimated adjusted odds ratios (aORs) and 95% confidence intervals using multivariable logistic regression analysis.

RESULTS: Overall, 2.7% of Asian American women were recorded to have PAH during pregnancy in the birth certificates. Specifically, 2.8% Asian Indian, 1.4% Chinese, 5.3% Filipino, 2.2% Japanese, 2.3% Korean, 2.2% Vietnamese and 3.0% other Asian ethnics reported having PAH. A significant difference in the number of previous pregnancies was among mothers with and without PAH (*P* value <.0001). A higher parity was associated with a significant reduction in the risk of PAH, where women who had 1-2 previous pregnancies (aOR: 0.61, 95%CI: 0.58, 0.65) and who had 3 or more previous pregnancies (aOR: 0.62, 95%CI: 0.57, 0.68) compared to nulliparous women, after controlling for potential co-factors.

CONCLUSIONS: Our study shows that nulliparity is significantly associated with a higher risk of PAH among Asian American women; and the risk varies further by different Asian ethnicities. Filipino American has higher risk of PAH than other Asian ethnic subgroups. Future studies should identify specific factors that are driving the disparities between Filipino and other Asian ethnics and compare the effect of parity on PAH between Asian American and other races in the U.S.

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BACKGROUND

Introduction:

As recommended by the National High Blood Pressure Education Program Working Group on High Blood Pressure in Pregnancy, hypertensive disorders of pregnancy (HDPs) are classified into 4 categories: 1) chronic hypertension, 2) preeclampsia-eclampsia, 3) preeclampsia superimposed on chronic hypertension, and 4) gestational hypertension (1). Gestational hypertension is defined by systolic blood pressure (SBP) of 140mm Hg or greater, or diastolic blood pressure (DBP) of 90mm Hg or greater as measured during or after the 20th week of gestation. Preeclampsia is the occurrence of hypertension and proteinuria after 20 weeks of gestation. Severe preeclampsia is accompanied by clinical signs and symptoms indicating visceral pain; and eclampsia is characterized by seizures of the tonic-clonic type (2). Along with sepsis and hemorrhage, HDP is one of the three main causes of maternal mortality in global population and nearly 15% of deaths are directly due to HDPs (3). The incidence of severe preeclampsia is increasing worldwide (4). Preeclampsia is annually accountable for approximately 60,000 maternal deaths worldwide (5). In the United States, HDPs represent the most significant complication of pregnancy and affect about 10% of all pregnancies. Overall, 10% to 15% of maternal deaths are associated with preeclampsia and eclampsia (6). Since gestational hypertension, preeclampsia and eclampsia have similar risk factors and are also important markers for future development of metabolic syndrome and cardiovascular diseases, pregnancy-associated hypertension (PAH) which includes these three medical conditions may be a useful indicator (7).

Although a protecting effect of multi-parity on PAH has been observed in previous studies that are based on populations of Iceland, Spain, Israel, Norway, Sweden, Saudi Arabia and non-Asians in the U.S. (7-14), the association between parity and PAH is not well-understood among Asian American women. As the fastest-growing racial group in the United States, Asian Americans experience higher rates of maternal morbidity and mortality in spite of their higher socioeconomic status compared to other races(15). It is of increasing importance to examine the association between parity and PAH in Asian American population. The purpose of this study was to investigate whether higher parity reduces the risk of PAH among Asian American women, and whether this association is altered across different Asian ethnic groups. The potential findings of this study will add to our knowledge of PAH and serve as useful information for future studies and interventions for maternal health among Asian Americans.

PAH:

PAH not only deeply influences process and outcome of pregnancy, but also has a long-lasting effect on the health of mothers and their children in their later life. During pregnancy, the development of hypertension after 20 gestational weeks is found to be associated with significant maternal and fetal morbidity and mortality including preterm delivery, small for gestational age, stillbirth, low-birth-weight infants (16). However, preterm infants aged between 22 and 29 weeks were observed to have lower odds of mortality if they were born to mothers who had maternal hypertension during pregnancy (17). Particularly, PAH can be devastating and life-threatening for both the mother and the fetus. Several large, population-based studies suggest that HDPs are associated with cardiovascular disease in later life (18-25). In cohorts with follow-up spanning over a

decade, women with a history of pregnancy-related hypertension have significantly increased risk of myocardial infarction, ischemic heart disease, heart failure, ischemic stroke, or other thromboembolic events (19, 23, 25, 26). There is also evidence showing women with HDPs have higher levels of insulin resistance than normotensive women during pregnancy and this difference persists after pregnancy and contributes to an increased risk of type 2 diabetes later in life (27). Offspring that were born to women with HDPs also have an increased risk of type 2 diabetes in their adult life (23, 27, 28). In a study based on Danish population, preeclampsia was found to be a shared prenatal risk factor for asthma, eczema, and allergy in childhood pointing toward in utero immune programming of the child (29). Preeclampsia is known to affect kidney function during pregnancy, studies in the recent two decades have found evidence that preeclampsia is also associated with kidney function impairment including end-stage renal diseases in later life (30-33).

Parity:

Parity refers to the number of previous pregnancies with a gestational time of greater than 20 weeks (34). Since dramatic alterations in the hormonal milieu and body morphology during pregnancy may have detrimental effects on the body (35), the association between parity and maternal health have been of concern for decades. In some studies, associations have been found between parity and adverse pregnancy outcomes (36, 37); while other studies indicated that multi-parity was not a risk for adverse pregnancy outcomes (38, 39). The inconsistent study results may be caused by limited sample size or failure to adjust for potential confounders like socioeconomic status. Female hormones, which change significantly during pregnancy, can affect

cardiovascular system, especially blood pressure(40). Though short-term change in hormones may lead to long-term effect on the cardiovascular system(41), previous studies indicate inconsistent effect of parity on hypertension in later life across different races and age groups(42-46). In a study based on a cohort of Chinese women over 50 years old, higher parity was found to be associated with elevated risk of metabolic syndrome (35). Association between higher parity and body mass index/obesity in later life was observed in several studies (47-49). There are also evidences supporting that higher parity, especially grand multiparity (having 5 or more previous pregnancies), is related to increased risk of diabetes in later life after adjustment for confounders (50-53). However, parity is not proven to have an important effect on diabetes-related chronic complications (54, 55). Apart from having elevated risks of the diseases above, primiparous mothers are also more likely to experience more complicated antenatal and labor courses including labor induction and Caesarean section delivery than multiparous mothers(56).

The role of parity on PAH:

Published studies have suggested a protective effect of multi-parity against PAH among women of other countries or non-Asian races in the United States. A study conducted by Gold et al. (7) in 2013 described incidence of PAH from adolescence through the fifth decade of life, including the effect of parity and race, in the United States using the National Center for Health Statistics public database from 4 years (2004, 2005, 2007, and 2008). Study data were stratified by maternal age group, parity (G1, first pregnancy; G2+, second or higher pregnancy), and racial group. They identified that incidence of PAH decreased with increased age in late adolescence in the G2+ group but

not the G1 group (total and all racial groups); the incidence of PAH was significantly greater for non-Hispanic black or non-Hispanic white than Hispanic groups for all age groups (*P* value ≤ .02) except age ≤15 years (G2+ group) and 45-54 years (both G1 and G2+ groups). It was concluded that incidence of PAH (G2+ group) decreased with increased age during adolescence and increased in the fifth decade (G1 and G2+ groups) (7). One notable weakness of this study is that Asian American women was not included in their study.

A retrospective study done by Gunnlaugsson et al. (8) randomly selected one 904 women in Iceland in 1985 to determine the incidence of pregnancy-induced hypertension (PIH) in Iceland, accounting for a quarter of all births in the country. Among them, 17.4% had PIH; 20.9% of nulliparous women were found to have PIH compared with 15.4% of the parous women (8). Although PIH was observed to be associated with higher parity in this study, true association remained unclear because no potential confounders were adjusted for.

A cohort study conducted by Strevens et al. (14) examined 600 Swedish women to investigate the impact of parity on blood pressures in a normal population of pregnant women. Multiple regression analysis of the DBP at term was performed with the variables parity, previous pregnancies, age, baseline BMI, weight gain and smoking status. The study found that the diastolic blood pressure (DBP) decreased slightly until 25–28 weeks of gestation. A steady increase thereafter led to values at term 7.3% above initial values and in nulliparous women the increase was significantly greater, 9.9% versus 5.4% in multiparous women. Nulliparous women showed mean DBP levels significantly higher than all parous women towards term. They concluded that

multiparous women have significantly lower DBP levels in pregnancy compared to nulliparous women (14).

Odegard et al. (13) conducted a case-control study based on Norwegian population to investigate the association between established risk factors for preeclampsia and different clinical manifestations of the disease. In the study, it was observed that nulliparity increased the risk of preeclampsia after adjusting for preeclampsia in previous pregnancy, blood pressure, maternal weight, cigarettes per day, and multiple birth pregnancy (OR 3.6, 95%CI 2.6-5.0) (13).

Co-factors in association between PAH and parity:

Several co-factors are known to influence the association between parity and PAH. In a previous study to describe incidence of PAH and eclampsia from adolescence through the fifth decade of life among non-Asian Americans, subjects were either stratified or restricted by factors including race, age, pre-gestational and gestational diabetes, pre-pregnancy hypertension, and tobacco use in pregnancy (7). In a study based on secondary analysis of a prospective cohort study of women present between 11 and 14 weeks gestation to assess impact of parity on screening efficiency of preeclampsia, factors including BMI, maternal age, and past history of preeclampsia were included as potential confounders (11). In a study based on Swedish population to assess association between parity and blood pressure, age, education level, smoking status, BMI, alcohol consumption, and cholesterol level, socio-economic status were controlled as confounders. Besides, some well-established risk factors for PAH should also be considered as potential confounders for the association between parity and PAH. In a systematic review of cohort studies, history of preeclampsia, pre-existing diabetes, family

history, raised BMI before pregnancy, maternal age > 40 years, renal disease, > 10 years since last pregnancy were found to be associated with increased risk of preeclampsia (10). Some recent studies have also identified obesity, depression, anxiety, gestational weight gain and migraine as risk factors for PAH (57-60).

Though a protecting effect of multi-parity on PAH have been observed in previous studies that are based on populations of different countries and races (7-14), studies on the association between parity and PAH especially among Asian Americans are lacking. As the fastest-growing racial group in the United States, Asian Americans experience higher rates of maternal morbidity and mortality in spite of their higher socioeconomic status compared to other races(15). It is of increasing importance to examine this association among Asian American population and provide relevant information for making policies and consulting parents. Using data from the 2014 U.S. vital records, we examined whether higher parity reduces the risk of PAH among Asian American women and whether the association is different across Asian ethnic groups.

METHODS

Data Source:

We used birth data of 2014 from the U.S. National Vital Statistics System. The National Vital Statistics System is a data collection program of the National Center for Health Statistics (NCHS) in the United States. The data are provided through contracts between NCHS and vital registration systems operated in the various jurisdictions legally responsible for the registration of vital events – births, deaths, marriages, divorces, and fetal deaths. In the United States, legal authority for the registration of these events resides individually with the 50 States, 2 cities (Washington, DC, and New York City), and 5 territories (Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands). These jurisdictions are responsible for maintaining registries of vital events and for issuing copies of birth, marriage, divorce, and death certificates. Birth data used in this study are provided from birth certificates and vital registration systems that are maintained and operated by all states and territories.

Study Population:

We conducted a secondary data analysis using the 2014 birth data from the National Vital Statistics System. Eligible women were Asian American mothers who had singleton live births in 2014. Women with missing information on PAH and/or parity were excluded from analysis.

Dependent variable – PAH:

PAH during pregnancy was ascertained based on a question on the birth certificate inquiring about presence or absence of PAH. The information concerning PAH status was collected directly from medical records and coded as 'Yes', 'No', 'Unknown', or 'Blank (not on the certificate)'. For our analysis, women whose PAH information was coded as "Unknown" or left blank were excluded form analysis.

Independent variable – Parity:

In our study, parity indicates how many births (including live births and fetal deaths) a mother has had before the birth that is included in the study. Number of parity was assessed using the question on the birth certificate inquiring about total birth order which refers to the number that the present birth represents. The original coding of total birth order were 1-7 as number of total birth order, 8 as 8 or more total births, and 9 as unknown or not stated. For our analysis, we coded parity based on total birth orders: '0' if total birth order is 1; '1-2' if total birth order is 2-3; and '3 or more' if total birth order is 4 or more.

Co-variables:

We examined following co-variables in our analysis: maternal age in years (<25, 25-34, ≥35), Asian ethnic subgroup (Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, Other Asian), Hispanic origin (Hispanic, Non-Hispanic), born in the US (Yes, No), marital status (Married, Unmarried), education in years (<12, 12, >12), interval since last live birth in years (<2, 2-4, ≥5), prenatal care initiation (No prenatal care, 1st trimester, 2nd trimester, 3rd trimester), periconceptional smoking (Yes, No), pre-pregnancy BMI (kg/m2) (<18.5, 18.5-24.9, 25.0-29.9, ≥30), weight gain during

pregnancy in pounds (<21, 21-40, 41-98), sex of infant (Female, Male), gestation age in weeks (<37, ≥37), payment source for delivery (Medicaid, Private insurance, Self-pay, Other), and pre-pregnancy diabetes (Yes, No). All co-variables were selected based on the literature review of previous studies (7).

Statistical analysis:

We examined crude association between co-variables and parity and crude association between co-variables and PAH using Chi-square test. We computed crude prevalence odds ratios (cORs) and 95% confidence intervals (95% CIs). Co-variables that are significantly associated with both parity and PAH will be selected in a full model together with all two-way interaction terms involving parity and selected co-variables.

We used logistic regression to estimate the association between parity and PAH. We computed adjusted odds ratios (aORs) and corresponding 95% CIs using three different reduced models. Reduced models were generated using three approaches: 1) reduced model 1 using: examined two-way interaction between parity and co-variables using likelihood ratio test and all interaction terms were dropped during this procedure, then used all possible subset approach to assess confounding, ran the models with all possible subsets of confounding terms from full model, models were selected as candidates if estimated ORs were within 10% of full model ORs, precision was checked by dividing upper confidence limit with lower confidence limit, best model was selected if the most gain in precision among all candidate models; 2) reduced model 2 using stepwise selection procedure: fitted in the full model with all predictors and interaction terms, remove any insignificant (>0.2) variables from the model before adding a significant (<0.2) variable to the model, at each step a new model is fitted, repeated

dropping and adding variables until no variables can be added or dropped, all interaction terms were dropped during this procedure; 3) a priori model in which co-variables were selected based on knowledge from previous studies. Multi-collinearity was checked for full model and each reduced model, interval since last live birth in years was found to be highly correlated with parity. After deleting interval since last live birth in years from co-variables and regenerated reduced models, multi-collinearity was no longer a factor for the new full model and reduced models.

For analysis, a two-sided *P* value of less than 0.05 was considered to indicate statistical significance. All statistical analyses were conducted using SAS® version 9.4 (SAS Institute Inc., Cary, NC). The study was approved by the Institutional Review Board at Emory University.

RESULTS

Using the U.S. vital records, a total of 235,303 Asian American mothers who had singleton live births in 2014 were identified for this study. Of these, 145 people who had missing PAH information, 2714 people who had missing parity information and 97 people who had missing information on both PAH and parity were excluded. In our study, we included 232,347 people with complete data on the primary exposure and outcome variables, constituting 98.7% of the original sample. There were 58827 Asian Indian women (25.3%), 58470 Chinese women (25.2%), 31444 Filipino women (13.5%), 6818 Japanese women (2.9%), 14510 Korean women (6.2%), 19806 Vietnamese women (8.5%), and 42472 women of other Asian ethnics (18.3%). To assess potential bias caused by exclusion, we compared selected demographic factors between women who were excluded from analysis and women who were included in the final sample. No significant differences were found between the two groups.

Of the 232,347 Asian American women examined in our study, 6326 (2.7%) women reported having PAH during pregnancy. Specifically, 2.8% Asian Indian, 1.4% Chinese, 5.3% Filipino, 2.2% Japanese, 2.3% Korean, 2.2% Vietnamese and 3.0% other Asian ethnics reported having PAH. Among women who had PAH during pregnancy, 2820 (44.6%) women were nulliparous, 2641 (41.7%) women had 1-2 previous pregnancies, and 865 women had 3 or more previous pregnancies. A significant difference in the number of parity was observed among women who did or did not have PAH during pregnancy (*P* value<.0001) (Table 2). In the unadjusted analysis, the odds of PAH was relatively low among women who had 1-2 previous pregnancies (cOR: 0.74, 95%CI: 0.70, 0.78) compared to nulliparous women; the odds of PAH among women

who had 3 or more previous pregnancies was close to the corresponding odds among nulliparous women (cOR: 1.02, 95%CI: 0.95, 1.11) (Table 2). PAH during pregnancy was observed to be prevalent among women who were aged 35 or older, Filipino, with Hispanic origin, born in the US, unmarried, with no previous live births or ≥ 5 previous live births, overweight or obese (BMI ≥ 25), smoked between 3 months before conception to 3 months after conception, gained more than 40 pounds in weight during pregnancy, had preterm births (<37 weeks), used private insurance to pay for delivery, and had pre-pregnancy diabetes. Except for sex of infant, all other co-factors were significantly different between women did and did not have PAH during pregnancy (*P* value<.0001) (Table 2).

We noted that prevalence of PAH was significantly different among three parity groups (*P* value <.0001) (Table 3). Associations between co-factors and parity were also examined in Table 3. Across groups of women who had different number of parity, significant difference was observed in distribution of maternal age, Asian ethnic subgroup, Hispanic origin, born in the U.S. or not, marital status, education level, interval since previous live birth, prenatal care initiation time, periconceptional smoking, pre-pregnancy BMI, weight gain during pregnancy, sex of infant, gestation age, payment source for delivery and pre-pregnancy diabetes (*P* value <0.05) (Table 3).

In Table 4, we summarized results from the multivariate logistic regression models. We found that multiparous Asian American women had lower odds of PAH during pregnancy compared nulliparous Asian American women adjusting for potential confounders. In the full model, the odds of having PAH during pregnancy were significantly reduced for Asian American women who had 1-2 previous pregnancies

(aOR: 0.61, 95%CI: 0.58, 0.65) and who had 3 or more previous pregnancies (aOR: 0.62, 95%CI: 0.57, 0.68) compared to nulliparous Asian American women, after controlling for age, Asian ethnic subgroup, Hispanic origin, born in the US or not, marital status, education, prenatal care initiation time, periconceptional smoking, pre-pregnancy BMI, weight gain during pregnancy, gestation age, payment source for delivery and pre-pregnancy diabetes (Table 4). Similar results were found using Reduced Model 1 that was obtained by all possible subset approach, where having 1-2 previous pregnancies (aOR: 0.61, 95% CI: 0.57, 0.64) and having 3 or more previous pregnancies (aOR: 0.62, 95% CI: 0.57, 0.68) among Asian Americans were significantly associated with lower odds of PAH during pregnancy compared to nulliparous Asian Americans, after adjusting for age, Asian ethnic subgroup, pre-pregnancy BMI, gestation age, payment source for delivery and pre-pregnancy diabetes (Table 4). Reduced Model 2 which was obtained using stepwise elimination approach and a-priori model which was based on knowledge from previous studies yielded results consistent with the findings from the full model and reduced model 1, further confirming the association between parity and PAH during pregnancy among Asian American women (Table 4).

DISCUSSION

Based on 2014 U.S. birth certificate data from the National Vital Statistics System, we found that the overall prevalence of PAH among Asian American women was 2.72%. Specifically, 3.11% of those who were nulliparous, 2.31% of those who had 1-2 previous pregnancies, 3.18% of those who had 3 or more previous pregnancies reported having PAH during pregnancy. Notably, Filipino American reported a PAH prevalence of 5.30%, which was the highest among all Asian ethnic subgroups. Our main finding was that Asian American women who had 1 or 2 previous pregnancies and those who had 3 or more previous pregnancies were respectively 39% and 38% less likely to experience PAH compared to nulliparous Asian American women. To our knowledge, our study is the first one to examine the association between parity and PAH among Asian American women in the U.S.

Prevalence of PAH among Asian American women was not found in previously published papers, limiting our ability to compared our findings. However, a retrospective cohort study based on the U.S. 2010 natality data reported a prevalence of 2.4% for preeclampsia among Asian/Pacific Islanders (61). Considering the similarity between the two study populations, we believe the prevalence of PAH from our study is consistent with the prevalence in previous studies.

Our results indicate that nulliparity increases the risk of PAH during pregnancy among Asian American women which is consistent with results of previous studies based on other different populations (7, 8, 13, 14). In a case-control study based on Norwegian population, nulliparity showed a stronger effect on PAH (aOR 3.6, 95%CI 2.6-5.0) compared to the result from our study; the difference in the association might be

explained by the disparity of inherent characteristics, years in which the data were collected and covariates that were controlled during analysis (13). In other previous relevant studies, the magnitude of association between parity and PAH cannot be directly compared with the result from our study, because the association was not calculated in forms of ORs or no confounders were adjusted during analysis. However, our study generated similar results with those studies in terms of prevalence/incidence of PAH across parity groups where prevalence of PAH was always higher among nulliparous women compared to multiparous women (7, 8, 13, 14).

Besides parity, our study also found several maternal characteristics to be associated with PAH during pregnancy. Odds of PAH were observed to be higher in older groups of Asian American women, similar association was reported among other races in the US (7). Contradictory to the result from previous studies, periconceptional smoking was found to be associated with higher risk of PAH (aOR 1.14, 95%CI 0.94-1.38) in our study, but this effect was not statistically significant (62). Women who were overweight or obese before pregnancy were subject to more than twice the odds of PAH compared to those who had normal BMI, and this results is consistent with previous studies (10). Additionally, pre-pregnancy diabetes (aOR 2.07, 95%CI 1.72-2.48), preterm birth (aOR 3.14, 95%CI 2.94-3.36) and having weight gain greater than 21 pounds were also significantly associated with higher risk of PAH as were proven by other studies (59, 62).

In our research, Asian American women who were born out of the US have significantly lower risk of PAH compared to those born in the U.S. The weak protective effect of being born out of the U.S. against PAH might be partially explained by the

difference between Asian and American conventional diet habits. It would be interested to study this phenomenon further using data sources, while accounting for the length of stay in the U.S. among mothers who are not natives.

In our study, payment source for delivery was included as an indicator of socio-economic status in the analysis. Women who used their own money instead of Medicaid or private insurance to pay for delivery had lower odds of PAH. Most notably, Filipino women had significantly higher odds of PAH compared with Asian Indian women, while other Asian ethnic subgroups all had lower odds than Asian Indian. The prevalence of PAH among Filipino women was 5.3% which was the highest among all Asian ethnic subgroups and nearly twice the PAH prevalence among all Asian American women in this study.

Our study has several strengths. First, we used data from the latest National Vital Statistics System (NCHS) which collects information from US Standard Certificate of Live Birth. Parity, PAH and other gestational medical conditions reported in birth certificate were abstracted directly from medical records instead of maternal self-reporting, so the informational bias is reduced and data source is relatively reliable. Second, NCHS includes 100% of the birth certificates registered in the U.S. Since more than 99% of births occurring in the U.S. are registered (62), our study sample is representative of the Asian American women in the U.S. Lastly, multiple potential confounders were considered in our study to increase the validity of findings thanks to the availability of such variables in the birth certificates. Our study included not only confounders which were frequently confirmed in previous studies like maternal age, marital status, pre-pregnancy BMI and diabetes, but also the ones that were seldom or

never considered before like Asian ethnic subgroup, interval since last live birth and payment source for delivery.

The findings of this study, however, should be viewed with caution in spite of the good quality of data. The primary limitation of this study would be failure to consider women who had miscarriages or still births because birth certificates only include information of women who had live births. PAH is associated with higher risk of fetal death as well as stillbirth which means a fair number of PAH cases may have been missed by including only those who had live births (63, 64). In addition, some potential confounders were not controlled in this study. Published studies indicate that previous history of preeclampsia, family history of preeclampsia and some pre-existing medical conditions are also risk factors of PAH. In our study, only pre-existing diabetes was included as a pre-existing condition in analysis, other medical conditions like hypertension, renal disease and autoimmune diseases were not considered because birth certificates provided limited information on such variables. Lastly, about 1.3% of the Asian American mothers who had singleton live births in 2014 were excluded from analysis due to missing information on PAH and/or parity. However, no significant differences in selected demographic features were found between the included and the excluded subjects.

To our knowledge, our research is the first one to study the population of Asian American women regarding the association between parity and PAH. Although Asian American is the fastest-growing racial group in the US, the literature relevant to Asian American is lacking compared to other races. By confirming the positive effect of nulliparity on PAH among Asian American after adjustment, our study has contributed to

the literature of gestational hypertensive disease specifically among this racial group. Our findings about nulliparity and other maternal features that increase risk of PAH can be taken into consideration as an element in counseling first-time Asian American parents. Reduction of pre-pregnancy weight, restriction of weight gain during pregnancy and positive control of pre-existing medical conditions should also be recommended to Asian parents. Since our study indicates a relatively high risk of PAH among Filipino American, more frequent monitoring and counseling for hypertensive diseases should be provided to this ethnic group.

In conclusion, our study found that nulliparity is significantly associated with higher risk of PAH among Asian American women after adjustment; and Filipino American has higher risk of PAH than other Asian ethnic subgroups by using birth data of 2014 from the National Vital Statistics System. Further studies are needed to identify specific factors that are driving the disparities between Filipino and other Asian ethnic subgroups. Besides, future studies comparing such association between Asian American and other races in the US would be important to the knowledge for counseling parents and public health policy-making.

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Table 1. Demographic characteristics of mothers by inclusion/ exclusion status (N=235,303)

Characteristics	Included (N=232,347) n(%)	Excluded (N=2,956) n(%)	*P value*[3]
Maternal age (years)			0.426
< 25	22,558 (9.7)	267 (9.0)	
25-34	150,579 (64.8)	1,920 (65.0)	
≥ 35	59,210 (25.5)	769 (26.0)	
Asian ethnic subgroup			0.609
Asian Indian	58,827 (25.3)	775 (26.2)	
Northeastern Asian[1]	79,798 (34.3)	1,016 (34.4)	
Southeastern Asian[1]	51,250 (22.1)	628 (21.2)	
Other Asian	42,472 (18.3)	537 (18.2)	
Born in the US			0.383
Yes	43,318 (18.7)	557 (19.4)	
No	188,139 (81.3)	2,321 (80.7)	
Marital status			0.089
Married	199,523 (85.9)	2,506 (84.8)	
Unmarried	32,824 (14.1)	450 (15.2)	
Education (years)			0.120
< 12	18,357 (7.9)	242 (8.2)	
≥ 12	207,180 (89.2)	2,458 (83.2)	
Periconceptional Smoking[2]			0.385
Yes	3,030 (1.4)	35 (1.2)	
No	221,707 (98.7)	2,207 (74.7)	
Sex of infant			0.709
Female	112,574 (48.5)	1,422 (48.1)	
Male	119,773 (51.6)	1,534 (51.9)	
Pre-pregnancy diabetes			0.237
Yes	1,545 (0.7)	23 (0.8)	
No	230,275 (99.1)	2,673 (90.4)	

Frequency of included and excluded subjects may vary because of missing data. Percentages may not be equal to 100 because of missing data

[1]Northeastern Asian include Chinese, Korean and Japanese; Southeastern Asian include Vietnamese and Filipino.

[2]Periconceptional smoking indicates smoking status between 3 months before conception to 3 months after conception

[3]P-value for chi-square tests

Table 2. Characteristics and PAH of Asian American mothers who had singleton births in the US, 2014

Characteristics	PAH (N=6,326) n(%)	Non-PAH (N=226,021) n(%)	Crude OR (95% CI)	*P value*[3]
Parity				<.0001
0	2,820 (44.6)	87,928 (38.9)	Referent	
1-2	2,641 (41.7)	111,739 (49.4)	0.74(0.70, 0.78)	
≥3	865 (13.7)	26,354 (11.7)	1.02(0.95,1.11)	
Maternal age (years)				<.0001
< 25	528 (8.3)	22,030 (9.7)	0.96(0.88,1.06)	
25-34	3,659 (57.8)	146,920 (65.0)	Referent	
≥ 35	2,139 (33.8)	57,071 (25.3)	1.50(1.43,1.59)	
Asian ethnic subgroup				<.0001
Asian Indian	1,646 (26.0)	57,181 (25.3)	Referent	
Chinese	822 (13.0)	57,648 (25.5)	0.50(0.46,0.54)	
Filipino	1,667 (26.4)	29,777 (13.2)	1.94(1.81,2.08)	
Japanese	149 (2.4)	6,669 (3.0)	0.78(0.66,0.92)	
Korean	339 (5.4)	14,171 (6.3)	0.83(0.74,0.94)	
Vietnamese	438 (6.9)	19,368 (8.6)	0.79(0.71,0.87)	
Other Asian	1,265 (20.0)	41,207 (18.2)	1.07(0.99,1.15)	
Hispanic origin				<.0001
Hispanic	215 (3.4)	4,752 (2.1)	1.66(1.44,1.90)	
Non-Hispanic	5,940 (93.9)	217,523 (96.2)	Referent	
Born in the US				<.0001
Yes	1,590 (25.1)	41,728 (18.5)	Referent	
No	4,713 (74.5)	183,426 (81.2)	0.67(0.64,0.71)	
Marital status				<.0001
Married	5,276 (83.4)	194,247 (85.9)	Referent	
Unmarried	1,050 (16.6)	31,774 (14.1)	1.22(1.14,1.30)	
Education (years)				0.002
< 12	425 (6.7)	17,932 (7.9)	0.82(0.73,0.92)	
12	839 (13.3)	28,980 (12.8)	Referent	
>12	4,833 (76.4)	172,528 (76.3)	0.97(0.90,1.04)	
Interval since last live birth (years)				
No previous live birth	3,469 (54.8)	103,827 (46.0)	1.84(1.66,2.04)	<.0001
< 2	399 (6.3)	21,967 (9.7)	Referent	
2-4	1,154 (18.2)	58,356 (25.8)	1.09(0.97,1.22)	
≥ 5	1,079 (17.1)	33,268 (14.7)	1.79(1.59,2.01)	
Prenatal care initiation				<.0001
No prenatal care	53 (0.8)	1,496 (0.7)	1.25(0.95,1.65)	
1st trimester	4,955 (78.3)	174,935 (77.4)	Referent	
2nd trimester	913 (14.4)	32,395 (14.3)	1.00(0.93,1.07)	
3rd trimester	207 (3.3)	10,006 (4.4)	0.73(0.63,0.84)	
Periconceptional Smoking[1]				<.0001
Yes	136 (2.1)	2,945 (1.3)	1.66(1.40,1.98)	
No	5,993 (94.7)	215,645 (95.4)	Referent	
Pre-pregnancy BMI (kg/m^2)				<.0001

Table 2. (Continued)

Characteristics	PAH (N=6,326) n(%)	Non-PAH (N=226,021) n(%)	Crude OR (95% CI)	*P value*[3]
Underweight (<18.5)	225 (3.6)	18,586 (8.2)	0.60(0.52,0.69)	
Normal weight (18.5-24.9)	2,776 (43.9)	137,666 (60.9)	Referent	
Overweight (25.0-29.9)	1,806 (28.5)	42,435 (18.8)	2.11(1.99,2.24)	
Obese (≥30)	1,262 (19.9)	16,025 (7.1)	3.91(3.65,4.18)	
Weight gain during pregnancy (pounds)				<.0001
< 21	1,584 (25.0)	53,599 (23.7)	Referent	
21-40	3,340 (52.8)	132,813 (58.8)	0.85(0.80,0.90)	
41-98	1,103 (17.4)	28,474 (12.6)	1.31(1.21,1.42)	
Sex of infant				0.779
Female	3,054 (48.3)	109,520 (48.5)	Referent	
Male	3,272 (51.7)	116,501(51.5)	1.00(0.96,1.06)	
Gestation age (weeks)				<.0001
Preterm (<37)	1,394 (22.0)	17,247 (7.6)	3.42(3.22,3.64)	
Term (≥37)	4,930 (77.9)	208,659 (92.3)	Referent	
Payment source for delivery				<.0001
Medicaid	1,628 (25.7)	59,209 (26.2)	0.91(0.86,0.97)	
Private insurance	4,208 (66.5)	139,578 (61.8)	Referent	
Self-pay	204 (3.2)	17,786 (7.9)	0.38(0.33,0.44)	
Other[2]	227 (3.6)	7,257 (3.2)	1.04(0.91,1.19)	
Pre-pregnancy diabetes				<.0001
Yes	155 (2.5)	1,390 (0.6)	4.06(3.43,4.80)	
No	6,159 (97.4)	224,116 (99.2)	Referent	

Frequency of PAH and non-PAH subjects may vary because of missing data. Percentages may not be equal to 100 because of missing data

PAH pregnancy-associated hypertension *BMI* body mass index

[1]Periconceptional smoking indicates smoking status between 3 months before conception to 3 months after conception

[2]Other includes Indian Health Service, CHAMPUS/TRICARE, Other government and other sources

[3]P-value for chi-square tests

Table 3. Characteristics of Asian American mothers who had singleton births, stratified by parity

Characteristics	Parity			
	0 (N=90,748) n(%)	1-2 (N=114,380) n(%)	≥3 (N=27,219) n(%)	P-value[3]
PAH				<.0001
Yes	2,820 (3.1)	2,641 (2.3)	865(3.2)	
No	87,928 (96.9)	111,739 (97.7)	26,354 (96.8)	
Maternal age (years)				<.0001
< 25	13,733 (15.1)	7,809 (6.8)	1,016 (3.7)	
25-34	63,908 (70.4)	72,838 (63.7)	13,833 (50.8)	
≥ 35	13,107 (14.4)	33,733 (29.5)	12,370 (45.4)	
Asian ethnic subgroup				<.0001
Asian Indian	24,932 (27.5)	28,753 (25.1)	5,142 (18.9)	
Chinese	24,071 (26.5)	29,325 (25.6)	5,074(18.6)	
Filipino	11,297 (12.4)	15,830 (13.8)	4,317 (15.9)	
Japanese	2,703 (3.0)	3,428 (3.0)	687 (2.5)	
Korean	6,082 (6.7)	7,048 (6.2)	1,380 (5.1)	
Vietnamese	7,351 (8.1)	10,115 (8.8)	2,340 (8.6)	
Other Asian	14,312(15.8)	19,881 (17.4)	8,279 (30.4)	
Hispanic origin				<.0001
Hispanic	1,598 (1.8)	2,329 (2.0)	1,040 (3.8)	
Non-Hispanic	87,555 (96.5)	110,252 (96.4)	25,656 (94.3)	
Born in the US				<.0001
Yes	17,555 (19.3)	20,078 (17.6)	5,685 (20.9)	
No	72,852 (80.3)	93,905 (82.1)	21,382 (78.6)	
Marital status				<.0001
Married	77,173 (85.0)	100,398 (87.8)	21,952 (80.6)	
Unmarried	13,575 (15.0)	13,982 (12.2)	5,267 (19.4)	
Education (years)				<.0001
< 12	4,932 (5.4)	9,156 (8.0)	4,269 (15.7)	
12	9,527 (10.5)	15,170 (13.3)	5,122 (18.8)	
>12	73,547 (81.0)	86,834 (75.9)	16,980 (62.4)	
Interval since last live birth (years)				
No previous live birth	90,515 (99.7)	15,604 (13.6)	1,177 (4.3)	<.0001
< 2	0 (0)	17,539 (15.3)	4,827 (17.7)	
2-4	0 (0)	48,497 (42.4)	11,013 (40.5)	
≥ 5	0 (0)	26,310 (23.0)	8,037 (29.5)	
Prenatal care initiation				<.0001
No prenatal care	641 (0.7)	610 (0.5)	296 (1.1)	
1st trimester	70,532 (77.7)	89,599 (78.3)	19,759 (72.6)	
2nd trimester	12,269 (13.5)	15,926 (13.9)	5,113 (18.8)	
3rd trimester	4,226 (4.7)	4,755 (4.2)	1,232 (4.5)	
Periconceptional Smoking[1]				<.0001
Yes	1,020 (1.1)	1,335 (1.2)	726 (2.7)	
No	86,752 (95.6)	109,104(95.4)	25,782 (94.7)	
Pre-pregnancy BMI (kg/m^2)				<.0001

Table 3. (Continued)

Characteristics	Parity			
	0 (N=90,748) n(%)	1-2 (N=114,380) n(%)	≥3 (N=27,219) n(%)	P-value[3]
Underweight (<18.5)	9,130 (10.1)	8,406 (7.3)	1,275 (4.7)	
Normal weight (18.5-24.9)	57,543 (63.4)	68,494 (59.9)	14,405 (52.9)	
Overweight (25.0-29.9)	14,385 (15.9)	23,020 (20.1)	6,836 (25.1)	
Obese (≥30)	5,034 (5.5)	8,753 (7.7)	3,500 (12.9)	
Weight gain during pregnancy (pounds)				<.0001
< 21	17,907 (19.7)	28,616 (25.0)	8,660 (31.8)	
21-40	54,373 (59.9)	67,383 (58.9)	14,397 (52.9)	
41-98	14,013 (15.4)	12,681 (11.1)	2,883 (10.6)	
Sex of infant				0.0066
Female	44,334 (48.9)	55,166 (48.2)	13,074 (48.0)	
Male	46,414 (51.1)	59,214(51.8)	14,145 (52.0)	
Gestation age (weeks)				<.0001
Preterm (<37)	7,007 (7.7)	8,743 (7.6)	2,891 (10.6)	
Term (≥37)	83,700 (92.2)	105,575(92.3)	24,314 (89.3)	
Payment source for delivery				<.0001
Medicaid	20,418 (22.5)	29,813 (26.1)	10,606 (39.0)	
Private insurance	59,479 (65.5)	70,566 (61.7)	13,741 (50.5)	
Self-pay	7,035 (7.8)	9,249 (8.1)	1,706 (6.3)	
Other[2]	2,858 (3.1)	3,719 (3.3)	907 (3.3)	
Pre-pregnancy diabetes				<.0001
Yes	419 (0.5)	795 (0.7)	331 (1.2)	
No	90,096 (99.3)	113,350(99.1)	26,829 (98.6)	

Frequency of different numbers of parity may vary because of missing data. Percentages may not be equal to 100 because of missing data

PAH pregnancy-associated hypertension; BMI body mass index

[1]Periconceptional smoking indicates smoking status between 3 months before conception to 3 months after conception

[2]Other includes Indian Health Service, CHAMPUS/TRICARE, Other government and other sources

[3]P-value for chi-square tests

Table 4. Adjusted logistic regression analysis examining the association between PAH and parity among Asian American mothers who had singleton births in the US, 2014

Exposure	Full Model aOR (95%CI)	Reduced Model 1 (All possible subset approach) aOR (95%CI)	A Priori Model aOR (95%CI)	Reduced Model 2 (Stepwise elimination approach) aOR (95%CI)
Parity				
0	Referent	Referent	Referent	Referent
1-2	**0.61 (0.58, 0.65)**	**0.61 (0.57, 0.64)**	**0.60 (0.57, 0.64)**	**0.62 (0.59, 0.66)**
≥3	**0.62 (0.57, 0.68)**	**0.62 (0.57, 0.68)**	**0.63 (0.58, 0.69)**	**0.63 (0.58, 0.69)**
Maternal age (years)				
< 25	0.73 (0.66, 0.82)	0.77 (0.69, 0.85)	0.75 (0.68, 0.84)	0.74 (0.67, 0.83)
25-34	Referent	Referent	Referent	Referent
≥ 35	1.61 (1.51, 1.71)	1.56 (1.47, 1.65)	1.63 (1.54, 1.73)	1.62 (1.52, 1.72)
Asian ethnic subgroup				
Asian Indian	Referent	Referent	Referent	Referent
Chinese	0.68 (0.62, 0.75)	0.70 (0.64, 0.76)	0.66 (0.61, 0.73)	0.67 (0.61, 0.74)
Filipino	1.70 (1.58, 1.84)	1.79 (1.67, 1.93)	1.79 (1.67, 1.93)	1.69 (1.57, 1.83)
Japanese	0.83 (0.69, 1.00)	0.85 (0.72, 1.01)	0.80 (0.67, 0.96)	0.82 (0.68, 0.98)
Korean	0.92 (0.81, 1.05)	0.94 (0.83, 1.06)	0.90 (0.80, 1.02)	0.91 (0.80, 1.03)
Vietnamese	0.93 (0.83, 1.05)	0.97 (0.86, 1.08)	0.96 (0.86, 1.08)	0.93 (0.83, 1.05)
Other Asian	1.08 (0.99, 1.18)	1.09 (1.00, 1.18)	1.07 (0.99, 1.16)	1.07 (0.98, 1.16)
Hispanic origin				
Hispanic	1.12 (0.95, 1.31)	NA	NA	NA
Non-Hispanic	Referent			
Born in the US				
Yes	Referent	NA	Referent	Referent
No	0.91 (0.85, 0.97)		0.87 (0.81, 0.92)	0.89 (0.84, 0.96)
Marital status				
Married	Referent	NA	NA	NA
Unmarried	1.00 (0.92, 1.08)			
Education (years)				
< 12	0.86 (0.75, 0.97)	NA	NA	0.86 (0.76, 0.98)
12	Referent			Referent
>12	0.93 (0.85, 1.02)			0.92 (0.85, 1.00)
Prenatal care initiation				
No prenatal care	0.98 (0.70, 1.39)	NA	NA	NA
1st trimester	Referent			
2nd trimester	0.98 (0.91, 1.06)			
3rd trimester	0.87 (0.75, 1.02)			
Periconceptional Smoking[5]				
Yes	1.14 (0.94, 1.38)	NA	1.27 (1.06, 1.52)	NA
No	Referent		Referent	
Pre-pregnancy BMI (kg/m^2)				
Underweight (<18.5)	0.65 (0.56, 0.75)	0.66 (0.58, 0.76)	0.68 (0.59, 0.78)	0.66 (0.57, 0.76)
Normal weight (18.5-24.9)	Referent	Referent	Referent	Referent
Overweight (25.0-29.9)	2.01 (1.88, 2.15)	1.96 (1.84, 2.08)	1.97 (1.85, 2.10)	2.02 (1.89, 2.15)
Obese (≥30)	3.64 (3.37, 3.94)	3.43 (3.19, 3.69)	3.39 (3.16, 3.65)	3.65 (3.38, 3.95)
Weight gain during pregnancy (pounds)				

Table 4. (Continued)

Exposure	Full Model aOR (95%CI)	Reduced Model 1 (All possible subset approach) aOR (95%CI)	A Priori Model aOR (95%CI)	Reduced Model 2 (Stepwise elimination approach) aOR (95%CI)
< 21	Referent	NA	NA	Referent
21-40	1.20 (1.12, 1.28)			1.20 (1.12, 1.28)
41-98	1.93 (1.77, 2.11)			1.94 (1.78, 2.11)
Gestation age (weeks)				
Preterm (<37)	3.14 (2.94, 3.36)	2.99 (2.80, 3.19)	NA	3.14 (2.92, 3.34)
Term (≥37)	Referent	Referent		Referent
Payment source for delivery				
Medicaid	0.99 (0.92, 1.06)	0.99 (0.93, 1.05)	1.03 (0.96, 1.10)	0.98 (0.91, 1.05)
Private insurance	Referent	Referent	Referent	Referent
Self-pay	0.62 (0.52, 0.73)	0.62 (0.53, 0.72)	0.63 (0.54, 0.74)	0.65 (0.55, 0.76)
Other[6]	0.97 (0.84, 1.12)	0.97 (0.84, 1.11)	0.98 (0.85, 1.12)	0.96 (0.83, 1.11)
Pre-pregnancy diabetes				
Yes	2.07 (1.72, 2.49)	2.04 (1.70, 2.45)	2.27 (1.90, 2.72)	2.04 (1.69, 2.45)
No	Referent	Referent	Referent	Referent

PAH pregnancy-associated hypertension; *BMI* body mass index; *aOR*, Adjusted Odds Ratio; *CI*, Confidence Interval.

[1]Full model includes parity, maternal age, Asian ethnic subgroup, Hispanic origin, whether born in the US, marital status, education, prenatal care initiation, periconceptional smoking, pre-pregnancy BMI, weight gain during pregnancy, gestation age, payment source for delivery, and pre-pregnancy diabetes as independent variables.

[2]Reduced model 1 includes parity, maternal age, Asian ethnic subgroup, pre-pregnancy BMI, gestation age, payment source for delivery and pre-pregnancy diabetes as independent variables.

[3]A priori model includes parity, maternal age, Asian ethnic subgroup, whether born in the US, periconceptional smoking, pre-pregnancy BMI, payment source for delivery, and pre-pregnancy diabetes as independent variables.

[4]Reduced model 2 includes parity, maternal age, Asian ethnic subgroup, whether born in the US, education, pre-pregnancy BMI, weight gain during pregnancy, gestation age, payment source for delivery, and pre-pregnancy diabetes as independent variables.

[5]Periconceptional smoking indicates smoking status between 3 months before conception to 3 months after conception

[6]Other includes Indian Health Service, CHAMPUS/TRICARE, Other government and other sources

Each variable is adjusted for all other variables presented in in each model.