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Knowledge, Attitudes, and Practices Related to Mold Exposure Among Residents and Remediation Workers in Posthurricane New Orleans

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ABSTRACT. To assess knowledge, attitudes, and practices related to mold exposure in postflood New Orleans, the authors surveyed 159 residents and 76 remediation workers, using logistic regression to explore associations. Nearly all answered "yes" to the questionnaire item, "Do you think mold can make people sick?" and most knew respirators were recommended for cleaning mold. Residents (87%) and workers (47%) said they believed that television or radio were the best ways to communicate information about mold. Workers (24%) also suggested employers provided the best means for communication of this information. Few participants reliably used all recommended protective equipment. Residents cited respirator discomfort and unavailability as reasons for noncompliance; workers cited discomfort and inadequate training, with 50% reporting respirator fit testing. Spanish-speaking workers relied on employers for information. Self-employed workers used protective equipment infrequently. The authors recommend that information on postflood mold exposure be disseminated through media and employers, that protective equipment be made readily available for residents, and that workers receive better training and fit testing. In addition, they suggest that targeted approaches may benefit Spanish-speaking workers and the self-employed.

KEYWORDS: flood, mold, personal protective equipment, remediation worker, respirator

On August 29, 2005, Hurricane Katrina made landfall along the Louisiana coast, leading to unprecedented flooding in the New Orleans area. Further flooding occurred after Hurricane Rita on September 24, 2005. In the aftermath, substantial mold growth occurred in 110,000 water-damaged homes[1] and in many commercial buildings. Exposure to mold in indoor environments is associated with respiratory symptoms, including asthma exacerbations, in addition to opportunistic fungal infections.[2] Respiratory symptoms were a common complaint among persons seeking healthcare in posthurricane New Orleans,[3] and anecdotal reports from providers suggested that such persons were being exposed to indoor mold. Calls from the public to local and federal hotlines indicated escalating concern about mold and incomplete understanding of safe remediation practices, from methods of limiting

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mold exposure to proper handling of toxic chemicals, such as bleach and ammonia.

Public health officials thus recognized the widespread potential for adverse health outcomes, particularly respiratory effects related to mold exposure and toxic injuries related to remediation. Public messages about health risks and recommendations for safe cleanup practices were disseminated in New Orleans after the flooding.[4] These messages included information about use of personal protective equipment (PPE) (gloves, goggles, respirators certified to filter small particles [instead of uncertified masks]) and dilute bleach (1 cup of bleach in 1 gallon of water). However, it was not clear that these messages, which were disseminated in the form of flyers, radio and television announcements, and Internet postings, were reaching the intended audience, given the frequency of respiratory symptoms among those seeking health care. Specifically, we were concerned about residents cleaning homes with water damage and mold growth, and workers remediating water-damaged and moldy buildings. To gauge the impact of educational activities, identify preferred means of postdisaster communication, and identify barriers to safe cleanup practices, we conducted a survey of the knowledge, attitudes, and practices of residents and remediation workers regarding mold and mold remediation.

METHODS

Questionnaires

We designed and pilot-tested 2 related 10-minute questionnaires, 1 for residents and the other for remediation workers. We designed the questions (highlighted in Tables 2–4) to address the content of educational messages (eg, knowledge of recommendations about PPE and bleach; attitudes about mold-associated illness); to explore issues surrounding communication of such messages (eg, knowledge that messages were disseminated; attitudes about sources of information and who is responsible for communicating messages); and to identify impediments to following recommendations (eg, practices employed during mold cleanup, including use of PPE and bleach; factors affecting those practices; this category included questions on whether PPE and instruction on its use were provided in the workplace and whether the worker had completed a respirator fit test). We collected information on demographics and experiences with flooding and mold, but not personal identifying information.

We administered the questionnaires from October 18, 2005, to October 23, 2005, in face-to-face interviews, in English or Spanish as appropriate, using a display of masks and respirators to facilitate communication. Questions were open-ended to elicit unprompted responses. After completing a questionnaire, the interviewer reviewed responses that indicated misperceptions, answered questions, and provided educational materials produced by the Louisiana Department of Health and Hospitals and the Centers for Disease Control and Prevention (CDC).

Survey Sites

To target at-risk residents and remediation workers, we conducted interviews in areas that had been flooded and were being repopulated. We surveyed residents at 3 public sites, located in geographically distinct communities, that were providing services and goods: a Federal Emergency Management Agency (FEMA) Disaster Recovery Center in St. Bernard Parish, a home improvement store on the West Bank of the Mississippi River, and a grocery store on the East Bank of the river. The stores were located in Jefferson Parish. Workers were surveyed at these 3 sites, at work sites in downtown New Orleans and St. Bernard Parish, and at informal gathering places, including campsites and social venues.

Eligibility

Any English- or Spanish-speaking adult at the survey site who self-identified as either a resident of the New Orleans area or a remediation worker was eligible to participate. We interviewed residents employed as remediation workers and volunteer remediators using the worker questionnaire.

Human Subjects Approval

CDC's Institutional Review Board reviewed the protocol and determined the investigation to be exempt from human subject regulations.[5]

Statistical Analyses

We used contingency tables and simple logistic regression to examine associations, and chi-square and Fisher's exact tests to determine statistical significance. Factors that were significant in these analyses were included in multiple logistic regression models, for which likelihood ratio chi-square tests were used to determine statistical significance. We applied stepwise logistic regression to determine which factors were independently significant. For analyses of respirator use, we categorized participants who reported always using respiratory protection (mask or respirator) but who did not specify type, as having always used a respirator. For all analyses, we considered p values less than or equal to .05 statistically significant. We conducted analyses using the SAS (version 9.1) and JMP (version 5.1) software packages (SAS Institute, Cary, NC).

RESULTS

Participants

We invited 332 people to participate, with 235 agreeing to be interviewed (159 residents, 76 remediation workers), for an overall response rate of 71%. No more than 15% of the worker sample was interviewed at any single work site or gathering place. A greater proportion of workers than residents were male, young, Spanish-speaking, and without a high school diploma (see Table 1).

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Knowledge

Sixty-eight percent of residents and 86% of workers indicated that they knew that a respirator should be used when cleaning mold (see Table 2). Forty-six percent of residents and 20% of workers reported knowing that 1 cup of bleach should be added to 1 gallon of water for cleaning mold. Most (73%) residents and half (49%) of workers reported having heard a public message about cleaning up mold. For residents, the most common source of information reported was the media (84%). For workers, the most common sources reported were the media (59%) and employers (24%).

Residents' knowledge of respiratory protection did not differ significantly on the basis of sex, age, race, or experiences

Table 1.—Characteristics of Surveyed Residents and Workers in Posthurricane New Orleans

Characteristic	Residents (N = 159)					Workers (N = 76)				
	n	%	*M*	Range	Mdn.	*n*	%	*M*	Range	Mdn.
Interview location										
FEMA center	30	19				2	3			
Home improvement store	62	39				20	26			
Grocery store	67	42				6	8			
Work site or other gathering place	0	0				48	63			
Male	82	52				70	92			
Age (y)			51	18–81				33	18–57	
Race										
White	111	70				34	45			
Black	36	23				9	12			
Other (Asian/Pacific Islander, Native American, other)	10	6				5	6			
No response given	2	1				28	37			
Primary language										
English	158	99				35	46			
Spanish	1	1				41	54			
Pre-Katrina/Rita state of residence	NA									
Louisiana						27	36			
Texas						16	21			
Florida						13	17			
Other						19	25			
No response given						1	1			
Type of employment	NA									
Company-employed						62	82			
Self-employed						14	18			
Education										
No high school	0	0				14	18			
Some high school	9	6				13	17			
High school graduate	52	33				24	32			
Some college	45	28				18	24			
College graduate	53	33				7	9			
Flood experience										
Previous residential flooding	43	27				NA				
Katrina/Rita residential flood level						NA				
None	51	32								
< 3 ft	42	26								
3–6 ft	28	18								
> 6 ft	37	23								
No response given	1	1								
Previous experience in flood remediation	NA							29		38
Experience with mold										
Previous residential flooding	27	17				NA				
Katrina/Rita residential mold extent						NA				
None	35	22								
< 10 ft^2	15	9								
10—100 ft^2	21	13								
> 100 ft^2	73	46								
House destroyed by storm*	6	4								
No response given	9	6								
Previous experience in remediation involving mold	NA					35	46			
Hours in moldy building since hurricane				0–1,080	5				0–364	120

Note. Race was self-reported. Most of the workers who declined to answer this question had identified their ethnicity as "Hispanic." NA = not applicable; the authors did not question this group of participants.
*Refers to houses for which the participants could not estimate mold extent because the storm had caused complete loss of housing structure.

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Table 2.—Responses of New Orleans' Residents and Workers to Questions on Knowledge Related to Mold Exposure After Hurricane Katrina

Question	Residents (N = 159)		Workers (N = 76)	
	n	%	n	%
Which mask should you use when cleaning up mold?				
None	1	1	1	1
Dust or surgical mask	24	15	4	6
Disposable or reusable respirator	108	68	65	86
Don't know	26	16	6	8
How much bleach should you add to 1 gallon of water for cleaning up mold?				
1 cup	73	46	15	20
Straight bleach, no water	14	9	7	9
Other amount	49	31	22	29
Don't know	23	14	32	42
Have you heard any public messages about cleaning up mold?				
Yes	116	73	37	49
Source of information*				
Media	98	84	22	59
FEMA/government	10	9	2	5
Employer	0	0	9	24
Other	8	7	4	11

*Based on the number of participants who reported hearing public messages (116 for residents, 37 for workers).

with flooding or mold. Residents who had heard a public message about cleaning up mold were more likely than those who had not to identify a respirator as appropriate PPE (72% vs 56%; $p = .05$). In addition, residents who were college graduates were more likely than were others to identify a respirator as appropriate PPE (83% vs 60%; $p < .01$). When combined in a multiple logistic regression model, having heard a message ($p < .05$) and having a college education ($p < .05$) were positively associated with identifying a respirator as appropriate PPE. Workers' responses did not differ significantly on the basis of sex, age, language, race, education, experiences with flooding or mold, having heard a public message about mold cleanup, or having been provided by their employers with respiratory protection or instructions on PPE use. Fewer self-employed workers than company-employed workers identified a respirator as appropriate PPE, but this difference did not reach statistical significance (71% vs 89%; $p = .10$).

Residents' knowledge of bleach use did not differ significantly on the basis of age, race, education, experiences with flooding or mold, or reported use of bleach for mold cleanup. Residents who had heard a public message were more likely than those who had not to respond that 1 cup of bleach should be added to 1 gallon of water (51% vs 33%; $p < .05$), as were female residents compared with male residents (57% vs 35%; $p < .01$). When combined in a multiple logistic regression model, female sex ($p = .01$) remained positively associated with understanding of bleach use, whereas having heard a message approached, but did not reach, statistical significance for a positive association ($p = .07$).

Attitudes

Nearly all participants (96% of residents, 95% of workers) answered "yes" to the question "Do you think mold can make people sick?" (see Table 3). Most (87%) residents and 47% of workers said television or radio, or both, would be the best way to communicate messages about mold. An additional 24% of workers said employers provided the best means for communicating this information.

As for the question of who is responsible for educating the public or workers about mold, the most common responses for residents were (1) the health department (58%) and (2) FEMA or another government agency (43%). For workers, the most common responses were (1) employers (70%) and (2) the Occupational Safety and Health Administration (OSHA) or another government agency (34%).

Residents' attitudes about responsibility for mold education did not vary by sex, age, race, or experiences with flooding. College graduates were more likely than were others to say the health department is responsible (81% vs 46%; $p < .0001$). Residents who reported more than 100 ft^2 of mold growth in their home were more likely than were others to say that FEMA or another government agency is responsible (55% vs 34%; $p < .01$).

Workers' attitudes about responsibility for mold education were not affected by sex, age, or experience with mold exposure. English speakers were more likely than were Spanish speakers to say the media (31% vs 2%; $p < .001$), the health department (10% vs 37%; $p < .01$), and OSHA (54% vs 17%; $p < .001$) are responsible for educating workers about mold, and less likely to say that employers

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Table 3.—Responses of New Orleans' Residents and Workers to Questions on Attitudes Regarding Mold Exposure After Hurricane Katrina

Question	Residents (N = 159)		Workers (N = 76)	
	n	%	n	%
Do you think mold can make people sick?				
Yes	153	96	72	95
Do you think you are personally at risk of getting sick from mold?				
Yes	105	66	62	82
Can a building still have a mold problem after visible mold is gone?				
Yes	83	52	61	80
Are you interested in learning more about cleaning up mold?				
Yes	107	67	62	82
Who should be responsible for educating public/workers about mold?*				
Media	28	18	12	16
Health department	92	58	17	22
FEMA/government	69	43	0†	0
OSHA/government	0†	0	26	34
Employer	0†	0	53	70
What would be the best way to communicate messages about mold to public/workers?				
Television/radio	139	87	36	47
Employers	0†	0	18	24
Other	20	13	22	30

*The total number of responses exceeds number of participants because more than 1 response to this question was allowed.
†No participant in this group specified this response under the "Other" option.

are responsible (49% vs 88%; $p < .001$). Workers who identified their race as white were more likely than those who did not to indicate that OSHA (47% vs 24%; $p < .05$) and the health department (35% vs 12%; $p < .05$) are responsible. Workers who were self-employed were more likely than those who were company-employed to respond that OSHA (71% vs 26%; $p < .01$) and the media (36% vs 11%, $p < .05$) are responsible. Workers who were college graduates were more likely than those who were not to say that OSHA is responsible (86% vs 29%; $p < .01$). Workers with prior experience working on flooded buildings were more likely than those without prior experience to indicate OSHA (55% vs 21%; $p < 0.01$) and less likely to indicate employers (55% vs 79%; $p < .05$).

When combined in multiple logistic regression models, the only factor positively associated with believing that the media ($p < .01$) and the health department ($p = .05$) are responsible for educating workers about mold exposure was using English as the primary language spoken. Using English as the primary language spoken ($p < .001$) and having prior experience working on flooded buildings ($p = .05$) remained negatively associated with believing that employers are responsible. Using English as the primary language spoken ($p < .01$), having a college education ($p < .05$), and having prior experience working on flooded buildings ($p < .01$) each remained positively associated with believing that OSHA is responsible for educating workers about mold.

Practices

Sixty-seven (42%) residents and 69 (91%) workers described already having participated in mold cleanup activities at the time of the interview. Of these residents, 66% reported always using gloves, 45% reported always using respiratory protection (mask or respirator), and 10% reported always using goggles during mold cleanup; the corresponding figures for these workers were 84%, 68%, and 48% (see Table 4). Not all participants specified the type of respiratory protection; at most, 30% of residents and 65% of workers always wore a respirator. No residents and at most 39% of workers reported always wearing all 3 types of recommended PPE (gloves, respirators, goggles). Furthermore, 28% of residents and 10% of workers reported never using *any respiratory protection (mask or respirator) when cleaning* mold. When asked why they did not always wear respiratory protection, residents ($n = 30$) most often cited discomfort (33%) and lack of availability (33%). Workers ($n = 19$) *most often cited discomfort (68%). Most (97%)* residents and 54% of workers reported using bleach to clean mold. A small minority (2 [3%] residents and 3 [4%] workers) reported having mixed bleach and ammonia.

Most company-employed workers reported being provided with gloves (100%), respiratory protection (mask or respirator) (95%), goggles (84%), and instruction on use of PPE (81%). Half (50%) of all workers indicated that they had had a respirator fit test. Reports of having had a respirator fit test were less common among self-employed than among

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Table 4.—Responses of New Orleans' Residents and Workers to Questions on Practices During Mold Cleanup After Hurricane Katrina

Question	Residents ($N = 67$)		Workers ($N = 69$)	
	n	%	*n*	%
How often have you used gloves?				
Never	10	15	3	4
Occasionally	5	7	3	4
Often	8	12	5	7
Always	44	66	58	84
How often have you used a mask?				
Never	19	28	7	10
Occasionally	5	8	55	7
Often	12	18	10	15
Always	30*	45	47†	68
No response given	1	1	0	0
Specify type‡				
Mask	13	39	3	7
Respirator	20	61	43	93
How often have you used goggles?				
Never	55	82	21	30
Occasionally	2	3	11	16
Often	3	5	2	3
Always	7	10	33	48
No response given	0	0	2	3
Which compounds have you used?§				
Bleach	65	97	37	54
Ammonia	0	0	3	4
Bleach mixed with ammonia	2	3	3	4
Soapy water	11	16	5	7
Water alone	1	1	1	1
Other	17	25	17	25

Note. Participants represented in this table reported that they had already participated in mold cleanup activities at the time of the interview.

*Ten of these residents specified a mask, 14 specified a respirator, and 6 did not specify; hence, at most 30% of residents reported always using a respirator.

†Two of these workers specified a mask, 34 specified a respirator, and 11 did not specify; hence, at most 65% of workers reported always using a respirator.

‡$N = 33$, for residents; $N = 46$, for workers.

§The total number of respondents exceeds the number of participants because more than 1 response to this question was allowed.

company-employed workers, although this difference did not reach statistical significance (29% vs 55%; $p = .07$).

For residents, reporting that they had always used PPE was not significantly associated with sex, age, race, education, or having heard a public message about cleaning up mold. Residents who reported past mold growth in their homes were more likely than those who did not to say that they always used gloves (88% vs 59%; $p < .05$); otherwise, experiences with flooding or mold were not associated. In addition, residents who identified a respirator as appropriate PPE were more likely than those who did not to report always using a respirator (42% vs 0%; $p < .0001$).

For workers, reporting that they always used PPE was not associated with sex, age, race, education, experiences with flooding or mold, hearing a public message about cleaning up mold, or being provided with PPE. Spanish-speaking workers were more likely than English-speaking workers to report always wearing goggles (63% vs 29%; $p < .01$), as were company-employed workers compared with the self-employed (54% vs 17%; $p = .01$). Although type of employment was not associated with reporting that respiratory protection always had been used, self-employed workers were more likely than company-employed workers to report never having used any respiratory protection (mask or respirator) (42% vs 4%; $p < .001$). Workers who identified a respirator as appropriate PPE were more likely than those who did not to report always having used a respirator (75% vs 0%; $p < .0001$, as were workers who had had a respirator fit test compared to those who had not (82% vs 49%; $p < .01$). Workers who described receiving instruction on PPE use were more likely to report always having used a respirator (73% vs 45%; $p < .05$) and goggles (57% vs 25%; $p = .01$). When the factors concerning respirator knowledge, fit testing, and receiving instruction on PPE use were combined in a multiple logistic regression model, both respirator knowledge ($p < .0001$) and fit testing ($p < .01$) were positively associated with always using respirators. When language, type of employment, and receiving instruction on PPE use were combined in a multiple logistic regression model, the only factor positively associated with always using goggles was using Spanish as the primary language ($p < .05$), whereas receiving instruction on PPE use approached, but did not reach, significance for a positive association ($p = .07$).

COMMENT

We found that New Orleans area residents and remediation workers were nearly uniformly aware that mold exposure can lead to health effects. Residents and workers were fairly, although not universally, knowledgeable about recommendations to use respirators when cleaning mold. They were less aware of the recommended dilution of bleach for cleaning mold. For residents, we found evidence suggesting that knowledge about safe practices was increased by public messages disseminated after the hurricanes. Also, despite disruptions in basic utilities, most residents and many workers described getting these messages via the media and expressed a belief that television and radio were the best means for communication of information on mold exposure.

Workers also indicated relying on employers for information. In particular, Spanish-speaking workers indicated that they believed employers (not the media or government) should be responsible for educating them about safe mold remediation. This difference in expectations between English-speaking and Spanish-speaking workers could reflect the impact of the language barrier itself. Additionally, some of the Spanish-speaking workers we interviewed were living on employer-sponsored housing compounds that were remote from population centers, so relative isolation from nonemployer sources of information also may have contributed.

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In this postdisaster setting, knowledge and attitudes that demonstrated an informed understanding of safe mold remediation did not necessarily translate directly into appropriate practices. Few participants described mixing bleach with ammonia, which can liberate chloramine compounds and cause potentially fatal toxic pneumonitis.[6,7] Yet during mold cleanup activities, just two thirds of residents reported always wearing gloves, and a minority reported consistently using respirators and goggles; not one resident reported always using all 3 types of PPE as recommended. Among workers, consistent use of PPE was more common, but still fewer than half of the workers reported using all three types of PPE reliably. Although knowledge of respirators was associated with respirator use, it was not a guarantee. More than half of the residents and a quarter of the workers who correctly identified respirators as appropriate PPE were either not using a respirator or not using it consistently. These discrepancies between what some participants knew or believed and what they actually did in practice suggests other that other barriers, beyond lack of insight, existed.

An important barrier for both residents and workers was respirator discomfort, a well-recognized limitation of respirator use in occupational settings.[8] Use of disposable respirators during physical activity is associated with physiological changes including increased respiratory rate, heart rate, and temperature of air near the face.[9] Furthermore, controlled-environment studies have demonstrated that wearer acceptance of respirators declines as environmental temperature and humidity rise.[10,11] The warm, humid conditions common in New Orleans were likely to exacerbate any discomfort associated with the physical work itself and lead to less wearer acceptance. Residents also noted lack of availability of respiratory protection. Availability was undoubtedly affected by the high postflood demand for respirators and by the fact that many stores were not open or had limited stock.

We also found evidence that the practices of employers influenced those of their workers. Workers who received instruction on PPE use tended to use PPE more consistently. In addition, respirator fit testing was associated with consistent respirator use. Federal standards require employers to provide respirators "when such equipment is necessary to protect the health of the employee."[12] An employer providing respirators must establish a respiratory protection program, including plans for selection and use of the respirators and fit testing and training of the workers. The observed positive associations between known components of a respiratory protection program and respirator use suggest that such programs played a role in protecting workers. The observation that only half of workers reported fit testing, however, indicates that many employers did not have respiratory protection programs.

We identified a group of workers, the self-employed, who may be particularly vulnerable. Although they represented less than 20% of our worker sample, self-employed workers stood out in terms of their lower respiratory protection knowledge and their tendency not to use recommended PPE or undergo respirator fit testing. The self-employed workers, like residents, may have been more affected by limited PPE availability, and probably had less access to respirator fit test services, compared with company-employed workers. Workers in small businesses are at higher risk for work-related illness and injury than workers in large businesses.[13] In construction (the type of work most comparable to remediation), the highest incidences of nonfatal injuries and illnesses are reported in small-to-medium businesses (businesses with fewer than 250 employees).[14] Thus, our finding that the practices of self-employed workers may put them at higher risk for work-related health outcomes reflects known patterns in occupational safety and health.

Our investigation benefited from several strengths. Because it was performed just 7 weeks after Hurricane Katrina, we were able to assess conditions early and provide timely feedback to local public health officials. We know of no similar surveys that have included remediation workers, making our work a unique examination of an under-studied group. Furthermore, we included Spanish-speaking people, who represented a substantial proportion of New Orleans remediation workers. Finally, because we gave participants information and answered their questions, our investigation also served an educational function.

The investigation had several limitations. Convenience sampling facilitated a rapid postdisaster response, but it may limit the ability to generalize our results. We attempted to address this issue by sampling at 3 distinct public sites and ensuring that workers from no single work site or gathering place composed more than 15% of the worker sample. In addition, because we relied on self-report, some of the associations we found may have been influenced by variations in reporting. Last, small numbers in certain subgroups precluded some analyses and may have affected our estimates of the strength of some associations.

In summary, although residents and workers demonstrated knowledge that mold exposure can cause adverse health effects, many residents and workers were not using recommended PPE during activities that could result in mold exposure. We found that lack of information and lack of resources were predominant factors. Health and safety agencies in the New Orleans area should continue to promote public health messages about mold, using in particular TV, radio, and for workers, communication from employers. In addition, messages and interventions should target worker subgroups, notably Spanish speakers, who may be less likely to use traditional public health information sources, and the self-employed, who are less likely to use PPE. Finally, for cleaning up mold after flooding, the public should have respirators readily available, and workers should be in respiratory protection programs.

Lessons from the experiences in New Orleans can be applied to future floods complicated by indoor mold growth. Early in the postdisaster setting, the damaged local infrastructure may not have the capacity to meet the increased need for PPE, including respirators. Under such conditions, public-private

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partnerships with manufacturers and retailers could be considered as a way to ensure adequate supply. Retailers also could serve an educational role by displaying only recommended respirators instead of uncertified masks. Members of the remediation workforce who do not speak English may not be well integrated into the larger community; direct contact with employers may reach such otherwise unreachable audiences. Self-employed workers and employees of small businesses may be at a disadvantage regarding access to fit testing services. Making such services available on a short-term basis also could be considered. Finally, over the long term, addressing issues of respirator discomfort may improve acceptability to wearers and thus increase use.

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