INTERNATIONAL JOURNAL OF ECONOMICS AND FINANCE STUDIES
Vol 9, Sayı 1, 2017 ISSN: 1309 -8055 (Online)

ESTIMATING THE EFFECTS OF TRAVEL DISTANCE AND COSTS ON EMERGENCY DEPARTMENT (ED) UTILIZATION: LEARNINGS FROM INDIVIDUAL LEVEL DATA[1]

Ibrahim Demir, PhD
Corresponding author
Department of Health Services Policy and Management
Arnold School of Public Health
University of South Carolina, 915 Greene St., Columbia, SC, 29208, USA
Phone: (803)777-3534 Fax: (803)777-1836
e-mail: demiri@mailbox.sc.edu

M. Mahmud Khan, PhD
Department of Health Services Policy and Management
Arnold School of Public Health
University of South Carolina
Columbia, SC, 29208, USA
e-mail: mkhan@mailbox.sc.edu

ABSTRACT

In recent years, Emergency Department (ED) visits have constituted approximately 10% of annual health care spending in the United States (U.S.). Understanding the dynamics of ED visits can help reduce overall spending on health care. This study analyzes the effects of travel distance on ED visits to a southeastern county community hospital in the U.S. between 2011 and 2015. Utilizing a zero-inflated negative binomial (ZINB) estimation, the study found that travel distance significantly affected both the number and probability of ED visits, ceteris paribus. The ED services are assumed to be "necessities" with very low price elasticity when the medical condition is actually of a life threatening type. If this assumption is true, then distance should have no impact on the probability of visiting ED, ceteris paribus. Our results indicate that distance remains as an important factor even when many different types of medical conditions have been incorporated in

[1] We are thankful to session participants and the discussant for helpful comments at the *85th Annual Meeting of Southern Economic Association November 21-23, 2015, New Orleans Marriott, New Orleans, Louisiana, USA.*

the model. This implies that ED visits are not considered as “absolute necessities” by patients. Appropriate level of use of ED is not as rigid as often assumed and ED-seeking behavior can be influenced by organizing alternative service channels in the geographic region. For example, presence of community health workers, free clinics, school clinics, and minute clinics can play important roles in reducing ED visits and associated health care spending and costs. This study provides significant policy implications on how to rationalize access to ED without adversely affecting health outcomes of the population.

JEL Classification: I10, I12, I18, R12, R41
Keywords: Health spending, emergency department utilization, travel cost, distance decay.

1. INTRODUCTION

Emergency Department (ED) visits account for up to 10% (approximately 300 billion dollars) of overall health care spending in the United States (U.S.) (Lee et al., 2013). ED visits in the U.S. have been on the rise, although the number of ED departments has been on the decline; the number of ED visits increased from 365 per thousand population in 1999 to 428 per thousand population in 2014 (AHA, 2014). In 2011, the number of ED visits was about 136 million and only 15% of them resulted in admission to the hospital (HCUP, DHHS). A portion of ED visits is considered non-urgent, primary care related, treatable in retail clinic settings, and, thus, preventable or avoidable (Pitts et al., 2010; Weinick et al., 2010; Cunningham and May, 2003). In this context, explaining the dynamics of ED visits has important policy implications in terms of cost-savings, access, and clinical quality of ED medical services. Better explanations of the dynamics of ED visits will lead to policies that will result in better (social welfare-improving) outcomes. For instance, a one-percent decrease in ED visits due to better explanation and relevant interventions will result in $3 billion dollars of additional funds per year that the economy will be able to spend on other goods and services.

Travel is a necessary input to obtain health care, including ED services. Patients need to travel from where they live or work to health care provider sites to obtain care. Travel costs create a tax-like effect on the demand for health care services, although the quantity effect of the “tax” will depend on the price elasticity of demand of the service being analyzed. If a service is considered a necessity, the price elasticity will be very low, implying that the “tax” will not affect the utilization of the service significantly. That is, everything else being equal, travel costs should not deter the appropriate ED (inelastic demand) visits as much as the ones that are primary-care-related. Thus, understanding the dynamics of ED visits and analyzing the relationship between avoidable ED visits and travel costs are crucial in policy evaluations of alternative approaches of lowering utilization of ED services without affecting overall health of the population adversely. In exploring the relationship between ED utilization and travel costs, Chen et al. (2015) found higher non-emergent utilization probability for shorter distances among publicly insured patients. They argue that estimated higher non-emergent utilization probability scores associated with shorter distances travelled by patients for the ED visits by Medicare and Medicaid patients indicate the importance of "convenience" factor as well as access to care on demand whenever the perceived needs arise. Lee et al. (2007) found a negative significant relationship between ED utilization and travel distance that patients who lived in census block groups in shorter distances to ED facilities have higher probability of visiting ED in Mississippi, USA.

Our study differs from preceding distance and ED utilization studies, such as Henneman et al. (2011), by focusing on the impact of travel cost on ED utilization and how the ED utilization of patients with different levels and severity of medical conditions are affected because of distance. Distance to facility may be considered as a barrier to access and limiting access through distance may affect health of population adversely, especially those who live at a higher distance from the service provider. Although non-urgent ED use can be identified ex-post, ex-ante identification of "appropriate" urgent care cases is difficult because of asymmetric information problem that exists between the patient and the provider. In addition, patient may not be fully aware of the possible prognosis of the medical symptoms and conditions she/he was facing when deciding whether to travel to the ED. Patient behavior in terms of ED use cannot be fully explained unless medical conditions as well as competing ED locations and primary care providers are taken into account. While Lee et al. (2007), Chen et al. (2015), and Henneman et al. (2011) used zip code centroids or census block centroids as the geographic origin of ED visits, as a major contribution, our study utilizes patient-level physical addresses as the geographic origin to calculate travel distance and costs for ED utilization. Despite the fact that it is easier to obtain zip code and census block-based health data, zip codes and census blocks come in different shapes and sizes and taking the centroids as the origin of visits rather than residential addresses can produce biased results. In this regard, our study is an improvement to preceding studies that have explored the relationship between ED utilization and travel distance.

As a policy suggestion, especially in rural areas where income and transportation barriers are higher, hub and spokes type of rotating mobile clinics, use of community health workers, and telemedicine that aim at reducing travel costs and increasing access to primary care can be effective in reducing avoidable ED visits as alternative sources of health care services.

2. FACTORS AFFECTING ED USE

The purpose of this analysis is to examine the effects of a number of variables, including travel distance, on the utilization of ED. The decision to seek care from ED should be similar to any other health care seeking behavior, unless utilization of ED is considered essential, given the medical condition of the patient. Services provided through ED are especially beneficial for types of medical conditions that adversely affect health and wellbeing of patients within a very short period of time. In other words, the benefits of receiving medical care decline very rapidly with time for the medical conditions most amenable to ED services. Since utilization of ED services is very time sensitive from the onset of medical condition, travel distance and time clearly becomes an important determinant of value of ED services to patients.

To understand the factors that affect ER-seeking behavior, a simple model of patient choice of services is developed here. Assume that patients behave as if they are trying to maximize utility or wellbeing. Patients seeking care may suffer from any of the medical or health conditions $\{M_i\}$. Let us assume that the conditions vary by severity of health outcomes and health outcome decline rate with time elapsed since the onset of the condition. It is possible to rank all the medical conditions by severity and by rate of decline of health over time. These ranked medical conditions can be written as: $\{M_1, M_2, M_3, \dots \dots . M_n\}$ and since the medical conditions ranked first require more urgent care, the value of ED service declines with increasing "n". If the distance to ED is not very high for patients, maximizing health outcomes and wellbeing will imply that patients with medical conditions ranked high in the list will seek care from ED. If we control for medical conditions and their severities, provided that the ED facility is not located too far away from patients, distance should have no impact on "appropriate" utilization of ED services. Clearly, what is appropriate use of ED may change based on alternative service availability in the geographic region as rational patients compare the cost of seeking care with the potential benefits to be obtained. For example, presence of community health workers, free clinics, school clinics, and minute clinics can encourage some patients, especially the ones with medical conditions that do not reduce health and wellbeing quickly, not to seek care from the ED. On the other hand, for patients living very close to the ED facility, cost of accessing care becomes low and even if the benefits of using ED service is low, cost may still justify seeking care from ED for higher indexed medical conditions (medical conditions ranked relatively low). In the continuum of medical conditions, there is no clear demarcation between appropriate and inappropriate use of ED –patients decide the use of ED based on their specific circumstances. Therefore, the policy options to reduce the utilization of ED must consider the factors that patients consider in deciding medical care seeking and the strategies to encourage patients to substitute ED for other services are likely to be more successful than identifying which medical conditions represent appropriate or inappropriate use of ED. For this reason, this paper will not make any attempt to define inappropriate use of ED as has been done by a number of authors (Weber et al., 2005; Ruger et al., 2004).

The decision to go to ED is mainly determined by the perceived severity of the case or condition, proximity to a primary care provider, closeness of substitutes for the services that can be obtained in the ED (clinics, physicians' offices, spouses, pharmacies, taking a pill), distance to ED facility and transportation costs, expected effectiveness of ED visit, expected out of pocket payments, insurance status, season, day, time, and various patient characteristics, such as health history, health status, age, chronic disease, education, gender, race, profession, and marital status.

3. EMPIRICAL METHODOLOGY

Travel costs to obtain medical care consists of the opportunity cost of travel time as rooted in the works of Becker (1965) and DeSherpa (1971) (see also, Truong and Hensher, 1985), and actual transportation costs, such as the fixed costs (vehicle, maintenance, insurance, etc.) and variable costs, such as the cost of gasoline. Depending on the type of data in hand and research objective, the relationship between ED utilization and travel costs can empirically be analyzed within two frameworks: First, the effects of transportation costs on the probability of an individual's ED utilization can be analyzed through a logistic estimation. More specifically, the determinants of the probability of utilizing ED and why some patients seek out other care avenues, such as primary care physician, do nothing, or taking a pill, for a particular health issue, say abdominal pain, while some others choose to go to the ED is an important policy question. Second, the effects of transportation costs on the counts of ED utilization can be analyzed through a count data estimation. This type of estimation will help to understand the effects of transportation costs on "frequent" ED users[2]. We will analyze the relationship between ED utilization and travel costs in a count data estimation. As seen in Appendix I-A, the counts of ED visits are zero-inflated as 63.44% of patients did not visit the ED during the study period. There can be two explanations for why some patients did not utilize ED: they are either (i) "certain" not to visit ED and they "strategically" avoid it, or, (ii) they just did not choose ED incidentally because of some underlying reasons or by chance.

Following Mullahy (1986), Heilbron (1989), and Lambert (1992), Zero-Inflated Poisson (ZIP) and Zero-Inflated Negative Binomial (ZINB) models must be preferred to OLS estimation when the count data are zero-inflated or over-dispersed, which also calls for a negative binomial (NB) form. Within an NB distributional form, the Vuong (1989) test indicates whether a ZINB distribution produces a better fit than the standard NB specification. In our data, the dependent variable, counts of ED visits, has been found to be zero-inflated (63.44% of patients had no ED visit) and over-dispersed by having its variance (= 5.58) substantially greater than its mean (=.826), N=40,702. Thus, the following ZINB distribution was assumed for the empirical model:

$$Pr(ED_i = g_i) = \begin{cases} \omega_i + (1-\omega_i)\left(\frac{1}{1-\alpha\lambda_i}\right)^{\frac{1}{\alpha}} & for\ g_i = 0; i = 1,2, \dots\dots n. \\ (1-\omega_i)\left(\frac{\Gamma\left(\frac{1}{\alpha}+g_i\right)}{\Gamma\left(\frac{1}{\alpha}\right)(g_i!)}\left(\frac{\alpha\lambda_i}{1+\alpha\lambda_i}\right)^{g_i}\left(\frac{1}{1+\alpha\lambda_i}\right)^{\frac{1}{\alpha}}\right. & for\ g_i > 0; i = 1, 2, \dots\dots. n. \end{cases} \quad (1)$$

where, Pr , is the probability of a visit being ED visit, ω_i is the probability of excess zeros and is assumed to follow a logit distribution, such that, $logit(\omega_i) = \boldsymbol{X_i\beta}$ where $\boldsymbol{X_i}$ is a $1xk$ vector of covariates and $\boldsymbol{\beta}$ is a $kx1$ column vector of coefficients. λ_i is the mean of the underlying negative binomial distribution, α is the dispersion parameter, such that, as $\alpha \to 0$, the ZINB model collapses into a ZIP (Zero-Inflated Poisson) model. The mean of the distribution in (1) is $E(ED_i) = (1-\omega_i)\lambda_i$ and the variance is $var(ED_i) = (1-\omega_i)\lambda_i + (1 + \omega_i\lambda_i + \alpha\lambda_i)$.

[2] The definition of "frequent users" is an ambiguous one and it ranges from 3 to 7 visits per year in the literature (Hunt et al., 2006).

In the vector of covariates, using travel distance in its level confirms with the exponential distance decay specification as a special case of “log-single” specification among various potential distance decay specifications (see Taylor, 1971).

4. DATA AND FINDINGS

To estimate the assumed ZINB specification for ED visit counts, this study utilizes county-level individual hospital visit data in a southeastern county in the U.S. The variable that contains the counts of ED visits was constructed from the codes in the data set that came from the hospital’s electronic medical record system. Outpatient visits were taken as non-ED visits. Excluding the ED visits that originated from outside the county, there were 40,702 ED visits that took place between November 2011 and June 2015. We constructed travel distance for each ED visit by geocoding residential physical addresses of patients utilizing Esri ArcGIS (Esri, 2011) software. Then, we used the geocodes to calculate the distances to the ED facility and travel distance and time to nearest primary care facilities. We used the Charlson index (Charlson et al., 1987) for morbidity and severity of both ED visits (admission Charlson index) and patient history as controls. We also substituted the Charlson index with hospitalization by construction a dichotomous variable based on the information that the ED visit resulted in hospitalization as an indication of severity. Reporting only the variables with significant coefficients, the findings of the ZINB estimation are listed in Table 1 as follows:

Table 1. ZINB Estimation Results of ED Visit Counts per Patient

ED Visit Count		Coefficient	Inflate Model Coefficient
Travel Distance to ED		-0.039***	0.082***
		(-13.45)	(7.7)
Distance to Nearest Primary Care Facility		-0.02***	
		(-11.16)	
Age (reference= 0 to 14)	15 to 54	0.30***	1.29*
		-9.25	(2.19)
	55 and older	-0.09*	1.28*
		(-2.56)	(2.15)
Gender (reference: female) Male		0.08***	0.58***
		(4.41)	(5.61)
Race (reference: African)	Other (Asian,	-0.60***	0.007

	Pacific Islander, Native Am.)		
		(-6.79)	(0.01)
	Caucasian	-0.30***	0.41**
		(-14.46)	(3.14)
	Hispanic	-0.32***	0.5
		(-5.07)	(1.48)
Medicaid		0.71***	-2.05***
		(32.08)	(-4.72)
Medicare		0.17***	-0.57***
		(6.53)	(-4.22)
Insurance Status (reference: non-Medicaid and Medicare coverage) No insurance		0.27***	-2.89***
		(11.37)	(-3.33)
Area (reference: Intervention area)		0.40***	-0.52***
		(14.2)	(-3.46)
JanJun 15		0.55***	
		(34.48)	
Hospitalize		1.03***	-43.73
		(45.86)	(-0.00)
Married		-0.19***	1.006***
		(-8.49)	-8.13
Widowed		-0.04	0.53*
		(-1.07)	-2.06
Constant		-0.15***	-3.93***
		(-4.22)	(-6.74)
Lnalpha _cons			-0.076***
			(-3.61)
N			40,702

z statistics in parentheses
* p<0.05, **p<0.01, *** p<0.001
Vuong test of ZINB vs. standard negative binomial: z = 8.91. Pr>z = 0.0000

As the variable of interest, travel costs, proxied with no-traffic travel distance to ED facility is found to be a significant factor on ED utilization in both count and inflate parts of the ZINB estimation that is listed in Table 1. More specifically, a 1-mile increase in travel distance to ED will decrease the expected log(count) of ED visits by -0.039, everything else being equal. Similarly, a 1-mile increase to the nearest primary care facility will decrease the log(counts) of expected ED visits by -0.023, everything else being equal. More interestingly, the log odds of being an excessive zero would increase by 0.082 with a 1-mile increase in travel distance, everything else being equal. That is, while travel costs discourage the count of ED visits, they also induce patients to strategically avoid the ED. While the signs of coefficients of Medicaid, Medicare, no insurance, intervention area, and hospitalize in the count part of the estimation were positive, they become negative in the inflate part of the estimations. This indicates that patients with Medicaid, Medicare, no insurance, from the intervention area, and patients who were hospitalized were less likely to be a “certain-zero” ED visitors. The opposite is true for the variables married and widowed that married and widowed patients strategically avoided the ED. These findings reveal that travel costs are a significant factor on ED visits both according to count and inflate estimation results of the ZINB estimation after having controlled for severity of the medical condition, age, gender, race, insurance status, hospitalization, being from an area where community health workers and mobile clinics interventions are in place (intervention area), visits in January-June 2015 period in which the interventions took place, and marital status.

In discussing our findings, we used residential physical addresses as the ED origin points, however, not all ED visits necessarily originate from residential addresses. Time of day, type of case or condition (accident or trauma), or how the patients were transported (if via ambulance, for instance) to the ED can be used as proxies where origin information is not available. This point still remains as an issue for the study. We assumed no time, technology, or policy effect over more than three years of the study period between 2011 and 2015. We also assumed constant prices (for gasoline, e.g.) for the same period. It is worth noting here that ED admission Charlson index of severity and comorbidity found to be insignificant in all estimations. While single-facility studies have their own advantages, especially, due to the availability of physical address data, the relationship between ED visits and travel costs can be explored by looking at ED visits to multiple ED facilities from a certain geographic area. Similarly, the inclusion of urgent care visits in the analysis along with outpatient visits can also potentially improve the estimations.

5. CONCLUSION

In this study, we analyzed the effects of travel distance and costs on the counts of ED visits per patient to a county community hospital between the years of 2011 and 2015. We found that, controlled for other factors, travel distance significantly affects both the count probability and excess zero (inflated) probability of ED visits through ZINB estimations. While higher travel distance and costs reduce the probability of ED visits, they induce patients to strategically avoid the ED. This finding contradicts our assertion that when controlled for medical condition, severity of medical condition, and availability of alternative primary care facilities, travel distance and costs should not have mattered in the decision whether to visit ED. More importantly, this finding indicates that some of the ED visits were primary care-related or could have been discouraged by having alternative delivery channels in the geographic region. Health care policies can hardly influence residential location and moving decisions, but they can alter the relative costs of non-urgent medical care options and reduce ED visits and associated costs without affecting the health of population adversely.

REFERENCES

AHA (American Hospital Association) 2014. Trendwatch Chartbook 2014. http://www.aha.org/research/reports/tw/chartbook/2014/14chartbook.pdf (accessed 4/10/2015).

Becker, Gary S. 1965. A theory of the allocation of time. *Economic Journal.* Vol. 75*(*299*)*. pp. 493–517.

DeSherpa, A. C. 1971. A theory of the economics of time. *Economic Journal*. Vol. 81(324). pp. 828-846.

Esri, 2011. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute.

Charlson, Mary E., Peter Pompei, Kathy L. Ales, C. Ronald MacKenzie. 1987. "A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation". *Journal of Chronic Diseases*. 40 (5): 373–83.

Chen, B. K., Hibbert, J., Cheng, X., & Bennett, K. 2015. Travel distance and sociodemographic correlates of potentially avoidable emergency department visits in California, 2006–2010: an observational study. *International Journal for Equity in Health*, *14*, 30. http://doi.org/10.1186/s12939-015-0158-y

Cunningham, Peter J. and Jessica H. May. 2003. "Insured Americans drive surge in emergency department visits". Center for Studying Health System Change. Issue Brief No. 70. October.

Henneman, Philip L., Jane L. Garb, Geoffrey A. Capraro, Haiping Li, Howard A. Smithline, Richard B. Wait. 2011. "Geography and Travel Distance Impact Emergency Department Visits". *The Journal of Emergency Medicine*. Volume 40. Issue 3. (March). Pages 333-339. http://dx.doi.org/10.1016/j.jemermed.2009.08.058

Hunt, Kelly A., Ellen J. Weber, Jonathan A. Showstack, David C. Colby, Michael L. Callaham. 2006. "Characteristics of Frequent Users of Emergency Departments". *Annals of Emergency Medicine*. Volume 48. Issue 1. July. Pages 1-8. http://dx.doi.org/10.1016/j.annemergmed.2005.12.030.(http://www.sciencedirect.com/science/article/pii/S0196064406000680)

Lee JE, Sung JH, Ward WB, Fos PJ, Lee WJ, Kim JC. 2007. "Utilization of the emergency room: impact of geographic distance". *Geospat Health*. May. 1 (2): 243-53. PubMed PMID: 18686249.

Lee, Michael H., Jeremiah D. Shuur, and Brian J. Zink. 2013."Owning the cost of emergency medicine: beyond 2%". *Annals of Emergency Medicine*, Volume 62. Issue 5. 498-505.e3.

Pitts, Stephen R., Emily R. Carrier, Eugene C. Rich, and Arthur L. Kellermann. 2010. "Where Americans get acute care: increasingly, it's not at their doctor's office". *Health Affairs*. September. Vol. 29 No. 9 1620-1629.

Ruger JP, Richter CJ, Spitznagel EL, et al. 2004. "Analysis of costs, length of stay, and utilization of emergency department services by frequent users: implications for health policy". *Acad Emerg Med*. 11:1311-1317.

Taylor, P. J. 1971. Distance Transformation and Distance Decay Functions. *Geographical Analysis*. 3: 221–238. doi: 10.1111/j.1538-4632.1971.tb00364.x

Truong, P. Truong and David A. Hensher. 1985. "Measurement of Travel Time Values and Opportunity Cost from a Discrete-Choice Model". *The Economic Journal*. Vol. 95. No. 378 (Jun.), pp. 438-451.

Vuong, Quang H. 1989. "Likelihood Ratio Tests for Model Selection and Non-Nested Hypotheses". *Econometrica*. Vol. 57. No. 2 (Mar.). pp. 307-333.

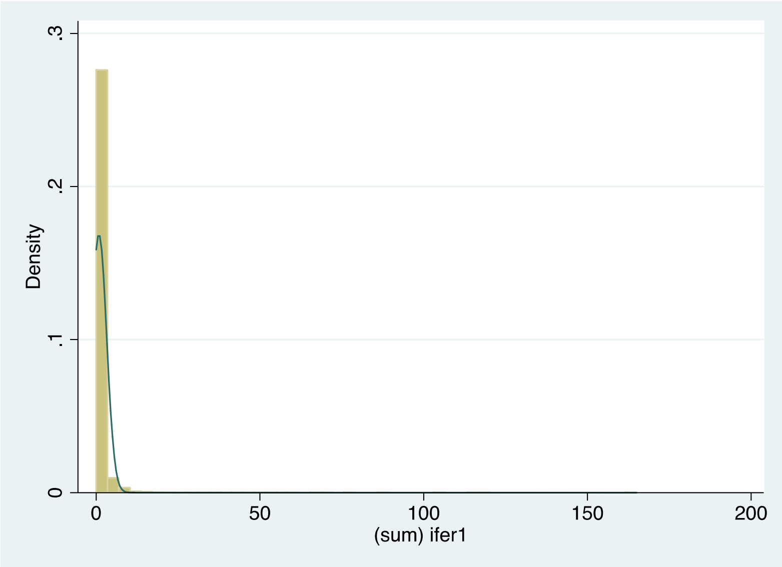
Weber EJ, Showstack JA, Hunt KA, et al. 2005. Does lack of a usual source of care or health insurance increase the likelihood of an emergency department visit? Results of a national population-based study. *Annals of Emergency Medicine*. 45:4-12.

Weinick, Robin M., Rachel M. Burns, and Ateev Mehrotra. 2010. “Many emergency department visits could be managed at urgent care centers and retail clinics”. *Health Affairs.* September. 29:91630-1636.

HCUP, DHHS at http://hcupnet.ahrq.gov/HCUPnet.jsp (accessed on 1/14/2015).

Appendix I

A. Distribution of ED visits



B. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ED Count	44,162	0.98	2.63	0	165
Gender	44,162	0.56	0.50	0	1
Travel Distance to ED Facility	44,162	7.63	10.41	0.003	1248.68
Distance to Nearest Primary Care Facility	44,162	10.04	11.21	0	1249.51
Medicaid	44,162	0.15	0.36	0	1
Medicare	44,162	0.21	0.40	0	1
No insurance	44,162	0.17	0.37	0	1
Hospitalized	44,162	0.14	0.35	0	1
Originates from intervention area	44,162	0.20	0.40	0	1
Married	40,987	0.41	0.49	0	1