Risk Factors of Hospital Readmission: Flu Vaccination of Health Care Workers, Comorbid Illness, and Socioeconomic Status

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Abstract

Vaccination of Health Care Workers (HCW) against influenza (flu) has been shown to protect nursing home patients; vaccination of all HCW is recommended by CDC. We examined the effect on readmission of HCW vaccination, comorbidity, and SES. Methods: From existing 2010-2013 QA reports of 2,242,598 NYC public hospital admissions, we developed GEE models with logistic transformation for 30 day readmission. Explanatory variables included: flu vaccination rates, patient demographics, medical history, zip code proxy SES variables, national flu rates, and weather. QIC was used for model selection.

Our model showed the following results (odds ratio/95% CI/increment for that OR (all p< .0001)): Protective factors: Female 0.64/0.62-0.66; English proficiency 0.95/0.94-0.96/*. Education>12th grade 0.75/0.73-0.78/*. Main risk factors: Exposure to unvaccinated HCW in prior 2-14 days: 8.59/8.27-8.93/0-100% vaccination rate; Age 1.06/1.05-1.08/10yrs; National rate of positive influenza culture 1.57/1.39-1.79/1%; Air temperature 1.5/1.46-1.54/10degC; Poverty level 1.39/1.31-1.47/* and the following comorbidities: Asthma 1.8/1.7-1.9; CHF 1.4/1.4-1.5; Psychiatric disorder 1.58/1.53-1.63; *proxy variable from zip code, 10% increase

Key Words: readmission, flu vaccination, health care workers, longitudinal data, marginal model, generalized estimating equations

1. Introduction

Centers for Medicare and Medicaid Services (CSM) have established the Hospital Readmission Reduction program in 2012 under the Patient Protection and Affordable Care Act [1] .Under these programs hospitals with excess readmissions are penalized. According to CMS, 30-day readmission can be defined as an "admission to a subsection hospital within 30 days of a discharge from the same or another subsection(d) hospital" for such conditions as acute myocardial infarction (AMI), heart failure (HF) and Pneumonia (PN) [2]. In 2013 over 2,200 hospitals paid about one percent of their Medicare payments resulting in $280 million in penalties [3]. Aside from penalties about $17.8 billion a year is spent on preventable readmissions [4,5].

It has been reported that since 2012 the national level of all-cause readmissions had a decrease of about five percent [1,2,4]. Use of information and research can provide additional insight into how to improve and integrate evidence-based decision making to reduce 30-day inpatient readmissions.

Vaccination of Health Care Workers (HCW) against influenza has been shown to have a protective effect against all-cause readmissions and mortality [6,7]. Vaccination of all HCW is recommended by the Centers for Disease Control and Prevention [8]. The vaccination rate of HCW increased ten percent over three years (2010-2013) [9]. 92% of physicians, 89% pharmacists and 89% nurses got flu vaccination in 2012-2013 season [9].

2. Objective

Using de-identified data from 2010 - 2013, we examined the effect of influenza vaccination of health care workers on 30-day all-cause inpatient readmissions to any hospital within the New York City Health and Hospitals Corporation (NYCHHC) network while controlling for demographics, co-morbidities and environmental factors.

3. Statistical Analysis

3.1 Data

The data were obtained from the New York City Health and Hospitals Corporation's (NYCHHC) data warehouse, the National Climatic Data Center (NCDC), the Centers for Disease Control and Prevention (CDC), and the United States Census Bureau. The final dataset consisted of 2,526,911 de-identified patient visits to eleven public hospitals within the NYCHCC network. Only visits that occurred between January 2010 and December 2013 were included. That time period was chosen since information about the NYCHCC health care workers (HCW) vaccination status was available. During those years, there were a total of 42,524 all-cause 30-day inpatient readmissions.

3.2 Endpoints

The study outcome was 30-day all-cause inpatient-to-inpatient readmission. For each hospitalization a 'Yes/No' flag indicates whether the patient was readmitted within 30 days of discharge. A patient could have more than one subsequent hospitalization to multiple institutions. Only admissions to facilities within the NYCHHC network were captured.

If there were one hospitalization:

$$\Pr(\text{flu exposure}) = 1 - p_{ij}$$

If there were more than one hospitalizations:

$$\Pr(\text{flu exposure}) = 1 - p^{j}_{ij}$$

The probability of flu exposure was measured on a continuous scale, ranging from 0 to 1. A value 0 indicated no exposure and a value of 1 represented 100% exposure to the unvaccinated HCW who themselves were exposed to influenza.

Our model was adjusted for the effects of demographics, comorbidities, and environmental factors. The demographic information included age, sex, race, employment, education, median income, English proficiency, and poverty level. Some of the variables were retrieved from the Census Bureau and matched to each individual by their zip code. We called those variables "proxies" for demographic and socio-economic status and were used to adjust for individual health profiles. The environmental factors considered were ambient air temperature, precipitation, dew point, wind speed, national and regional influenza rate. Demographic and socio-economic proxy variables were used to adjust for individual health profiles. Prior research shows a relationship between weather and readmission for some conditions (4).

3.3 Analysis

The univariate analyses of predictors and 30-day readmission were done using the Student's t-test or the Wilcoxon-Mann-Whitney test for continuous variables and the chi-square test for categorical variables, as appropriate. Variables that were significant at 0.2 level were included in the main-effects model.

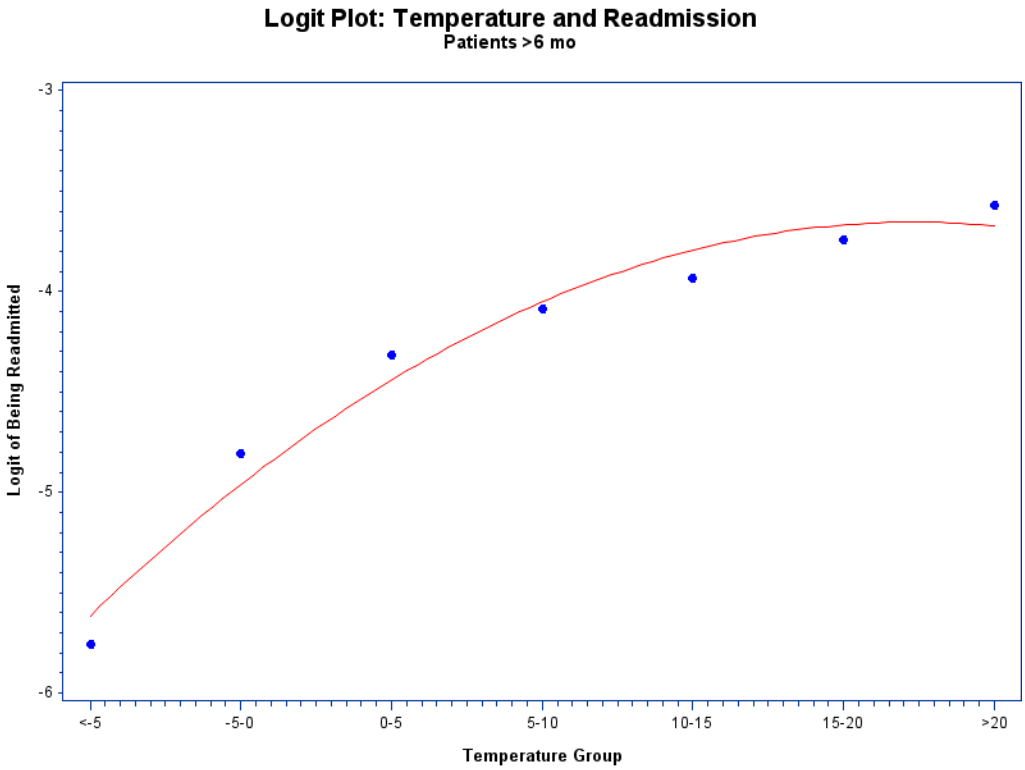

Figure 1: Logit plot of temperature and readmissions

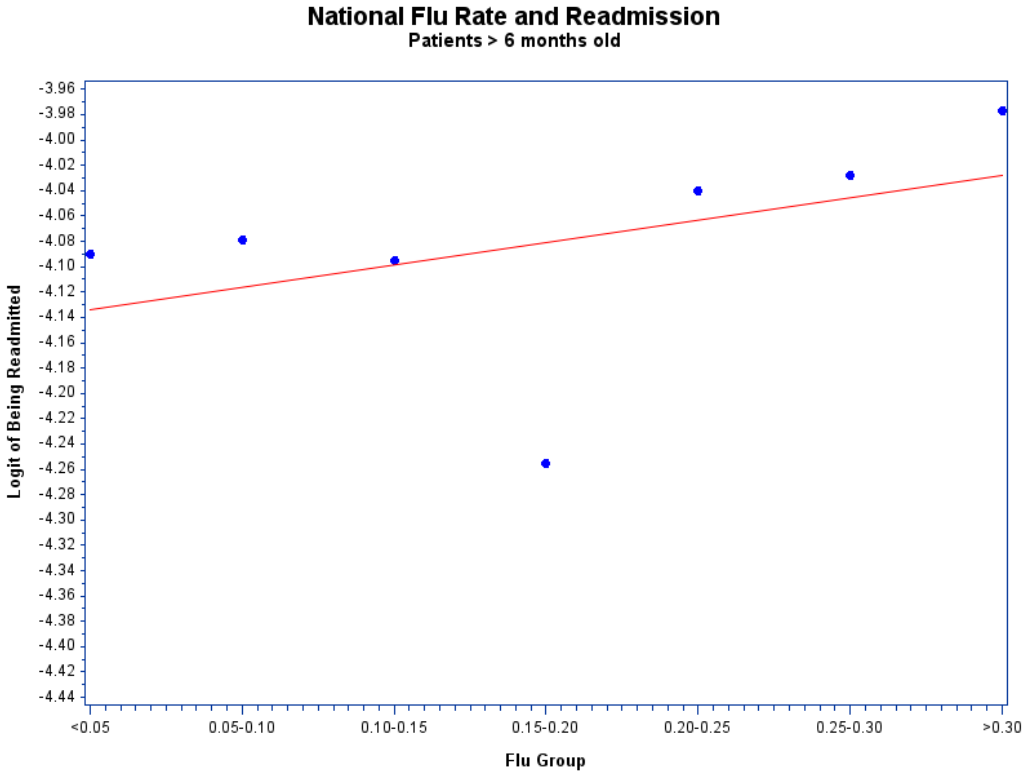

Figure 2: Logit plot of national influenza rate and readmissions

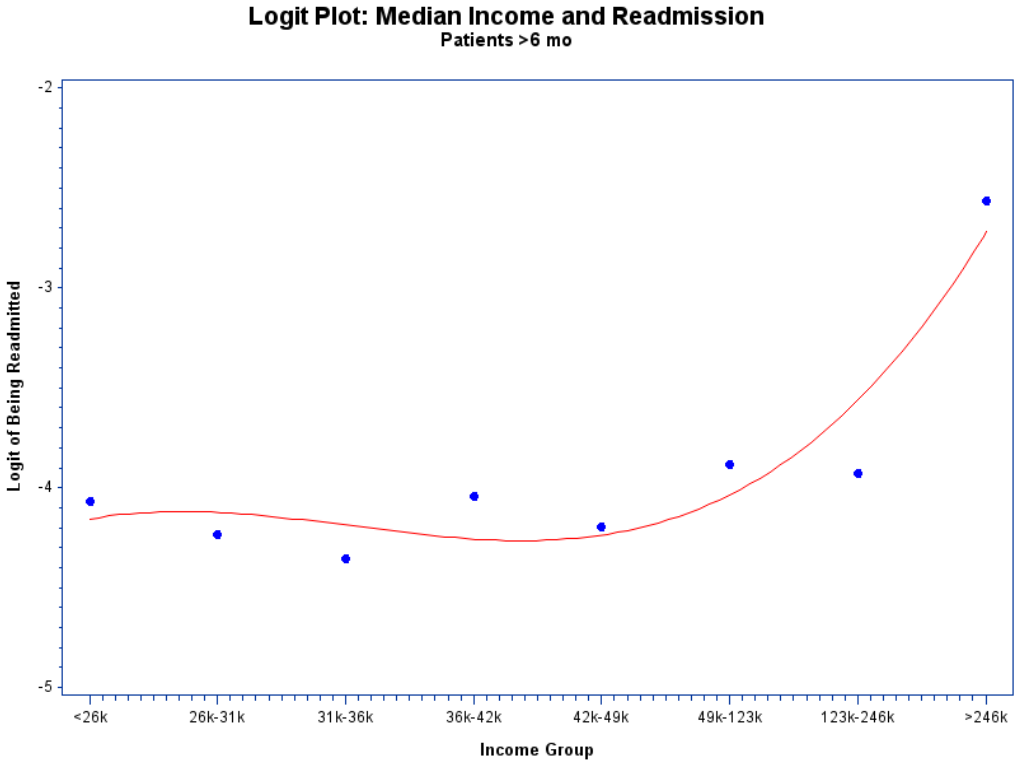

Figure 3: Logit plot of median income and readmissions

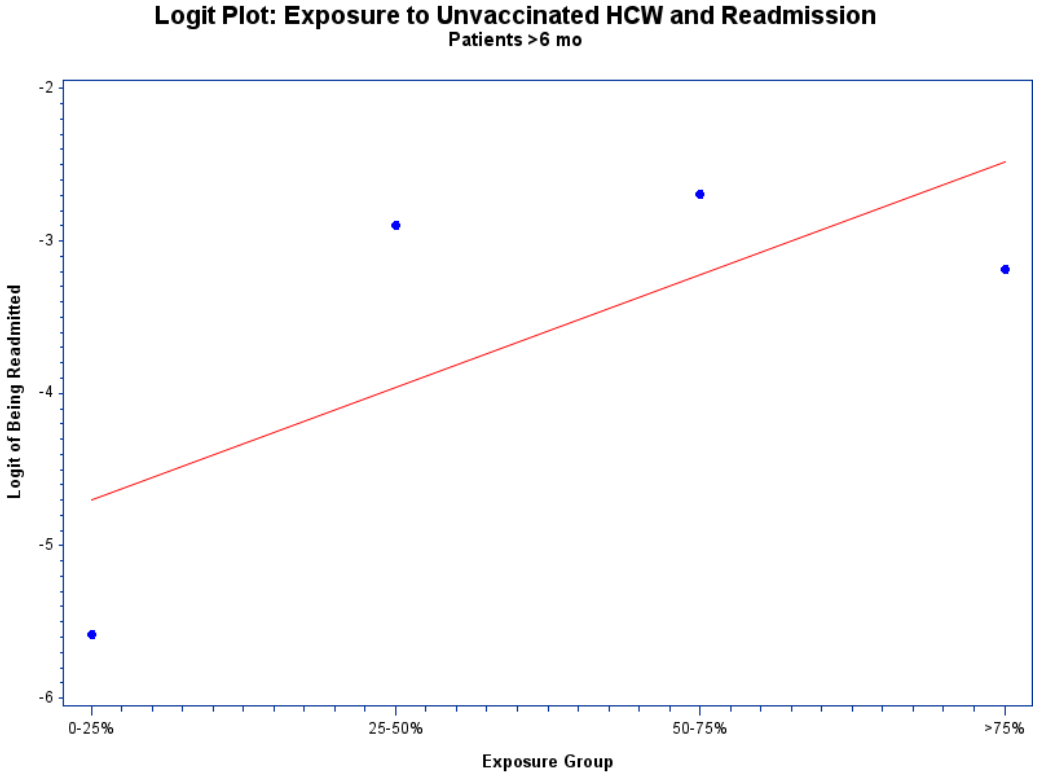

Figure 4 Logit plot of probability of flu exposure and readmissions

Generalized estimating equations (GEE) method with a logistic transformation was used to model the relationship between readmissions and HCW flu vaccination [10]. GEE was chosen to account for the correlation in outcomes between multiple readmissions within a subject. Only patients older than 6 month were included in the model.
The quasi-likelihood information criterion (QIC) was used for model selection[11].

Statistical analysis was performed using SAS 9.3 for Windows.

4. Results

The final model had twenty four independent predictors:

- Probability of Flu Exposure
- Demographics: Sex, race, age, poverty level, median income, English proficiency, GED
- Comorbidities: HIV, CDIFF, hepatitis, tumor, diabetes, psychological disorder, CHF, hypertension, CAD, systolic and diastolic BP, Pulmonary Embolism
- Environmental Factors: National flu rate, mean temperature (C), total precipitation

Table 1: Final model: Odds Ratio, 95% Confidence Limits, P-values

Predictor	*OR*	*95% Confidence Interval*	*P-Value*
Pr(flu exposure)	8.59746	(8.27383, 8.93376)	<.0001
Female	0.63999	(0.61824, 0.66251)	<0.0001
Race: Asian	1.20936	(1.12203, 1.30348)	<0.0001
Race: Hispanic	0.87217	(0.83777, 0.90799)	<0.0001
Race: Native American	1.12913	(0.96726, 1.31807)	0.1140
Race: Native Hawaiian/Pacific Islander	0.94088	(0.64294, 1.37689)	0.8018
Race: Other	0.62245	(0.56986, 0.67988)	<.0001
Race: South Asian/Middle East	1.08599	(0.98914, 1.19231)	0.0710
Race: Unknown	0.60911	(0.38809, 0.95603)	0.0374
Race: White	1.20404	(1.14899, 1.26174)	<.0001

Predictor	*OR*	*95% Confidence Interval*	*P-Value*
Age (10yrs)	1.06458	(1.05235, 1.07696)	<.0001
National flu rate	1.57880	(1.38888, 1.79469)	<.0001
Asthma	1.81103	(1.72575, 1.90051)	<.0001
History of HIV	1.15436	(1.10652, 1.20426)	<.0001
CDIFF	5.63895	(4.91467, 6.46998)	<.0001
History of viral hepatitis	1.16642	(1.09203, 1.24588)	<.0001
History of malignant tumor	2.47653	(2.36519, 2.59311)	<.0001
History of diabetes	1.04497	(1.00463, 1.08693)	0.0370
History of psychological disorder	1.57907	(1.52811, 1.63174)	<.0001
History of CHF	1.44583	(1.37223, 1.52338)	<.0001
History of hypertension	1.76794	(1.69123, 1.84813)	<.0001
History of CAD	1.31301	(1.25600, 1.37260)	<.0001
Systolic CHF	2.09292	(1.93015, 2.26940)	<.0001
Diastolic CHF	2.29664	(2.09820, 2.51384)	<.0001
Pulmonary embolism	2.33086	(1.90784, 2.84769)	<.0001
Mean temperature (10C)	1.50237	(1.46383, 1.54193)	<.0001
Total precipitation	5.92353	(4.76636, 7.36163)	<.0001
Total precipitation^2	0.12897	(0.08980, 0.18524)	<.0001
Total precipitation^3	1.92716	(1.67569, 2.21637)	<.0001

Predictor	*OR*	*95% Confidence Interval*	*P-Value*
Poverty level (10%)	1.38677	(1.30607, 1.47247)	<.0001
Median Income ($5,000)	1.02828	(1.02444, 1.03212)	<.0001
English proficiency (10%)	0.95136	(0.94304, 0.95975)	<.0001
GED (10%)	0.75333	(0.73016, 0.77724)	<.0001

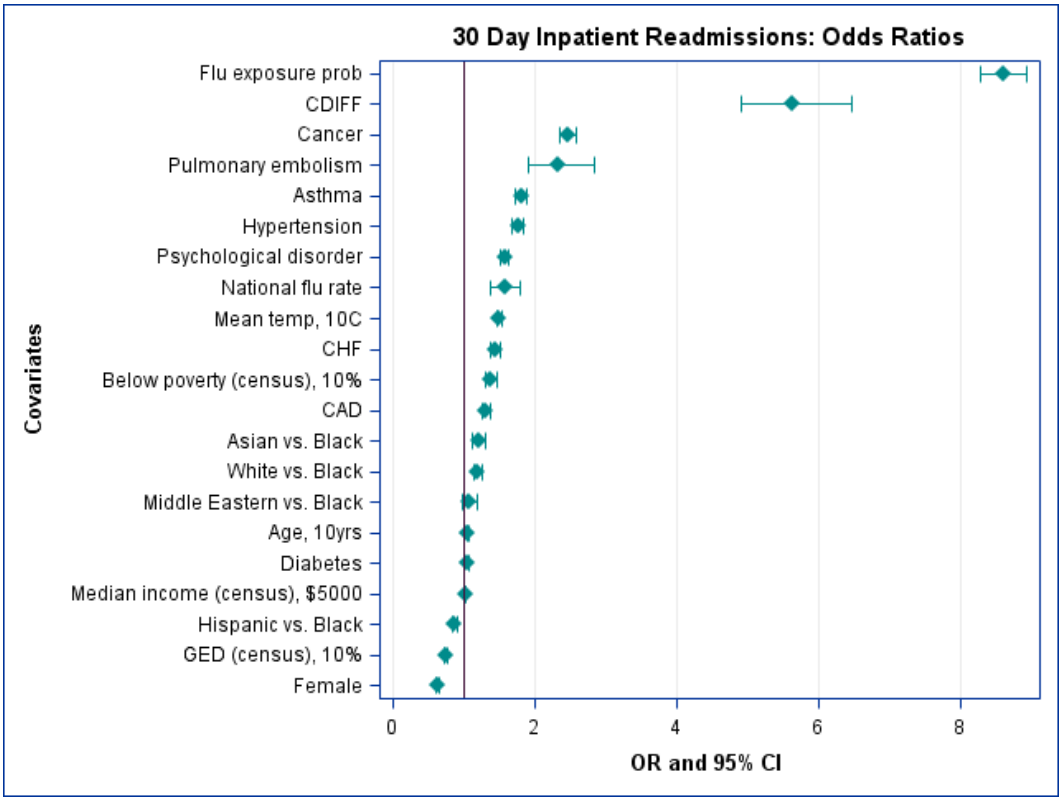

Figure 5: Forest Plot for selected predictors

Probability of flu exposure is a significant predictor for 30-day all-cause inpatient readmissions. Patients with increased exposure to unvaccinated health care workers have higher odds of being readmitted within 30 days of discharge adjusting for all other factors (OR = 8.6 [8.27, 8.93]).

5. Discussion

This project adds the effect of HCW vaccination to existing CQI models of 30-day all-cause inpatient readmissions. We used data collected between January 2010 and December 2013 from the NYCHHC data warehouse, the National Climatic Data Center, the Centers for Disease Control and Prevention, and the United States Census Bureau. We had a total of 2,526,911 de-identified patient visits and 42,524 of them were all-cause 30-day inpatient readmissions.

Our final GEE model with the logistic transformation includes 24 independent predictors. Patients with increased exposure to unvaccinated health care workers have higher odds of being readmitted within 30 days of discharge adjusting for all other factors (OR = 8.6 [8.27, 8.93]). This odds ratio calculation is not meant to imply that we observed any instances of 100% exposure and the only cases of 0% exposure occurred when the influenza rate was 0.

This research adds some light to the heated discussions about requiring vaccination if healthcare workers, particularly influenza vaccination. This research was done in New York, a state that recently added influenza to the list of required vaccinations for HCW [12].

CDC and Department of Health (DOH) recommendations/requirements were largely based on observing the effect of HCW vaccination in long-term nursing homes. To our knowledge, this paper is the first examination of the effect of HCW vaccination in acute care hospitals. In general, admission at these hospitals is for a few days; for most patients, most of a 30-day interval will be spent in the "outside world." Most of these patients will also have much wider exposure to people who are neither patients nor HCW. Theoretically, the same beneficial effect noticed in nursing homes might be harder to detect in the "noise", larger error terms, of data from acute care hospitals. We see a small, but detectable beneficial effect of HCW vaccination. Future research may develop models that include the effects of patient vaccination, or measures of patient exposure to people other than HCW and fellow patients.

Although our study showed a highly significant result and has potentially important implications, certain limitations should be considered. First, it is extremely challenging to track patients who are admitted to different hospitals. A seven factor (name, address, social security, date of birth, gender, ethnicity, country of birth) verification method was used to make sure the same patient was seen in more than one of our facilities; we have no way of knowing which patients were readmitted outside of our system. Second, proxy variables were used for socio-economic status, which may not reflect the true characteristic of each patient. Healthcare worker vaccination rate were measured at the end of the year, not on days when the readmissions occurred.

Despite the limitations of our study, our findings carry important implications on the value of HCW vaccination to reduce of 30-day all-cause inpatient readmissions. Future research on HCW influenza vaccinations and readmissions is needed to confirm our findings. The effect of HCW vaccination on costs, admission rates and mortality may also show important relationships

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References

1. Readmissions-Reduction-Program. 2014. Available at: http://cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html/. Accessed September 24, 2014.
2. 30-day death and readmission measures data. Available at: http://www.medicare.gov/hospitalcompare/Data/30-day-measures.html. Accessed May 2, 2014.
3. Examining Medicare's Hospital Readmissions Reduction Program – Health Affairs Blog. Available at: http://healthaffairs.org/blog/2014/07/24/examining-medicares-hospital-readmissions-reduction-program/. Accessed September 24, 2014.
4. Reducing Hospital Readmissions: It's About Improving Patient Care – Health Affairs Blog. Available at: http://healthaffairs.org/blog/2013/08/16/reducing-hospital-readmissions-its-about-improving-patient-care/. Accessed May 2, 2014.
5. The Revolving Door: A Report on U.S. Hospital Readmissions - Robert Wood Johnson Foundation. Available at: http://www.rwjf.org/en/research-publications/find-rwjf-research/2013/02/the-revolving-door--a-report-on-u-s--hospital-readmissions.html. Accessed May 2, 2014.
6. Ahmed F, Lindley MC, Allred N, Weinbaum CM, Grohskopf L. Effect of influenza vaccination of healthcare personnel on morbidity and mortality among patients: systematic review and grading of evidence. *Clin. Infect. Dis.* 2014;58(1): 50-7. Available at: http://www.ncbi.nlm.nih.gov/pubmed/24046301. Accessed August 21, 2014.
7. Herzog NS, Bratzler DW, Houck PM, et al. Effects of previous influenza vaccination on subsequent readmission and mortality in elderly patients hospitalized with pneumonia. *Am. J. Med.* 2003;115(6):454-61. Available at: http://www.ncbi.nlm.nih.gov/pubmed/14563502. Accessed May 2, 2014.
8. Healthcare Worker Flu Immunization. Available at: http://www.wsha.org/0397.cfm. Accessed May 2, 2014.
9. Doctors are more likely to get flu shots than nurses | The Advisory Board Daily Briefing. Available at: http://www.advisory.com/daily-briefing/2013/09/30/doctors-are-more-likely-to-get-flu-shots-than-nurses. Accessed May 2, 2014.
10. Marginal Models: Generalized Estimating Equations. Available at: http://www.stats.uwo.ca/faculty/bellhouse/stat 9945b/zizhen_Presentation 2.pdf. Accessed May 2, 2014.
11. The GENMOD Procedure: Generalized Estimating Equations :: SAS/STAT(R) 9.2 User's Guide, Second Edition. Available at: http://support.sas.com/documentation/

cdl/en/statug/63033/HTML/default/viewer.htm#statug_genmod_sect043.htm. Accessed September 24, 2014.

12. Health Care Personnel. Available at: https://www.health.ny.gov/prevention/immunization/health_care_personnel/. Accessed September 26, 2014.