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Hospital Care for the Newborns between Weekdays and Weekend*

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Abstracts

This study analyzed whether the higher mortality of weekend-born children compared to weekday-born are due to lowered staffing ratio over the weekend or unobserved health condition of newborns. Unlike the previous studies we use the census of US births and truly exogenous birth timing by focusing on vaginal deliveries without induction or stimulation. The statistically significantly higher mortality rate for weekend-born babies was no longer observed when birth weight was included as a proxy for unobserved health condition and these results are robust across various samples and different locations. Our findings are robust to high risk groups such as cesarean section and low birth weight samples.

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Ⅰ. Introduction

Some previous research comparing across hospitals (Aiken et al.,

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1987; Needleman et al., 2001) has shown that low nurse staffing levels adversely affect patients. Other research (Bell and Redelmeier, 2001) has used within hospital variation instead of cross-sectional variation to compare staffing-level differences between weekdays and weekends. As a response to these findings, the California Assembly Bill 394 (AB394) was passed in California in 1999. In January 2002, the California Department of Health Services (DHS) prepared a draft of appropriate nurse/patient staffing ratios: the ratio was1 to 1 in an emergency room and 1 to 8 in a well-baby nursery. The legislation finally took effect in January 2004. As of September 2009, the District of Columbia and 14 states had enacted similar legislation, or had adopted regulations regarding nurse staffing, and an additional 17 states were considering nurse staffing legislation, according to the American Nurses Association.[1] In addition, the Registered Nurse Safe Staffing Act (S. 58/H.R. 876) is currently pending in the US congress (http://thomas.loc.gov/cgi-bin/bdquery/z?d112:s.58:).

However, it is hard to find true causality using these studies, due to omitted variables bias and endogenous sorting (Cook et al. 2010). Hospitals with high staffing levels, for example, are more likely to have better equipment and technology, and a greater number of highly skilled medical staff, which is not easy to observe and control well in studies. Therefore, staffing effects can be overestimated. Conversely, if hospitals assign a higher staffing ratio to severely ill patients, who are more likely to have an adverse outcome, then the impact of staffing levels on patient outcome will be underestimated due to unobserved patient characteristics.

Our study tries to answer whether higher mortality rate of

1) http://www.ehow.com/info_8157355 laws-minimum-nursepatient-ratio.html. Accessed on June 2012.

weekend-born children compared to weekday-born is due to lower staffing level over the weekend or unobserved newborn characteristics.[2)] We focus on newborns for a couple of reasons. First, this vulnerable population may be a marginal group on whom nursing will have the greatest impact,[3)] and second, the most detailed information is available for this population which means less unobserved characteristics. Previously, Gould et al. (2003) used births in California for 1995-1997 and found that after adjusting for the weight of the infants, the effect of weekends on the odds ratio of infant mortality was not any more significant. However, they include deliveries clearly not exogenous in timing such as scheduled delivery. In addition, their study only uses California data and California might not be representative of US. To overcome these limitations we add several innovations. First, we restrict the sample to vaginal delivery without induction and stimulation. Doctors, for example, might change the timing of the birth using scheduled delivery, induction, or stimulation. Furthermore, some Cesarean sections might be scheduled but others emergency operation. Second, we use data from all of the

2) One limitation of this paper is that we don't measure staffing directly. Therefore, there is still some possibility that we do not measure staffing per se but things correlated with it. For example, doctor's work schedule could be highly correlated with the nurse schedule. The reason, however, that we are focusing on nurse staffing in this paper is based on the fact that there are the ones who monitors the patients closely and catch the first signal of emergency situation and report to the doctors. With this understanding previous literature focus on nurse staffing and we agree with their point of view. Evans and Kim (2006) showed staffing level (registered nurse and nurse aid) difference between weekday and weekend in hospitals using 1997 and 2001 current population survey. They found 2 to 10 times more staffs working during weekdays compared to weekends.

3) Infant mortality rate was 6.7 per 1,000 live births in the US in 2007, compared to an average of 3.9 in other Organization for Economic Co-operation and Development (OECD) countries (OECD, health at a glace 2009). As a reflection, CA legislation requires a 1:2 nurse staffing ratio for neonatal intensive care units, one of the highest ratios.

US, rather than data from California alone, since response might vary by state. In addition, we use more recent data for analysis. Finally, we measure more relevant short-term outcomes to hospital staffing, such as mortality within 3 days of birth, rather than neonatal mortality (mortality rate over 28 days), bearing in mind that newborns usually remain in hospital for 2 or 3 days. This will increase our chance of finding true staffing effects in hospital rather than some other confounding effects.

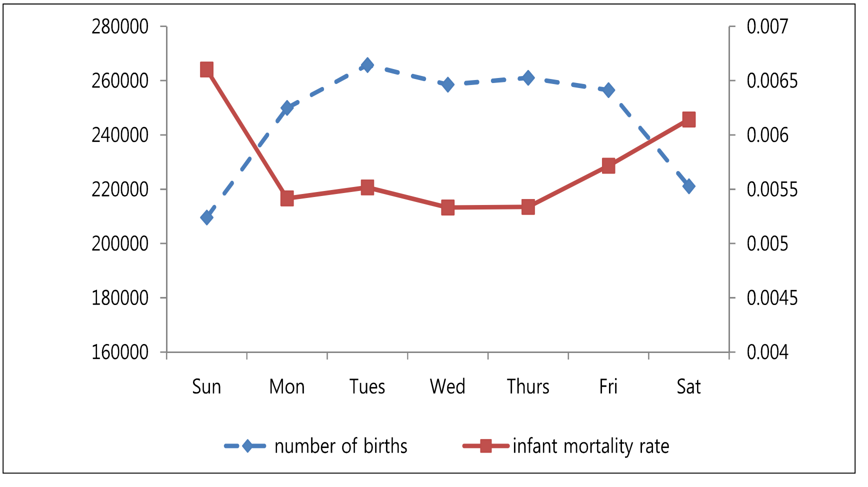
Ⅱ. Methods

Data

This study used the 2002 Linked Infant Birth/Death Data of the National Center for Health Statistics. Data include demographic information regarding parents and the babies as well as various measures of pregnancy conditions, such as birth weight. We used delivery method to identify scheduled delivery. We assumed that Cesarean section was scheduled. In addition, induction or stimulation of vaginal delivery was used to adjust delivery timing, so the study sample was restricted to vaginal delivery without induction or stimulation. Mothers having vaginal delivery without induction or stimulation cannot choose a delivery date, so the number of babies born in this category should be evenly distributed throughout the days of the week. In addition, the initial condition of the vaginally delivered babies born without induction or stimulation should not differ, regardless of weekday or weekend birth. Figure 1 shows the number of babies born on Sundays through Saturdays for the year 2002. Even after we restrict the sample to vaginal delivery without induction or stimulation only, the number of babies born on weekends was 15% less than the number of those born on weekdays. This means that there are still remaining unobserved characteristics even in the detailed data like this. Figure 1 also shows higher infant mortality rate among weekend-born babies than those born during weekdays.

A number of differences remained in this group, so we used birth weight as additional control for state of health at birth.

【Figure 1】 Number of births and infant mortality rate: U.S. 2002



Econometric Model

We ran the ordinary least square (OLS) model of the form:

$$Y_{is} = \beta_0 + \beta_1 \ WEEKEND_{is} + \beta_2 X_{is} + \mu_s + \varepsilon_{is} \qquad (1)$$

Where i stands for individual and s stands for state.

Y_{is} indicates infant deaths within 1, 3, 7, 28, and 365 days of birth. A death equals 1; otherwise, the value equals 0. The most relevant measure is infant deaths within 3 and 7 days, because new infants receive nursing care for approximately 36 hours of birth on average, and for a period not exceeding 7 days. $WEEKEND_{is}$ is the independent variable that is the focus of this study. If a child is born at a weekend (Saturday and Sunday, when the number of nurses is low), it equals 1, and if the child is born on a weekday (Monday through Friday, when the number of nurses is high), it equals 0. X_{is} includes the explanatory variables, such as demographic information.[4)] μ_s is state-specific fixed effect, which controls for permanent differences across states in the outcomes of their patients. Finally, ε_{is} is an error. There might be an unobserved correlation between births within a state, even after state-fixed effects are controlled; therefore, we calculated standard errors clustered by state.

Ⅲ. Results

Table 1 shows the descriptive statistics of the analysis data used in this study. We focus on a sub-sample of 1.7 million observations relating to vaginal delivery (without induction or stimulation) among 3.9 million newborns from the census of births in 2002. In the upper block, we report outcome variables. Deaths within 1, 3, 7, and 28 days, and 1 year of birth were measured. When the infant was born by vaginal delivery, the average number of infant deaths within 1 year was seven babies per 1,000 newborns. Over half of the infants who died within 1 year died within 1 week, with most dying within 3 days. In the lower block, we report independent variables. The proxy of health condition, birth weight, was 3293 grams on average. In our

4) We do not include any decision variables like gestational weeks as independent variables.

sample, 51% were boys.

【Table 1】 Descriptive statistics

Variables	All Vaginal*	
	Mean	Standard Deviation
Dependent Variables		
Died within 1 day**	3.618	60.042
Died within 3 days**	3.880	62.169
Died within 7 days**	4.126	64.102
Died within 28 days**	4.890	69.759
Died within 365 days**	6.918	82.884
Independent Variables		
Weekend	0.250	0.433
Birth Weight (gram)	3293.31	566.47
Male	0.505	0.500
Age of the Mother	26.790	6.118
observations	1,722,434	

Note: We use linked Birth/Infant Death data from the National Center of Health Statistics for 2002.
* All Vaginal includes observations delivered by vaginal birth without induction or stimulation.
** Died within 1, 3, 7, 28, and 365 days is binary variable of death within 1, 3, 7, 28, and 365 days after birth respectively and reported as per 1000 births.

In Table 2, we report the amount of infant deaths within a certain period of time, which is the coefficient of our interest in the vaginal delivery group that the timing of birth is close to random. In the first column, we show results including state-fixed effects only; we then add demographic information in the second column. In the third column, we add the birth weight as a quadratic form to capture the unobserved state of health at birth. In the first row, we present death that occurred within 1 day of birth. When 1,000 babies were born, 0.569 more died if they were born at weekends, rather than weekdays, and this number decreased slightly to 0.567 as we include more information. In the third column when we control birth weight, weekend becomes

【Table 2】 Impact of weekend on Death per 1,000 live births

	All Vaginal		
	(1)	(2)	(3)
		Died within 1 day	
Weekend	0.569***	0.566***	0.025
	(0.119)	(0.113)	(0.099)
Birth Weight			-0.283***
			(0.011)
Birth Weight Square†			0.042***
			(0.002)
		Died within 3 days	
Weekend	0.618***	0.618***	0.050
	(0.123)	(0.116)	(0.093)
Birth Weight			-0.295***
			(0.011)
Birth Weight Square†			0.044***
			(0.002)
		Died within 7 days	
Weekend	0.636***	0.634***	0.045
	(0.125)	(0.119)	(0.094)
Birth Weight			-0.304***
			(0.011)
Birth Weight Square†			0.045***
			(0.002)
		Died within 28 days	
Weekend	0.689***	0.680***	0.026
	(0.140)	(0.135)	(0.090)
Birth Weight			-0.331***
			(0.012)
Birth Weight Square†			0.049***
			(0.002)
		Died within 365 days	
Weekend	0.705***	0.661***	-0.064
	(0.159)	(0.152)	(0.117)
Birth Weight			-0.353***
			(0.012)
Birth Weight Square†			0.052***
			(0.002)
Other independent variables	State	State+ Demographic+ Birth information	State+ Demographic+ Birth information+ Birth Weight+ Birth Weight Square
observations		1,722,434	

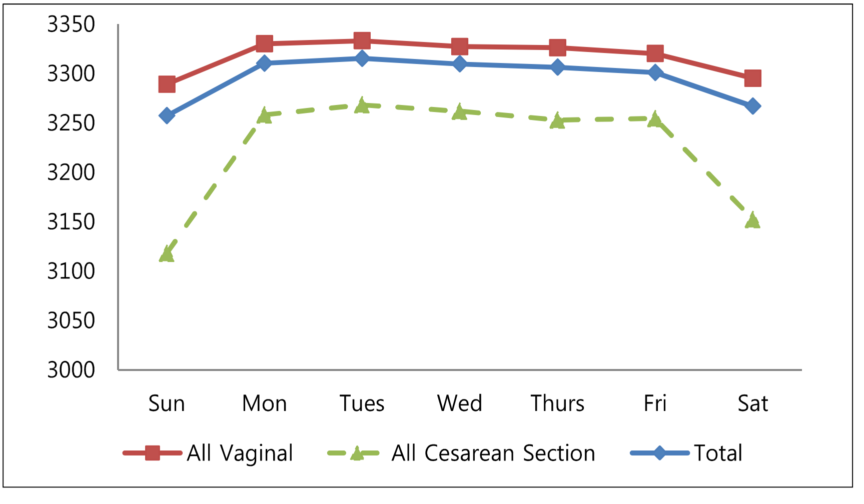
Note: The Standard errors in the parentheses are clustered at the state level. See note for Table 1 for the sample restrictions. Columns (1) include weekend, and state-fixed effects only and columns (2) include sex, plurality, race, education, marital status, live birth order, and age of mother in addition to the previous column. Columns (3) include birth weight and birth weight square in addition to the previous column.

† coefficient and standard errors are multiplied by 1,000,000 to show the number.

*** p<0.01, **p<0.05, * p<0.1.

statistically insignificant and 0.025 per 1,000 newborns died, which is miniscule. Birth weight is used as a proxy for the health condition of baby at birth (Rosenzweig and Schultz 1983; Grossman and Joyce 1990; Rosenzweig and Wolpin 1991, 1995; Currie and Moretti 2003). Hospital care starts at the time of hospitalization and birth weight has been decided before the admission to the hospital. Therefore, controlling birth weight is to make sure that we measure the hospital care only clearly. Figure 2 gives us an idea why controlling birth weight erased the health outcome differences. We showed the average birth weights by the day of the week and found that lower health condition (birth weights) for weekend born children.

【Figure 2】Average birthweight: U.S. 2002



Death within 3 days of birth, which is reported in the second row, showed a similar pattern. The first column showed 0.618 more baby deaths per 1,000 newborns born at the weekend, compared to those born on weekdays. When we add birth weight, this shrinks to 0.05 and is statistically insignificant. In the third row, we present data relating to those infants who died within 7 days of birth, and the same pattern is revealed. The magnitude does not show any qualitative change and widening the window to 1 year does not alter the results.

We will present some robustness check on Table 3. Big advantage of vaginal birth sample without induction or stimulation is the exogenous timing of birth. The downside, however, could be the power of the results since mortality rate is quite low among this healthy population. Vaginal birth sample is the last one who will be impacted by hospital care. Although huge number of observation for vaginal sample gave us some relief we decided to check more vulnerable newborns although there is cost of less exogenous timing of births. Two samples have been considered: Low birth weight sample(≤2,500 gram) and cesarean section sample. These two samples have severe health condition and higher probability of adverse events. We present last two specifications in Table 3. In the first column of the Table 3 mortality within a day for weekend born low birth weight one compared to weekday born low birth weight per 1,000 births is 4.9 more babies died and it is statistically significant results at 95% confidence level. This magnitude is 8.6 times higher than vaginal sample. The third column of Table 3 show similar but slightly small magnitude results for cesarean section sample. However, in the second and fourth column we present that there is no statistically significant difference between weekday born and weekend born after we control birth weight which is unobserved characteristics of health condition of baby at birth. Even for the high risk babies higher mortality for weekend born does not exist after controlling health condition at birth. We found qualitatively the same results with reported above for other samples like low birth weight among cesarean section births. We concluded that higher mortality of weekend-born children is due to unobserved

【Table 3】Robustness check: Impact of weekend on Death per 1,000 live births

	Low Birth Weight		All Cesarean Section	
	(1)	(2)	(3)	(4)
		Died within 1 day		
Weekend	4.855***	1.065	1.819***	0.191
	(1.445)	(1.085)	(0.212)	(0.150)
Birth Weight		-1.137***		-0.063***
		(0.029)		(0.003)
Birth Weight Square†		0.294***		0.009***
		(0.008)		(0.000)
		Died within 3 days		
Weekend	5.295***	1.300	2.100***	-0.025
	(1.426)	(1.007)	(0.235)	(0.180)
Birth Weight		-1.165***		-0.082***
		(0.030)		(0.002)
Birth Weight Square†		0.300***		0.012***
		(0.008)		(0.000)
		Died within 7 days		
Weekend	5.044***	0.897	2.387***	-0.085
	(1.428)	(0.999)	(0.247)	(0.176)
Birth Weight		-1.181***		-0.095***
		(0.029)		(0.003)
Birth Weight Square†		0.303***		0.014***
		(0.008)		(0.000)
		Died within 28 days		
Weekend	5.248***	0.640	3.135***	-0.146
	(1.414)	(0.947)	(0.296)	(0.220)
Birth Weight		-1.129***		-0.125***
		(0.028)		(0.003)
Birth Weight Square†		0.312***		0.018***
		(0.007)		(0.001)
		Died within 365 days		
Weekend	4.891***	-0.108	4.202***	-0.037
	(1.557)	(1.171)	(0.339)	(0.303)
Birth Weight		-1.240***		-0.158***
		(0.027)		(0.004)
Birth Weight Square†		0.310***		0.022***
		(0.007)		(0.001)
Other independent variables	State+ Demographic+ Birth information	State+ Demographic+ Birth information+ Birth Weight+ Birth Weight Square	State+ Demographic+ Birth information	State+ Demographic+ Birth information+ Birth Weight+ Birth Weight Square
Observations	113,896		1,017,380	

Note: The Standard errors in the parentheses are clustered at the state level. Low birth weight sample was selected among vaginal births.
† coefficient and standard errors are multiplied by 1,000,000 to show the number.
*** p〈0.01, **p〈0.05, * p〈0.1.

health condition at birth rather than staffing level variation over the weekend.

Ⅳ. Conclusion

We try to measure the impacts of being born in the weekend when the staffing is low on health outcomes measured by mortality. We restrict the sample to vaginal birth without induction or stimulation since this is the most random sample in terms of timing of birth Mortalities between weekdays and weekend born children show statistically significant results. Statistically significant higher mortality rate for weekend born babies, however, are completely disappeared after including birth weight as a control.

We also examine the low birth weight babies who are more vulnerable for hospital care and did not find any evidence of increased adverse event depending on weekend born versus weekdays born after controlling health at birth. Our results were robust to cesarean section sample or California sample as well. We conclude that health outcome differences between weekday born and weekend born disappears when we control health condition at birth.

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◈ *References* ◈

Aiken L. H. and Mullinix C. F., "The Nurse Shortage. Myth or Reality?" *New England Journal of Medicine*, 317(10), 1987, pp. 641-646.

Bell, C. M. and Redelmeier, D. A., "Mortality Among Patients Admitted to Hospitals on Weekends as Compared with Weekdays," *The New England Journal of Medicine*, 345(9), 2001, pp. 663-668.

Cook, A., Gaynor, M., Stephens, Jr., M., and Taylor, L. June, "The Effect of Hospital Nurse Staffing on Patient Health Outcomes: Evidence from California's Minimum Staffing Regulation." NBER Working Paper No. 16077, 2010.

Currie, Janet, and Enrico Moretti, "Mother's Education and the Intergenerational Transmission of Human Capital: Evidence from College Openings," *Quarterly Journal of Economics*, 118, 2003, pp. 1495-1532.

Evans, W. and B. Kim, "Patient Outcomes When Hospitals Experience a Surge in Admissions," *Journal of Health Economics*, 25(2), 2006, pp. 365-388.

Gould J. B., Qin C., Marks A. R. and Chavez G., "Neonatal Mortality in Weekend vs Weekday Births," *Journal of the American Medical Association*, 289(22), 2003, pp. 2958-2962.

Grossman, Michael, and Theodore J. Joyce, "Unobservables, Pregnancy Resolutions, and Birth Weight Production Functions in New York City," *Journal of Political Economy*, 98, 1990, pp. 983-1007.

Needleman J., Buerhaus P., Mattke S., et al., *Nurse-staffing Levels and Patient Outcomes in Hospitals*, Final Report for Health Resources and Services Administration, Contract No. 230-99-0021, 2001.

Rosenzweig, Mark R., and T. Paul Schultz, "Estimating a Household Production Function: Heterogeneity and the Demand for Health Inputs, and Their Effects on Birth Weight," *Journal of Political Economy*, 91, 1983, pp. 723-746.

Rosenzweig, Mark R., and Kenneth I. Wolpin, "Inequality at Birth: The Scope for Policy Intervention," *Journal of Econometrics*, 50, 1991, pp. 205-228.

____, "Sisters, Siblings, and Mothers: The Effects of Teen-Age Childbearing on Birth Outcomes," *Econometrica*, 63, 1995, pp. 303-326.

신생아에 대한 주중, 주말간 병원서비스의 격차*

김 범 수** · 김 민 지***

논문초록

본 논문은 주말 출생아의 사망률이 주중 출생아와 비교해서 높은 것이 주말에 낮은 간호사 비율에 의한 것인지 아니면 신생아의 관측되지 않는 차이에 의한 것인지를 분석하고자 하였다. 기존 연구들과는 달리 미국의 전수 출생아 자료를 사용하였고 그 중에서도 자극이나 유도 분만 없이 순수히 자연분만으로 이루어진 출생시간이 완전히 외생적인 출생을 대상으로 하였다. 주말 출생아의 통계적으로 유의하게 높은 사망률은 신생아의 몸무게를 관측되지 못한 건강상태를 측정하는 대리변수로 포함시키면 사라지게 되며 이러한 결과는 지역별로 서로 다른 샘플에서도 변하지 않았다. 또한 훨씬 사망률이 높은 제왕절개 분만의 경우나 저체중 출산아의 경우를 보더라도 같은 결론에 도달하였다.

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