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## Attitudes of healthcare workers in U.S. hospitals regarding smallpox vaccination

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### Abstract

**Background:** The United States is implementing plans to immunize 500,000 hospital-based healthcare workers against smallpox. Vaccination is voluntary, and it is unknown what factors drive vaccine acceptance. This study's aims were to estimate the proportion of workers willing to accept vaccination and to identify factors likely to influence their decisions.

**Methods:** The survey was conducted among physicians, nurses, and others working primarily in emergency departments or intensive care units at 21 acute-care hospitals in 10 states during the two weeks before the U.S. national immunization program for healthcare workers was announced in December 2002. Of the questionnaires distributed, 1,165 were returned, for a response rate of 81%. The data were analyzed by logistic regression and were adjusted for clustering within hospital and for different number of responses per hospital, using generalized linear mixed models and SAS's NLMIXED procedure.

**Results:** Sixty-one percent of respondents said they would definitely or probably be vaccinated, while 39% were undecided or inclined against it. Fifty-three percent rated the risk of a bioterrorist attack using smallpox in the United States in the next two years as either intermediate or high. Forty-seven percent did not feel well-informed about the risks and benefits of vaccination. Principal concerns were adverse reactions and the risk of transmitting vaccinia. In multivariate analysis, four variables were associated with willingness to be vaccinated: perceived risk of an attack, self-assessed knowledge about smallpox vaccination, self-assessed previous smallpox vaccination status, and gender.

**Conclusions:** The success of smallpox vaccination efforts will ultimately depend on the relative weight in people's minds of the risk of vaccine adverse events compared with the risk of being exposed to the disease. Although more than half of the respondents thought the likelihood of a bioterrorist smallpox attack was intermediate or high, less than 10% of the group slated for vaccination has actually accepted it at this time. Unless new information about the threat of a

smallpox attack becomes available, healthcare workers' perceptions of the vaccine's risks will likely continue to drive their ongoing decisions about smallpox vaccination.

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## Background

The United States began to implement a national plan to immunize half a million hospital-based healthcare workers against smallpox in early 2003. Prospective vaccinees are healthcare workers in emergency departments, intensive care units, and other settings who would be crucial first-line responders in the event of a bioterrorist attack using smallpox. However, vaccination is voluntary, and many staff members are declining. In Israel, almost half of healthcare workers and security and rescue squad personnel refused voluntary smallpox vaccination in 2002 due to concerns about vaccine adverse events, according to one press report [1].

In early December 2002, just before the current smallpox vaccination plan was announced, we carried out a survey of U.S. healthcare workers' opinions about smallpox vaccination in order to inform preparedness efforts. Although much has happened to change public opinion since that time, our findings provide insight into factors that influence the ongoing decision-making of healthcare workers about this vaccine.

## Methods

### Study Sample

We surveyed a convenience sample of healthcare workers at 21 (of 22 invited) acute-care hospitals in 10 states between December 2 and 18, 2002 to determine their knowledge, attitudes, and projected behavior regarding smallpox vaccination. All but one of the hospitals were members of the Prevention Epicenters established by the Centers for Disease Control and Prevention (CDC) or the Duke Infection Control Outreach Network (DICON). The hospitals were located in Massachusetts (8), North Carolina (3), Maryland (2), Virginia (2), and Georgia, New York, Missouri, Illinois, Iowa and Oregon (1 each). The population of interest for the survey was emergency department (ED) and intensive care unit (ICU) staff, although surveys were also completed by limited numbers of other staff (e.g. radiology technicians) who might plausibly be involved in a smallpox admission. Of the 1,443 surveys distributed to staff, 1,165 were completed within the required time-frame, for a response rate of 81%.

### Procedures

The hospital epidemiologists or infection control practitioners obtained institutional review board (IRB) approval (or, in some cases, exemption from review) and administered the survey to their hospital's ED and ICU staff. Collaborators agreed to return a minimum of 25

completed surveys to the study investigators by December 20, 2002.

The self-administered survey was anonymous, confidential, and voluntary. It was distributed during staff meetings or in person on an individual basis, or occasionally via mailboxes. A draft smallpox vaccine information sheet (CDC's 11/20/2002 version, see Additional File 1) was placed inside each folded questionnaire. The draft information sheet did not include photographs of adverse reactions, nor did it describe the inflammatory response at immunization site that occurs among a substantial fraction of individuals. At 16 of the 21 hospitals, a good-quality pen was handed out with each survey; at another, small gift certificates were used; the remaining 4 hospitals did not employ gifts. The completed surveys were collected at each site by the collaborator, who also tracked the total number of surveys that had been distributed.

### Survey instrument

The questionnaire (see Additional File 2) consisted of 17 multiple-choice questions, mostly about respondents' attitudes and projected behavior regarding smallpox and smallpox vaccination, knowledge and topics of concern, and self-assessed health history relative to smallpox vaccination (previous vaccination, contraindications). A number of questions addressed demographic and occupational characteristics. A question at the end of the survey asked how carefully respondents had read the enclosed vaccine information sheet.

### Analysis

The main outcome variable was respondents' expressed willingness to accept vaccination, which was dichotomized as yes/probably vs. no/probably not/don't know and then correlated with potential predictors of response, individually and by multivariate logistic regression. The variables initially included in the model were perceived risk of a smallpox attack, region, main work area, profession, age, gender, presence or absence of children  $\leq 18$  years old at home, self-assessed previous vaccination status, self-assessed level of knowledge about smallpox vaccination, and how well one had read the vaccine information sheet. This list includes all the questions on the questionnaire except those addressing: reasoning underlying one's attitude toward vaccination, contraindications, and projected behavior under hypothetical scenarios. These excluded variables were considered irrelevant as predictors or were intractable for inclusion due to the structure of the corresponding questions;

**Table 1: Healthcare workers' characteristics and self-reported willingness to accept smallpox immunization**

	Total		By expressed willingness to be immunized				p-value*
	n	%	Yes/probably		Probably not/no/ don't know		
	n	%	n	%	n	%	
All	1165	100 %	708	61%	450	39%	
Perceived risk of attack							<0.0001
High/intermediate	610	53%	422	70%	184	30%	
Low/next to zero	400	35%	185	47%	212	53%	
Can't guess	144	12%	95	66%	49	34%	
Region							0.03
Northeast (9 hospitals)	503	43%	278	56%	222	44%	
Mid-Atlantic & Southeast (8 hospitals)	317	27%	205	65%	111	35%	
Midwest & West (4 hospitals)	345	30%	225	66%	117	34%	
Main work area							0.11
ED or ED consult	558	48%	349	63%	208	37%	
ICU (adult or pediatric) or consult	434	37%	248	57%	184	43%	
Other/none specified	173	15%	111	66%	58	34%	
Profession							0.86
Physician	351	30%	210	61%	137	39%	
Non-physician clinician	642	55%	392	61%	248	39%	
Other/none specified	172	15%	106	62%	65	38%	
Age							0.41
Up to 29	277	24%	170	62%	106	38%	
30-39	356	31%	206	58%	147	42%	
40-49	315	27%	191	61%	121	39%	
50 or over	207	18%	135	65%	72	35%	
Gender							<0.0001
Male	408	35%	257	63%	148	37%	
Female	743	65%	440	60%	299	40%	
Children < 18 at home? **							<0.0001 **
Yes	461	41%	281	61%	177	39%	
No	676	59%	413	61%	259	39%	
Ever vaccinated against smallpox							0.07
Yes	606	52%	384	64%	217	36%	
No	418	36%	241	58%	175	42%	
Not sure	140	12%	82	59%	58	41%	
How well informed about risks and benefits of smallpox vaccination							0.0002
Very well	138	12%	98	72%	39	28%	
Fairly well	474	41%	304	65%	167	35%	
Not well	456	39%	255	56%	198	44%	
Not at all	94	8%	50	53%	44	47%	
How carefully read accompanying smallpox vaccine information sheet **							<0.0001 **
Read carefully	534	47%	326	62%	204	38%	
Read some parts	182	16%	111	62%	69	38%	
Skimmed quickly	234	21%	150	64%	84	36%	
Didn't read it	189	17%	106	56%	83	44%	

NB: Where subtotals do not add to 1,165, this is due to missing answers on the questionnaire. \* Adjusted for clustering within hospital and variation in the number of responses per hospital. \*\* Two variables, children at home and reading the VIS, were statistically significant in the bivariate analysis but were excluded from the multivariate model. Hospital-specific odds ratios for favoring vaccination with children at home compared to without children at home ranged from 0.22 to 5.5, but only one of the 21 was statistically significant (OR 1.14, p=.03). Similarly, on hospital-specific analysis, odds ratios for the various levels of reading the VIS compared to not reading it at all varied from 0.09 (for reading parts of it) to 5.3 (for reading it carefully) and none were statistically significant. We concluded that there was little evidence of a meaningful association and removed both variables from the final multivariate model.

overall results on them are presented in univariate form without weighting or other adjustment. All p-values and estimates from the logistic regression analysis (and presented in the tables) are adjusted for clustering within hospital and for different number of responses per hospital, using generalized linear mixed models [2]. The data were analyzed in SAS using the NLMIXED procedure. A fuller description of the analysis is available on request.

## Results

### **Characteristics of the hospitals and respondents**

Seventeen of the 21 hospitals were in the Northeast and Mid-Atlantic/Southeast (Table 1). Eleven were tertiary-care centers, with 69% of the respondents; 9 were community hospitals, with 27% of the respondents; and one was a Veterans Administration hospital, with 4%. The median number of beds was 427, with a range of 113 to 1,442. Approximately half of respondents worked in the ED (or provided consultation to it), approximately half were nurses, and approximately two-thirds were women (Table 1).

### **Perceptions of smallpox threat and vaccine risks**

Fifty-three percent of respondents thought the risk of a smallpox attack in the U.S. within the next two years was either "intermediate" (38%) or "high" (15%), while 35% saw it as either "low" (29%) or "next to zero" (6%), and 12% said "can't guess." Opinions varied widely among the various hospitals, with a range of 27% to 73% per hospital considering the risk of an attack to be intermediate or high ( $p < .02$ , chi-square test on crude data).

Twelve percent of respondents felt they were "very well informed" about smallpox vaccination, 41% felt "fairly well informed," 39% said "not well informed," and 8% answered "not at all informed" (Table 1). The topics about which information was most commonly desired were (1) the likelihood and nature of adverse events (28% of the answers chosen), (2) the risks and health problems of transmitting vaccinia to others (15% of the answers), and (3) the risk of a smallpox attack (15%) (Table 2). The most frequently chosen top concern about vaccination was the risks compared to the benefits of vaccination (53%), followed by the risks of transmitting vaccinia to family or friends (26%). Of the different types of adverse events, 70% of respondents were most concerned about severe reactions like encephalitis, severe infection, and death; while 18% were more concerned about the more frequent mild-to-moderate reactions, and 11% said they were not particularly worried about vaccine adverse events.

When asked at the end of the survey how carefully they had read the accompanying vaccine information sheet, 47% of respondents said they had read it carefully, 16%

said they had read parts of it, 21% reported skimming it quickly, and 17% said they hadn't read it (Table 1). Attention to the vaccine information sheet appeared to be associated with one's top concern ( $p = .035$ , chi-square test on crude data), with, for example, 30% of those reporting having carefully read it listing transmission of vaccinia to family or friends as their principal concern, compared to 17%–26% of the groups reading the vaccine information sheet less carefully or not at all.

### **Self-assessed health history relative to smallpox vaccination**

Fifty-two percent of respondents reported having been previously vaccinated against smallpox, 36% said they had not, while 12% weren't sure. Of those < 30 years of age, 11% reported having been vaccinated; of those  $\geq 30$ , 23% reported *not* having been vaccinated (Table 2). Six percent reported having a child or children < 1 year of age at home, currently a "precaution" rather than a contraindication to smallpox vaccination. Forty-five percent of those who completed the question on contraindications said either "yes" (37%) or "don't know" (8%) to at least one of the contraindications in our list of 8. The most common (self-reported) contraindication was household member with current or past history of eczema or atopic dermatitis – 16% of respondents reported this situation. The next most frequent contraindication was current or past history of eczema or atopic dermatitis in oneself, reported by 13%.

### **Attitudes toward smallpox vaccination**

In response to the question, "If you were [medically] eligible for vaccination and were offered smallpox vaccine today, would you choose to be vaccinated?," 61% of healthcare workers answered "yes" (32%) or "probably" (29%), while the remaining 39% answered "probably not" (11.6%), "no" (11.6%), or "don't know" (15.7%). Attitudes varied by hospital, ranging from 17% to 82% of respondents per hospital inclined toward accepting vaccination ( $p = .0004$ , chi-square test on crude data).

In bivariate analyses, one's opinion of the risk of a smallpox attack was strongly associated with willingness or desire to be immunized ( $p < .0001$ ), with 70% of those perceiving an intermediate-high risk of attack and 66% of those without an opinion about the risk being inclined toward vaccination, compared to 47% of those seeing the risk as low (Table 1). Region other than the Northeast, male sex, having children 18 years or younger at home, being very well-informed about the risks and benefits of vaccination, and reading the vaccine information sheet were associated with planning to be vaccinated (but see caveats in footnote to Table 1). Willingness to be vaccinated was not associated with the demographic variables work area, profession, or age.

**Table 2: Healthcare workers' vaccine safety concerns and self-assessed health history**

	n	%
Topics about which more information desired*		
Likelihood and nature of adverse events	639	28%
Risk of a smallpox attack	328	15%
Risks and health problems of transmitting vaccinia	339	15%
Whether experts/respected peers getting vaccinated	232	10%
Length of protection from previous vaccination	253	11%
Facts about smallpox disease	233	10%
Liability and compensation	159	7%
None – no additional information needed	48	2%
Other	14	1%
Top concern		
Risks outweigh benefits	566	53%
Might transmit vaccinia to family or friends	277	26%
Other	65	6%
Might be expected to work with/near smallpox patient	57	5%
Might transmit vaccinia to patients	52	5%
Might have to miss work after vaccination	39	4%
Might have to work extra hours	21	2%
General type of adverse event most concerned about		
More frequent mild to moderate reactions	207	18%
Less frequent moderate to severe reactions	801	70%
Not particularly concerned about adverse reactions	130	11%
Self-reported history of smallpox vaccination, age < 30		
Yes	30	11%
No	215	78%
Not sure	32	12%
Self-reported history of smallpox vaccination, age ≥ 30		
Yes	573	65%
No	198	23%
Not sure	106	12%
Child/children < 1 year of age at home (a precaution)		
Yes	72	6%
No	1065	94%
With at least 1 contraindication (of list of 8)		
Yes (≥ 1)	415	37%
Not sure (≥ 1)	84	8%
No (none)	620	55%
Self-reported contraindications**		
Household member with history of eczema/atopic dermatitis	182	16%
History of eczema/atopic dermatitis	145	13%
Pregnancy or attempting to get pregnant	88	8%
Other acute, chronic, or exfoliative skin condition...	80	7%
Household member with other skin condition	68	6%
Immunosuppressed household member	45	4%
Immunosuppression	19	2%
Allergy to vaccine component	15	1%

\* Respondents were instructed to choose up to 2 answers; percentages are of total answers chosen. \*\* Percentages represent (number saying "yes")/(total respondents giving any answer about the respective condition).

In multivariate analyses that adjusted for clustering within hospital, the number of responses per hospital, work area, profession, and age, four variables were associated with willingness to be vaccinated: perceived risk of an attack (odds ratio (OR) for high/intermediate compared to low perceived risk, 3.2 (95% CI, 2.4–4.2)), self-assessed

knowledge about smallpox vaccination (OR for very well compared to not at all informed, 2.0 (95% CI, 1.1–3.7)), self-assessed previous smallpox vaccination status (OR for vaccinated compared to not, 1.5 (95% CI, 1.0–2.1)), and gender (OR for men, 1.4 (95% CI, 1.1–2.0)) (Table 3).

**Table 3: Predictors of healthcare workers' self-reported willingness to accept smallpox immunization, results of multivariate analysis**

	Odds ratio* (95% CI)	p-value
Perceived risk of a smallpox attack in U.S. within 2 years		<0.0001
High/Intermediate	3.2 (2.4, 4.2)	
Low/Next to zero	Ref	
Can't guess	2.7 (1.7, 4.1)	
Region		0.13
Northeast	Ref	
Mid-Atlantic & Southeast	1.4 (1.0, 2.0)	
Midwest & West	1.5 (1.0, 2.3)	
Main work area		0.16
Emergency Department or ED consult	1.3 (1.0, 1.7)	
Intensive Care Unit or ICU consult	Ref	
Other/none specified	1.4 (0.9, 2.2)	
Profession		0.76
Physician	Ref	
Non-physician clinician	1.1 (0.8, 1.6)	
Other/none specified	0.9 (0.6, 1.5)	
Age		0.07
Up to 29	1.5 (0.9, 2.4)	
30–39	1.1 (0.7, 1.6)	
40–49	1.0 (0.7, 1.5)	
50 or over	Ref	
Gender		<0.001
Female	Ref	
Male	1.4 (1.1, 2.0)	
Ever vaccinated		0.046
Yes	1.5 (1.0, 2.1)	
No	Ref	
Not sure	1.1 (0.7, 1.7)	
Informed		<0.001
Very well	2.0 (1.1, 3.7)	
Fairly well	1.5 (0.9, 2.4)	
Not well	1.0 (0.6, 1.7)	
Not at all	Ref	

\* adjusted for clustering within hospital and variation in the number of responses per hospital

Region was not associated with attitude toward vaccination in the multivariate analysis.

**Projected behavior under hypothetical "post-event" scenarios**

Respondents' interest in vaccination depended to some extent on geographic proximity of a hypothetical future smallpox case. Of those in any doubt about vaccination (i.e. answering anything other than an unqualified "yes" to the question of whether they would get vaccinated "today"), 30% said they would seek vaccination if a case were laboratory-confirmed overseas; of the remainder who said no, 53% said they would do so if a case were confirmed in the U.S. a thousand miles away; of the remainder, 70% said they would seek vaccination if a case were confirmed in their city. Those uninterested in getting vaccinated even if a case occurred in their city amounted to at least 9% of the starting group (possibly more, as

there was some drop-out over the course of the multi-part question).

When asked if they would report to work if they had not been vaccinated recently and had learned that a patient with smallpox had just been admitted to their facility, 32% of respondents said "yes," while 68% expressed reservations to varying degrees: 36% said "yes, but only if I knew I could get vaccinated on arrival," 17% responded "probably," 5% said "probably not," and 10% said "no." Among those answering "probably" and "probably not", the most common contingency mentioned was the measures taken to contain/prevent transmission of the infection, followed by location of the patient relative to oneself. Age was a significant factor in willingness to go to work under these conditions – 20% of respondents under 30 vs. 35% of those 30 or older gave an unconditional

"yes." There were no statistically significant differences among gender or professional strata in this regard.

### Discussion

Our findings may explain why smallpox vaccine uptake has been relatively limited during the first several months of the U.S. national effort – as of May 2003, only 7% of the target group of 500,000 health care workers had accepted vaccination. In our survey, the most commonly cited concern was the risk vs. benefit of vaccination, followed by the risk of transmitting vaccinia virus. These matched the two most frequently chosen topics about which more information was desired for making the decision, suggesting that the health-related risks of vaccination are paramount considerations for people and ones about which they feel insufficiently informed. (Liability and compensation were not so important to those contemplating vaccination, although these issues may have become more important since then.) Since that time, there have been reports of cardiac problems and deaths shortly after vaccination. On the other side of the balance, the major factor affecting expressed willingness to be immunized was the perceived threat of bioterrorism. Those rating the risk of a bioterrorist attack using smallpox as intermediate or high were more likely to favor vaccination. It seems probable that a heightening of concerns about vaccine adverse events relative to the fear of a bioterrorist attack underlies the currently low acceptance of smallpox vaccination.

There are two likely reasons for the fact that far fewer workers have been vaccinated than the 61% expressing a general willingness (and even the 32% stating a clear intention) to get vaccinated in our December 2002 survey. First, well-publicized decisions of some hospitals and large unions of healthcare workers in early 2003 not to participate in the program, together with the subsequent reports of cardiac problems and deaths following vaccination, likely changed the minds of many prospective vaccinees. Second, social desirability bias tends to cause surveys like this one to overestimate acceptance of vaccination [3]. For example, at one study hospital, only 4 of the 28 respondents who said they intended to be vaccinated in our survey actually accepted the vaccine when, shortly thereafter, it was offered.

A limitation of this study was that the group surveyed was not a random sample of the population of interest, which has implications for the generalizability of the results. However, hospitals from several regions of the country were included, and the response rate was high (>80%), including in venues where most members of a particular sub-group would have been expected to be present (e.g. staff meetings of ED doctors). Moreover, our results for healthcare workers are similar to those of random-digit-

dial telephone surveys of the general public also carried out in 2002 [4,5], both in the proportions of respondents reporting willingness to be vaccinated and in the perception of risk of a smallpox attack.

We found wide variation among hospitals in both the proportion of staff expressing a willingness to be immunized and the proportion perceiving a threat of bioterrorist attack. Bivariate analyses turned up no pattern with respect to geographic region, size of hospital, or type of hospital (community vs. tertiary care). It is possible that local effects (e.g. in-hospital education programs, opinions of hospital authorities, the rumor mill) are important in healthcare workers' decision-making, at least on this issue.

Knowledge about smallpox vaccination was one of the factors associated with expressed willingness to be vaccinated, but we think it more likely that an intention to get vaccinated leads one to seek more information rather than that greater information leads one to seek vaccination.

Responses about projected behavior under hypothetical scenarios involving a smallpox release are perhaps not reliable, as the level and effect of panic likely cannot be accurately imagined. Nonetheless, it is worth noting that social desirability bias would tend to overestimate the proportion of people willing to put themselves at risk for the common good. Thus, the one-third of respondents who said (without qualification) they would come to work unvaccinated in the event of a smallpox admission is likely an overestimate.

### Conclusions

We conclude that the success of smallpox vaccination efforts will ultimately depend on the relative weight in people's minds of the risk of vaccine adverse events compared with the risk of being exposed to the disease. Although more than half of the group we surveyed thought the likelihood of a bioterrorist smallpox attack was intermediate or high, less than 10% of the group slated for vaccination has actually accepted it at this time. Unless new information about the threat of a smallpox attack becomes available, perceptions of the vaccine's risks will likely continue to drive the ongoing decisions of healthcare workers about this vaccine.

### Competing Interests

None declared.

### Authors' Contributions

KY developed the questionnaire in collaboration with the other co-authors, oversaw the analysis, and drafted most of the manuscript. TL conceived of, designed, and guided the study and critically contributed to the interpretation

and writing. VR obtained approval from IRBs, oversaw production and distribution of the questionnaire, designed and cleaned the original databases, and drafted a section of the manuscript. MO performed the statistical analyses and aided in the data interpretation. DS participated in the design, funding, and critical review of the study. DY helped develop the questionnaire and oversaw its deployment in a large hospital, achieving a high level of participation there. RP secured the participation of hospital epidemiologists, oversaw all phases of the study, and critically contributed to the interpretation and writing. All authors read and approved the final manuscript.

### Description of Additional data files

### Additional material

#### Additional file 1

1. *Yih Appendix 1.pdf* is CDC's 11/20/2002 draft smallpox vaccine information sheet, which was distributed with the questionnaire.

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[<http://www.biomedcentral.com/content/supplementary/1471-2458-3-20-S1.pdf>]

#### Additional file 2

2. *Yih Appendix 2.pdf* is the questionnaire.

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[<http://www.biomedcentral.com/content/supplementary/1471-2458-3-20-S2.pdf>]

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