

Cost-Minimization Analysis of the U.S. Army Accession Screening and Immunization Program

MAJ Jeff Tzeng, MC USA*; CAPT Christopher Jankosky, MC USN*; Hayley Hughes, DrPH, MPH†

ABSTRACT Objectives: Significant Army resources are utilized to identify nonimmune recruits for targeted vaccinations against hepatitis A, hepatitis B, measles, rubella, and varicella. Therefore, a cost-minimization analysis between the Accession Screening and Immunization Program (ASIP) and the previously utilized universal vaccination program will assist military public health policy makers in decisions that enhance force health protection. Methods: Serological immunity data on 41,146 Fort Leonard Wood, Missouri, Army basic training recruits aged 17 to 42 years from October 1, 2007 to September 30, 2009 were utilized. Vaccination, serology, and other direct and indirect costs were determined using the Federal Supply Schedule and local base immunization data. TreeAge Pro 2009 version 1.0.2 was used for the analysis. Results: The cumulative annual cost for the universal vaccination program totaled \$1,504,587, whereas the cumulative costs for the ASIP totaled \$1,094,025, for a cost-savings of \$410,561 annually at this basic training site. Conclusions: Over \$400,000 of annual savings was realized from the ASIP compared to universal vaccination at Fort Leonard Wood, thus confirming the cost-savings theorized by the implementation of the ASIP.

INTRODUCTION

In 2005, the U.S. Army instituted a system wide immunization program called the Accession Screening and Immunization Program (ASIP).¹ The purpose of the ASIP was to ensure the highest level of immunity against hepatitis A, hepatitis B, measles, rubella, and varicella, while reducing overall vaccination costs. This program was focused on incoming enlisted military recruits at all five Army basic combat training sites: Fort Benning, Fort Knox, Fort Sill, Fort Jackson, and Fort Leonard Wood. The standards for immunization delivery are outlined in the ASIP policy and direct training posts to perform serological screening associated with these five vaccine-preventable diseases. Current Army vaccination dosing schedules follow the recommendations of the Centers for Disease Control and Prevention and the Advisory Committee on Immunization Practices: measles/mumps/rubella (MMR)—two doses (0, 4 weeks), hepatitis A—two doses (0, 6 months), hepatitis B—three doses (0, 1, 6 months), and varicella—two doses (0, 4 weeks).²

ASIP sites serologically test for hepatitis A, hepatitis B, varicella, measles, and rubella immunity. If the recruit shows serological immunity, he/she does not receive that respective vaccination and evidence of immunity is recorded in the Army's electronic immunization tracking system, Medical Protection System. If the recruit does not show evidence of serological immunity, he/she receives the vaccination during basic training. Serological testing for mumps did not occur because of the high level of concurrent immunity of mumps in recruits who were immune to measles and rubella (92.2% to 96.1%).³ Nonimmunity for either measles or rubella will result in required vaccination with MMR. Vaccination of

MMR was only averted when both measles and rubella immunity was evident. Recruits who were 18 years or older and required both hepatitis vaccines received the bivalent hepatitis A and hepatitis B vaccine. Younger recruits, along with those who required only hepatitis A or B, received the respective monovalent hepatitis vaccine. Adult doses of monovalent hepatitis A vaccines were given to those who were 19 years and older. Adult doses of monovalent hepatitis B vaccines were given to those who were 20 years and older. If the recruit was younger than these ages, then pediatric doses of monovalent vaccines were given. Because of the length of basic training, recruits only receive the 0 (initial) and 1 month doses of any vaccine series started. Subsequent doses were given when due, usually during advanced training or at their next duty station.

Before the implementation of the ASIP, the Army administered MMR, hepatitis A, and hepatitis B vaccines universally to all incoming recruits without screening for pre-existing immunity. Varicella vaccine administration before the implementation of ASIP, however, was based on a questionnaire for a negative history of varicella vaccine or disease.⁴

With approximately 120,000 new Army recruits annually, the cost expenditures for vaccines are substantial, and the projected decrease in unnecessary vaccinations, based on pre-existing immunity, should result in cost-savings to the Army compared to the universal vaccination program. Previous estimates for unnecessary vaccines (MMR, hepatitis A, hepatitis B, and varicella) for Army basic combat training sites were approximately \$41 million in cumulative costs for fiscal years 2006–2011.⁴ In 2007, approximately 1 year after implementation of the ASIP, an economic analysis was performed, supporting the assertion that the vaccine cost-savings exceeded the cost of implementing local serologic screening programs.⁵

It has been several years since full implementation of the ASIP in 2006 and with 2 years of retrospective data from one site, a comprehensive cost comparison of the ASIP to

*Department of Preventive Medicine and Biometrics, Uniformed Services University of the Health Sciences, Room A1040, 4301 Jones Bridge Road, Bethesda, MD 20814-4712.

†Military Vaccine (MILVAX) Agency, 7700 Arlington Boulevard, Falls Church, VA 22042.

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the universal vaccination program can determine whether the ASIP policy is producing the cost savings anticipated. To accomplish this, a cost-minimization analysis was conducted between the ASIP and the universal vaccination programs by evaluating the results of one Army basic combat training site as a surrogate for the remaining four basic combat training sites. This operational evaluation of the ASIP will update previous analyses and the results of this study will provide military public health leaders with the data and an evidence-based analysis to construct future vaccination policies.

METHODS

Alternatives and Assumptions

The efficacy of the two vaccination strategies (ASIP and universal) were assessed using a cost-minimization analysis over a 2-year time period.^{6,7} Assumptions include equal immunogenicity in both strategies and the cost of vaccination, antibody serology testing, labor, and adverse events resulting from vaccinations.

Construction of Decision Tree

A decision tree was constructed using standard software TreeAge Pro 2009 version 1.0.2 (TreeAge Software, Williamstown, Massachusetts) and analyzed to model the current ASIP vaccination algorithm (64 possible vaccination combinations, based on age and immunity status) and compared it to universal vaccination method (eight possible vaccination combinations based on age and theoretical reported history of varicella immunity). A simplified schematic of the decision model is shown in Figure 1.

Data

Under an approved research protocol by the Uniformed Services University of the Health Sciences Institutional Review Board, deidentified serological immunity data (hepatitis A, hepatitis B, measles, rubella, and varicella antibodies) and

demographic data (gender, race, and age at time of serology) on 41,164 basic training recruits from Fort Leonard Wood, Missouri, were obtained from the Military Vaccine (MILVAX) Agency from October 1, 2007 to September 30, 2009. Serological results of varicella zoster, measles, and rubella IgG antibodies, hepatitis A virus IgG/IgM antibody, and hepatitis B virus surface antibody (IgG Ab) were analyzed. The serological data were categorized by MILVAX as immune, nonimmune, or equivocal; per ASIP guidelines, equivocal results were categorized as nonimmune.

The proportions of the study population by demographic variables (i.e., gender, age, and ethnicity) and serological immunity status for the five vaccine-preventable diseases were analyzed using SPSS for Windows version 16.0 (IBM, Armonk, New York).

Vaccine-specific rates of adverse events were obtained from the scientific literature (Table I). Mild vaccine-related side effects from hepatitis A and B vaccinations include localized redness, mild fever, or headaches, but are rare.⁸⁻¹¹ Severe adverse events such as respiratory distress and anaphylaxis from monovalent and bivalent hepatitis A and B vaccines were similar at less than 1 per 100,000 doses.⁸⁻¹¹ The attenuated live-virus vaccines, MMR and varicella, have a higher rate of mild side effects at 50 and 1,000 per 100,000 doses, respectively, but with severe adverse events rarely occurring.¹²⁻¹⁶

Cost Calculation of ASIP and Universal Vaccination Program

The cost of vaccination per recruit was calculated for each of the 64 possible vaccination combinations for the ASIP and eight possible vaccination combinations for the universal vaccination program. Vaccine costs were obtained through the Federal Supply Schedule for August 2008.¹⁷ Additionally, the ASIP costs included universal serological testing for hepatitis A and B, measles, rubella, and varicella and included laboratory equipment contracts, reagents, reagent storage,

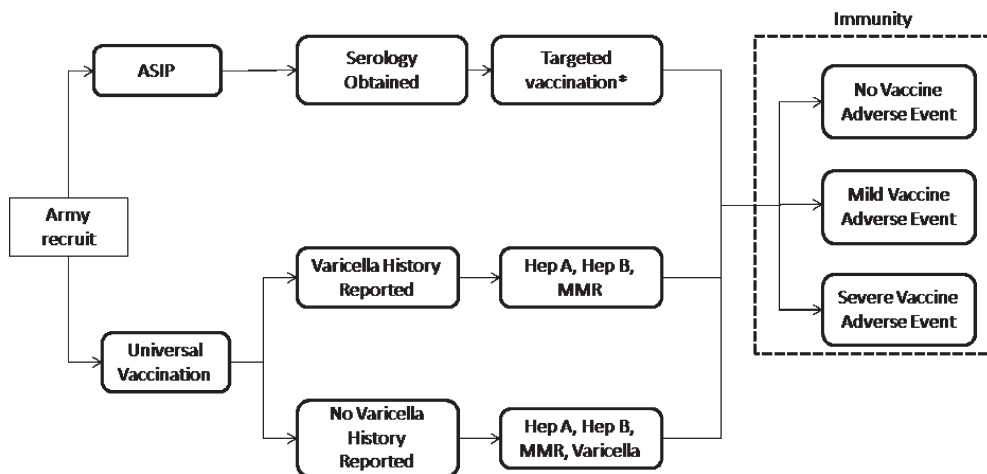


FIGURE 1. Simplified schematic of decision tree model. *Targeted vaccination based on serology results, as summarized in Table IV.

TABLE I. Mild and Severe Vaccine-Related Adverse Event Rates for Analytic Model

Vaccine Type	Mild Rates (Per 100,000 Doses)	Severe Rates (Per 100,000 Doses)	Source
Hepatitis A	10	<1	7-10
Hepatitis B	0	<1	7-10
Bivalent Hepatitis A and B	0	<1	7-10
MMR	50 (33-1,600)	0.1 (0.1-3)	11-14
Varicella	1,000 (1,000-2,000)	0.2 (0.2-1.4)	11-14

supplies, and laboratory personnel costs.^{4,5} No laboratory costs were incurred in the cost calculation of the universal vaccination for hepatitis A and B, measles, rubella, and varicella since vaccinations were administered for hepatitis A and B, measles, and rubella regardless of prior immunity status. Varicella vaccinations were determined based on a self-reported varicella exposure questionnaire; however, the costs of these questionnaires were negligible and not included in the cost analysis. Table II details all costs utilized in the model in 2011 adjusted dollars (Bureau of Labor and Statistics, <http://data.bls.gov/cgi-bin/cpicalc.pl>). This included costs of vaccine-related adverse events from hepatitis A, hepatitis B, MMR, and varicella that were obtained from scientific literature.^{8,13,14,17,18} A sensitivity analysis^{6,7} was conducted to test the robustness of the eco-

nommic model using various vaccine-related adverse event rates, serological testing costs, and personnel labor costs.

RESULTS

Seroprevalence and Demographics

A total of 41,164 recruits at Fort Leonard Wood during October 1, 2007 to September 30, 2009 were analyzed. Age ranged from 17 to 42 years (mean = 20.8 years, SD 4.2 years). Males and females represented 76.2% and 23.8%, respectively (Table III). Caucasians represented the largest proportion of the study population at 73.8%, followed by African Americans at 13.2%.

As displayed in Table III, 6.4% of recruits were serologically immune to hepatitis A only, 43.7% were immune to hepatitis B only, 13.0% were immune to both hepatitis A and B, and 36.9% were nonimmune to both hepatitis A and B. Although the majority of recruits were serologically immune to both measles and rubella (63.3%), 8.1% were

TABLE II. Cost Estimates and Model Data Adjusted to 2011 Dollars

Parameter	Base Case (Sensitivity Range) (\$)	Source
Vaccine ^a		
Hepatitis A (Pediatric Dose) 0.5 mL	14.01	16
Hepatitis A (Adult Dose) 1.0 mL	19.72	16
Hepatitis B (Pediatric Dose) 0.5 mL	8.43	16
Hepatitis B (Adult Dose) 1.0 mL	26.10	16
Bivalent Hepatitis A and B	29.33	16
Varicella	68.93	16
MMR	37.74	16
Serology Testing Reagent ^a		
Hepatitis A	4.11 (4.10-4.12)	4
Hepatitis B	4.32 (4.23-4.36)	4
Measles	2.51 (2.35-2.66)	4
Rubella	2.13 (1.90-2.35)	4
Varicella	2.43 (2.35-2.52)	4
Diagnostic Testing Platform ^b		
Hepatitis A and B	207,074 (205,493-208,655)	4
Measles, Rubella, Varicella	152,802 (139,103-167,556)	4
Personnel Labor Cost ^b		
2 Full-Time Equivalent	92,209 (89,574-94,843)	4
Adverse Events		
Mild	67.98 (67.98-147.61)	7, 12, 13
Severe	440.34 (161.50-31,146.48)	7, 12, 13

^aPer dose or test. ^bAnnual cost.

TABLE III. Summary of Recruit Demographics at Fort Leonard Wood, Missouri, From October 1, 2007 to September 30, 2009

	Frequency	Percent
Gender		
Male	9,814	23.8
Female	31,350	76.2
Total	41,164	100.0
Race		
Asian	1,186	2.9
African American	5,441	13.2
Hispanic	3,691	9.0
Native American	380	0.9
Caucasian	30,368	73.8
Other	98	0.2
Total	41,164	100.0
Serology		
Hepatitis Immune		
A Only	2,635	6.4
B Only	18,004	43.7
A and B	5,343	13.0
Nonimmune	15,182	36.9
Measles/Rubella Immune		
Measles Only	9,072	22.0
Rubella Only	2,699	6.6
Measles and Rubella	26,069	63.3
Nonimmune	3,324	8.1
Varicella		
Immune	38,657	93.9
Nonimmune	2,507	6.1

TABLE IV. Frequencies and Percentages of Vaccine Combinations for ASIP and Universal Vaccination Program (N = 41,164)

S. No.	Vaccines Administered				≥20 Years Old		19 Years Old		18 Years Old		17 Years Old	
	Hepatitis A	Hepatitis B	MMR	Varicella	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
ASIP				X	609	1.5	314	0.8	610	1.5	205	0.5
	2	X		X	2,256	5.5	1,139	2.8	1,473	3.6	555	1.3
	3	X	X	X	3,365	8.2	927	2.3	1,106	2.7	420	1.0
	4	X			5,007	12.2	2,411	5.9	3,081	7.5	1,035	2.5
	5		X	X	422	1.0	172	0.4	270	0.7	91	0.2
	6	X	X		4,999	12.1	1,307	3.2	1,550	3.8	565	1.4
	7		X		814	2.0	221	0.5	341	0.8	113	0.3
	8	X		X	138	0.3	92	0.2	148	0.4	61	0.1
	9		X	X	34	0.1	15	0.0	33	0.1	15	0.0
	10	X	X	X	249	0.6	81	0.2	82	0.2	46	0.1
	11			X	41	0.1	36	0.1	46	0.1	17	0.0
	12	X		X	201	0.5	121	0.3	193	0.5	93	0.2
	13		X	X	41	0.1	21	0.1	27	0.1	5	0.0
	14			X	60	0.1	43	0.1	55	0.1	28	0.1
	15				1,230	3.0	661	1.6	1,044	2.5	344	0.8
	16	X	X	X	218	0.5	110	0.3	122	0.3	35	0.1
Universal	1	X	X	X	18,702	45.4	7,152	17.4	9,475	23.0	3,328	8.1
Vaccination	2	X	X	X	982	2.4	519	1.3	706	1.7	300	0.7
Program												

nonimmune to both, 22% were immune to measles only, and 6.6% were immune to rubella only. Frequencies of the vaccination combinations under the ASIP and universal vaccination program of the recruit population are summarized in Table IV.

ASIP and Universal Vaccination Program Costs and Sensitivity Analysis

The cumulative annual cost for the universal vaccination program totaled \$1,504,587, whereas the cumulative costs for the ASIP totaled \$1,094,025 (Table V). This equals a cost-savings of over \$400,000 annually from utilizing the ASIP over the universal vaccination program at one basic training site, Fort Leonard Wood, Missouri. Not surprisingly, the largest cost burden for both programs was the cost of vaccinations, which accounted for half of the ASIP costs and over 90% of the universal vaccination program costs. When analyzing the full range of variables for the ASIP and universal vaccination program, the cost of vaccine-related adverse events accounted for the

largest range (Table V), but the total cost of both programs fluctuated minimally.

DISCUSSION

The overall seroprevalence for measles antibodies among the recruits was 85.3%, which is comparable to previous studies (84.6%).¹⁹⁻²¹ Rubella immunity was measured at 69.9% and was lower than rates noted in previously published literature (73.3% -93.2%).^{19,20,22} The data demonstrate increased immunity to hepatitis A and B over time, which is understandable as a result of the introduction of hepatitis A and B vaccinations in routine childhood immunization schedules in 1999 and 1991, respectively.²³⁻²⁵ Studies among recruits in 2001 and 2004 showed that 12.5% were seropositive for hepatitis A antibodies, and 31.5% were seropositive for hepatitis B antibodies.^{23,24,26} Hepatitis A and hepatitis B immunity in this 2008-2009 recruit population was 19.4% and 56.7%, respectively. Varicella immunity in this study population was similar to a U.S. Navy recruit cohort from 1997 to 2000, which showed an immunity level of 93%.²⁷

TABLE V. Summary of Total Program Costs for ASIP and Universal Vaccination Program Per Year

	ASIP		Universal	
	Base Cost (\$)	Range (\$)	Base Cost (\$)	Range (\$)
Vaccine	540,258	—	1,454,340	—
Serology	144,748	140,737-148,176	—	—
Diagnostic Device	359,876	344,596-376,211	—	—
Labor	46,105	44,787-47,422	46,105	44,787-47,422
Adverse Events	3,038	2,189-66,936	4,142	2,674-139,819
Total Cost	1,094,025	1,072,567-1,179,002	1,504,587	1,501,801-1,641,581
Savings	410,561	322,799-569,014		

The cost-savings estimated in this study was \$410,561 annually for one basic combat training site. Compared to the immunity rates among earlier recruit populations, the cost-savings of averting unnecessary vaccinations offsets the costs associated with serological screening. If immunity rates remain stable or increase for recruits, overall cost-savings are expected to continue. Similar cost-savings are anticipated at the remaining basic combat training sites for the Army, where serological immunity levels of recruits are thought to be comparable.

With a large proportion of the program costs originating from vaccines, this is an important area to focus further cost containment. Based on the sensitivity analysis, the model fluctuated minimally. This was largely attributable to the homogenous labor cost and low rates of vaccine-related adverse events. The initial investment cost of the serological diagnostic testing platform was stable regardless of the number of recruits tested; therefore, a greater cost-savings would be anticipated at larger basic training sites.

CONCLUSION

The ASIP was implemented in 2005 at all five Army basic combat training sites to decrease costs and avoid unnecessary vaccinations for recruits. This cost-minimization analysis indicates that annual cost-savings was \$410,561 (27% of the total cost of the universal vaccination program) with the implementation of ASIP at Fort Leonard Wood during the study period.

This analysis provides information for policy and decision makers of the Army and other services (Navy, Air Force, Marine Corps, and U.S. Coast Guard) on the value of the ASIP. Findings of this study support the continuation of the ASIP across all five Army basic combat training sites. In a time when cost containment is increasingly important for the Army, this study demonstrates substantial cost-savings while also decreasing the number of unnecessary vaccinations given to recruits.

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