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Cost-Effectiveness of a Program to Eliminate Disparities in Pneumococcal Vaccination Rates in Elderly Minority Populations: An Exploratory Analysis

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ABSTRACT

Objective: Invasive pneumococcal disease is a major cause of preventable morbidity and mortality in the United States, particularly among the elderly (>65 years). There are large racial disparities in pneumococcal vaccination rates in this population. Here, we estimate the cost-effectiveness of a hypothetical national vaccination intervention program designed to eliminate racial disparities in pneumococcal vaccination in the elderly. **Methods:** In an exploratory analysis, a Markov decision-analysis model was developed, taking a societal perspective and assuming a 1-year cycle length, 10-year vaccination program duration, and lifetime time horizon. In the base-case analysis, it was conservatively assumed that vaccination program promotion costs were $10 per targeted minority elder per year, regardless of prior vaccination status and resulted in the elderly African American and Hispanic pneumococcal vaccination rate matching the elderly Caucasian vaccination rate (65%) in year 10 of the program. **Results:** The incremental cost-effectiveness of the vaccination program relative to no program was $45,161 per quality-adjusted life-year gained in the base-case analysis. In probabilistic sensitivity analyses, the likelihood of the vaccination program being cost-effective at willingness-to-pay thresholds of $50,000 and $100,000 per quality-adjusted life-year gained was 64% and 100%, respectively. **Conclusions:** In a conservative analysis biased against the vaccination program, a national vaccination intervention program to ameliorate racial disparities in pneumococcal vaccination would be cost-effective.

Keywords: cost-effectiveness, disparities, invasive pneumococcal disease, vaccination.

Introduction

Invasive pneumococcal disease (IPD) is a major cause of morbidity and mortality in the United States, causing 40,000 hospitalizations and 4,000 deaths annually [1]. Elderly populations are particularly vulnerable, with greater than 30% of IPD-attributable hospitalizations and 50% of IPD-attributable deaths occurring in this group [2].

The 23-valent pneumococcal polysaccharide vaccine (PPSV23) prevents IPD and is universally recommended at age 65 years in the United States [3,4]. Current pneumococcal vaccination rates in the elderly, however, remain far below the 90% goal set by the *Healthy People 2010* objective, with substantial racial disparities; only 65% of Caucasians, 45% of African Americans, and 40% of Hispanics in this age group reported having ever received pneumococcal vaccination in 2009 [5]. Racial vaccination disparities are particularly concerning given significantly higher IPD incidence in African American, Hispanic, and Native-American populations [2,6–8].

Prior research suggests that national programs to reduce disparities in influenza vaccination in elderly minorities can be cost-effective [9]. This work, however, has not been extended to pneumococcal vaccination and, thus, it remains unclear as to whether a program to reduce disparities in pneumococcal vaccination would also be cost-effective. Here, a Markov decision-analysis model was used to assess the cost-effectiveness of a hypothetical national vaccination intervention program designed to eliminate known racial disparities in pneumococcal vaccination rates in the elderly. The goal of this exploratory analysis was to quantify broad cost and effectiveness parameters that a cost-effective vaccination program would need to satisfy, and not to specifically delineate program parameters.

Methods

Perspective and Model Cohort

In the base-case analysis, a societal perspective was taken, including both direct medical and direct nonmedical costs and following the reference case recommendations of the US Panel on Cost-Effectiveness in Health and Medicine [10]. The model cohort was the combined 2006 US 65-year-old African-American and Hispanic birth cohort. We assumed that individuals had

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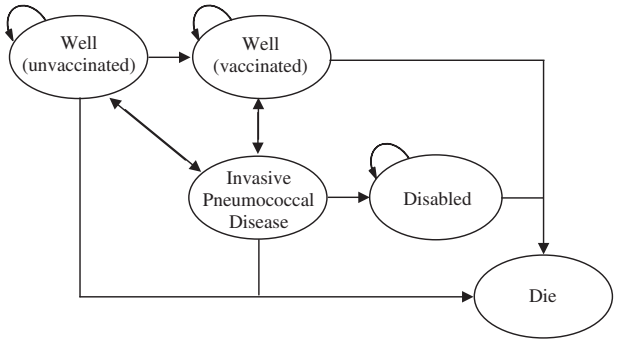

Fig. 1 – The Markov state transition diagram. The only differences between the intervention and no-intervention arms of the model are the cost of the vaccination program and the probability of receiving pneumococcal vaccination in every Markov cycle.

either not previously received the PPSV23 or, if they had, there was no residual IPD protective immunity.

Model Structure

To estimate the cost-effectiveness of a hypothetical US national vaccination intervention program to eliminate racial disparities in pneumococcal vaccination rates, a Markov decision-analysis model was developed by using TreeAge Pro 2009 (TreeAge Software, Inc., Williamstown, MA). The model used a 1-year cycle length and a lifetime time horizon, examining a 10-year vaccination intervention program. The 10-year program duration allowed for assumptions regarding declining program impact on population vaccination rates and declining vaccination-related IPD immunity with time. In both the intervention and no-intervention arms of the model, the target population began in a well (-unvaccinated) health state and transitioned to well (-vaccinated), IPD, disabled, or dead health states on the basis of annual probabilities of receiving vaccination, acquiring IPD, becoming disabled because of IPD, or dying because of IPD or other causes (Fig. 1). Annual mortality rates due to other causes were modeled on the basis of 2006 US mortality tables [11]. Given little data on the likelihood of disability with IPD, we used IPD meningitis rates as a proxy, understanding that not all meningitis leads to disability and that other forms of IPD can. We assumed that all IPD cases were hospitalized and did not first seek outpatient care, biasing the model against the vaccination program [2]. The only differences between the model arms were vaccination program costs and the probability of vaccination in model years 1 to 10.

IPD Incidence, Disability, and Mortality

Age-specific estimates of IPD incidence, disability (meningitis), mortality, vaccine serotype coverage, and the likelihood of immunocompromising conditions were obtained from 2007-2008 Active Bacterial Core surveillance data (Table 1). As IPD incidence—but not IPD case fatality—is known to vary by race, race-specific estimates of IPD incidence were incorporated [2,6–8]. African American IPD incidence was estimated by assuming that the proportion of IPD cases for each African American age cohort was the same as the proportion of IPD cases for each age cohort in the entire elderly population. This assumption was tested in sensitivity analyses in which IPD incidence was varied from 80% to 120% of the base-case value to examine model robustness when this assumption was relaxed. Lacking empirical data, we estimated IPD incidence in Hispanics on the basis of relative incidence rates of IPD in African American and Hispanic pediatric populations (relative risk 1.22:1) [7]. Because these are pediatric literature data, a secondary analysis was performed in which the relative IPD risk in these populations was varied from 80% to 120% of the base-case value, based on author estimates, to account for possible differences between pediatric and elderly cohorts. A population-weighted average IPD incidence was then estimated from the elderly African American and Hispanic populations on the basis of the relative size of these two populations (ratio 1.49:1) [12]. This IPD incidence estimate is in part a function of current pneumococcal vaccination uptake and thus likely underestimates IPD incidence when the theoretical absence of PPSV23 is modeled. To account for current pneumococcal vaccination effects on IPD incidence rates, elderly African American and Hispanic IPD rates were adjusted on the basis of data from a previous study suggesting that PPSV23 had led to IPD incidence reductions of 27.8, 13.5, 11.0, 1.7, and 3.4%, respectively, in the 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 years and older age cohorts across races (Table 1) [13]. We elected not to model changes in herd immunity for several reasons. First, the elderly IPD incidence rate has been stable from 2005 to 2010 [1,14]. Second, it is difficult to predict the impact of the recently

Table 1 – Epidemiology of invasive pneumococcal disease (IPD) in the US elderly population, 2007–2008.

	Age cohorts (y)			
	65–69	70–79	≥80	Source
IPD cases per 100,000 per year in the general population (all races)	25.9	33.9	60.1	ABCs
African American population	41.6	54.5	96.4	Estimate*†
Hispanic population	34.0	44.6	78.9	Estimate*‡
African American, Hispanic weighted average	38.5	50.5	89.3	Estimate*§
IPD outcomes per 100,000 per year in the general population (all races)				
IPD meningitis	1.6	1.3	1.3	ABCs
IPD death	2.9	3.9	11.9	ABCs
PPSV23 vaccine serotype coverage (all races)	74.1%	65.8%	62.9%	ABCs
Population immunocompromised (all races)	13.1%	20.2%	23.8%	ABCs

ABCs, Active Bacterial Core surveillance network; PPSV23, 23-valent pneumococcal polysaccharide vaccine.
* Estimates of race-level IPD incidence do not include corrections for prior vaccination status explained in the text.
† Based on ABCs population-level data on the incidence of IPD in the African American population.
‡ Based on relative incidence of IPD in African American and Hispanic pediatric populations [7].
§ Based on incidence of IPD in African American and Hispanic elderly populations and relative population sizes [12].