Varicella Susceptibility and Vaccination Strategies in Young Adults

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Background: **Varicella infection causes substantial morbidity in young adults. Most military basic trainees are 18 to 21 years old, yet the Army has no varicella vaccination policy. We therefore determined varicella susceptibility in a population of Army basic trainees, examined variables that might predict antibody status, and developed a vaccination strategies model.**

Methods: **Fifteen-hundred ninety-five trainees completed a demographic and historical questionnaire. Varicella antibody status was determined on 1201 volunteers. These data plus information from the literature were used to construct a decision tree of vaccination strategies that was applied to the total population of Army basic trainees in 1995 (n = 65,298).**

Results: **Fifty (4.2 percent) of 1201 soldiers were antibody negative. Trainees who lived with no or 1 sibling while growing up were most likely to be seronegative ($P < 0.01$). The positive predictive value of a history of varicella was 98.5 percent, whereas the negative predictive value of a negative history of varicella was 23 percent. In the vaccination strategies model, serologically testing soldiers with a negative history of varicella and vaccinating those without protective antibodies was the most cost-effective approach.**

Conclusions: **In young adults a positive varicella history accurately predicts immunity, but verification of a negative history with antibody testing is recommended before vaccination. (J Am Board Fam Pract 1998;11:296-306.)**

Varicella infections are a major source of morbidity and mortality in young adults.[1] The risks of varicella infection increase after 15 years of age and are particularly great in those aged 20 years and older.[1,2] Seroprevalence studies estimate that 8 percent of adults 20 years and older lack evidence of antibody against varicella virus and are thus considered susceptible to chickenpox.[1,3-5] Of these adults an estimated 33 per 100,000 per year will become infected with the varicella virus.[2] Fourteen to 18 per 1000 adult cases require hospitalization for their illness (1 in 400 for varicella pneumonitis) compared with only 1 to 2 per 1000 childhood cases, and for every 100,000 adults infected per year, 31 die from their infection.[2] After the age of 25 years serious complications of infection become even more likely, but the absolute number of susceptible patients decreases dramatically.[6]

The consequences of varicella infection can be more striking for Army trainees than for age-matched civilians. Although military trainees and their age-matched civilian counterparts have similar susceptibility to varicella infection,[3-5] recruits are required to live in barracks, an environment that promotes the rapid spread of highly contagious organisms. In studies of military varicella epidemics, up to 70 percent of susceptible adults have become infected.[7] Because of the potential for epidemic spread, barracks-dwelling trainees with chickenpox are routinely hospitalized for isolation purposes. If they miss more than 48 consecutive hours of training, recruits are disenrolled from training and must recycle at a later date, which results in a considerable financial burden to the Army. In 1995, 45 (0.07 percent) of 65,298 active-duty Army basic training entrants were reported to be hospitalized for clinical chickenpox (LTC Mark

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Rubertone, MD, MPH, Walter Reed Army Institute of Research (WRAIR), e-mail, 28 Aug 1996). The actual number of trainees infected is likely to be higher because it is probable that some cases were not accurately reported or went unrecognized and some soldiers might have been allowed to convalesce at home.

Although the varicella vaccine was approved for use by the Food and Drug Administration in 1995, the Department of the Army has not yet established an official policy regarding varicella vaccination. Finding and vaccinating susceptible trainees could reduce wasted financial and manpower resources, but the most cost-effective approach remains unclear. Several studies have shown that a stated history of having had chickenpox correlates well with the presence of antibodies to varicella virus. A negative or unsure history of chickenpox, however, has not reliably predicted negative antibody status in the studies, with 60 to 80 percent of people in these response groups having detectable antibody against varicella.[3,5] Even though antibody testing for all soldiers before vaccination against varicella would be the most accurate way to protect them against chickenpox, it might not be the most desirable strategy for economic and logistic reasons.

Studies in the pediatric population suggest that presumptive vaccination based on clinical history alone is a more cost-effective approach than first verifying antibody status in children who have a negative or uncertain history of chickenpox before vaccination.[8-11] Generalization of results from pediatric patients to soldiers is not appropriate, however, because susceptibility rates are much higher in children. There are no studies evaluating the cost-effectiveness of varicella vaccination strategies in an adult population.

Another issue with relevance to any proposed Army varicella vaccination policy is the unexplained declining rate of hospitalizations for varicella in the past several years. The number of recruits reported hospitalized annually from 1990 to 1995 has declined from 149 to 45 (LTC Mark Rubertone, MD, MPH, WRAIR, personal communication, 28 Aug 1996). Similar findings have also been reported recently in the US Navy population, which had only 473 hospitalizations (a rate of 74 per 100,000 personnel) in all active-duty Navy and Marine Corps personnel in 1994.[12,13] Thus, it is unclear whether susceptibility data from even the recent past remain applicable to recent recruits.

The purposes of this study were (1) to define the current prevalence of antibodies to the varicella virus in active-duty Army Advanced Individual Training (AIT) recruits, (2) to determine whether demographic variables and patient-reported chickenpox history can accurately predict antibody status, and (3) to develop a decision model to explore the effectiveness and costs of various options for vaccinating susceptible recruits against varicella.

Methods

Demographic Study

Study participants included in-processing AIT students from the 447th Signal Battalion located at Fort Gordon, Ga. Newly arrived soldiers reported on a weekly basis to the Connelly Health Clinic, a troop medical clinic on Fort Gordon, during the 8-month study period, which ran from 29 April through 9 December 1996. AIT soldiers are young men and women completing their Army basic training requirement.

Participating soldiers were read a standardized statement regarding the purposes of the study and briefed on the risks of phlebotomy. Every soldier then received a copy of the study questionnaire, which contained questions regarding the following demographic variables: sex, age, ethnicity, education level, geographic region of origin, population of city of origin, and number of siblings living with the soldier while growing up. One question also required the soldiers to recall whether they definitely had, probably had, did not have, or were not sure whether they had chickenpox in the past. All soldiers were asked to complete the questionnaire regardless of participation in the phlebotomy portion of the study.

After questionnaire completion, soldiers were asked to volunteer for phlebotomy. Volunteers reviewed and signed an informed consent form according to the guidelines established by the research protocol, which was approved by the Eisenhower Army Medical Center (EAMC) Institutional Review Committee. Phlebotomy was performed by medics, nurses, physicians, and physician assistants. Five to 10 mL of blood were collected in red-top tubes according to standard blood-drawing techniques and precautions. Serum samples were labeled with the participat-

Table 1 Decision Analysis Model: Probabilities and Costs.

Variable and Source	Data*
Probabilities	
Trainee susceptibility to varicella	
Number trainees enrolled, 1995†	65,298
Accuracy of serologic test[14]	0.974 (sensitivity range 0.042 - 0.065)
Percent susceptible (current study)	0.042
Negative predictive value of no or uncertain history of varicella (current study)	0.23
Positive predictive value of definite or probable history of varicella (current study)	0.985
For patients with no history of varicella	
Vaccine protection - one dose[16]	0.82
Vaccine protection - two doses[16]	0.94
Patient requires hospitalization (Army policy)	1
Probability of physician visit within 24-hr onset of symptoms (Army policy)	1
Costs	
Serologic test materials‡	$1.32
Venipuncture and processing‡	$4.18
Vaccine dose§	$39.44
Administration of vaccine‖	$2.50
Medical costs per case	
Hospitalization¶	$3805.50
Outpatient visit¶	$105.00
Training costs to Army per case#	$35,750.00

Note: All costs are expressed as cost to the US Army.
*Estimates based on personal communications:
†Dr. Mark Rubertone, Walter Reed Army Institute of Research, e-mail, 28 Aug 1996.
‡MAJ William Boisvert, Eisenhower Army Medical Center (EAMC), Clinical Laboratory Manager, e-mail, 19 Dec 1995.
§CPT Daren Marionneaux, MD, Officer in Charge, Connelly Health Clinic, telephone, 21 Dec 1995.
‖LTC Gail Erlitz, RN, Ft Gordon, US Army Practical Nurse Course, telephone, 6 Jan 1996.
¶CPT Jeannie Hurlbert, Nurse Methods Analyst, EAMC Resource Management Division, telephone and memorandum, 5 and 7 Jan 1996.
#Ms. Martha McCravy, Resource Management, Fort Jackson Resource Management Division, telephone, 12 Feb 1996.

ing soldier's name and social security number and transported within 2 hours to the hospital laboratory at EAMC, where they were immediately stored at -20 to -70 °C and analyzed within 1 week of collection according to manufacturer recommendations.

Antibody testing for varicella IgG antibody was performed using the Varicelisa II test kit (BioWhittaker, Inc, Walkersville, Md), an enzyme-linked immunosorbent assay (ELISA) for Varicellavirus IgG antibody in human serum. The manufacturer reports an assay sensitivity of 98.7 percent, specificity of 94.7 percent, and accuracy of 97.4 percent compared with the reference standard varicella antibody test, the fluorescent antibody to membrane antigen (FAMA) assay.[14]

One of the study investigators (JSD) maintained a master log with the names and antibody assay results of both the participating and nonparticipating soldiers. Confidentiality was maintained, as individual serologic test results were only known by laboratory personnel and the investigating physicians. Participating soldiers were mailed the results of their serum assay and directed to their local troop clinic for further questions.

Data analysis was performed on an IBM-compatible computer using SPSS for Windows, Version 6.1.3.[15] Percentages were calculated for responses to questionnaire demographic and history questions. A series of chi-square analyses were conducted to compare the responses to the various demographic variables with the results of serologic testing. Discriminant analysis was performed on responses to the varicella historical questions designed to predict serologic status.

Vaccination Approaches Model

A decision tree (Figure 1, parts 1, 2, and 3) was created to outline potential policy options and projected outcomes for varicella vaccination in Army AIT students. Decision tree branches were constructed for both one- and two-vaccination approaches. Although two doses of vaccine are routinely recommended for adult immunization, we wanted to determine whether a single dose might be more cost-effective in a mass protection troop setting. The model assumes that no patients would be lost to follow-up because AIT student time is accounted for 24 hours a day throughout the training period. Because the accuracy of the ELISA assay is 97.4 percent, all policy options involving antibody testing include branches for both false-positive and false-negative test results.[14]

Several possible end points for each policy option might be obtained: natural protection, vaccine-induced protection, and no protection. Those with natural protection were presumed safe from chickenpox. A subset of those undergoing vaccination were assumed still susceptible to varicella based on reported vaccine failure rates for the one-vaccine (18 percent) and two-vaccine (6 percent) approaches.[16]

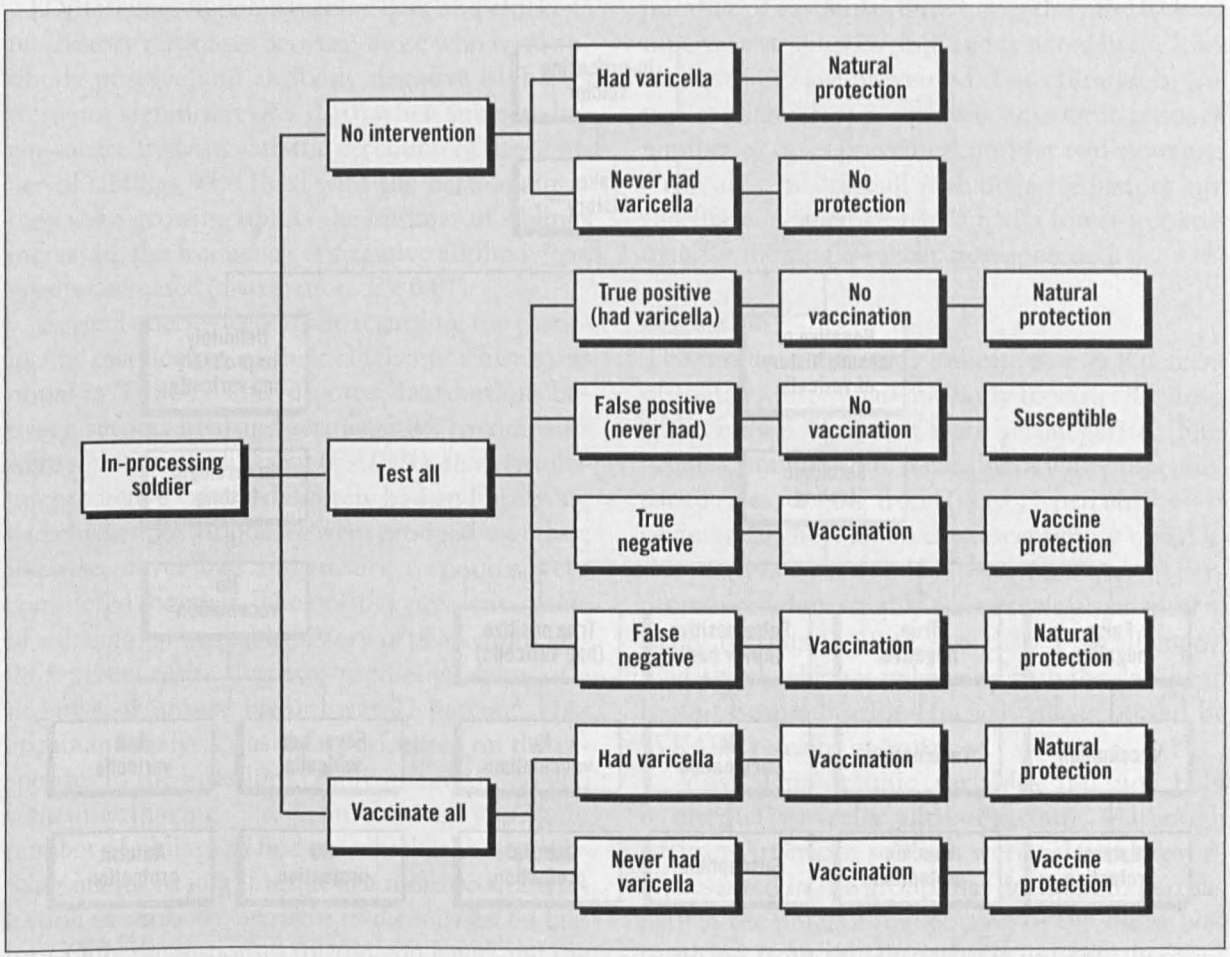

Figure 1. Varicella vaccination policy options decision tree. Part 1: no intervention, test all, and vaccinate all.

Probabilities and Costs

Probabilities and costs incorporated into the model (Table 1) were derived from the current demographic study, previously published data, information from Army expert sources, and best-guess estimates. For our cost analysis, we considered only short-term (defined as the duration of AIT training) cost to the Army and did not consider long-term costs or cost to individual soldiers. Outcomes of the model were expressed in dollars per case of chickenpox prevented and net expense (expenses versus projected savings) for each policy option.

Results

Demographic Study

A total of 1595 soldiers participated during the 8-month study. The demographic data for participants who did and did not volunteer for phlebotomy were analyzed, and no significant differences were found between these groups except as noted below. The modal participating soldier was 17 to 19 years old (63 percent of the participants), male (79.2 percent), and white (65.5 percent). The soldier was a high school graduate (73.5 percent) who lived with 1 to 2 siblings (63.4 percent) while growing up in the Midwestern or Southern United States (59.6 percent) in an urban area with a population greater than 100,000 (29.4 percent). Of the 1595 soldiers who completed the questionnaire, 1201 (75 percent) consented to have their blood drawn. A higher proportion of African Americans declined phlebotomy (36 percent) compared with whites (23 percent) ($P < 0.01$ for difference). There were more soldiers aged 17 to 19 years old (70 percent) in the group that refused phlebotomy than there were in the group that volunteered to have blood drawn (61 percent) ($P < 0.01$). The primary reason given for declining phlebotomy was a dislike or fear of needles (67.8 percent).

Table 2 shows the varicella IgG ELISA assay results for the 1201 soldiers who consented to have their blood sampled; 50 (4.2 percent) phlebotomy participants had negative antibody tests. The

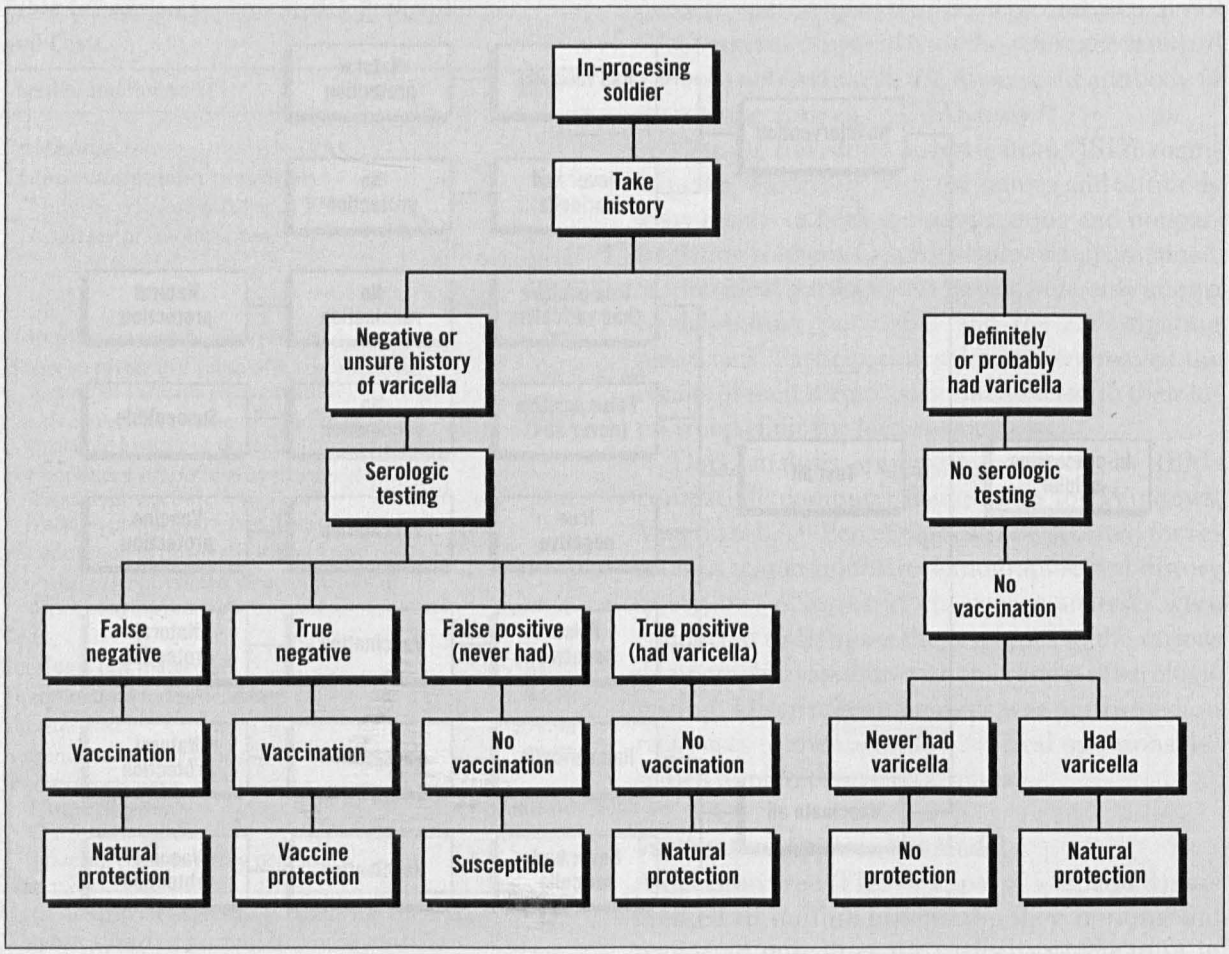

Figure 1. Varicella vaccination policy options decision tree. Part 2: take history, test those with negative history, vaccinate if test is negative.

modal antibody-negative soldier was 17 to 19 years old, male (88 percent), white (62 percent), and a high school graduate (74 percent), and lived with 1 or 2 siblings (80 percent) while growing up in the Midwestern or Southern United States (60 percent) in an urban area with a population greater than 100,000 (30 percent), similar to the modal survey population soldier.

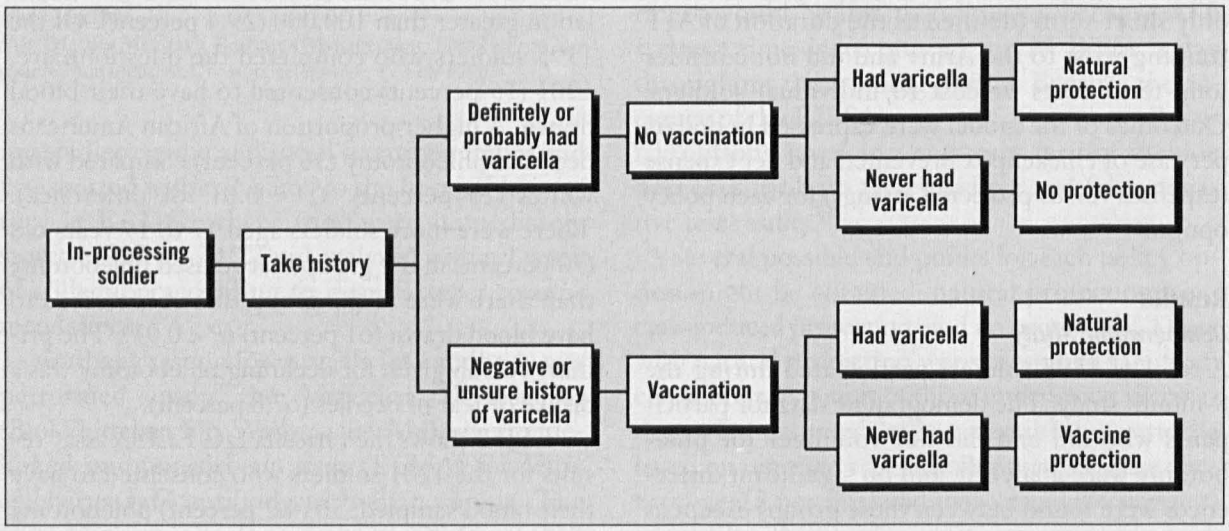

Figure 1. Varicella vaccination policy options decision tree. Part 3: take history, vaccinate all with negative history.

Differences in demographic data and chickenpox history responses between those who were antibody positive and antibody negative (Table 2) were not significant ($P > 0.10$) when subjected to chi-square analyses with the exception of the number of siblings who lived with the participant as they were growing up. As the number of siblings increased, the frequency of negative antibody test results decreased (distribution, $P < 0.01$).

Several queries were made regarding the participants' recollection of their chickenpox history as noted in Table 2. The response distributions between seropositive and seronegative participants were significantly different ($P < 0.01$). In determining predictive values, definitely had and probably had chickenpox responses were grouped together; likewise, never had and unsure responses were considered together. The positive predictive value of a definite or probable history of chickenpox was 98.5 percent; the negative predictive value of a negative or unsure history was 23 percent. Discriminant analysis was then performed on the responses to the questions "did you have," "do you remember having," "did someone tell you," and number of siblings to find out whether these qualifying questions might result in a more accurate selection of antibody-negative soldiers based on history. Only the responses to "did you have" and the number of siblings contributed significantly to the prediction of serologic status (Wilks' λ 0.89 for both, $P < 0.00001$).

Vaccination Approaches Model

Table 3 summarizes the projected number of cases prevented, savings for prevented cases, total cost and cost per case prevented, and net cost for each policy option in the model. Also included are the baseline number of cases of varicella and cost associated with these cases assuming no intervention, using the 1995 data from WRAIR.

The "vaccinate all" model was the most effective in regard to number of cases prevented, but it was associated with the highest net expense of all strategies. The model of "test all with negative history and vaccinate if negative test" resulted in fewer cases prevented but was the least expensive option. The "vaccinate all with negative history" option resulted in an identical number of cases prevented as the "test all with negative history" approach but was more expensive. Finally, the "test all" strategy resulted in an intermediate number of cases prevented, was the next to least expensive strategy overall, and resulted in the lowest cost per case prevented. For all models, the two-vaccination approach was superior in terms of number of cases prevented, and for two strategies ("test all" and "test all with negative history and vaccinate if negative test") had a lower net cost than for the single-vaccination approach.

Discussion

The results of this study indicate that 95.8 percent of soldiers tested had antibody to varicella virus, while only 4.2 percent were seronegative. This negative antibody rate is consistent with other published rates ranging from 2.8 to 11 percent.[3-5,17,18] Of interest, the 4.2 percent susceptibility noted in this study is considerably lower than the 6.9 percent reported in a highly comparable population of Army recruits in 1989, less than a decade ago.[4] This trend, which is in keeping with the decline in recruit hospitalizations for varicella reported by WRAIR, remains unexplained.

Most demographic variables did not help to predict varicella antibody status. Although African-American soldiers were relatively overrepresented in the group that declined to participate in the phlebotomy portion of the study, bias resulting from this disparity is unlikely, because earlier studies have not shown a differential susceptibility to varicella infection in this group. The overrepresentation of young (17- to 19-year-old) soldiers in the group that declined phlebotomy could conceivably result in a spuriously low rate of seronegativity, since people in this age group are more likely than older adults to be seronegative. Nevertheless, it is unlikely the relatively small disparity would alter significantly the magnitude of our findings, because more than 90 percent of these soldiers would still be expected to possess antibodies to varicella.

The lack of influence of geographic region of origin on serologic status differs somewhat from earlier studies suggesting that children and young adults from island countries and territories (especially Puerto Rico) have higher susceptibility rates.[7,19] The bulk of our participants, however, were from the Midwest, Northeast, and South, with very few representatives from Puerto Rico and island nations. One demographic variable, however, was of value: those participants who grew up in households having no or 1 sibling were statis-

Table 2. Demographic and Varicella Historical Data for Participants Who Agreed to Serologic Testing (n - 1201).

Characteristics	Seropositive n - 1151	Seronegative n - 50	*P* value
Demographics			
Sex (n - 1201)			NS
Male	914 (79)	44 (88)	
Female	237 (21)	6 (12)	
Age, years (n -1197)			NS
17-19	702 (61)	30 (60)	
20-22	264 (23)	14 (28)	
23-25	104 (9)	5 (10)	
26-up	77 (7)	1 (2)	
Ethnicity (n - 1199)			NS
African American	193 (17)	12 (24)	
White	773 (67)	31 (62)	
Hispanic	23 (2)	0 (0)	
Other	160 (14)	7 (14)	
Education (n - 1199)			NS
General equivalency diploma (GED)	38 (3)	1 (2)	
High school graduate	833 (72)	37 (74)	
College entry	210 (18)	11 (22)	
College degree or higher	68 (6)	1 (2)	
Region of origin (n - 1184)			NS
Northeast	196 (17)	7 (14)	
Midwest	391 (34)	16 (32)	
South	301 (27)	14 (28)	
West	204 (18)	10 (20)	
Other country	42 (4)	3 (6)	
Population, city of origin (n - 1195)			NS
>100,000	331 (29)	15 (30)	
50-100,000	161 (14)	8 (16)	
25-50,000	116 (10)	5 (10)	
10-25,000	204 (18)	9 (18)	
5-10,000	152 (13)	5 (10)	
<5000	181 (16)	8 (16)	
Number of siblings (n - 1198)			< 0.01
none	94 (8)	7 (14)	
1	368 (32)	24 (48)	
2	349 (30)	16 (32	
3	196 (17)	1 (2)	
4 or more	141 (12)	2 (4)	
Varicella history			
Siblings have chickenpox? (n - 1201)			
Definitely yes	888 (77)	28 (56)	< 0.01
Probably yes	101 (9)	0 (0)	
No	97 (8)	14 (28)	
Don't know	65 (6)	8 (16)	
Ever had chickenpox? (n - 1201)			< 0.01
Definitely yes	959 (83)	14 (28)	
Probably yes	75 (7)	1 (2)	
No	78 (7)	28 (56)	
Don't know	39 (3)	7 (14)	
Remember having chickenpox? (n - 1201)			< 0.01
Yes	855 (74)	9 (18)	
No	235 (20)	39 (78)	
Not sure	61 (5)	2 (4)	
Someone tell you you had chickenpox? (n - 1201)			< 0.01
Yes	944 (82)	13 (26)	
No	148 (13)	32 (64)	
Not sure	59 (5)	5 (10)	
Ever had varicella vaccine? (n - 1199)			NS
Yes	310 (26)	15 (30)	
No	221 (19)	10 (20)	
Not sure	618 (54)	25 (50)	

Table 3. Policy Options and Projected Outcomes.

Vaccination Strategy	One Vaccination	Two Vaccinations
Test all		
Total cases prevented (% reduction)	11 (24)	16 (36)
Total savings for prevented cases, $	436,260	634,560
Cost per case prevented, $	56,131	44,472
Total cost of approach, $	617,443	711,557
Net expense, $	181,183	76,997
Vaccinate all		
Total cases prevented (% reduction)	33 (73)	41 (91)
Total savings for prevented cases, $	1,308,780	1,626,060
Cost per case prevented, $	84,637	134,192
Total cost of approach, $	2,793,036	5,501,872
Net expense, $	1,484,256	3,703,202
Test all with negative history, vaccinate if negative test		
Total cases prevented (% reduction)	4 (9)	7 (16)
Total savings for prevented cases, $	158,640	277,620
Cost per case prevented, $	75,321	52,948
Total cost of approach, $	301,283	370,638
Net expense, $	142,643	63,548
Vaccinate all with negative history		
Total cases prevented (% reduction)	4 (9%)	7 (16)
Total savings for prevented cases, $	158,640	277,620
Cost per case prevented, $	132,287	124,722
Total cost of approach, $	529,148	873,056
Net expense, $	353,668	565,966

Note: Based on total of 65,298 active-duty Army recruits for 1995 and total number of reported cases of varicella in this group of 45. Analyzed first-year estimated reductions in varicella and associated expense required to obtain reduction. Baseline cost to Army for these cases (ie, no intervention) estimated at $1,784,723.

tically more likely to be antibody negative ($P < 0.01$). This finding makes sense based on the decreased risk of exposure during childhood for those with few or no siblings.

We found the soldier's clinical history of chickenpox to be helpful. The positive predictive value for the presence of antibodies when definite and probable history of chickenpox responses were combined was 98.5 percent, whereas the negative predictive value when negative and unsure responses were combined was 23 percent. The high positive predictive value of the combined "definitely had" and "probably had" varicella historical responses has also been noted by Struewing et al,[5] who reported a positive predictive value for varicella antibody of more than 95 percent. More troubling is the person who gives an unsure or negative history of varicella. Of this group (152 of 1201 or 12.7 percent of soldiers who had blood drawn), only 35 were antibody negative (23 percent). Therefore, approximately three fourths of those with a negative or unsure history of chickenpox turned out to have demonstrable antibody to varicella.

A model was developed to help determine the costs and efficacies of various vaccination strategies applied to a large population—all recruits entering the Army in 1995. Clearly the "vaccinate all" strategy yields the largest reduction in varicella cases, 73 percent for single vaccinations and 91 percent for two vaccinations. This approach, however, would lead to the unnecessary vaccination of 95 percent of our study population and would likely entail a prohibitively high cost unless complete eradication of varicella was desired.

"No intervention" is at the opposite end of the spectrum and represents the current policy of the US Army. Given the potential morbidity and mortality related to varicella infection in young adults, and the potential loss of student training time, reduced operational readiness, and expensive hospitalization for isolation from fellow barracks dwellers, however, we believe this policy would be defensible only if no other option were feasible.[12,18,19] This assertion is supported by our conviction that the estimates used in our model very likely underrepresent the costs to the Army associated with a case of varicella in an AIT student. For

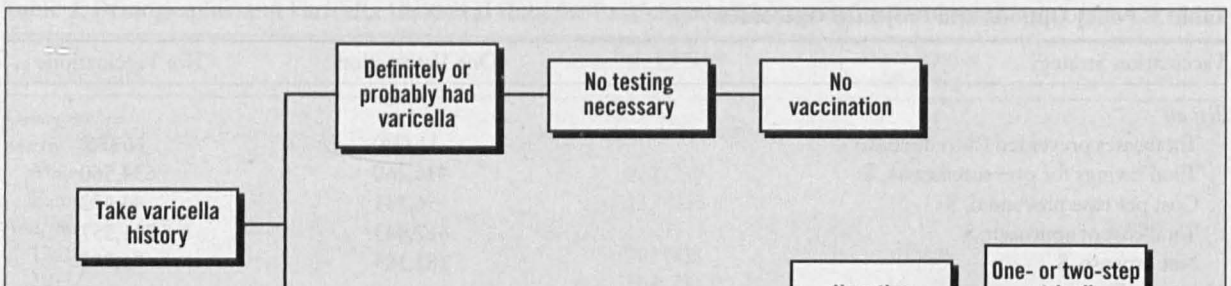

Figure 2. Recommended algorithm for targeted varicella testing and vaccination of adolescents and young adults.

example, the cost of transporting an infected trainee home for convalescence and then back to a military post to recycle through training was not available. We believe there are many other costs associated with training soldiers that remain hidden in the complex Army finance system and were thus not accounted for in our models.

The other three strategies involve selective vaccination. If a negative or unsure history is given, then a soldier can be tested or simply vaccinated. The vaccination of all soldiers without confirmatory testing would result in the unnecessary vaccination of about 75 percent of soldiers in this group and was the most expensive of the three approaches; thus, it will not be considered further. Targeted vaccination only for those soldiers with a negative varicella history who are then found to have negative varicella antibody testing yielded the lowest net expense. A disadvantage of both history-based strategies was that they resulted in the lowest reduction in cases (9 percent with single vaccination and 16 percent with double vaccination). Targeted vaccination might ultimately be an acceptable compromise, however, since the few soldiers with false-positive tests (1.4 percent), as well as those few soldiers who gave a positive history of varicella but are truly susceptible, would still have more likelihood of protection by herd immunity than with the present "no intervention" policy.

The "test all" strategy was the second-least expensive and was associated with a reduction in the number of cases of varicella that fell in between the history-based approaches and the "vaccinate all" strategy. If future varicella antibody assays with a higher accuracy are developed, or if the test can be obtained at a cost lower than our estimate, this approach might become very attractive.

In summary, the decision model shows the clear value of obtaining a clinical history of varicella when caring for adolescents and young adults, in large groups or as individuals, with unknown susceptibility. We believe that the Army should strongly consider this approach for implementation at the earliest opportunity. For example, the Army might adopt a policy of surveying all recruits regarding clinical varicella history, with subsequent serologic testing for those with negative histories, during their induction medical evaluations. Those with a positive history (definitely had or probably had) of varicella are overwhelmingly likely to possess antibodies to varicella and require no further testing, and the small number of antibody-negative recruits who would be missed would be protected by an ever-growing herd immunity. For those with negative (never had or unsure) histories, we recommend antibody testing and subsequent targeted vaccination of soldiers who are confirmed seronegative (Figure 2).

This approach provides the most optimal balance of number of cases prevented versus total cost of implementation. Also clear from the model is that a two-vaccination approach results in higher protection rates, and thus a lower net implementation cost, than a single vaccination approach. A policy of antibody testing all young adults and vaccinating those with a negative test would be a reasonable second option if the Army is willing to absorb a slightly higher cost for a small increase in the number of cases prevented or if the test can be obtained at a lower cost. Other options in the deci-

sion model appear to be less desirable from a cost-effectiveness standpoint.

Our models cannot be used to determine policy in isolation, because they merely provide an estimate of efficacy versus cost for various strategies. For example, if the Army determines that near-complete eradication of varicella infections in new recruits is warranted at any cost, then vaccinating all recruits might be justified. Army policy makers must first establish a clear goal for any varicella vaccination program, at which point we believe our data would be helpful in selecting the strategy that will best achieve the goal.

It should be emphasized that office-based clinicians who care for adolescents and young adults might also find our suggested approach useful. For example, students with uncertain varicella antibody status who are leaving home to attend college, particularly if they will live in a dormitory, might benefit from antibody screening and targeted vaccination. Furthermore, health care personnel responsible for student health policy at high schools, colleges, and such health care training centers as medical schools should be able to extrapolate our data to their daily care of adolescents and young adults.

When screening young adults for varicella susceptibility, asking them how many siblings they lived with while growing up might also prove worthwhile. Our study design did not allow prospective testing of this variable as a screening tool. Given that those soldiers who grew up with 1 or no siblings were statistically more likely to be seronegative than those with 2 or more siblings, however, the prospective use of this simple question might be worthy of investigation as a way to target serologic testing within a group who report a negative history of varicella.

Several caveats must be emphasized in regard to our cost information. First, because the many different AIT courses vary widely in duration and associated equipment and costs, we assumed a typical 6-week AIT course with the cost noted in Table 1. Second, we had difficulty obtaining consistent information from various sources about the true cost to the Army of basic and AIT training. Additionally, we obtained no reliable answers regarding which costs were accounted for (overhead, military pay, equipment, health benefits, etc) in the aggregate cost figures that were quoted. As a result, as noted above, we suspect many hidden costs were not accounted for in our models. Additionally, the costs utilized for vaccine and antibody testing are those listed by the manufacturer. Were the Army or another institution to contract for these materials, it is quite likely these costs would be lower and might change the cost per case prevented ratio for the various options. For all these reasons, our cost analysis was not intended to be exhaustive and should be viewed primarily as a way to give some additional perspective to the utility of the various vaccination strategies.

The reported decrease in incidence of varicella infection in young adults during the last 5 years,[13,20] coupled with the call for universal varicella vaccination of children issued by the Advisory Committee on Immunization Practices (ACIP), American Academy of Pediatrics (AAP), and the American Academy of Family Physicians (AAFP), suggest a dramatic decline in susceptibility to varicella within the next 20 years. Until then, a strategy of targeted history taking and serologic testing appears to be the most prudent approach to protecting adolescents and young adults from this potentially life-threatening infection.

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