

A REPRINT FROM

Disaster Medicine and Public Health Preparedness

An Official Publication of the American Medical Association

October 2012

Nuclear Power Plant Emergency Preparedness: Results From an Evaluation of Michigan's Potassium Iodide Distribution Program

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A JAMA NETWORK
PUBLICATION

ORIGINAL RESEARCH

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ABSTRACT

Background: In 2009, the Michigan Department of Community Health (MDCH) made potassium iodide (KI), a nonprescription radio-protective drug, available by mailing vouchers redeemable at local pharmacies for KI tablets, at no cost to residents living within 10 miles of Michigan's 3 nuclear power plants (NPPs). MDCH conducted an evaluation of this program to determine Michigan's KI coverage and to assess general emergency preparedness among residents living near the NPPs.

Methods: KI coverage was estimated based on redeemed voucher counts and the 2010 Census. Telephone surveys were administered to a random sample (N=153) of residents living near Michigan's NPPs to evaluate general emergency preparedness, reasons for voucher use or nonuse, and KI knowledge.

Results: Only 5.3% of eligible residences redeemed KI vouchers. Most surveyed residents (76.5%) were aware of living near an NPP, yet 42.5% reported doing "nothing" to plan for an emergency. Almost half of surveyed voucher users did not know when to take KI or which body part KI protects. Among voucher nonusers, 48.0% were either unaware of the program or did not remember receiving a voucher.

Conclusions: Additional efforts are needed to ensure that all residents are aware of the availability of KI and that recipients of the drug understand when and why it should be taken. Minimal emergency planning among residents living near Michigan's NPPs emphasizes the need for increased emergency preparedness and awareness. Findings are particularly salient given the March 2011 Fukushima Daiichi Nuclear Power Plant emergency in Japan.

(Disaster Med Public Health Preparedness. 2012;6:263-269)

Key Words: radiation preparedness, potassium iodide, KI, nuclear power plant, public health evaluation

Potassium iodide (KI) is a nonprescription prophylactic that blocks thyroidal uptake of radioactive iodine, one of a number of carcinogenic radionuclides that would be released during a nuclear power plant (NPP) accident.¹ Ingestion of KI immediately before or concurrent with radioactive iodine exposure effectively reduces the risk of developing thyroid cancer, with some limitations.²⁻⁵ Epidemiological studies, conducted in the aftermath of the 1986 Chernobyl disaster, suggest timely KI prophylaxis blocks upward of 95% of the radioactive dose, thereby reducing thyroid cancer risk more than 3-fold.^{2,4,6}

BACKGROUND

Potassium Iodide, Nuclear Power Plants, and Thyroid Cancer

In spite of KI's radio-protective properties, the US Nuclear Regulatory Commission (NRC) historically included KI in its requirements for emergency preparedness to supply only NPP personnel and emergency first responders.^{7,8} Large-scale public distribution plans had not been instituted due to concern over the possibility that the inclusion of a public KI component might complicate existing nuclear emergency plans, which rely on

the critical protective actions of evacuation and sheltering-in-place to reduce the risk of all radiation-related cancers.⁸

However, in 2001, the NRC revised its emergency planning rules to mandate that all states with residents living inside the 10-mile emergency planning zone (EPZ) of an NPP consider offering KI to the public as a supplemental protective measure.⁹ With this mandate, the NRC extended an offer of two free KI doses per person for the EPZ populations of all states electing to initiate a distribution program.⁹ States accepting the offer were responsible for developing, funding, and implementing KI distribution and public education programs.

In 2004, the National Research Council conducted an extensive review of the response to the NRC's KI offer and described distribution approaches taken by participating states, noting that KI distribution plans would need to be tailored to correspond to local conditions.¹⁰ To date, 23 of 34 eligible states, including Michigan, have accepted the NRC's offer and subsequently implemented KI distribution programs.¹¹ States have employed a variety of distribution strategies (eg, mailing

KI, disseminating KI during staged public clinics, making KI available at local health departments). Only New Jersey¹²⁻¹⁴ and Vermont¹⁵ have published results from evaluations of their distribution programs for NRC-funded KI. An evaluation of a door-to-door KI delivery program in Tennessee was also published; however, this program took place 20 years before the inception of NRC's free KI program.¹⁶

Michigan's KI Program and Evaluation Aims

After extensive deliberation over implementation costs and the perceived risks and benefits of KI distribution, the Michigan Department of Community Health (MDCH) accepted the NRC's offer in 2008, and subsequently developed plans for distribution to the approximately 190 000 residents living within the EPZs surrounding Michigan's three NPPs. The rationale for proceeding with the program included: (1) KI is a safe and medically effective drug if taken in the appropriate dosage at the appropriate time, (2) the potential health benefits of KI outweigh any medical risks, (3) making KI available to the public pre-event would offer an extra measure of protection to those who choose to obtain KI, and (4) it would be difficult to justify the state's nonacceptance of the NRC's KI offer to the public if an actual or threatened radiologic release from one of Michigan's NPPs occurs.

The goal of Michigan's KI program was to provide EPZ residents with the opportunity to choose to include KI as a supplemental protective measure in their nuclear emergency preparations. Michigan's KI distribution plan was modified from a similar KI program executed in Minnesota in 2007 (Onalee Grady-Erickson, written communication). In October 2009, MDCH bulk-mailed KI vouchers, redeemable at five local pharmacies for a free KI supply, to 78 503 residential EPZ addresses and 4748 business or school addresses. At the time of the voucher mailing, media outlets (eg, newspaper, television, radio), public forums, and an MDCH website provided information to the public about the program.

To improve the effectiveness and acceptability of future KI distribution campaigns, MDCH conducted an evaluation of year 1 of its KI distribution program. The evaluation addressed three concerns. First, it sought to determine residential and population KI coverage, both overall and stratified by EPZ. Second, it aimed to assess nuclear emergency preparedness among Michigan EPZ residents. Third, it intended to elucidate reasons for either KI voucher use or nonuse. The goals of the evaluation were to determine inadequacies in nuclear preparedness among EPZ residents, underscore program areas needing improvement for subsequent distribution cycles, and augment the scant information currently available on best practices for KI distribution programs.

METHODS

The study population consisted of 78 503 residences located within Michigan's three EPZs and an estimated 190 774 individuals based on the 2010 US Census population of all towns and cities fully or partially located within each 10-mile EPZ radius. Michigan's

NPPs include the Fermi 2 Nuclear Power Plant, located in Monroe; the Cook Nuclear Plant, located in Bridgman; and the Pali-sades Power Plant, located in Covert Township. Although businesses and schools were included in the bulk mailing of vouchers, they were not included in this evaluation.

When a KI voucher was redeemed, the redeeming pharmacy was required to return it to the MDCH. Each completed voucher included the name, address, and phone number of the person redeeming the voucher and the number of adults and children living at the residence for which KI was requested. These data were entered into a KI voucher-user database. A separate database, the MDCH bulk-mailing database, housed all EPZ addresses slated to receive vouchers. Voucher-user addresses were removed from this database to create a KI voucher-nonuser database. All databases were password protected and placed behind a firewall by MDCH.

KI Coverage

Overall residential KI coverage was determined by dividing the total number of redeemed vouchers by the total number of mailed KI vouchers. Similarly, for residential KI coverage stratified by EPZ, the number of redeemed vouchers per EPZ was divided by the number of vouchers mailed per EPZ. Vouchers redeemed in association with PO Box numbers (N = 37) or non-EPZ addresses (N = 165) were not included in numerator counts.

The KI voucher-user database contained self-reported information on the number of adults and children living at each redeeming residence. Hence, it was possible to determine Michigan's overall KI population coverage by dividing the number of individuals with access to KI, or the sum of the numbers of adults and children living at each redeeming residence, by the estimated number of individuals living in all three EPZs. Similar calculations stratified by EPZ were also performed.

Telephone Surveys

A telephone survey instrument was designed to collect information from Michigan EPZ residents on general nuclear preparedness, reasons for KI voucher use or nonuse, knowledge of KI use, and demographic parameters. The instrument included both closed-ended and open-ended questions, many of which had been used previously during an evaluation of New Jersey's 2002 KI distribution program.¹²⁻¹⁴ All demographic questions were adapted from the 2010 Behavioral Risk Factor Surveillance System questionnaire.¹⁷

The survey posed three nuclear preparedness questions. The first queried each respondent's knowledge of living within 10 miles of an NPP. The second asked respondents to list all NPP preparedness activities completed by the interviewees themselves or by household members (eg, planning an evacuation route, purchasing extra food or water, designating a family meeting place). The third asked respondents how they would react on hearing a three-minute signal from a Civil Defense siren (eg, tune to the Emergency Alert System [EAS]), evacuate, shelter-in-place).

The survey also asked interviewees the reasons for either their participation or nonparticipation in the KI distribution program. In addition, to assess knowledge of KI use, voucher users were asked to identify which part of the body KI “protects” from radiation (correct answer: thyroid) and when KI should be taken during an emergency event (correct answer: when a “general emergency” is declared). Finally, demographic items gathered each respondent’s age, sex, race, education level, employment status, and marital status.

The survey instrument was pilot tested to ensure ease of delivery and question clarity. Telephone interviews were then conducted via a random sampling method stratified by EPZ and KI voucher-use status, to ensure that both KI voucher users and nonusers from each Michigan EPZ were represented in the study sample.

The methodology employed to recruit KI voucher users for interviews differed somewhat from that used to recruit nonusers. Because the KI voucher-user database housed both the addresses and phone numbers of all voucher users, addresses and linked phone numbers were stratified by EPZ and then randomized using computer software to create an ordered call list. However, the KI voucher nonuser database contained only addresses without corresponding phone numbers. Consequently, the call list for nonvoucher users was created by stratifying the addresses of all KI voucher nonusers by EPZ and then randomizing each EPZ using computer software. Voucher nonuser phone numbers were sequentially obtained via a reverse address look-up aid (eg, the white pages) to create a call list.

Residences were called according to the call lists. If there was no answer or an answering machine was reached, an additional call attempt was made, with one of the two call attempts made during nonworking hours. On reaching an answering machine, a message was left with a call-back number. Potential respondents were screened to ensure all eligibility criteria were met. Eligible participants were defined as adult Michigan EPZ residents (aged 18 years or older) residing at their current EPZ residence prior to October 1, 2009, the date MDCH sent the KI vouchers by bulk mail. Willing, eligible respondents gave their verbal consent to participate. Surveys were conducted from June through August 2010. All data were entered into a secured MDCH database. χ^2 tests were performed to explore associations between collected variables and KI voucher-use status.

All study protocols were deemed exempt by MDCH’s Institutional Review Board and the University of Michigan’s Institutional Review Board of Health Sciences and Behavioral Sciences.

RESULTS

KI Coverage

KI was obtained for 5.3% (N=4176) of Michigan EPZ residences, covering 5.6% (N=10 615) of the estimated population residing within Michigan’s EPZs. Table 1 presents residential and population KI coverage for Michigan, both overall and stratified by EPZ. Residential and population KI coverage

TABLE 1

KI Coverage in Michigan, Overall and Stratified by EPZ, as Determined During the 2010 Evaluation of the 2009 KI Distribution Cycle

Nuclear Plant	No. of Residences That Redeemed Vouchers		
	Redeemed KI Vouchers	EPZ Residences	Residential KI Coverage, %
Fermi	2186	42 332	5.2
Cook	1251	21 541	5.8
Palisades	739	14 630	5.1
Overall	4176	78 503	5.3
Nuclear Plant	No. of Individuals With Access to KI		
	Individuals	EPZ Population	Individual KI Coverage, %
Fermi	5716	94 775	6.0
Cook	3100	58 347	5.3
Palisades	1799	37 652	4.8
Overall	10 615	190 774	5.6

Abbreviations: EPZ, emergency planning zone; KI, potassium iodide.

TABLE 2

Demographic Variables of Interest for Telephone Survey Interviewees Stratified by KI Voucher-Use Status^a

Variables by Category	KI Voucher Users N = 78 (50.9%) Distribution Count (%)	KI Voucher Nonusers N = 75 (49.1%) Distribution Count (%)
Age, y		
≥30 and <40	4 (5.7)	8 (11.1)
≥40 and <50	9 (11.8)	13 (17.8)
≥50 and <60	18 (23.7)	15 (20.6)
≥60 and <70	18 (23.7)	16 (21.9)
≥70 and <80	20 (26.3)	17 (23.3)
≥80	7 (4.7)	4 (5.5)
Total	76 (100.0)	73 (100.0)
Mean age	63.3 (SD = 13.7)	60.1 (SD = 15.2)
Sex		
Male	31 (39.7)	31 (41.3)
Female	47 (60.3)	44 (58.7)
Total	78 (100.0)	75 (100.0)
Race		
White	73 (96.1)	64 (87.7)
Black	2 (2.6)	5 (6.9)
Native American	1 (1.3)	4 (5.5)
Total	76 (100.0)	73 (100.0)
Education level		
≤High School	28 (36.8)	33 (45.8)
>High School	48 (63.2)	39 (54.2)
Total	76 (100.0)	72 (100.0)
Employment status		
Employed	25 (32.5)	29 (39.7)
Unemployed	7 (9.1)	10 (13.7)
Retired	45 (58.4)	34 (46.6)
Total	77 (100.0)	73 (100.0)
Marital status		
Married	50 (65.8)	54 (73.0)
Divorced	7 (9.2)	7 (9.5)
Widowed	13 (17.1)	13 (17.6)
Other	6 (7.9)	0
Total	76 (100.0)	74 (100.0)

Abbreviation: KI, potassium iodide.

^aDuring the 2010 evaluation of Michigan’s 2009 public KI distribution program. Overall, N=153; however, totals for all variables do not sum to 153 due to missing data. None of the demographic differences between KI voucher users and nonusers was found to be statistically significant.

TABLE 3

Responses to Emergency Preparedness Survey Questions and Prior Knowledge of Michigan's 2009 KI Distribution Program^{a,b}

Variables by Category	Overall N = 153 (100.0%) Distribution Count (%)	KI Voucher Users N = 78 (50.9%) Distribution Count (%)	KI Voucher Nonusers N = 75 (49.1%) Distribution Count (%)
Knew living within 10-mile EPZ?			
Yes	117 (76.5)	60 (76.9)	57 (76.0)
No	36 (23.5)	18 (23.1)	18 (24.0)
Total	153 (100.0)	78 (100.0)	75 (100.0)
Prepared for a nuclear emergency? ^c			
Yes	88 (57.5)	58 (74.4)	30 (40.0)
Planned evacuation route	31 (20.3)	16 (20.5)	15 (20.0)
Purchased extra water	22 (14.4)	12 (15.4)	10 (13.3)
Purchased extra food	18 (11.8)	8 (10.3)	10 (13.3)
Designated family meeting place	10 (6.5)	4 (5.1)	6 (8.0)
Made emergency kit	6 (3.9)	3 (3.8)	3 (4.0)
Other	31 (20.3)	17 (21.8)	14 (18.7)
No (did nothing)	65 (42.5)	20 (25.6)	45 (60.0)
Knew How to Properly Respond to Hearing a 3-min Civil Defense Siren? ^d			
Yes (tune to EAS)	57 (37.3)	37 (47.4)	20 (26.7)
No or don't know	96 (62.7)	41 (52.6)	55 (73.3)
Evacuate	32 (20.9)	15 (19.2)	17 (22.7)
Shelter-in-place	29 (19.0)	10 (12.8)	19 (25.3)
Other	55 (35.9)	29 (37.2)	26 (34.7)
Don't know	24 (15.7)	10 (12.8)	14 (18.7)

Abbreviations: EAS, emergency alert system; EPZ, emergency planning zone; KI, potassium iodide.

^a Provided by telephone interviewees during the program's 2010 evaluation, overall and stratified by KI voucher-use status.

^b Overall, N=153. Respondents were not limited to a single response for emergency nuclear preparedness survey questions, so percents do not sum to 100.0%.

^c Preparing for a possible nuclear event in any type of way was significantly and positively associated with KI voucher-use status ($\chi^2_{(1)}=18.47, P \text{ value} < .0001$).

^d Proper knowledge of how to respond to a nuclear emergency event was significantly and positively associated with KI voucher-use status ($\chi^2_{(1)}=7.06, P \text{ value}=.0079$).

TABLE 4

Interviewees' Responses to Michigan's 2009 KI Distribution Program via Telephone Surveys During the Program's 2010 Evaluation^a

Reasons Cited for KI Voucher Use	Distribution Count (%) (N = 78)
To be prepared	45 (57.7)
To be safe	14 (18.0)
It was free	11 (14.1)
It was recommended	10 (12.8)
Close proximity to nuclear plant	7 (9.0)
Concerned about plant safety	5 (6.4)
Other	13 (16.7)
Reasons Cited for KI Voucher Nonuse	Distribution Count (%) (N = 75)
Didn't know about program	27 (36.0)
Don't know	14 (18.7)
Didn't receive voucher	9 (12.0)
Too busy to redeem voucher	8 (10.7)
Wasn't interested in KI program	5 (6.7)
Forgot about KI voucher	5 (6.7)
Lost KI voucher	4 (5.3)
Felt it was unnecessary	3 (4.0)
Other	2 (2.7)

Abbreviation: KI, potassium iodide.

^a Respondents were not limited to a single response for this survey question, so percents do not sum to 100.0%.

remained similar across Michigan's EPZs (Fermi = 5.2%, Cook = 5.8%, Palisades = 5.1%; and Fermi = 6.0%, Cook = 5.3%, Palisades = 4.8%, respectively).

Telephone Surveys

A total of 153 EPZ residents completed a telephone survey, including 78 KI voucher users and 75 nonusers, corresponding to a 59.8% success rate among those EPZ individuals who answered the phone (N = 256). Demographic characteristics of survey respondents by KI voucher-use status are presented in Table 2. The mean age of interviewees was 61.7 years (SD = 14.5). Approximately 40.0% of respondents were male and 60.0% were female; this gender distribution was consistent across KI voucher-use status. A higher percentage of voucher users (96.1%) identified as white, as compared to nonusers (87.7%). The majority of respondents reported being retired (52.7%), with voucher users reporting retirement more often (58.4%) than voucher nonusers (46.6%). However, none of these differences was found to be statistically significant.

Results of the emergency preparedness questions, overall and by voucher-use status, are presented in Table 3. Most EPZ residents (76.5%) were aware of living within 10 miles of an NPP. Yet, 42.5% of interviewees reported doing "nothing" to plan for a possible plant emergency. This result varied significantly by voucher-use status, as users reported doing "nothing" far less

often (25.6%) than nonusers (60.0%) [$\chi^2_{(1)} = 18.47$, P value $< .0001$]. Among respondents indicating they currently had at least one type of emergency plan in place, 20.3% had planned an evacuation route, 14.4% had purchased extra water, and 6.5% had designated a family meeting place. Only 37.3% of interviewees stated they would tune to the EAS on hearing a three-minute signal from a Civil Defense siren, which is the correct behavioral response. Voucher users answered this item correctly more frequently (47.4%) than nonvoucher users (26.7%) [$\chi^2_{(1)} = 7.06$, P value = 0.0079]. Incorrect responses included evacuating immediately (20.9%) and sheltering-in-place (19.0%). Fifteen percent of interviewees were unsure what to do on hearing a three-minute Civil Defense siren.

Reasons cited for either participation or nonparticipation in Michigan's KI program are presented in Table 4. Voucher users most often reported the following reasons for obtaining KI: "to be prepared" (57.7%), "to be safe" (18.0%), "the KI was free" (14.1%), and "it was recommended" (12.8%). The most common reasons for nonparticipation among voucher nonusers were "didn't know about program" (36.0%), "don't know" (18.7%), and "didn't receive voucher" (12.0%). Only 6.7% said they "weren't interested" and 4.0% said they "felt KI was unnecessary."

Regarding knowledge of KI use, 97.4% of the interviewed voucher users knew where their household KI supply was located. However, 42.3% did not know that KI's effects are only imparted to the thyroid, and 43.6% were not sure when KI should be taken, in spite of the inclusion of this information in MDCH's voucher mailing and by the pharmacy on obtaining KI.

DISCUSSION

Michigan's overall residential KI coverage was lower than the 8% reported by Minnesota for the first year of its similarly structured KI distribution program but higher than the 1.1% reported for Vermont's pre-event distribution program, which required submission of an application to a public health department.¹⁵ It should be noted that Michigan's coverage rate is likely underestimated because the denominator included the population of some towns that extended beyond the 10-mile EPZ radii. Unlike New Jersey, where residential KI coverage varied widely by EPZ and by zip code within each EPZ (from 1% to 60%), KI coverage across Michigan's EPZs was similar.¹²⁻¹⁴ A 2004 review of KI distribution programs by the National Research Council concluded that states with voluntary pickup programs by residents at specified locations generally resulted in KI distribution to no more than 5% of the population.¹⁰ The results of this evaluation are consistent with this finding.

Federal regulations set forth by the NRC (10 CFR 50.47) require NPP licensees to make "... information available to the public on a periodic basis on how they will be notified and what their initial actions should be in an emergency."¹⁸ Michigan's NPPs meet this requirement by mailing a brochure containing public safety information to all EPZ addresses annually. These

mailings include information about evacuation routes, emergency Civil Defense sirens, and recommended personal emergency preparedness measures. In Michigan, 85.0% of surveyed individuals remembered receiving an NPP mailing and 69.2% knew its location at the time of interview.

In spite of the emergency preparedness information provided in the NPP mailings, nearly half (42.5%) of interviewees reported doing "nothing" to prepare for an emergency. A much larger proportion of voucher nonusers (60%) reported doing "nothing" compared to voucher users (25.6%), suggesting that voucher users were generally more concerned about emergency preparedness than nonusers and that the general attitude toward emergency preparedness was a determining factor in whether people took action to obtain KI. Only 20.3% of all interviewees had developed evacuation routes, despite inclusion of these safety recommendations in the NPP mailings. Similar deficiencies in emergency preparedness were also reported in an evaluation of New Jersey's 2002 KI program.¹²⁻¹⁴ Further, a mere 6.5% of interviewees reported designating a family meeting place, a key component of family emergency plans. Although the survey did not specifically ask interviewees if they had a general family emergency plan in place, open-ended responses to the emergency planning question suggest that the proportion of Michigan households with family emergency plans in place may be smaller than the 2006 national figure (39.0%) published by the US Department of Homeland Security.¹⁹

Almost half of interviewed voucher nonusers (48.0%) said they did not obtain KI because they were either unaware of the program, in spite of media coverage, or did not remember receiving a voucher in the mail. Only 6.7% stated that they lacked interest in the program. These findings suggest that MDCH's strategy of bulk-mailing KI vouchers, accompanied by several weeks of media advertising and informational website postings, was inadequate to inform a portion of Michigan's EPZ residents about the availability of KI. New Jersey's KI evaluation concluded that effective KI distribution programs require considerable education and outreach components, and the results of this evaluation support this assertion.¹²⁻¹⁴ Different approaches to voucher provision and more effective outreach are needed during future KI campaigns to ensure all EPZ residents receive sufficient information to make an informed choice about whether to obtain KI.

While almost all voucher users (97.4%) knew where their KI supply was stored, a large proportion reported not knowing when KI should be taken (43.6%). Many (42.6%) also reported not knowing that KI protects only the thyroid from radiation. These results are similar to findings from New Jersey's KI evaluation, in which 95% of KI recipients reported knowing where their supply was, yet 20% did not know when to take KI and 30% were unaware that KI only protects the thyroid.¹⁴ These findings indicate additional efforts are needed to ensure that KI recipients understand when and why KI should be taken.

The radiological events following the damage to the Fukushima Daiichi Nuclear Power Plant in Japan from the earthquake and tsunami starting March 11, 2011,²⁰ emphasize the importance of effective education regarding the hazards of radiation and the appropriate actions to take during radiation emergencies for the entire US public, not just for people who live near an NPP. Risk communication about the absence of radiation risk that this Japanese NPP event posed to the US population did not deter people in the United States from buying KI.²¹ In Michigan, more than 500 KI vouchers were redeemed in the two months subsequent to this radiological emergency in Japan, whereas only 35 vouchers had been redeemed during the same time frame the previous year.

LIMITATIONS

Due to time and financial constraints, the final sample size was small in comparison to EPZ denominator populations, limiting the generalizability of the results to the larger EPZ population. A comparison of some demographics of respondents to those of the general population in the counties encompassing the 10-mile EPZs of the three NPPs, according to data generated from the US Census Factfinder website for 2009 population estimates, suggests that these differences are potentially significant, in that:

- 54% of the interviewees were aged 60 years or older, as compared to 20% in the general population
- 59% of the interviewees were female, as compared to 51% in the general population
- 57% of the interviewees had completed some post-high school education, as compared to 35% in the general population
- 67% of the interviewees were married, as compared to 42% in the general population.

Other limitations point to the need to use caution when attempting to generalize study results to the entire Michigan EPZ population. First, the percent of disconnected phone numbers varied by KI voucher-use status. More than one-fifth of voucher non-user numbers had been disconnected, while only 6.5% of voucher-user numbers had been disconnected. This finding indicates possible selection bias, as voucher nonusers might have differed from voucher users (eg, more transient, different socioeconomic characteristics). In addition, the majority of interviewees were retired, whereas only 36.0% were currently employed. Self-selection bias, in which retired persons may have been more likely to answer the phone, less likely to have caller ID technologies, or more likely to participate in telephone surveys, might have occurred. Finally, although EPZ businesses were mailed KI vouchers, and approximately 2% were redeemed, businesses were not included in this evaluation due to a lack of resources.

Program evaluations of other and future KI distribution campaigns should be conducted to assess the validity and reliability of this study's findings. Additional effort should be made to capture a larger interviewee sample size to augment statistical power. Research is also needed to further elucidate the predictors of knowl-

edge, attitudes, and behaviors likely to lead to health-protective responses to radiation emergencies. For instance, further exploration into the statistically significant association between completing any type of emergency preparedness activity and KI voucher-use status might provide additional insight into the determinants of participation in voluntary emergency preparedness campaigns. Given this strong positive association, expanded emergency preparedness education programs across Michigan's EPZ communities might serve to bolster participation in a future Michigan KI distribution program and better prepare residents for an actual emergency event. Finally, in an attempt to clarify the percent of Michigan households with general family emergency plans in place, it would prove useful to include a survey question that specifically explores whether interviewees have outlined a general family emergency preparedness plan.

CONCLUSIONS

An evaluation of Michigan's pharmacy-based KI distribution program was conducted after the conclusion of year 1 of the program. It was found that 5.3% of eligible residences took advantage of the opportunity to secure a supply of free KI tablets for their households. However, about half of the interviewed KI voucher nonusers did not obtain KI because they were unaware of the program, despite a mailing, media coverage, and an informational KI website. Therefore, improved communication strategies are needed in future distribution campaigns to promote awareness of KI's availability so that all Michigan EPZ residents can make an informed decision on whether to obtain KI.

Lack of understanding regarding KI and general NPP emergency preparedness among this sample of Michigan EPZ residents was notable. Results emphasize the need for expanded educational platforms and initiatives targeted to EPZ residents to increase NPP emergency preparedness and facilitate awareness of emergency protocols. Further, different communications strategies may need to be used to reach different demographic groups within the EPZs. As previously noted, federal regulations require NPPs to educate their respective EPZ populations on emergency procedures¹⁸; consideration should be given to amending these regulations to ensure that emergency planning information is conveyed to the public in a manner that achieves a measurable standard of effectiveness. The need for improved education of the entire US public about KI use and emergency procedures during NPP emergencies is especially salient given the events at the Fukushima Daiichi Nuclear Power Plant in Japan following the March 11, 2011, earthquake and tsunami.

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Disclosure: Mss Stanbury and Zwolinski had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Support and Funding: Funding for this evaluation was provided by cooperative agreement U90/CCU524243-06 from the Centers for Disease Control and Prevention (CDC) to the Office of Public Health Practice at the University of Michigan School of Public Health, 5U90TP517018-10 from the CDC to the Michigan Department of Community Health, and by Michigan's three nuclear power plant companies to the State of Michigan for nuclear power plant emergency preparedness.

Received for publication October 17, 2011; accepted March 13, 2012.

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