Vaccination Rates are Associated With Functional Proximity But Not Base Proximity of Vaccination Clinics

Citation	Beshears, John, James J. Choi, David I. Laibson, Brigitte C. Madrian, and Gwendolyn I. Reynolds. 2016. "Vaccination Rates Are Associated With Functional Proximity But Not Base Proximity of Vaccination Clinics." Medical Care 54 (6) (June): 578–583. doi:10.1097/mlr.0000000000000523.
Published Version	doi:10.1097/MLR.0000000000000523
Citable link	http://nrs.harvard.edu/urn-3:HUL.InstRepos:34737827
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Vaccination Rates Are Associated with Functional Proximity but Not Base Proximity of Vaccination Clinics

Abstract

Background: Routine annual influenza vaccinations are recommended for persons 6 months of age and older, but less than half of U.S. adults get vaccinated. Many employers offer employees free influenza vaccinations at workplace clinics, but even then, take-up is low.

Objective: To determine if employees are significantly more likely to get vaccinated if they have a higher probability of walking by the clinic for reasons *other* than vaccination.

Method: We obtained data from an employer with a free workplace influenza vaccination clinic. Using each employee's building entry/exit swipe card data, we test whether *functional proximity*—the likelihood that the employee walks by the clinic for reasons other than vaccination—predicts whether the employee gets vaccinated at the clinic. We also test whether *base proximity*—the inverse of walking distance from the employee's desk to the clinic—predicts vaccination probability.

Participants: 1,801 employees of a health benefits administrator that held a free workplace influenza vaccination clinic.

Results: A two standard deviation increase in functional proximity is associated with a 6.4 percentage point increase in the probability of vaccination (total vaccination rate at company = 40%), even though the average employee's desk is only 166 meters from the clinic. Base proximity does not predict vaccination probability.

Conclusions and Relevance: Minor changes in the environment can have substantial effects on the probability of vaccination. If these results generalize, health systems should emphasize functional proximity over base proximity when locating preventive health services.

Key Words: vaccination, clinics, workplace wellness, proximity, **preventive** care, influenza

Introduction

The annual economic cost of influenza-attributable illness for adults ages 18 and over is estimated to be $87.1 billion—$10.4 billion in direct medical costs, $16.3 billion in lost earnings, and $60.4 billion in lost statistical lives (1). Routine annual influenza vaccination is recommended for all persons 6 months of age and older without contraindications (2), but only 46 percent of adults over 18 years of age were vaccinated in the 2011-12 influenza season (3). Twenty percent of adults ages 18 to 64 who receive an influenza vaccination receive it at their workplace (4). However, less than half of employees with access to a free workplace influenza vaccination clinic are vaccinated (5).

One common approach to increasing the use of preventive healthcare services is to reduce the physical distance between the individual's base location and the healthcare facility, so that obtaining healthcare is less burdensome. But previous literature has reached conflicting conclusions about the relationship between distance from an individual's home to health care facilities and usage of health care services (6, 7, 8, 9, 10, 11). Other research has found that forgetfulness or a failure to plan is partially responsible for the low take-up of vaccinations and other preventive health behaviors (12, 13, 14). Therefore, we hypothesized that the likelihood of visiting a free workplace influenza vaccination clinic would be greater among individuals who have a higher probability of walking by the clinic for reasons other than vaccination and thus being reminded of the vaccination opportunity. Furthermore, we hypothesized that this probability would be a more powerful predictor of vaccination than the distance between the employee's desk and the clinic.

Using desk location information and employees' building entry/exit swipe card data from a company that offered a free two-day worksite influenza vaccination clinic, we separately identify the vaccination effects of base proximity—the inverse of walking distance between one's desk and the clinic—and functional proximity—the likelihood of passing near the clinic during the course of a normal work day (i.e., days when the clinic is not open).

Methods

Study Design

We study the 2011 influenza vaccine uptake of employees at the headquarters of a health benefits administrator in the U.S. These employees are generally not healthcare personnel. All of them have health insurance. Of the company's total workforce (including those not based at the headquarters), 26% are African Americans and 37% are racial minorities.

There are two main buildings at the company headquarters. Building One houses 520 employees and is the site of the vaccination clinic; Building Two houses 1,281 employees. The two buildings are 131 meters apart and connected by an enclosed passageway. The clinic was located near the cafeteria in Building One and adjacent to the passageway connecting the two buildings. The clinic was conducted from October 19 to 20, 2011, and it was advertised during the three weeks prior. Figure 1 shows a stylized diagram of the two buildings and the passageway, as well as the location of the clinic.

The company requires employees to swipe a personalized electronic badge to open the external doors of its buildings, which include the doors to the passageway between the buildings. The company provided us data on the date and time of each swipe in September and October 2011. If an employee swipes her badge and holds the door open for another employee, we do not observe that other employee. The badge swipe data are therefore an incomplete measure of all movements between the buildings. The company also gave us data on employee characteristics and vaccination uptake, scaled architectural plans of the buildings, and employee desk maps.

Predictive Variables and Hypotheses

We use the frequency of an employee's badge swipes for entry into Building One at the end of the passageway from Building Two to create proxies for an employee's "functional proximity" to the clinic. Recall that this door is adjacent to the clinic location, and employees in Building Two who did not walk outdoors had to use this door to reach the clinic. Therefore, we believe that the badge swipe data capture a high fraction of Building Two employees' visits to the clinic location. In contrast, employees in Building One did not have to use this door to access the clinic, since the clinic was in Building One. Badge swipe data consequently capture a smaller fraction of Building One employees' visits to the clinic location. In sum, badge swipes measure functional proximity to the clinic much more accurately for employees in Building Two than for employees in Building One. Hence, we expect attenuation bias from measurement error to affect our estimates of functional proximity's effect on vaccination much more severely for Building One employees than for Building Two employees.

We would expect a mechanical relationship between the number of badge swipes on clinic days and vaccination, since most Building Two employees who were vaccinated swiped in order to get to the clinic. Therefore, we construct our functional proximity measures using the number of badge swipes during only the 59 *non-clinic* days in September and October—that is, excluding October 19-20. We do not use the months prior to September because the number of badge swipes during the summer is more likely to be affected by vacations, making them less reflective of routines while in the office. We exclude months after October to keep reverse causality from affecting our results; those who get vaccinated might have more badge swipes in subsequent months because they are not home sick with influenza. The last ten days of October do not create such reverse causality concerns because it takes about two weeks after vaccination for immunity to develop (15).

We create three measures: the number of badge swipes on all non-clinic days (including weekends, when the business was not officially open but the building was accessible to employees), the number of badge swipes on non-clinic weekdays from 9 am to 2:30 pm (the hours that the clinic was open on clinic days), and the number of badge swipes on non-clinic weekdays before 9 am and after 2:30 pm (the hours that the clinic was closed on clinic days).

We had three functional proximity hypotheses:

***Hypothesis 1 (H1)*:** For employees based in Building Two (where the clinic was not located), the number of badge swipes for the entry door to Building One on non-clinic days will be positively associated with vaccination.

Hypothesis 2 (H2). For employees based in Building Two, the number of badge swipes for the entry door to Building One on non-clinic days from 9 am to 2:30 pm (clinic hours) will be more predictive of vaccination than the number of badge swipes for the entry door on non-clinic days before 9 am and after 2:30 pm (non-clinic hours).

Hypothesis 3 (H3). For employees based in Building One (where the clinic was located), the number of badge swipes for the entry door to Building One on non-clinic days will not be associated with vaccination, regardless of the time of day.

We also measure the minimum walking distance from each employee's desk to the clinic using the architectural plans of Buildings One and Two. Vertical distance is excluded from this measure, although horizontal distance to any necessary stairs is included. We test whether "base proximity" (the reciprocal of minimum walking distance in meters) is associated with flu shot uptake.

> ***Hypothesis 4 (H4)*. For Building Two employees, base** proximity will be a weaker predictor of vaccination than the number of badge swipes.

We use the reciprocal of walking distance in order to reduce the possible impact of outliers whose desk is very far away from the clinic. However, using walking distance as our measure of base proximity yields similar results.

Andersen's Behavioral Model of Health Services Use (16) identifies three components that drive health service utilization: the predisposition to use services, factors that enable the use of services, and the need for services. Our study focuses on the location of health services, which is a key enabling factor, along two dimensions: functional proximity and base proximity. Predisposing characteristics that incline an individual to get an influenza vaccination that have been documented in the literature include age, gender, race, education, socioeconomic status, insurance status, prior experience with influenza vaccination, beliefs about the efficacy and side effects of vaccination, and predictions of the percentage of coworkers who will be vaccinated (17, 18). Of these, our data allow us to control directly for age and gender, and we know that all employees in our sample have health insurance. We are also able to control for 12 binary variables indicating which of the company's 12 job grades—which are related to job title and description—maps to the individual; three binary variables for if the worker is **full**-time, **a**

regular hire (rather than **temporary), or** salaried **(rather than hourly**); and a binary variable for whether the employee has an office instead of a cubicle (indicating higher job status). Job characteristics will be correlated with the employee's education, race, and socioeconomic status. If controlling for job characteristics causes the coefficients on functional proximity and base proximity to attenuate significantly, this would raise concern that the absence of direct education, race, etc. controls is responsible for any significant proximity effects that we find. The absence of other predisposing, enabling, and need characteristics in our data biases our study's estimates of proximity effects only to the extent that these unobserved variables are correlated with functional or base proximity.

We additionally control for binary variables indicating on which building floor level the employee's desk is located in order to correct for the exclusion of vertical distance from our base proximity measure. Age, gender, and job grade data are occasionally missing for an employee. We correct for this via three binary variables indicating whether age, gender, or job grade is missing. The age, gender, or job grade variable values are set to zero when the relevant data are missing.

Statistical Analysis

Our initial descriptive analysis of the main variables consists of computing their means and (where relevant) standard deviations. We also report *p*-values from tests of whether these variables' means differ between Building One and Building Two.

In our main analysis, we run regressions separately by building to evaluate the impact of employees' proximity to the clinic on their likelihood of receiving an influenza vaccination. For each building's regressions, we standardize our two proximity measures to each have zero mean and unit variance within the building. In order to ease the interpretation of marginal effects from the regression coefficients, we use a linear probability model (i.e., an ordinary least squares regression with a binary indicator for receiving a vaccination as the dependent variable), which provides the linear approximation to the conditional expectation function that minimizes the mean squared prediction error. Linear probability models do not rely upon the strong functional and distributional assumptions of logit and probit regressions, and are in this sense more robust (19). Our results are similar when estimated using logit regressions, as shown in Supplemental Digital Content Tables A1 and A2. All analyses were run using Stata version 13.1 (Stata Corporation, College Station, TX).

Results

Table 1 shows summary statistics for employees in each building. In Building One, 38% of employees received an influenza vaccination, compared to 41% of employees in Building Two. The mean distance to the clinic for employees in Building One is 69.2 meters, compared to 205.1 meters for employees in Building Two. Building One employees swiped their badge 18.22 times on average during the 59 non-clinic days (i.e., 0.31 times per day), of which 10.97 swipes occurred between 9 am and 2:30 pm on non-clinic weekdays and 7.10 swipes occurred before 9 am or after 2:30 pm on non-clinic weekdays. Building Two employees swiped 4.65 times on average during the non-clinic days, of which 2.84 occurred between 9 am and 2:30 pm on non-clinic weekdays and 1.79 occurred before 9 am or after 2:30 pm on non-clinic weekdays.

Table 2 shows coefficients from regressions where the dependent variable is a binary indicator for getting vaccinated. Each column corresponds to a different regression on the same sample (all employees in Building Two), with standard errors and *p*-values below each coefficient point estimate. The only control variable in column 1 is badge use on September to October non-clinic days. **Column 2 controls instead for badge use at different times of day during September to October non-clinic days.** Column 3 controls **only for base proximity. Column 4 controls** for both badge use on September to October non-clinic days **and base proximity**, in addition to which floor the employee's desk is on, **demographics**, and job characteristics. **Column 5 shows** the effect of badge use at different times of day **and base proximity with the** additional controls. Table 3 shows analogous regression results for Building One employees, with the same column scheme. **Supplemental Digital Content Tables A3 and A4 contain the full set of regression coefficients using proximity variables that have not been standardized.**

Consistent with H1, we find that a one standard deviation increase in an employee's badge use during non-clinic days in September and October increases the employee's vaccination likelihood by 2.6 percentage points (p = 0.068; Table 2, Column **1). Supporting H2, when we limit badge swipes to only the hours during non-clinic weekdays when the influenza clinic would be offered on clinic days (9 am to 2:30 pm), the badge swipe effect increases in magnitude and is statistically significant (p = 0.045; Table 2, Column 2), while the effect of non-clinic weekday badge use *outside* of the clinic time window is much smaller and not statistically significant (p = 0.845; Table 2, Column 2).**

In contrast, base proximity in Building Two is unrelated to the vaccination rate (p = 0.672; Table 2, Column 3), as hypothesized in H4. When controlling for both proximity measures simultaneously, as well as the floor the employee's desk is on, demographic controls, and job characteristics, the insignificance of base proximity remains unchanged (p = 0.893; Table 2, Column **4**), while the badge swipe effect strengthens in magnitude and significance (p =

0.011; Table 2, Column **4**). A one standard deviation increase in functional proximity, as measured by total non-clinic day badge swipes, implies a 3.2 percentage point increase in the probability of vaccination for employees in Building Two (Table 2, Column **4**). The fact that our estimate of the functional proximity effect strengthens when we include job characteristic controls suggests that it is not being driven by our inability to control directly for education, race, socioeconomic status, and insurance status. Furthermore, we measure functional proximity with more error than we do base proximity, making more striking the fact that our functional proximity measure significantly predicts vaccination whereas base proximity does not.

The last column of Table 2 shows that even after controlling for base proximity and the other explanatory variables, the effect of non-clinic weekday badge swipes **during** the times when the influenza clinic **would be** offered (9 am to 2:30 pm) **remains** statistically significant (p = 0.031; Table 2, Column 5), **while** the effect of **weekday** badge use outside of the clinic time window **remains** statistically **insignificant** (p = 0.904; Table 2, Column 5).

As noted earlier, badge swipe data for Building One employees is a poor proxy for functional proximity to the clinic. Accordingly, total badge swipes for employees in Building One do not significantly predict vaccinations (p = 0.489 without additional controls, p = 0.812 with additional controls; Table 3, Columns **1** and **4**). Vaccination is not predicted by swipes during clinic times on non-clinic weekdays (p = 0.213 without additional controls, p = 0.193 with additional controls; Table 3, Columns **2** and 5) or swipes outside of clinic times on non-clinic weekdays (p = 0.490 without additional controls, p = 0.254 with additional controls; Table 3, Columns **2 and 5). Therefore, H3 is confirmed. As in Building Two, base proximity in Building One is unrelated to the probability of vaccination (p = 0.308; Table 3, Column 3), and remains so after adding additional control variables (p = 0.751; Table 3, Column 4).**

Discussion

Close proximity of health care facilities to individuals' "activity spaces," the set of locations regularly visited during the course of daily living, has been hypothesized to be an enabling resource—in the sense of Andersen (20)—for receiving health services. Cromley and Shannon (21) hypothesize that health care facilities' proximity to activity spaces—i.e., functional proximity—is even more important for facilitating health care access than their proximity to individuals' homes. However, empirical evidence on this hypothesis is limited, in large part due to difficulties with identifying and measuring proximity to activity spaces. Nemet and Bailey (22) find that health care utilization is higher among the rural elderly if their primary health care provider is located within their activity space. However, they cannot rule out the possibility that this positive correlation arises due to reverse causality—the individual's activity space encompasses the physician's location *because* the individual visits the physician frequently. In addition, they measure activity space via respondent self-reports, which are subject to reporting and recall bias. A number of studies have found that offering influenza vaccinations at the workplace, either at fixed locations or using mobile vaccination carts, is effective at increasing vaccination rates (23, 24, 25, 26, 27, 28, 29, 30). But because functional and base proximity to the vaccination facilities were not separately measured, the importance of each factor cannot be separately identified.

Our study uses objective measures of activity space and base proximity, and we can rule out reverse causality because our functional proximity measure excludes days on which the vaccination clinic was operating. We find that functional proximity to the clinic is associated with increased vaccination rates. An employee in Building Two who traveled through the door adjacent to the clinic two standard deviations more often during *non-clinic* days in September and October was 6.4 percentage points more likely to be vaccinated. On the other hand, base proximity to the vaccination clinic (the inverse of the distance from one's desk) is not associated with a higher likelihood of vaccination. When thinking about the enabling factors in Andersen's Behavioral Model of Health Service Use, our results suggest that functional proximity has more impact on increasing health care use than base proximity.

Our study has some limitations. Worker base proximity and functional proximity to the clinic were not randomly assigned, so we cannot completely rule out the possibility that omitted variables that affect vaccination probability (such as race, education, beliefs about vaccination efficacy, etc.) are also correlated with our proximity measures, thus biasing the estimated relationships between proximity and vaccination probability. Future research could measure other predisposing, enabling, and need factors in the studied population so that these characteristics can be directly controlled for when estimating the enabling effect of proximity. In addition, our data come from a single company during a single flu vaccination campaign. Therefore, our results may not generalize to other populations or to other years where there is a different amount of public attention placed on the risks of influenza.

Summary and Conclusions

Using objective measures of functional and base proximity to a workplace influenza vaccination clinic, we find that the probability of an employee getting vaccinated increases with functional proximity (the likelihood that the employee walks by the clinic for reasons other than vaccination) but not with base proximity (the inverse of walking distance from the employee's desk to the clinic). A two standard deviation increase in functional

proximity is associated with a 6.4 percentage point increase in the probability of vaccination, even though the average employee's desk is only 166 meters from the clinic.

Employers currently administer 20% of influenza vaccinations for adults between the ages of 18 to 64 (31). The results of our study suggest that one way to assess the structural quality of a workplace preventive care clinic is its functional proximity to employees. Clinics should be placed in a location that workers frequently walk past, which is not necessarily the location that is physically closest to workers' base locations.

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