Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

OBSTETRICS

Pneumonia and pregnancy outcomes: a nationwide population-based study

Yi-Hua Chen, PhD; Joseph Keller, MD; I-Te Wang, MD; Ching-Chun Lin, MA; Herng-Ching Lin, PhD

OBJECTIVE: Using 2 nationwide population-based datasets, this study aimed to assess the risk of adverse pregnancy outcomes, including low birthweight (LBW), preterm birth, small for gestational age (SGA), cesarean section (CS), lower Apgar score, and preeclampsia/eclampsia, between women with and without pneumonia.

STUDY DESIGN: This study included 1462 women who had been hospitalized with pneumonia during pregnancy and used 7310 matched women without pneumonia as a comparison group.

RESULTS: Compared to women without pneumonia, conditional logistic regression analyses showed that the adjusted odds ratios for LBW, preterm birth, SGA, CS, Apgar scores <7 at 5 minutes, and preeclampsia/eclampsia in women with pneumonia were 1.73 (95% confidence interval [CI], 1.41–2.12), 1.71 (95% CI, 1.42–2.05), 1.35 (95% CI, 1.17–1.56), 1.77 (95% CI, 1.58–1.98), 3.86 (95% CI, 1.64–9.06), and 3.05 (95% CI, 2.01–4.63), respectively.

CONCLUSION: Women with pneumonia during pregnancy had significantly higher risk of LBW, preterm birth, SGA, low Apgar scores infants, CS, and preeclampsia/eclampsia, compared to unaffected women.

Key words: pneumonia, pregnancy, pregnancy outcome

Pneumonia is a common infection of the pulmonary parenchyma[1] that is a significant cause of hospitalization for respiratory disorders during pregnancy,[2] complicating 0.5-1.5 per 1000 pregnancies in the United States.[3-6] Pneumonia is the most frequent cause of fatal nonobstetric maternal death in the United States.[7-9] It is widely held that several physiologic and immunologic changes experienced during pregnancy may predispose pregnant women toward a more severe course of pneumonia,[10] which may result in greater maternal and fetal morbidity and mortality.[6,11-15]

The relationship between pneumonia and pregnancy outcome has long been a topic of interest among researchers. A growing number of studies have found that women with pneumonia were more likely to have preterm deliveries[3,5,10,12,15-22] as well as lower average birthweight[2,14-16] and small for gestational age (SGA) infants[4,14] compared to women without pneumonia. Moreover, Romanyuk et al[16] also found that pneumonia was significantly associated with placental abruption, intrauterine growth restriction, cesarean section (CS), low Apgar scores, and severe preeclampsia.

Even though several studies have explored the risk of adverse pregnancy outcomes among women with pneumonia, their studies generated inconsistent findings that remain to be resolved. A number of studies failed to observe any increased risk of preterm[4,23-25] and low birthweight (LBW) infants[4] among women with pneumonia. In addition, Shariatzadeh and Marrie[6] and Jin et al[4] suggested that pneumonia may not have any negative effects related to fetal outcome at all, and speculated that pneumonia may be very well tolerated during pregnancy. Therefore, the relationship between pneumonia and pregnancy outcomes remains unclear to date. Since

prior studies dealing with the present topic have tended to be hospital-based studies often characterized by low case numbers or population subgroups, their inconsistent finding may have been due to the use of selective data, limited sample sizes, and inadequate control of confounding factors.

To fill this gap in the literature this study aimed to examine the risk of adverse pregnancy outcomes (LBW, preterm birth, SGA, CS, congenital anomalies, Apgar scores at 5 minutes, and preeclampsia/eclampsia) in pregnant women with pneumonia using a nationwide population-based dataset in Taiwan. To the best of our knowledge, this is the largest and most complete nationwide population-based study to investigate the relationship between pneumonia and adverse pregnancy outcomes.

MATERIALS AND METHODS
Database
Two nationwide population-based datasets were used in this study: The Taiwan National Health Insurance (NHI) Research Dataset (NHIRD) and the Taiwan national birth certificate registry. The NHIRD includes all the registration files as well as original claims data for reimbursements covered by the Taiwan NHI pro-

TABLE 1

Sociodemographic characteristics of pregnant women with and without pneumonia in Taiwan, 2005 (n = 8772)

Variable	Women with pneumonia (n = 1462)		Comparison women (n = 7310)		
	No.	%	No.	%	*P* value
Infant characteristics					
Sex					.068
Male	788	53.9	3749	51.3	
Female	674	46.1	3561	48.7	
Maternal characteristics					
Parity					.616
1	744	50.9	3625	50.0	
2	554	37.9	2784	38.1	
≥3	164	11.2	874	11.9	
Age, y					1.000
<20	50	3.4	250	3.4	
20-24	352	24.1	1760	24.1	
25-29	454	31.1	2270	31.1	
30-34	427	29.2	2135	29.2	
>34	179	12.2	895	12.2	
Education level					.070
≤Junior high school	160	10.9	713	9.7	
Senior high school	1041	71.2	5121	70.1	
≥College	261	17.9	1476	20.2	
Alcohol abuse/alcohol dependence syndrome	3	0.2	7	0.4	.258
Gestational diabetes	48	3.3	227	3.1	.722
Gestational hypertension	44	3.0	192	2.6	.409
Anemia	158	10.8	723	9.9	.287
Coronary heart disease	20	1.4	45	0.6	.002
Hyperlipidemia	31	2.1	139	1.9	.579
Obesity	9	0.6	36	0.5	.548
Geographic region					.604
North	614	42.0	3105	42.5	
Center	393	26.9	1988	27.2	
South	412	28.2	2045	27.9	
East	43	2.9	172	2.4	
Paternal age, y					.892
<30	518	35.4	2602	35.6	
30-34	466	31.9	2363	32.3	
>34	478	31.7	2345	32.1	

Chen. Pneumonia and pregnancy. Am J Obstet Gynecol 2012.

gram for about 25.68 million enrollees in Taiwan. Taiwan launched the NHI program in 1995 and has since maintained >95% enrollment rate, with the coverage >98.5% since 2007. The NHIRD thus allows researchers to follow up on all the medical service utilizations of every pregnant women in Taiwan. In addition, many studies have demonstrated the high validity of the Longitudinal Health Insurance Database 2000,[26,27] with hundreds of papers employing the NHIRD having been published in internationally peer-reviewed journals.

The second dataset was the Taiwan national birth certificate registry, which included data on both infant and parental birth dates, gestational week at birth, birthweight, sex, parity, place of birth, parental educational level, and maternal marital status. Since it is mandatory that all births are registered in Taiwan, birth certificate data are considered to be very accurate and comprehensive.

With the assistance of the Bureau of Health Promotion, Department of Health, Taiwan, these 2 nationwide population-based datasets were linked. Since these 2 datasets consist of de-identified secondary data, this study was waived from full review by the Institutional Review Board of Taipei Medical University.

Study sample

This cross-sectional study features a study group and a comparison group. As for the selection of the study group, we first identified 218,776 women with live singleton births between Jan. 1, 2005, and Dec. 31, 2005. If a woman experienced >1 singleton birth during the study period, we only included the first birth in the study group. We also designated this delivery as the index delivery. Thereafter, we identified 1462 women who had been hospitalized with a diagnosis of pneumonia (*International Classification of Diseases, Ninth Revision, Clinical Modification* codes 480–483.8, 485–486, and 487.0) during their pregnancies from the total 218,776 women who we selected above. In Taiwan, it is standardized practice that all pregnant women with pneumonia are hospitalized.

Data on the gestational age and delivery date of each infant were also available

in this study, which allowed us to calculate the period of pregnancy for each woman. In addition, we randomly retrieved 7310 comparison women (5 for every woman with pneumonia) to match the distribution of the study group in terms of age (<20, 20-24, 25-29, 30-34, and ≥35 years). As a result, 8772 women were included in this study.

Variables of interest

The selected variables for adverse pregnancy outcomes were LBW (<2500 g), preterm gestation (<37 completed weeks of gestation), SGA (birthweight <10th percentile for gestational age–specific birthweight distribution), major congenital anomalies (hydrocephaly, anencephaly, microcephaly, meningomyelocele, encephalocele, and spina bifida), Apgar scores at 5 minutes (<7), preeclampsia/eclampsia, and CS.

This study also took potential confounding factors into consideration in the regression models. These included factors consisting of maternal characteristics (highest educational level, gestational diabetes, gestational hypertension, coronary heart disease [CHD], anemia, hyperlipidemia, alcohol abuse/alcohol dependence syndrome, and obesity), infant sex and parity, and paternal age.

Statistical analysis

We performed all the analyses conducted in this study using a software package (SAS System for Windows, version 8.2; SAS Institute Inc, Cary, NC). We used χ^2 tests to explore the differences in maternal, paternal, and infant characteristics between women with and without pneumonia. We further used conditional logistic regression analyses (conditioned on maternal age) to calculate the odds of adverse pregnancy outcomes between women with and without pneumonia after adjusting for maternal, paternal, and infant characteristics. A 2-sided P value < .05 was considered statistically significant in this study.

RESULTS

Of the 1462 women with pneumonia, 1363 (about 93%) were bacterial pneumonia. Table 1 presents the distributions of maternal, paternal, and infant characteristics between women with and without pneumonia. After matching for maternal age, we found that there was no significant difference in the distribution of infant sex, parity, maternal highest educational level, and geographic region. In addition, there was no significant difference in the prevalence of comorbidities of gestational diabetes, gestational hypertension, anemia, hyperlipidemia, alcohol abuse/alcohol dependence syndrome, and obesity between women with and without pneumonia. However, women with pneumonia were more likely to have CHD than women without pneumonia ($P = .002$).

The prevalence of adverse pregnancy outcomes is presented in Table 2. It shows that women with pneumonia had a higher prevalence of LBW infants (9.8% vs 5.9%, $P < .001$), preterm births (12.3% vs 7.1%, $P < .001$), SGA infants (20.7% vs 16.2%, $P < .001$), CS (55.5% vs 40.6%, $P < .001$), preeclampsia/eclampsia (2.7% vs 0.8%, $P < .001$), and Apgar scores <7 at 5 minutes (0.7% vs 0.2%, $P < .001$) than women without pneumonia. There were no significant differences in the prevalence of major congenital anomalies (0.9% vs 0.7%, $P = .396$) between women with and without pneumonia. Moreover, the distributions of adverse pregnancy outcomes did not differ significantly for women with viral and with bacterial pneumonia (data not shown in table).

Table 3 presents the crude and adjusted odds ratios (ORs) for adverse pregnancy outcomes between women with and without pneumonia. Conditional logistic regression analyses (conditioned on maternal age group) revealed that compared to women without pneumonia, the OR for LBW, preterm birth, SGA, CS, Apgar scores <7 at 5 minutes, and preeclampsia/eclampsia in women with pneumonia were 1.73 (95% confidence interval [CI], 1.41–2.12), 1.71 (95% CI, 1.42–2.05), 1.35 (95% CI, 1.17–1.56), 1.77 (95% CI, 1.58–1.98), 3.86 (95% CI, 1.64–9.06), and 3.05 (95% CI, 2.01–4.63) respectively, after adjusting for highest maternal educational level, marital status, geographic region, gestational diabetes, gestational hypertension, CHD, anemia, hyperlipidemia, obesity, and alcohol abuse/alcohol dependence syndrome, as well as infant sex and parity, and paternal age. There was no increased OR for congenital anomalies for women with pneumonia.

Furthermore, we analyzed the OR for adverse pregnancy outcomes according to pregnancy trimester. We found that the onset of pneumonia in about 93.6% of the women analyzed in this study occurred during the first trimester. Table 4 shows that when compared to comparison women, the adjusted OR for LBW, preterm birth, SGA, CS, Apgar scores <7 at 5 minutes, and preeclampsia/eclampsia in women with pneumonia during

TABLE 2
Distributions of adverse pregnancy outcomes associated with pneumonia

Variable	Women with pneumonia (n = 1462)		Comparison women (n = 7310)		P value
	No.	%	No.	%	
Low birthweight	143	9.8	430	5.9	< .001
Preterm birth	180	12.3	520	7.1	< .001
Small for gestational age	303	20.7	1187	16.2	< .001
Cesarean section	812	55.5	2965	40.6	< .001
Congenital anomalies	13	0.9	50	0.7	.396
Low Apgar score at 5 min	10	0.7	12	0.2	< .001
Preeclampsia/eclampsia	39	2.7	60	0.8	< .001

Chen. Pneumonia and pregnancy. Am J Obstet Gynecol 2012.

TABLE 3
Risks of adverse pregnancy outcomes associated with pneumonia

Variable	Women with pneumonia vs comparison women
Low birthweight	
OR[a] (95% CI)	1.74[c] (1.43–2.12)
Adjusted OR[b] (95% CI)	1.73[c] (1.41–2.12)
Preterm birth	
OR[a] (95% CI)	1.84[c] (1.53–2.20)
Adjusted OR[b] (95% CI)	1.71[c] (1.42–2.05)
Small for gestational age	
OR[a] (95% CI)	1.35[c] (1.17–1.56)
Adjusted OR[b] (95% CI)	1.35[c] (1.17–1.56)
Cesarean section	
OR[a] (95% CI)	1.83[c] (1.63–2.06)
Adjusted OR[b] (95% CI)	1.77[c] (1.58–1.98)
Congenital anomalies	
OR[a] (95% CI)	1.30 (0.71–2.41)
Adjusted OR[b] (95% CI)	1.15 (0.62–2.15)
Low Apgar score at 5 min	
OR[a] (95% CI)	4.19[c] (1.81–9.72)
Adjusted OR[b] (95% CI)	3.86[d] (1.64–9.06)
Preeclampsia/eclampsia	
OR[a] (95% CI)	3.31[c] (2.20–4.98)
Adjusted OR[b] (95% CI)	3.05[c] (2.01–4.63)

CI, confidence interval; *OR,* odds ratio.

[a] Calculated by conditional logistic regression (conditioned on maternal age group); [b] Adjustment made for mother's education, gestational diabetes, gestational hypertension, anemia, coronary heart disease, hyperlipidemia, obesity, alcohol abuse/alcohol dependence syndrome, geographic region, paternal age, and infant's sex, and parity; [c] $P < .001$; [d] $P < .01$.

Chen. Pneumonia and pregnancy. Am J Obstet Gynecol 2012.

the first trimester of pregnancy were 1.73, 1.70, 1.35, 1.79, 3.74, and 3.17, respectively.

COMMENT

Our nationwide population-based study demonstrated that after adjusting for comorbidities and potential confounders, mothers with pneumonia were 1.73, 1.71, 1.35, 1.77, 3.86, and 3.05 times more likely than unaffected mothers to have LBW, preterm birth, SGA, CS, low Apgar scores, and preeclampsia/eclampsia, respectively. Furthermore, we analyzed the risk for adverse pregnancy outcomes according to pregnancy trimester. We found that the onset of pneumonia of about 93.6% of the women with pneumonia analyzed in this study occurred during the first trimester. These women were also found to be more likely than comparison women to have adverse pregnancy outcomes. However, we further investigated the effect of etiology on the occurrence of adverse pregnancy outcomes among women with a case of pneumonia during their pregnancies, and failed to detect a statistically significant difference in the occurrence of LBW, preterm birth, SGA, CS, and preeclampsia/eclampsia between women with viral and bacterial pneumonia.

Our findings are consistent with prior studies that found women with pneumonia were more likely to have preterm deliveries,[3,5,10,12,15-22] babies with lower average birthweights,[3,14-16] and SGA infants[3,14] than women without pneumonia. In addition, our results are also in line with 1 study conducted by Romanyuk et al[16] that found pneumonia to be significantly associated with CS, low Apgar scores, and preeclampsia. Although some previous studies failed to observe any increased risk of preterm[4,23-25] or LBW[3] infants among women with pneumonia, these inverse conclusions were mostly based on studies utilizing patient self-reports and characterized by relatively small sample sizes and an inadequate control of confounding. Therefore, their recall bias and other potential limitations may have resulted in an under-ascertainment of pneumonia during the study pregnancy, which would have clearly undermined the strength of their findings.

The mechanisms by which pneumonia produces adverse pregnancy outcomes are still unclear. Development of the fetus is largely determined by the morphology and functioning of the mother-placenta-fetus system.[28,29] It is possible that pneumonia during pregnancy may infect the placenta. Infection may then be transmitted to the fetus from the placenta through the umbilical vein, or via the aspiration or ingestion of amniotic fluid contaminated by placental or genital infections. Intrauterine infection has emerged as a frequent and important mechanism of disease in preterm birth.[30-33] The onset of preterm labor can be considered a mechanism of the host defense against intrauterine infection whereby the mother eliminates infected tissues (membranes, decidua, and/or fetus) to maintain reproductive fitness.[34] Moreover, a higher risk of LBW and SGA was noted in the pneumonia group, probably due to the lower gestational age at delivery.

On the other hand, there is a widespread general belief that pregnant women with severe acute respiratory syndrome have frequent episodes of oxygen desaturation. Their gravid uterus has been shown to elevate the diaphragm by up to 4 cm in the third trimester, while oxygen consumption is increased by 20% during pregnancy and functional residual capacity is decreased, rendering the woman intolerant to hypoxia.[35] Therefore, severe maternal respiratory

TABLE 4
Risks of adverse pregnancy outcomes according to pregnancy trimester

Variable	Comparison women n = 7310	Women with pneumonia		
		First trimester n = 1368	Second trimester n = 45	Third trimester n = 49
Low birthweight				
Adjusted OR[a] (95% CI)	1.00	1.73[b] (1.40–2.13)	1.18 (0.36–3.88)	1.34[c] (1.01–1.80)
Preterm birth				
Adjusted OR[a] (95% CI)	1.00	1.70[b] (1.41–2.05)	0.85 (0.25–2.84)	1.43[c] (1.12–1.84)
Small for gestational age				
Adjusted OR[a] (95% CI)	1.00	1.35[b] (1.17–1.57)	1.34 (0.64–2.80)	1.12 (0.89–1.42)
Cesarean section				
Adjusted OR[a] (95% CI)	1.00	1.79[b] (1.59–1.99)	N/A	N/A
Congenital anomalies				
Adjusted OR[a] (95% CI)	1.00	1.04 (0.54–2.03)	2.75 (0.36–21.19)	1.41 (0.72–2.75)
Low Apgar score at 5 min				
Adjusted OR[a] (95% CI)	1.00	3.74[c] (1.55–9.01)	N/A	2.18[d] (1.09–4.38)
Preeclampsia/eclampsia				
Adjusted OR[a] (95% CI)	1.00	3.17[b] (2.08–4.83)	N/A	N/A

CI, confidence interval; *N/A*, case number <5; *OR*, odds ratio.

[a] Adjustments made for mother's education, gestational diabetes, gestational hypertension, anemia, coronary heart disease, hyperlipidemia, obesity, alcohol abuse/alcohol dependence syndrome, geographic region, paternal age, and infant's sex, and parity; [b] $P < .001$; [c] $P < .01$; [d] $P < .05$.

Chen. Pneumonia and pregnancy. Am J Obstet Gynecol 2012.

illness affecting the fetal oxygen supply may seriously endanger the fetus. Wong et al[20] found that these patients had frequent episodes of oxygen desaturation, often falling <90%. The situation resembles that of those living at high altitudes, causing a low arterial partial pressure of oxygen[36,37] and consequent adverse pregnancy outcomes. In addition, since the stress of severe hypoxia usually necessitates delivery by CS, a higher risk of CS was also noted in our pneumonia mothers.

This study used a large, unselected national dataset to demonstrate that women with pneumonia were at an increased risk for having adverse pregnancy outcomes compared to unaffected mothers. Moreover, in this study the majority of pregnant women with a case of pneumonia experienced the onset of disease during their first trimester. This finding is supported by a study conducted by Lindsay et al[38] that reported a decline in the rate of influenza-like illness episodes as the stage of pregnancy progressed. One possible reason under-

lying this finding may involve behavioral changes that may be associated with a woman's pregnancy status and knowledge of her pregnancy status. Women in the second and third trimesters of their pregnancies, who are more likely to be aware of their pregnancy status, may be more prudent in avoiding occasions where they may encounter people with colds, the flu, or other respiratory track infections, and may adopt a stricter practice of other preventative behaviors such as an increased frequency of hand washing. On the other hand, women who are not yet pregnant or have become pregnant but are unaware of their pregnancy status may be less likely to engage in such preventative behaviors. It is further possible that some of the women experiencing pneumonia in this study had already encountered or had been infected with pneumonia at the time they became pregnant but were only at a subclinical or incubation stage of the disease. Nevertheless, the underlying factors contributing to the higher incidence of pneumonia during the

first trimester remain obscure and deserve further investigation.

There are substantial implications of this study. We believe that the increased risk for adverse birth outcomes among women with pneumonia during their pregnancies warrants a higher level of surveillance among this population to ensure that medical intervention be exercised as soon as possible. This recommendation is supported by 1 recent review study which observed that concern for fetal outcome should not delay treatment, as improvement in maternal status and most particularly oxygenation is the best way to ensure that the fetus will be protected. In addition, the treatment in the gravid patient should generally follow standard guidelines for the treatment of pneumonia in adults.[39] Therefore, early recognition of the disease process and prompt treatment are required to best ensure for an optimal outcome for both mother and fetus. Furthermore, primary prevention in the form of a pneumococcal vaccine is both available and recommended for pregnant women

with underlying diseases (eg, immuno-compromised states, diabetes, chronic cardiopulmonary diseases) to reduce their risks of pneumonia episodes.[39] The results of this study further underscore the utility of this vaccine.

The clinical course of pneumonia in pregnancy was well described 20-30 years ago. However, to the best of our knowledge all the previous studies investigating pregnancy outcomes among women with pneumonia have been conducted in Western countries with this investigation being the first study regarding pregnancy outcomes among women with pneumonia in Asia. Unlike prior studies that included participants from diverse ethnic groups, >98% of Taiwan's residents are of Chinese Han ethnicity, so the composition of the population is quite homogenous. While this may exempt our study from potential confounding by race, it also means that our results may not be generalizable to other ethnic groups. In addition, we used nationwide population-based datasets, linking the NHIRD with the national registry of births, which leaves little room for selection and nonresponse biases. Moreover, the very large sample size used in this study provides ample statistical power to detect differences between pregnant women with and without pneumonia in risk of adverse birth outcomes.

Despite the strengths of our study mentioned above, our findings still need to be interpreted with caution due to several important limitations. First, the NHIRD lacks clinical information, and therefore did not allow us to differentiate study participants according to the severity of their pneumonia. Secondly, the NHIRD uses discharge diagnoses provided by treating physicians, and no standardized criteria were used to define cases. This may have left room for bias due to case misclassification. Lastly, although we have adjusted for the influence of some potential maternal and pregnancy-specific confounders, information such as maternal smoking history, substance abuse, alcohol consumption, and body mass index (particularly prepregnancy maternal body mass in-

dex) was not available through our datasets.

Our study demonstrated that after adjusting for potential confounders, women with pneumonia during pregnancy had significantly higher risks of LBW, preterm birth, SGA, low Apgar scores, CS, and preeclampsia/eclampsia, compared to unaffected mothers. Since the exact mechanisms underlying these associations are not yet known, future studies are recommended, both to replicate the results of this study and to clarify the mechanisms behind them, enabling more specific interpretation of these findings. ∎

REFERENCES

1. Rodrigues J, Niederman MS. Pneumonia complicating pregnancy. Clin Chest Med 1992;13:679-91.
2. Richey SD, Roberts SW, Ramin KD, Ramin SM, Cunningham FG. Pneumonia complicating pregnancy. Obstet Gynecol 1994;84:525-8.
3. Yost NP, Bloom SL, Richey SD, Ramin SM, Cunningham FG. An appraisal of treatment guidelines for antepartum community- acquired pneumonia. Am J Obstet Gynecol 2000;183:131-5.
4. Jin Y, Carriere KC, Marrie TJ, Predy G, Johnson DH. The effects of community-acquired pneumonia during pregnancy ending with a live birth. Am J Obstet Gynecol 2003;188:800-6.
5. Benedetti TJ, Valle R, Ledger WJ. Antepartum pneumonia in pregnancy. Am J Obstet Gynecol 1982;144:413-7.
6. Shariatzadeh MR, Marrie TJ. Pneumonia during pregnancy. Am J Med 2006;119:872-6.
7. Kaunitz AM, Hughes JM, Grimes DA, Smith JC, Rochat RW, Kafrissen ME. Causes of maternal mortality in the United States. Obstet Gynecol 1985;65:605-12.
8. Niederman MS, Bass JB Jr, Campbell GD, et al. Guidelines for the initial management of adults with community-acquired pneumonia: diagnosis, assessment of severity, and initial antimicrobial therapy; American Thoracic Society; Medical Section of the American Lung Association. Am Rev Respir Dis 1993;148:1418-26.
9. Hopwood HG Jr. Pneumonia in pregnancy. Obstet Gynecol 1965;25:875-9.
10. Brito V, Niederman MS. Pneumonia complicating pregnancy. Clin Chest Med 2011;32:121-32.
11. Ramsey PS, Ramin KD. Pneumonia in pregnancy. Obstet Gynecol Clin North Am 2001;28:553-69.
12. Madinger NE, Greenspoon JS, Ellrodt AG. Pneumonia during pregnancy: Has modern technology improved maternal and fetal outcome? Am J Obstet Gynecol 1989;161:657-62.

13. Jenkins TM, Troiano NH, Graves CR, Baird SM, Boehm FH. Mechanical ventilation in an obstetric population: characteristics and delivery rates. Am J Obstet Gynecol 2003;188:549-52.
14. Berkowitz K, LaSala A. Risk factors associated with the increasing prevalence of pneumonia during pregnancy. Am J Obstet Gynecol 1990;163:981-5.
15. Munn MB, Groome LJ, Atterbury JL, Baker SL, Hoff C. Pneumonia as a complication of pregnancy. J Matern Fetal Med 1999;8:151-4.
16. Romanyuk V, Raichel L, Sergienko R, Sheiner E. Pneumonia during pregnancy: radiological characteristics, predisposing factors and pregnancy outcomes. J Matern Fetal Neonatal Med 2011;24:113-7.
17. Oxorn H. The changing aspects of pneumonia complicating pregnancy. Am J Obstet Gynecol 1955;70:1057-63.
18. Goodrum LA. Pneumonia in pregnancy. Semin Perinatol 1997;21:276-83.
19. Siston AM, Rasmussen SA, Honein MA, et al. Pandemic 2009 influenza A (H1N1) virus illness among pregnant women in the United States. JAMA 2010;303:1517-25.
20. Wong SF, Chow KM, Leung TN, et al. Pregnancy and perinatal outcomes of women with SARS. Am J Obstet Gynecol 2004;191:292-7.
21. Banhidy F, Acs N, Puho EH, Czeizel AE. Maternal acute respiratory infectious diseases during pregnancy and birth outcomes. Eur J Epidemiol 2008;23:29-35.
22. Getahun D, Ananth CV, Oyelese Y, Peltier MR, Smulian JC, Vintzileos AM. Acute and chronic respiratory diseases in pregnancy: associations with spontaneous premature rupture of membranes. J Matern Fetal Neonatal Med 2007;20:669-75.
23. Morken NH, Gunnes N, Magnus P, Jacobsson B. Risk of spontaneous preterm delivery in a low-risk population: the impact of maternal febrile episodes, urinary tract infection, pneumonia and ear-nose-throat infections. Eur J Obstet Gynecol Reprod Biol 2011;159:310-4.
24. Harger JH, Ernest JM, Thurnau GR, et al. Risk factors and outcome of varicella-zoster virus pneumonia in pregnant women. J Infect Dis 2002;185:422-7.
25. Paryani SG, Arvin AM. Intrauterine infection with varicella zoster virus after maternal varicella. N Engl J Med 1986;314:1542-6.
26. Cheng CL, Kao YH, Lin SJ, Lee CH, Lai ML. Validation of the National Health Insurance Research Database with ischemic stroke cases in Taiwan. Pharmacoepidemiol Drug Saf 2011;20:236-42.
27. Kang JH, Chen YH, Lin HC. Comorbidity profiles among patients with ankylosing spondylitis: a nationwide population-based study. Ann Rheum Dis 2010;69:1165-8.
28. Maiorov KB, Bocharova IV. The functional activity of macrophages in mouse strains opposite in sensitivity to experimental tuberculosis. Probl Tuberk 1996;1:8-10.
29. Stray-Pedersen B. New aspects of perinatal infections. Ann Med 1993;25:295-9.

30. Minkoff H. Prematurity: infection as an etiologic factor. Obstet Gynecol 1983;62:137-44.
31. Romero R, Mazor M, Wu YK, et al. Infection in the pathogenesis of preterm labor. Semin Perinatol 1988;12:262-79.
32. Romero R, Sirtori M, Oyarzun E, et al. Infection and labor, V: prevalence, microbiology, and clinical significance of intraamniotic infection in women with preterm labor and intact membranes. Am J Obstet Gynecol 1989;161: 817-24.

33. Goncalves LF, Chaiworapongsa T, Romero R. Intrauterine infection and prematurity. Ment Retard Dev Disabil Res Rev 2002;8:3-13.
34. Romero R, Espinoza J, Kusanovic JP, et al. The preterm parturition syndrome. BJOG 2006;113(Suppl):17-42.
35. Alaily AB, Carrol KB. Pulmonary ventilation in pregnancy. BJOG 1978;85:518-24.
36. Unger C, Weiser JK, McCullough RE, Keefer S, Moore LG. Altitude, low birthweight, and infant mortality in Colorado. JAMA 1988;259:3427-32.

37. Moore LG, Rounds SS, Jahnigen D, Grover RF, Reeves JT. Infant birthweight is related to maternal arterial oxygenation at high altitude. J Appl Physiol 1982;52:695-9.
38. Lindsay L, Jackson LA, Savitz DA, et al. Community influenza activity and risk of acute influenza-like illness episodes among healthy unvaccinated pregnant and postpartum women. Am J Epidemiol 2006;163:838-48.
39. Graves CR. Pneumonia in pregnancy. Clin Obstet Gynecol 2010;53:329-36.