



Monitoring receipt of seasonal influenza vaccines with BRFSS and NHIS data: Challenges and solutions

Andrew E. Burger*, Eric N. Reither

Yun Kim Population Research Laboratory, Department of Sociology, Utah State University, 0730 Old Main Hill, Logan, UT 84322-0730, United States



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ABSTRACT

Despite the availability of vaccines that mitigate the health risks associated with seasonal influenza, most individuals in the U.S. remain unvaccinated. Monitoring vaccination uptake for seasonal influenza, especially among disadvantaged or high-risk groups, is therefore an important public health activity. The Behavioral Risk Factor Surveillance System (BRFSS) – the largest telephone-based health surveillance system in the world – is an important resource in monitoring population health trends, including influenza vaccination. However, due to limitations in the question that measures influenza vaccination status, difficulties arise in estimating seasonal vaccination rates. Although researchers have proposed various methodologies to address this issue, no systematic review of these methodologies exists. By subjecting these methods to tests of sensitivity and specificity, we identify their strengths and weaknesses and advance a new method for estimating national and state-level vaccination rates with BRFSS data. To ensure that our findings are not anomalous to the BRFSS, we also analyze data from the National Health Interview Survey (NHIS). For both studies, we find that restricting the sample to interviews conducted between January and September offers the best balance of sensitivity (>90% on average), specificity (>90% on average), and statistical power (retention of 92.2% of vaccinations from the target flu season) over other proposed methods. We conclude that including survey participants from these months provides a simple and effective way to estimate seasonal influenza vaccination rates with BRFSS and NHIS data, and we discuss potential ways to better estimate vaccination rates in future epidemiologic surveys.

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1. Introduction

Seasonal influenza produces a substantial disease burden in the United States, claiming the lives of thousands [1] and hospitalizing hundreds of thousands every year [2,3]. Influenza is one of the leading causes of mortality in the United States [4] and also drains billions of dollars from the economy [5,6]. Unlike some infectious diseases that have been eradicated or greatly reduced, influenza remains a potent foe of public health [7].

Despite widely available vaccines for seasonal influenza, millions go unvaccinated every year [8,9]. Vaccination surveillance is therefore an important public health activity in achieving the influenza vaccination objectives outlined in *Healthy People 2020* [10]. Two major epidemiologic surveys – the Behavioral Risk Factor Surveillance System (BRFSS) and the National Health Interview

Survey (NHIS) – monitor the receipt of seasonal influenza vaccines in the U.S. population. However, the effectiveness of these surveys has been limited by their inability to definitively match respondents to specific flu seasons. Several methodologies have been developed to address this issue in the BRFSS, but there is currently no systematic evaluation of these approaches. Our study first examines the effectiveness of BRFSS-focused methodologies, and then replicates the main findings with NHIS data.

1.1. The measurement problem

1.1.1. Measures of influenza vaccination pre-2009 BRFSS

Since 2001, every participant in the BRFSS has been asked “During the past 12 months, have you had a flu shot?” This question does not specify the exact timing of vaccinations, making it difficult to link them to specific flu seasons which typically begin in October or November, peak in January or February, and then diminish until the start of next year’s flu season [11]. Within any single wave of the BRFSS, most data on the receipt of influenza vaccinations correspond to the previous year’s flu season – i.e., the target flu season. However, there are also many respondents who report a vaccine for a non-target flu season. Without information on the

* Corresponding author at: Utah State University, Department of Sociology, 0730 Old Main Hill, Logan, UT 84322-0730, United States. Tel.: +1 435 227 5241; fax: +1 435 797 1240.

E-mail addresses: Andrew.burger@aggiemail.usu.edu (A.E. Burger), Eric.reither@usu.edu (E.N. Reither).

timing of influenza vaccinations, it is difficult to know if estimates of season-specific vaccination rates are accurate.

1.1.2. Measures of influenza vaccination post-2009 BRFSS

Beginning in 2009 for the BRFSS (and 2005 for the NHIS) a follow-up question was introduced to ascertain the month and year of the reported influenza vaccination. This question identifies the exact flu season for reported vaccinations – providing us with the information necessary to conduct this study. However, as we discuss in Section 4.1, the follow-up question also has certain limitations that may introduce modest biases in rate estimates. Moreover, because the follow-up question is still relatively new, it cannot be used in longer-term trend studies. The methods that we discuss in this study are potentially relevant to all BRFSS and NHIS survey years, including those with and those without the follow-up question.

1.1.3. Selected methodologies

The methodologies under review come from four different studies: Linn et al. [12], Lu et al. [13], Setse et al. [8], and Burger et al. [14]. While other methodologies may exist, this selection of studies provides us with a range of approaches that will help us identify best practices. Before examining the effectiveness of these methods, we briefly discuss the approach utilized in each study.

Linn et al. [12] assess racial/ethnic disparities in seasonal influenza vaccinations for the 2007 flu season using data from the 2008 BRFSS. In their 2007 estimates, Linn et al. [12] include all vaccination responses from the 2008 BRFSS. The authors acknowledge that this method includes responses from the other flu seasons, but note that “when the sample was restricted to the first quarter of 2008 to avoid respondents referencing different influenza seasons, the overall prevalence and disparities were essentially the same” (p. 1339). Although we do not dispute this finding, vaccination rates can differ across flu seasons based on variability in media coverage [15,16] and vaccination availability [17].

In recognition of this point, the other three methodologies introduce sample restrictions in the effort to exclude vaccinations received for a non-target flu season. For example, Lu et al. [13] include only participants who were interviewed from February–August of the 2007 BRFSS. Setse et al. [8] employ an even more restrictive selection criterion by retaining only participants who were interviewed from March–August in the 2000–2009 BRFSS. Both studies share the goal of removing respondents who were vaccinated for non-target flu seasons, but an inadvertent consequence may be the elimination of many respondents who were vaccinated for the target flu season.

To minimize such data loss in their study of the 2000–2009 flu seasons, Burger et al. [14] use a more generous criterion by including all respondents interviewed from January–September of each BRFSS survey year. However, it is not currently known whether this improvement in statistical power comes at the price of substantially reduced specificity and/or sensitivity. A formal comparison of all four approaches will permit us to address these issues.

2. Methods

2.1. Data

For our analyses we use data from the Behavioral Risk Factor Surveillance System (BRFSS) and the National Health Interview Survey (NHIS) Sample Adult files. Both surveys provide an annual report on health behaviors and conditions for the non-institutionalized U.S. adult population. The BRFSS gathers data via telephone interviews conducted at the state level and is then compiled by the CDC to be nationally representative. The NHIS performs household interviews to gather information from its representative

selection of participants. We limit our analyses to the 2009–2011 waves of the BRFSS and the 2005–2011 waves of the NHIS.

2.2. Measures

Data from the 2009–2011 BRFSS and the 2005–2011 NHIS contain the standard flu question plus a question about vaccination timing, allowing us to perform tests of sensitivity and specificity. Our study examines vaccinations administered through an intradermal injection, commonly referred to as the ‘flu shot’. We exclude flu mists from the 2009–2010 BRFSS and 2005–2011 NHIS as it could result in multiple vaccination reports for some respondents. Fortunately, during this time frame, only 1.7% of reported influenza vaccinations in the BRFSS and 2.7% of reported vaccinations in the NHIS were administered via a flu mist. The 2011 BRFSS groups both vaccine administration methods into a single measure, but given the low prevalence of flu mist vaccinations among adults, there is no discernible effect on our results.

Although there is no official declaration regarding the timing of flu seasons, it is generally accepted that they begin in the fall and continue through the spring of next year [11,18]. Summer months are generally a quiet period for seasonal influenza activity, and may be regarded as the vanishing tail end of the epidemic curve for most flu seasons. Since vaccinations are usually available before the onset of the flu season, we assign vaccinations occurring between September of one year and August of the following year to the same flu season.

2.3. Analytic approach

We first present descriptive information regarding the composition of samples produced by applying each method to the 2009–2011 waves of the BRFSS. We then use BRFSS data to calculate the sensitivity and specificity of each approach. Tests of sensitivity and specificity have been employed with success in both clinical and non-clinical research [19–21] and are calculated via the following formulas:

$$\text{Sensitivity} = \frac{\text{True positives}}{\text{True positives} + \text{False negatives}} \times 100$$

$$\text{Specificity} = \frac{\text{True negatives}}{\text{False positives} + \text{True negatives}} \times 100$$

To replicate our BRFSS findings, we perform similar analyses with NHIS data. Unlike the BRFSS, many of the public NHIS files available from the CDC do not provide details about the month in which the respondent was interviewed, but instead group respondents into interview quarters due to confidentiality issues. This provides a convenient way to replicate the approaches outlined in Linn et al. [12] and Burger et al. [14], as these methods include interview months that happen to correspond precisely with NHIS quarterly data.

3. Results

3.1. Comparison of methods using BRFSS data

Fig. 1 presents the total number of vaccinated respondents that match to target or non-target flu seasons by interview month. A substantial majority of vaccinations (97.1%) reported during interview months January–September correspond to the target flu season. Conversely, most vaccinations (79.7%) reported between October–December correspond to the post-target flu season.

In Table 1, we partition respondents into target and non-target flu seasons by applying the four methodologies under review.

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