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Cost-Effectiveness Analysis of a Television Campaign to Promote Seasonal Influenza Vaccination Among the Elderly

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ABSTRACT

Background: The U.S. policy goals regarding influenza vaccination coverage rate among the elderly include the increase in the coverage rate and the elimination of disparities across racial/ethnic groups. **Objective:** To examine the potential effectiveness of a television (TV) campaign to increase seasonal influenza vaccination among the elderly. **Methods:** We estimated the incremental cost-effectiveness ratio (ICER, defined as incremental cost per additionally vaccinated Medicare individual) of a hypothetical nationwide TV campaign for influenza vaccination compared with no campaign. We measured the effectiveness of the nationwide TV campaign (advertised once a week at prime time for 30 seconds) during a 17-week influenza vaccination season among four racial/ethnic elderly groups (N=39 million): non-Hispanic white (W), non-Hispanic African American (AA), English-speaking Hispanic (EH), and Spanish-speaking Hispanic (SH). **Results:** The hypothetical campaign cost was $5,960,000 (in 2012 US dollars). The estimated campaign effectiveness ranged from −1.1% (the SH group) to 1.42% (the W group), leading to an increased disparity in influenza vaccination among non-Hispanic white and non-Hispanic African American (W-AA) groups (0.6 percentage points), W-EH groups (0.1 percentage points), and W-SH groups (1.5 percentage points). The estimated ICER was $23.54 (95% confidence interval $14.21–$39.37) per additionally vaccinated Medicare elderly in a probabilistic analysis. Race/ethnicity-specific ICERs were lowest among the EH group ($22.27), followed by the W group ($22.47) and the AA group ($30.55). The nationwide TV campaign was concluded to be reasonably cost-effective compared with a benchmark intervention (with ICER $44.39 per vaccinated individual) of a school-located vaccination program. Break-even analyses estimated the maximum acceptable campaign cost to be $14,870,000, which was comparable to the benchmark ICER. **Conclusions:** The results could justify public expenditures on the implementation of a future nationwide TV campaign, which should include multilingual campaigns, for promoting seasonal influenza vaccination.

Keywords: cost-effectiveness, elderly population, influenza vaccination, television campaign.

Introduction

Influenza-associated disease is a major cause of death in the United States [1,2]. Influenza and pneumonia ranked ninth among all causes of death for all age groups [1] and seventh for the elderly in 2010 [3]. The elderly (65 years and older) accounted for 90% of deaths due to flu diseases [2]. In addition, the total economic costs of influenza amounted to $29 billion annually (adjusted to 2010 US dollars) including the direct medical costs ($10.2 billion) and the indirect costs (loss of productivity $18.8 billion) among the entire US population [4]. Specifically, the annual burden of medical costs on the elderly was $5.5 billion (adjusted to 2010 US dollars) [5].

Despite this, the influenza vaccination coverage rate among the elderly has been far from the 2020 Healthy People goal of 90% [6]. It fluctuated around 70%, on average, from the 2000 to 2001 influenza season to the 2012 to 2013 influenza season [7–10]. Also, persistent racial/ethnic disparities in influenza vaccination have been reported [7–10]. For instance, the influenza vaccination rates among racial/ethnicity groups for the 2012 to 2013 season were 67.9%, 54.5%, and 65.8% in non-Hispanic white (W), non-Hispanic African American (AA), and Hispanic (H) groups, respectively [9]. Disparities in influenza vaccination among W-AA and W-H groups were 13.4 and 2.1 percentage points, respectively [9].

Several potential determinants were suggested to explain why the vaccination rates remained at a suboptimal level among the Medicare elderly. One potential determinant is the time cost of vaccination, which was empirically suggested by a study of the nationally representative Medicare elderly [11]. The importance of time cost is also implied by the elimination of the out-of-pocket expenditure on influenza vaccination under Medicare since 1993 [12]. Options to reduce such time cost include a standing order vaccination program for patients admitted to a hospital [13] and taking advantage of clinic visits primarily for

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medical care other than vaccination to vaccinate for influenza [11]. Other potential determinants include individual-level demographic characteristics, socioeconomic factors, influenza vaccine supply, and influenza epidemic activity levels [11,14].

Potential determinants for racial/ethnic disparities are exemplified by racial/ethnic differences in perceptions about influenza vaccination [15]. For instance, the AA elderly had a distrust of the vaccine effectiveness [16] and hence were three times more likely to never receive influenza vaccination during their lifetime than were the W elderly [17]. Other determinants include less use of general preventive care among minority groups, provider bias, and differences in vaccine availability among minority groups [14,18].

On the basis of the recent literature and the potentially large positive impact of a nationwide television (TV) campaign, we focused on a nationwide TV campaign in this study. Our previous study found a strong association between nationwide TV network coverage on influenza-related topics and influenza vaccination among the Medicare elderly by analyzing the 1999 to 2001 Medicare Current Beneficiary Survey (MCBS) data [19]. In addition, the TV campaign was reported to be generally effective in changing health behavior (e.g., nutrition, physical activity, and use of tobacco, alcohol, and illicit drugs) and health service utilization (e.g., cancer screening, prevention of heart disease, immunization programs [for measles, mumps, and rubella], and antibiotic use) [20–22].

There were several TV campaigns to promote seasonal influenza vaccination, such as a Centers for Disease Control and Prevention–promoted campaign through various media including TV [23], a California statewide TV campaign [24], and corporate campaigns [25]. Nevertheless, to our knowledge, the effectiveness or the cost-effectiveness of these TV campaigns was not quantitatively evaluated, probably because of the methodological difficulties. Two foreign studies reported the effectiveness of a TV campaign for adult vaccination. One study from Sweden reported that the mass media campaign (including TV, newspapers, and posters) in a local community decreased the influenza-associated hospital treatments among the elderly [26]. The other study from Australia found that a local TV advertisement for free pneumococcal immunization (targeting community-dwelling individuals 50 years and older) statistically increased the vaccine order among physicians by 4.5% in 2006 [27].

To our knowledge, there is no study that has performed an economic evaluation (e.g., the cost-effectiveness) of a nationwide TV campaign for seasonal influenza vaccination operated by a single institution in the United States. To fill the gaps in the literature, the present study aimed to perform a cost-effectiveness analysis to examine whether the hypothetical nationwide TV campaign for seasonal influenza vaccination would be reasonably cost-effective among the US Medicare elderly as compared to no nationwide TV campaign. The present study focuses on the Medicare elderly population, mainly because the nationally representative data required to test the research question are available only among the Medicare population. This is also because the TV campaign is expected to be more effective among the elderly population than among the younger population because of the following reasons: The elderly (65 years and older) spent three times more time watching TV than did young adults (15–64 years) in 2006 [28]. Specifically, the elderly (65 years and older) were estimated to spend 2.9 to 4.5 hours per day (half of their leisure time) watching TV in 2012 [29]. TV was the second most widely used information source (the first source among mass media), after medical professionals, which was the most popular information source, on influenza vaccination among the elderly in 2000 [30].

This study reveals 1) whether the nationwide TV campaign for seasonal influenza vaccination is cost-effective compared with a benchmark intervention for influenza vaccination (for details, see the Methods section) and 2) the maximum total campaign cost allowable to be compared with this benchmark in cost-effectiveness. The results help justify the implementation of a future nationwide TV campaign for seasonal influenza vaccination and possibly other vaccinations.

Methods

Model Description

We developed a decision-analytical model to evaluate a hypothetical nationwide TV campaign to promote seasonal influenza vaccination among the US Medicare elderly from the societal perspective. The societal perspective was adopted because a federal or state government agency is more likely to financially support a future actual TV campaign than do other stakeholders because of the great benefits of the TV campaign for the general public. Despite the societal perspective, we focused on the intermediate outcome (i.e., vaccine receipt) without accounting for final outcomes such as influenza vaccine preventable medical care expenditure and productivity loss among the working population. This was because this potential cost-saving amount depends on influenza vaccine effectiveness (varying substantially across years owing to vaccine-antigen match), timing and severity of epidemic activity, and other year-specific factors [31–33]. Consequently, the present cost-effectiveness analysis focuses on the uncertainties regarding the TV campaign's narrowly defined cost and intermediate health outcome (i.e., vaccine receipt), excluding another set of uncertainties regarding year-to-year variations in potential cost savings.

This hypothetical TV campaign was assumed to be aired during a single influenza vaccination season in 2012. The target population is a hypothetical cohort of 2012 Medicare elderly 65 years and older (N = 39 million) [34], including only four racial/ethnic groups of non-Hispanic white (W), non-Hispanic African American (AA), English-speaking Hispanic (EH), and Spanish-speaking Hispanic (SH) [14,35]. Because past studies found that disparities in influenza vaccination among the non-Hispanic white and Hispanic groups are largely explained by language differences [14,36–38], EH and SH individuals were distinguished on the basis of whether Spanish was used in an interview in the MCBS.

The parameters in the decision tree model (Fig. 1) are listed in Table 1, reflecting the racial/ethnic differences in parameters including population proportion, baseline vaccination coverage rate, and effectiveness of the TV campaign [8–10,14,35,39]. All costs were converted to 2012 US dollars by using the consumer price index [40]. The decision tree model was constructed using TreeAge Pro 2013 software [41]. The MCBS data analysis used STATA version 12 [42].

Cost Parameter

The hypothetical TV campaign costs consisted of the one-time advertisement production cost and the broadcasting cost (Table 1) [43,44]. The latter covered the cost of airing for 30 seconds during prime time (8:00–11:00 PM) once a week on the three nationwide TV networks—ABC, CBS, and NBC—for 17 weeks from September 1, 2012, to December 31, 2012.

Effectiveness Parameters

Intervention effectiveness was defined in two ways. The primary analysis assumed that the increase in the vaccination rate is multiplicative to the baseline vaccination rate. For instance, an increase in the vaccination rate among the W vaccination group

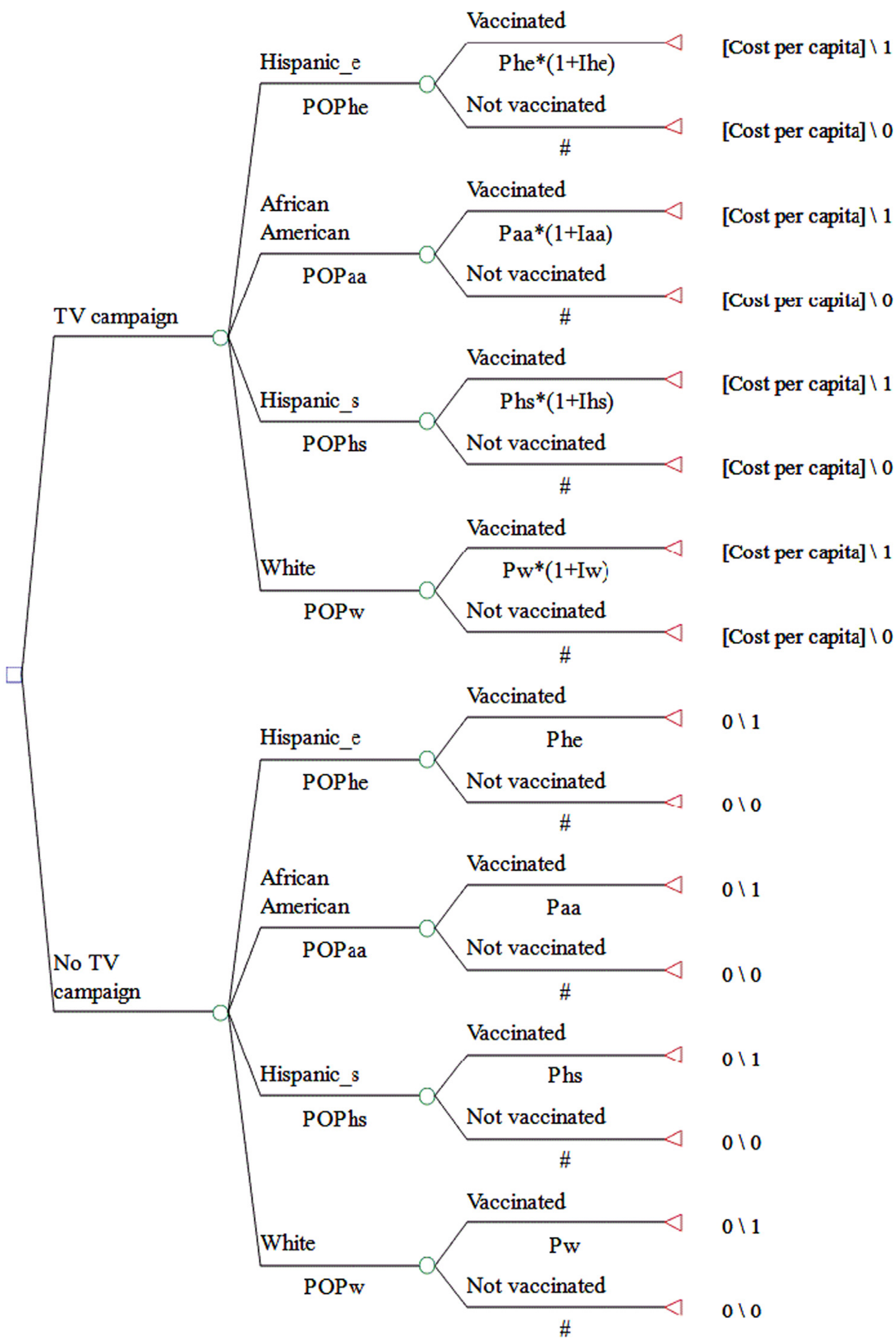

Fig. 1 – Decision tree model. Asterisk indicates the multiplication. Cost_camp, total cost of the TV campaign; Cost per capita (Cost_camp/POP), per capita TV campaign cost; Hispanic_e, English-speaking Hispanic; Hispanic_s, Spanish-speaking Hispanic; Paa, baseline (vaccination rate) of the non-Hispanic African American population; Paa*Iaa, increase in vaccination coverage rate is multiplicative to the baseline vaccination rate because of the TV campaign among the non-Hispanic African American population; Phe, baseline (vaccination rate) of the English-speaking Hispanic population; Phe*Ihe, increase in vaccination coverage rate is multiplicative to the baseline vaccination rate because of the TV campaign among the English-speaking Hispanic population; Phs, baseline (vaccination rate) of the Spanish-speaking Hispanic population; Phs*Ihs, increase in vaccination coverage rate is multiplicative to the baseline vaccination rate because of the TV campaign among the Spanish-speaking Hispanic population; POP, total number of the Medicare elderly including four racial/ethnic groups; POPaa, proportion of the non-Hispanic African American population; POPhe, proportion of the English-speaking Hispanic population; POPhs, proportion of the Spanish-speaking Hispanic population; POPw, proportion of the non-Hispanic white population; Pw, baseline (vaccination rate) of the non-Hispanic white population; Pw*Iw, increase in vaccination coverage rate is multiplicative to the baseline vaccination rate because of the TV campaign among the non-Hispanic white population.

Table 1 – Definitions of model parameters.

Variable	Estimate	Range	Source
Cost of TV campaign*			
Cost of TV campaign for Sep 1–Dec 31 (Cost_camp)	$5,960,000 (= A + (B × 3 × 17))	$4,146,000 to $9,988,000	
A: Production cost of 30-s campaign	$350,000		[43]
B: Broadcasting cost of 30-s prime time advertisement on three nationwide networks	$110,000	$74,000 to $189,000	[44]
Baseline vaccination coverage rate without the TV campaign			
Total	65.20%	59.6% to 69.6%	[8–10,39]
Non-Hispanic white (Pw)	67.70%	63.2% to 71.1%	[8–10,39]
Non-Hispanic African American (Paa)	50.10%	39.7% to 56.1%	[8–10,39]
Hispanic			
Hispanic (English speaking) (Phe)	65.50%	57.5% to 71.1%	[14]
Hispanic (Spanish speaking) (Phs)	41.90%	30.7% to 52.7%	[14]
Vaccination coverage rate increase (%) with the TV campaign (primary analysis)			
Non-Hispanic white (Iw)	1.42%	0.53% to 1.63%	Our analysis
Non-Hispanic African American (Iaa)	0.79%	0.73% to 2.26%	Our analysis
Hispanic			
Hispanic (English speaking) (Ihe)	1.40%	0.58% to 1.78%	Our analysis
Hispanic (Spanish speaking) (Ihs)	−1.10%	−4.18% to 3.07%	Our analysis
Vaccination coverage rate increase (pp) with the TV campaign (secondary analysis)			
Non-Hispanic white (Iw)	0.95 pp	0.35 to 1.06 pp	Our analysis
Non-Hispanic African American (Iaa)	0.39 pp	0.35 to 1.06 pp	Our analysis
Hispanic			
Hispanic (English speaking) (Ihe)	0.95 pp	0.35 to 1.06 pp	Our analysis
Hispanic (Spanish speaking) (Ihs)	−0.55 pp	−2.30 to 1.06 pp	Our analysis
Medicare elderly population			
Total (2012) (POP)	39,037,404		[34]
Non-Hispanic white (POPw)	83.30%		[35]
Non-Hispanic African American (POPaa)	9%		[35]
Hispanic (7.7%)			[35]
Hispanic (English speaking) (POPhe)	4.20%		[14]
Hispanic (Spanish speaking) (POPhs)	3.50%		[14]

Note. All costs in 2012 US dollars.
Cost_camp, total cost of TV campaign; Iaa, Increase in vaccination coverage rate among non-Hispanic African American population; Ihe, Increase in vaccination coverage rate among English speaking Hispanic population; Ihs, Increase in vaccination coverage rate among Spanish speaking Hispanic population; Iw, Increase in vaccination coverage rate among non-Hispanic white population; Paa, baseline (vaccination rate) of the non-Hispanic African American population; Phe, baseline (vaccination rate) of the English-speaking Hispanic population; Phs, baseline (vaccination rate) of the Spanish-speaking Hispanic population; POP, total number of Medicare elderly including four racial/ethnic groups; POPaa, proportion of the non-Hispanic African American population; POPhe, proportion of the English-speaking Hispanic population; POPhs, proportion of the Spanish-speaking Hispanic population; POPw, proportion of the non-Hispanic white population; pp, percentage point; Pw, baseline (vaccination rate) of the non-Hispanic white population.
* Rounded to 1000.

was the baseline vaccination rate (e.g., 70%) multiplied by the proportion (e.g., 0.95% × 70%). The secondary analysis assumed that the increase in the vaccination rate is additive (e.g., an increase by 0.95 percentage points), which does not depend on the baseline vaccination rate. We estimated the race/ethnicity-specific multiplicative increases (primary analysis) and additive increases (secondary analysis) in the vaccination rate by analyzing our original MCBS data. The results of primary and secondary analyses are reported in the Results section and in Appendix A found at http://dx.doi.org/10.1016/j.jval.2015.03.1794, respectively.

In the primary analysis, intervention effectiveness was measured by the number of additionally vaccinated Medicare elderly, which was calculated by multiplying 1) the number of 2012 Medicare elderly population [34] with 2) the proportion of each racial/ethnic group [14,35], 3) the race/ethnicity-specific baseline vaccination coverage rate, and 4) the race/ethnicity-specific change in the vaccination rate (percentage from the baseline rate) due to the TV campaign (Table 1). In the secondary analysis, intervention effectiveness was measured by multiplying component 1 with component 2 and 5) the race/ethnicity-specific change in the vaccination rate (percentage point) due to the TV campaign, which was independent of the baseline vaccination rate.

Components 1 and 2 were obtained from the Centers for Medicare & Medicaid Services report, the US Census Bureau 2012 population estimates, and the literature [14,34,35]. The hypothetical 2012 Medicare elderly sample included only W, AA, EH, and SH racial/ethnic groups (N = 39 million).

Component 3 was obtained from race/ethnicity-specific vaccination coverage rates from the 1999 to 2000 season to the 2012 to 2013 season for the total, W, and AA groups among the elderly [8–10,39]. Because these data did not distinguish the EH and SH groups in the Hispanic population, the vaccination coverage rate among the EH and SH groups was obtained from our previous study during the four seasons (from 2000–2001 to 2004–2005) [14]. The average, minimum, and maximum rates of vaccination coverage in those seasons were used to define parameter values and distributions [8–10,14,39].

Components 4 and 5 were derived from our original cross-sectional multivariate survival analyses of the 1999 to 2001 MCBS data set [45], and the distinction was made between the EH and SH groups (detailed results are reported in Appendix B found at http://dx.doi.org/10.1016/j.jval.2015.03.1794). These 3 years were chosen because they represent different levels of vaccine supply delay/shortage; that is, no delay/shortage in the 1999 to 2000 season, severe delay/shortage in the 2001 to 2002 season, and moderate delay/shortage in the 2002 to 2003 season [19].

Following our past study [19], we performed a multivariate survival analysis that used the generalized gamma model because of the following reasons: 1) implausibly large estimates in logit models, 2) unstable estimates in Cox models that cannot include geographic variations in covariates, and 3) Wald test results rejecting exponential, Weibull, and log-normal models while not rejecting gamma models. The dependent variable for the multivariate survival analysis was vaccine receipt date identified by analyzing Medicare claims data. This analysis aimed to estimate the race/ethnicity-specific association between the vaccine receipt timing (i.e., measured as the number of days from September 1) and the "preceding" daily TV coverage on influenza, controlling for potential confounding factors. The key covariate of daily TV coverage was measured by counting the number of TV program transcripts, for the three nationwide TV networks, that included the keywords of influenza/flu and vaccine delay/shortage [19]. Other covariates included three types of media, vaccine supply, regional/individual factors, individual demographic characteristics, and socioeconomic factors [19].

The interaction terms between race/ethnicity and daily TV coverage were tested to examine racial/ethnic differences in vaccination timing. The annual vaccination rates were predicted using the estimated coefficients of parameters. Then, the incremental effects of daily TV coverage on race/ethnicity-specific annual vaccination rates were predicted by increasing 1 unit of daily TV coverage. Those incremental effects of the daily TV coverage were used as a proxy for the race/ethnicity-specific change in the vaccination rate (percentage point) due to the TV campaign.

Cost-Effectiveness Analysis

We determined the incremental cost-effectiveness ratio (ICER) indicating incremental dollar value (2012 US dollars) per additionally vaccinated Medicare elderly because of the TV campaign compared with the no-TV campaign. We concluded that this TV campaign was cost-effective if its ICER was lower than the ICER of a similar benchmark intervention ($44.39 per additionally vaccinated individual) [46]. Among past similar interventions, the selected benchmark intervention of a school-located vaccination program was most similar to the present study in terms of its aim, broad target population, and potential positive spillover effect. In other words, this intervention of a school-located vaccination program was selected as a benchmark intervention because it aimed to motivate a broad patient population to come to a clinic for vaccination, not targeting a narrowly defined population such as a specific insurer's enrollees, patients visiting a clinic, and patients admitted to a hospital. In addition, the benchmark intervention of a school-located vaccination program motivated not only some parents to have their child vaccinated at a school-located vaccine clinic but also other parents to have their child vaccinated at a physician clinic (i.e., a positive spillover effect beyond vaccinations at a school) [46].

Other past similar interventions targeted specific populations, for example, a reminder intervention among a specific insurer's enrollees (ICER $3.98–$18.57 per vaccinated individual) [47], a reminder intervention among patients admitted to a hospital (ICER $77.07–$551.00 per vaccinated individual, including influenza vaccine administration cost) [48], and financial incentives to the primary care physicians (ICER $7.08 per vaccinated individual) [49].

The deterministic model used point estimates of all model parameters with an assumption of no vaccine delay/shortage during the influenza vaccination season. To address the model parameter uncertainty, we performed 1) one-way sensitivity analyses of the deterministic model and 2) probabilistic analyses. One-way sensitivity analyses changed the parameter values, with probable ranges presented in Table 1 on the basis of the literature and our MCBS analysis. Also, break-even analyses were performed to find threshold levels for model parameters to make the TV campaign equally or more cost-effective than the aforementioned benchmark intervention. Break-even analyses were performed using possible ranges of parameter values. These analyses were performed for each racial/ethnic group as well as for the whole population.

The probabilistic analyses used triangular distributions defined by likeliest values (using point estimates in a deterministic model) and minimum and maximum values (using ranges of estimates in one-way sensitivity analyses) for all model parameters listed in Table 1. To address the uncertainty of parameters, the mean and 95% confidence interval (CI) of the ICER were obtained by conducting Monte-Carlo simulation (10,000 iterations). If the 95% CI included $44.39 (the value of the benchmark intervention), the probability of ICERs (<$44.39) for 10,000 iterations was calculated.

To test the robustness of the cost-effectiveness analysis results across racial/ethnic-specific groups, we performed another set of sensitivity analyses, estimating ICERs unique to each of the four racial/ethnic groups. These subpopulation analyses examined how the effectiveness of the same TV campaigns among different racial/ethnic groups affected group-specific ICERs when the program cost (per person) is equal as in all other analyses. All other analyses estimated and used a common ICER estimate for all racial/ethnic groups.

Results

According to the deterministic model, the nationwide TV campaign for seasonal influenza vaccination increased the number of vaccinated Medicare elderly by 335,000 (rounded to the nearest 1,000) with the incremental cost of $5,960,000, compared with no such TV campaign, leading to the ICER of $17.79 (per additionally vaccinated Medicare elderly) (Table 2). This ICER estimate of the nationwide TV campaign for influenza vaccination was concluded to be cost-effective, and hence preferred to the no-TV campaign, on the basis of the fact that its ICER was smaller than the benchmark ICER ($44.39) [46].

The probabilistic model yielded results similar to those yielded by the deterministic model. The mean ICER for 10,000 estimates (iterations) was $23.54 (per additionally vaccinated Medicare elderly). The upper bound of the 95% CI for these ICER estimates, ranging from $14.21 to $39.37, was also below the benchmark threshold ICER value ($44.39). Thus, the cost-effectiveness of the nationwide TV campaign for influenza vaccination was concluded to be robust to the uncertainties of model parameters.

Table 3 summarizes the results of one-way sensitivity analyses of the deterministic model. For the parameters of broadcasting cost, baseline vaccination coverage rate, and vaccination coverage rate increase with the TV campaign (for each of the four racial/ethnic groups), the main ICER estimates among the whole population (Table 2) were robust to the probable ranges of these

Table 2 – Cost-effectiveness analysis.

Model	Strategy	Cost ($1000)*	Incremental cost ($1000)*	Effect (1000 persons)*	Incremental effect (1000 persons)*	ICER ($ per additionally vaccinated Medicare elderly)
Base-case model	Comparator	0		25,418		
	Intervention	5960	5960	25,753	335	17.79
Probabilistic model (95% CI)	Comparator	0		25,226 (24,157–26,207)		
	Intervention	6713 (4685–9226)	6713 (4685–9226)	25,522 (24,441–26,520)	296 (184–378)	23.54 (14.21–39.37)

Note. All costs in 2012 US dollars.
CI, confidence interval; ICER, incremental cost-effectiveness ratio, indicating the cost (dollar value) per additionally vaccinated Medicare elderly.
* Rounded to 1000.

parameters. Break-even analyses estimated that the TV campaign would remain more cost-effective than a benchmark intervention (a school-located vaccination program) [46] as long as either the total campaign cost is less than $14,870,000 (rounded to 10,000) or the vaccination coverage rate increase with the TV campaign is greater than 0.5% at least among the W group (not shown in the tables).

Although the nationwide TV campaign increased the overall influenza vaccination rate among the W, AA, and EH groups, it also increased racial/ethnic disparities in vaccination rates because of the differential TV campaign effects on the vaccination rate. Specifically, disparities in influenza vaccination among Non-Hispanic white and non-Hispanic African American (W-AA), Non-Hispanic white and English-speaking Hispanic (W-EH), and Non-Hispanic white and Spanish-speaking Hispanic (W-SH) groups increased by 0.6, 0.1, and 1.5 percentage points, respectively (Table 4).

Table 5 summarizes the results of another set of sensitivity analyses, subpopulation analyses for each racial/ethnic group. Among the four racial/ethnic groups examined, the TV campaign was most cost-effective among the EH group, followed by the W group. The ICERs estimated by the probabilistic model were $22.27 (as the mean, with 95% CI $12.87– $39.40) and $22.47 (as the mean, with 95% CI $13.15–$39.56) for the EH group and the W group, respectively. All these ICER estimates, for example, the means and the upper bounds of 95% CIs, were below the benchmark value ($44.39).

In contrast, the TV campaign was relatively less cost-effective among the AA group, with the ICER being $30.55 (as the mean, with 95% CI $15.03–$53.44). Because the 95% CI included the benchmark threshold ICER value ($44.39), the TV campaign was concluded to be relatively less cost-effective among the AA group than among W and EH groups. Among the SH group, the TV campaign was dominated by "without the TV campaign" because of the increased cost but the decreased vaccination rate after the TV campaign.

Table 3 – Summary of the results of one-way sensitivity analyses.

Variable	ICER ($ per additionally vaccinated Medicare elderly) (low end)	ICER ($ per additionally vaccinated Medicare elderly) (high end)
Broadcasting cost (74,431–188,974)	12.37	29.81
Vaccination coverage rate increase with the TV campaign		
Non-Hispanic white (0.53%–1.63%)	15.43	42.84
Non-Hispanic African American (0.73%–2.26%)	16.51	17.84
English-speaking Hispanic (0.58%–1.78%)	17.58	18.26
Spanish-speaking Hispanic (−4.18% to 3.07%)	16.59	18.79
Baseline vaccination coverage rate without the TV campaign		
Non-Hispanic white (63.2%–71.1%)	16.99	18.96
Non-Hispanic African American (39.7%–56.1%)	17.70	17.94
English-speaking Hispanic (57.5%–71.1%)	17.72	17.88
Spanish-speaking Hispanic (30.7%–52.7%)	17.70	17.87

Note. All costs in 2012 US dollars. Maximum acceptable campaign cost (when ICER = $44.39) = $14,874,000.
ICER, Incremental cost-effectiveness ratio, indicating the cost (dollar value) per additionally vaccinated Medicare elderly.

Discussion

Our findings are expected to make two types of contributions to the literature. One is the robust and reasonable cost-effectiveness of the hypothetical nationwide TV campaign for seasonal influenza vaccination, which helps justify a future campaign. The campaign's ICERs ($17.79–$23.54 [per additionally vaccinated Medicare elderly]) are lower than the benchmark ICER of $44.39 for a school-located vaccination program for elementary school students [46]. The other contribution is that the TV campaign effect was estimated to differ across racial/ethnic groups, leading to an increase in racial/ethnic disparities in influenza vaccination without additional considerations. Therefore, a future campaign needs to include supplemental activities to prevent a potential increase in racial/ethnic disparities in influenza vaccination. As discussed in further paragraphs, the additional cost of these supplemental activities appears less likely to change our qualitative conclusion about the cost-effectiveness of the TV campaign.

The robustness of the estimated cost-effectiveness of the TV campaign was quantitatively confirmed by the probabilistic model (Table 2), one-way sensitivity analyses of the deterministic model (Table 3), the comparable results across subpopulations

Table 4 – Racial/ethnic disparity of influenza vaccination coverage.

Variable	With TV campaign	Without TV campaign	Disparity increase with TV campaign
Non-Hispanic white	68.70%	67.70%	NA
Non-Hispanic African American (disparity with white)	50.5% (18.2%)	50.1% (17.6%)	0.6 pp
English-speaking Hispanic (disparity with white)	66.4% (2.3%)	65.5% (2.2%)	0.1 pp
Spanish-speaking Hispanic (disparity with white)	41.4% (27.3%)	41.9% (25.8%)	1.5 pp

NA, not applicable; pp, percentage point.

(Table 5), and the secondary analysis with a different set of effectiveness assumptions (Appendix Tables A1–A4 found at http://dx.doi.org/10.1016/j.jval.2015.03.1794). One exception was observed among the SH group. For this group, the TV campaign was dominated by "the comparator (no-TV campaign)" because of a reduction in the number of vaccinated SH elderly after the campaign (Table 5). In addition, although still cost-effective, the TV campaign tended to be relatively less cost-effective among the AA group than among W and EH groups because of smaller positive effects of the TV campaign among the AA group.

These differential TV campaign effects across racial/ethnic groups were estimated by performing the original cross-sectional multivariate survival analyses using MCBS data merged with the data on TV coverage on influenza. These race/ethnicity-specific effects were estimated with consideration of racial/ethnic differences in individual socioeconomic status and other potential confounding factors because these factors were included as covariates in the aforementioned multivariate survival analyses.

Two possible reasons may explain such different campaign effects. The first reason is applicable for the AA group and for the SH group. Our past study found that the limited influenza vaccine supply was positively associated with increased racial/ethnic disparities in influenza vaccination [14]. This was possibly because health care providers located in areas with a larger proportion of underserved racial/ethnic populations may have experienced a relatively greater decrease in influenza vaccine provision than did providers in areas with a lower proportion [14]. In other words, when the TV coverage on influenza would increase the demand for influenza vaccination [19], a relative vaccine supply shortage might occur. Under the limited influenza vaccine supply, all racial/ethnic minority groups would be less likely to have access to influenza vaccine even during their clinic visits than would the W group.

The second reason is that English is a language barrier for the SH group [50]. The elderly in this SH group are less likely than other racial/ethnic groups to be exposed to English TV programs covering influenza because they are more likely to watch Spanish TV networks. This information exposure disparity, combined with the increased demand for influenza vaccine among all other racial/ethnic groups, could result in the relatively limited access to influenza vaccine among the SH group, ultimately leading to a negative effect of the campaign among the SH group.

To prevent the potential increase in racial/ethnic disparities in influenza vaccination, a future TV campaign needs to include supplemental activities such as airing multilingual campaign advertisements (e.g., on Spanish TV networks) and sustaining vaccine delivery to safety net providers for vulnerable racial/ethnic minority groups. Our qualitative conclusion about the

Table 5 – Subpopulation analyses: Separate cost-effectiveness analysis for each race/ethnic group.

Race/ethnicity	Strategy	Base-case model					Monte- Carlo simulation ICER (95% confidence interval)
		Cost ($1000)*	Incremental cost ($1000)*	Effect (1000 persons)*	Incremental effect (1000 persons)*	ICER ($ per additionally vaccinated Medicare elderly)	
Non-Hispanic white	Comparator	0		22,014			
	Intervention	4965	4965	22,326	312	15.88	22.47 (13.15–39.56)
Non-Hispanic African American	Comparator	0		1,760			
	Intervention	536	536	1,774	14	38.57	30.55 (15.03–53.44)†
Hispanic (English speaking)	Comparator	0		1,066			
	Intervention	248	248	1,080	14	16.65	22.27 (12.87–39.40)
Hispanic (Spanish speaking)‡	Comparator	0		578			
	Intervention	211	211	572	−6	Dominated	Dominated

Notes. These subpopulation analyses examined how the effectiveness of different TV campaigns among racial/ethnic groups affects the group-specific ICERs when the program cost (per person) is equal as in all other analyses presented in Tables 1–4. All other analyses (Tables 1–4) estimated and used a common ICER estimate for all racial/ethnic groups. All costs in 2012 US dollars.

ICER, incremental cost-effectiveness ratio, indicating the cost (dollar value) per additionally vaccinated Medicare elderly.

* Rounded to 1000.

† ICER < $44.39: 90% (African American) of 10,000 iterations.

‡ "TV campaign" was dominated by "without the TV campaign."

cost-effectiveness of the TV campaign is expected to remain even if a future TV campaign includes the additional cost of these supplemental activities. This is partly because our break-even analysis estimated the maximum acceptable campaign cost (comparable to the school-located influenza vaccination program) to be $14.9 million, which is 2.5 times greater than the campaign cost assumed in the present analysis.

This is also partly because the positive campaign spillover effect is highly likely to occur among the younger population (children and adults younger than 65 years, which is a 6.3 times larger population than the elderly population) [51]. Such additional effectiveness will make the TV campaign more cost-effective. It is difficult to estimate, however, this spillover effect of a TV campaign because the vaccination timing data (i.e., claims data) were available only for fragmented younger populations. Despite no direct evidence of the TV vaccination campaign effectiveness among the younger population, one study reported that a TV campaign was effective for tobacco control among nonelderly populations (younger than 65 years) [52].

As explained in the Methods section, our analysis excluded another set of uncertainties regarding the potential cost saving that may vary substantially across years. If influenza vaccination is certain to decrease the direct medical expenditure by $40 per vaccinated elderly, the focused TV campaign would be a cost-saving intervention. A future study is expected to additionally model these potential cost savings by influenza vaccination subsequent to a TV campaign.

Our analyses may have three limitations. The first is the potentially limited external validity of the TV campaign effectiveness based on the 1999 to 2001 data analysis that did not explicitly account for the Internet media. Despite the increased role of the Internet media and the relatively reduced role of TV [53], the results of the present study are expected to be reasonably generalizable because of the following reasons: The recent literature showed that the elderly still spent half of their leisure time watching TV in 2012 [29] and that the Internet media had a complementary relationship with the traditional mass media in 2003 [54]. Also, because our original analyses included covariates of other media such as a wire service news agency (Associated Press) and a nationwide newspaper (*USA Today*) [19], the TV effectiveness seems less likely to be substantially overestimated.

The second limitation is the uncertainty regarding the TV campaign effectiveness, which is potentially influenced by the baseline vaccination rate and a delay/shortage of influenza vaccine supply. The former issue is addressed by our model parameter baseline vaccination rate, which was defined by the range of 14 seasons from 1999 to 2012. The latter issue is partly addressed by our analysis that represents three levels of vaccine supply during three seasons, that is, no, moderate, or severe delay/shortage, as explained in the Methods section [14,19].

The third limitation is our assumption that the efficacy of the daily TV coverage on influenza-related topics is equivalent to the effectiveness of the TV campaign. Although the validation of this assumption needs the implementation of an actual TV campaign, the effectiveness of the actual TV campaign could be lower than the estimated efficacy of the daily TV coverage. Because the content of an actual TV campaign would substantially influence the TV campaign effectiveness [55], the content will need to be carefully designed.

Conclusions

We conclude that a future nationwide TV campaign for seasonal influenza vaccination would be reasonably cost-effective when the cost-effectiveness was evaluated among the Medicare elderly only. Although the TV campaign would increase the overall vaccination coverage rates among the Medicare elderly, the differential TV campaign effect across racial/ethnic groups would lead to increased racial/ethnic disparities in vaccination. To prevent the potential increase in racial/ethnic disparities in influenza vaccination, a future TV campaign needs to include supplemental activities such as airing multilingual campaign advertisements (e.g., on Spanish TV networks), local campaigns/outreach programs, and sustaining vaccine delivery to safety net providers for vulnerable racial/ethnic minority groups.

Our qualitative conclusion about the TV campaign cost-effectiveness is expected to be robust, even if a future TV campaign accounts for the additional cost of these supplemental activities that are not included in the present study. This is partly because the maximum acceptable campaign cost is 2.5 times greater than the campaign cost assumed in the present study and partly because the positive campaign spillover effect is highly likely to occur among a younger population other than the Medicare elderly.

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Supplemental Materials

Supplemental material accompanying this article can be found in the online version as a hyperlink at http://dx.doi.org/10.1016/j.jval.2015.03.1794 or, if a hard copy of article, at www.valueinhealthjournal.com/issues (select volume, issue, and article).

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