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Field Sanitation in U.S. Agriculture: Evidence from NAWS and Future Data Needs

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Abstract

Objectives: We studied relationships between demographic and work-related characteristics and exposure to health-related risk associated with field sanitation within the population of U.S. farmworkers while critically examining adequacy of existing data toward understanding patterns.

Methods: We used statistical and econometric large-sample data methods to analyze correlations between observable variables and access to field sanitation as measured by responses to the nationally and regionally representative National Agricultural Workers Survey (NAWS).

Results: Analysis suggests that field sanitation risk is relatively low on U.S. farms, especially in the most current periods, though there is regional variation. A number of socioeconomic characteristics are predictive of remaining gaps in access to basic field sanitation. We found that men, workers with less education, workers who do not speak English well, and those from Mexico are systematically more likely to lack access to field sanitation than are other workers, all else equal. We also found associations with job-related characteristics.

Conclusion: We conclude that regulatory standards do not affect all workers equally and that field sanitation risk for some workers has continued though the current period. Basic sanitation definitions provided in available data are limited and may not reflect the true extent of risk associated with the incomplete nature of field sanitation access. This motivates the importance of continued study of field sanitation and of targeted public policies.

Keywords

Agricultural workers; NAWS; occupational safety; sanitation

Introduction

Limited sanitation access and quality at the workplace is a health risk of interest in the fields of occupational and public health. There is a perception in some previous academic literature that U.S. hired farmworkers, particularly migrant and indigenous workers, do not have access to basic field sanitation.[1] In this article, we document the extent of past and current sanitation access and risk within the population of U.S. farmworkers using representative data, analyze relationships between demographic and work-related characteristics and exposure to health-related risk associated with field sanitation, and simultaneously consider the adequacy of existing data toward understanding these patterns.

In the United States, field sanitation is regulated as part 1928.110 of the Occupational Safety and Health Administration standards in Title 29 of the Department of Labor's section of the Code of Federal Regulations. Regulatory standards apply to farms employing more than 10 workers per day in field work and have been in effect since 1987. Regulations specifically indicate the provision of free potable drinking water with either single-use drinking cups or by fountains that do not require shared cups. The provisions also require that a toilet and a hand washing facility be available within a quarter mile walk of the field location for each 20 employees subject to the condition that workers work at least 3 hours at a time.[2,3]

In this article, we examine how field sanitation and the related risk of negative exposures (to the extent identifiable in the literature) has varied over time and across regions, and identify demographic and work-related correlates to sanitation access using methodologies from statistical and economic analysis. This is important for the design of future public health and labor regulation policies affecting U.S. farmworkers. We further discuss limitations in analyzing true sanitation risk due to gaps in existing survey instruments and in current data collection.

Previous literature and background

Early references to risk on U.S. farms cited field sanitation as a major concern. Sakala[4] summarized farmworker vulnerabilities in groups based on pesticides, sun, injury, and sanitation. However, far earlier work, such as Leone and Johnston,[5] also acknowledged often unsanitary farm work conditions. Other early literature examined sanitation practice in some detail, though our literature review suggests that current details are largely absent. Arbab and Weidner6 performed an audit of 936 migrant farmworkers without access to water and sanitation facilities looking for fecal-related symptoms. The data they collected revealed that farmworkers displayed a rate of diarrhea 20 times higher than the "urban poor." From this, the authors concluded that increased access to water and sanitation facilities could drastically cut this number.

Ciesielski, Handzel, and Sobsey,[7] in a 2-year study of the microbiological quality of drinking water in 27 randomly selected North Carolina migrant labor camps, found high levels of total and fecal-coliform contamination. The authors suggested that the regulations of the time may have been unsatisfactory in their scope. Slesinger and Ofstead,[8] in the context of Wisconsin field and cannery workers in a wide variety of crops, found that the introduction of new federal regulations (specifically the ones documented earlier in the Introduction to this article) improved the overall sanitation both within housing and in work environments. However, Slesinger and Ofstead emphasized that "little change occurred in the health care status of use patterns of Wisconsin migrant workers."

More recent research has investigated the relationship between pesticides and sanitation. Arcury et al.[9] showed in their study of farmworkers in North Carolina that in many cases, farmworkers and farmers hold differing beliefs on pesticide safety, which in turn have an impact on sanitation practices. Farmworkers reported that they "as a whole are not benefitting from the current safety and sanitation regulations designed to reduce exposure to pesticides and other agricultural chemicals." In particular, they cited difficulties with translation between predominately English-speaking farmers and Spanish-speaking migrant

farmworkers as well as issues with the way safety information conveyed. One such instance was that safety information may only list “what farmworkers should do without telling farmworkers why they are being asked to do it.”[9] This can lead to sanitation issues resulting from the mishandling of pesticides and other farm chemicals.

Concluding with strikingly similar results, Whalley et al. expressed four major themes that emerge from the study: (1) safety regulations are often left unmet; (2) safety behaviors related to pesticides are often ignored; (3) peak farming seasons can lead to overcrowding in farmworker camps leading to break downs in sanitation; and (4) there is a noticeable difference in sanitation and safety conditions of H-2A workers and non-H-2A workers.10 The authors suggested that more research is needed to account for cultural and social factors. This conclusion, however, echoed the sentiments of many within the literature that more enforcement of regulations is needed to combat these sanitation issues.

A recent study by Walton et al. pointed towards a gap in workers’ attitudes towards sanitation. These authors, through field observations, found that farmworkers were “much more adherent to using protective clothing than to engage in protective washing.”11 This suggested that more research should be done as to the knowledge and beliefs that inform farmworkers’ choices of hand washing, and also draws attention to clothing as an avenue for sanitation issues. Test pilots run in Washington state orchards have looked at various practical ways to combat the spread of pesticides, from washing tables to designated ventilated change- rooms.[12]

While practices such as hand washing may be spoken of as common knowledge, the problem of the dissemination of this knowledge regarding field sanitation is still an open question in the agricultural community. While studies are few in number, the most recent reveal that magazines and newspapers still act as the most used source for information (with 77% of respondents reporting monthly use) with three-quarters of those trusting that source mostly or completely. While more modern sources, such as the Internet, are used by 58% of the respondents, only 49% report that they mostly or completely trust it.[13] The preference of sources can lead to a staggered implementation of sanitation practices, depending on where the farmers and workers get their information.

Methods

The U.S. Department of Labor, Employment and Training Administration’s National Agricultural Workers Survey (NAWS) provides nationally and regionally representative detailed information of U.S. farmworkers and their demographic and work-related characteristics.[14] The NAWS is both a nationally and regionally representative survey of employed U.S. farmworkers (for agricultural regions with appropriate survey weights, which were used in our own analysis).

The NAWS sampling procedure is based on four levels. First, regions are defined based on USDA’s Quarterly Agricultural Survey of farm employers. Second, simple random samples of “crop reporting districts” (farm labor areas), then of counties or county aggregates (for small areas), and finally of employers, are conducted with probabilities proportional to size

and sampling weights constructed. Workers are approached at worksites for interviews, which are available in several languages, and the interviews themselves are conducted at locations and times agreeable to individual respondents.

The public-use NAWS sample is collapsed to six regions (from the 12 that are used in the first sampling procedure step mentioned before). The Eastern NAWS region includes North Carolina, Virginia, Kentucky, Tennessee, West Virginia, Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont, Delaware, Maryland, New Jersey, and Pennsylvania. The Southeast includes Arkansas, Louisiana, Mississippi, Alabama, Georgia, South Carolina, and Florida. The Midwest includes Illinois, Indiana, Ohio, Iowa, Missouri, Kansas, Nebraska, North Dakota, South Dakota, Michigan, Minnesota, and Wisconsin. The Southwest includes Arizona, New Mexico, Oklahoma, and Texas. The Northwest includes Idaho, Montana, Wyoming, Colorado, Nevada, Utah, Oregon, and Washington. Finally, California is separable in these data and is represented as its own agricultural region.

There were 61,211 respondents in the full dataset from 1989 through 2014, which were conducted in three seasonal waves per year. Respondents were hired workers in crop production, of which H-2A workers are excluded. These data were combined across years (and across seasons, which are suppressed in the public-use data) to create the final pooled cross-sectional dataset. Approximately 16% of the final sample was engaged in field crops, 33% was in fruit crops, 18% was in horticulture, 27% was in vegetables, and 6% was in miscellaneous crops. The NAWS data also include several variables concerning health history, pesticide exposure, quality and access to health care, sanitation, and some minimal information on training including training relating to safety.

Our methodology involved detailing field sanitation responses pertaining to the availability of toilets, of water to wash hands, and of clean drinking water and disposable cups. The survey questions were “Does your employer provide water to wash hands?” and “Does your employer provide a toilet?” We coded responses “yes” as a value of one and responses of “no” as a value of zero. We coded responses of “I don’t know” as missing.

Sanitation questions have been asked over the lifetime of the NAWS survey (since its start in fiscal year 1989), thus allowing for a substantial time series. A third sanitation question—“Does your employer provide (EVERYDAY) clean drinking water and disposable drinking cups?”—was available only from year 1999 onward. This restriction on time frame reduced the relevant sample of respondents for this particular question to 38,691 workers. While being broadly descriptive, the three survey questions did not match the specificity of field sanitation regulations as described in the Introduction which presents some limitations.

Demographic and work-related variables that we correlated to the field sanitation question responses provided more detail. We examined a binary variable for sex (female = 1 and male = 0), and a variable for age of the respondent worker as reported in years. Education of the respondent was reported as years of formal schooling. Farm experience was reported as number of years doing farm work in the United States (in which the worker completed 15 days of work or more). Tenure with farm employer was measured as the number of years the worker reported working for the current employer (with all years in which a worker worked

at least one day counted as one). We also examined a binary variable equaling one for workers who report having a spouse present in the United States and zero otherwise, and a variable for the number of children that a worker reported having present in the United States. We constructed a binary variable equaling one for U.S.-born workers and zero for all others, another equaling one for naturalized citizen and zero for all others, and similarly constructed variables for workers reporting having Green Cards or other work authorization, and separately for workers who reported being undocumented. We coded a binary variable corresponding to one for the case that the worker reported proficiency with English spoken language with zero otherwise (worker reported speaking English “well” or “somewhat well” versus worker reported speaking English “a little” or “not at all”), and another binary variable which indicated one for a worker who reported being from Mexico and zero otherwise.

Wages reported in the NAWS survey are linked to the farmworker’s primary task and are reported on a per-hour (for hourly paid workers) or per-hour equivalent (for piece rate paid workers) basis. We converted this hourly equivalent wage into 2014 U.S. dollars (inflation-adjusted using the Consumer Price Index from the Bureau of Labor Statistics).

Other work-related variables we analyzed included a binary variable set at one for workers who reported that they were paid by piece rates and zero otherwise (and similar binary variables for workers who reported hourly payment versus all others, and for those who reported salary or combination (both piece rate and hourly) payment versus all others, respectively. We also examined dummy (binary) variables corresponding to each of field crops, fruit crops, horticultural crops, vegetable crops, and miscellaneous crops. Finally, we included binary task variables corresponding to preharvest, harvest, postharvest, semi-skill, and supervisory or other tasks. The final statistical model also included a linear time trend which we constructed to increment up at a constant rate over time.

Description of statistical analysis

We examined time series graphs for the three sanitation series based on the proportion of “yes” responses to the field sanitation-access questions. This allowed us to track the percentage of workers with access to water for hand washing, to toilets, and to drinking water, respectively.

We then examined geographic differences in weighted-survey means across the six regions observable in the public-use data. Subsequent analysis was based on examination of the statistical and economic significance of differences in group means across groups of workers defined by whether or not they reported access to the various sanitation measures. The null hypothesis was that there is zero difference between the means of variables for workers who have access to field sanitation and who do not have access. The alternative hypothesis was that there is a non-zero difference, either positive or negative. Weighted-survey means were used as the basis of the tests and groups were compared based on a number of socioeconomic and job-related characteristics.

We reported survey-weighted means along with standard errors for each demographic and work-related characteristic summarized individually for subgroups of workers who reported

access to basic field sanitation by the available measures and those who reported that they did not have access. We conducted 1% statistical significance and 5% statistical significance tests for the difference in these group means, and reported the results of these tests indicating whether the p-value was less than 0.01 (high statistical significant difference) or less than 0.05 (moderate statistical significant difference). We discussed magnitude of differences in corresponding text.

Finally, we examined a limited dependent variable multivariate regression model to further study the statistical differences across these sanitation-access groups. Probit modeling allowed us to hold other observable factors constant while adjusting for the existence of time trends. We reported Probit marginal effects along with robust standard errors. We again noted cases where the p-value was less than 0.01 (high statistical significant difference) or less than 0.05 (moderate statistical significant difference), and discussed magnitudes and economic significance of differences.

Results

Figure 1 shows the series of time trend graphs of average in the categories of exposures to sanitation risk. All sub-figures used survey weights to maintain representativeness of the underlying population. The figures in panels (a) and (b) were drawn to illustrate the proportion of farmworkers over time who reported access to water to washing hands and access to toilets, respectively. While there was some variation in the early years of the survey, the proportion of workers with access to basic sanitation approached one by the end of the years that were available.

Panel (c) provides the trend in access to clean drinking water and disposable cups. As a large proportion of the sample reported some access to clean drinking water and disposable cups, there was limited variation from year to year in these responses. This was similar to the overlapping periods in panel (a) and (b). More than 91% of the sample (by the overall weighted-sample mean) had access to all three types of sanitation. However, this could only be computed based on the sample for years past 1999 due to the differences in questions by survey year. We therefore considered the individual measures separately in order to use the broader data when available.

Regional and socioeconomic differences

Although the time trend graphs suggested almost full coverage of field sanitation access nationally, these data masked important differences. To consider regional differences in addition to time variation, Table 1 provides details of regional variation in exposure to sanitation risk. The values in the table correspond to proportions of the samples by region which report that they do have access to the type of field sanitation indicated. Notably, California had the highest averages across all categories in regards to worker responses indicating access to basic field sanitation. For example, 96.4% of workers in California reported access to water for hand washing, and 97.8% and 97.9% of farmworkers in this state reported access to toilets and drinking water, respectively. The northwest and the Midwest regions also had relatively high access to basic sanitation facilities. This was in

contrast to lower access to basic sanitation in the east and southeast, and most notably in the southwest.

Table 2 presents means and standard errors of a number of demographic and work-related characteristics of farmworkers for the subsamples based on responses to dichotomous field sanitation-access questions. Whether or not differences in means were statistically significant is presented in columns after the subgroup characteristics. Since large sample sizes may be correlated with the finding of a plentitude of statistically significant patterns at conventional levels, we focused on discussion of economic significance of the magnitudes of differences.

The emergence of divergent patterns among demographic characteristics pointed toward multiple avenues of inquiry specifically in water for hand washing. Approximately 24% of workers with access to water for hand washing were women in comparison to only 15% of those without access. This indicated a potentially important gender differential. Similar gender gaps emerge, with female workers having greater concentrations in the subsamples reporting access to toilets and drinking water. Furthermore, we found that access to water for hand washing and to toilets was increasing in age. Higher levels of education, farm experience, and tenure correlated with better field sanitation outcomes. These factors are referred to as “human capital” in some literatures and can be viewed as proxies for the value of personal job-related ability. This is consistent with a story of those with more permanent positions on the farm (who are often also older) having greater access to basic field sanitation.

Between access to toilets and water for hand washing (50,330 vs. 50,028 observations), there was a high correlation (about 64%) between respective patterns, indicating that in some areas workers had access to multiple types of sanitation studied, whereas in other locations workers did not have access to any field sanitation. The exception was drinking water; although, in this case the sample was restricted to the more current time period. This means that the overall composition of worker characteristics may have been different than in the earlier period.

Farmworkers who were born in U.S. or were naturalized citizens were more likely to have access to hand wash stations. Approximately 4.2% of both the subsamples who reported access to field sanitation and who reported no access to sanitation indicated they were naturalized citizens. This similar distribution of naturalized citizenship across groups with and with access to sanitation was in contrast to the lower percentage of naturalized citizens in the group which reported no access to water for hand washing reporting (only 2.9% of that subsample reported having naturalized citizenship). For drinking water, a slightly higher percentage of workers with access to drinking water reported being undocumented than did workers in the no-access category. English-language-speaking facility (defined as a “yes” response if a worker reported a high level of proficiency (3 or 4 on a 4-point scale) and defined as a no response if a worker reported a proficiency level of 1 or 2) was systematically associated with access to water for hand washing and to toilets.

In terms of work-related characteristics, the sample of workers who reported having access to water for hand washing had slightly higher average wages. These farmworkers also reported piece rate pay structure less frequently (14% in comparison to 30%) than did workers who reported a lack of access to water for hand washing and toilets. Conversely, those with access were more likely to report an hourly wage structure. As hourly pay structure was found to be more frequent among more permanent farmworkers, this suggested that temporary workers may face higher risk in terms of remaining field sanitation exposures on U.S. farms.

These results came with a few caveats, due to the nature of the NAWS data. In terms of the farmworkers hand wash category, the final data were comprised of more than 50,000 observations, while the no-access category was slightly more than 34,000 observations. Furthermore, time elements were masked in this analysis and the time series (Figure 1) revealed that more variation in access occurred in the early years of the NAWS than in the later years. These features motivated econometric statistical analysis.

Multivariate statistical analysis

We present marginal effects from Probit limited dependent variable regression models in Table 3. Multivariate regression analysis had the advantage of allowing the isolation of statistical correlations between individual variables and the dependent variables indicating field sanitation access while holding all other variables (e.g., personal, regional, and time period differences) constant. Values in the table therefore were interpreted as changes in the probability of access to sanitation defined separately for the three field sanitation response questions.

The probability of access to water for hand washing is presented in column (1). The probability of access to toilets is examined in column (2), and the probability of access to drinking water and cups is reported in column (3). The regressions by access category controlled for the effects of socioeconomic, demographic, and work-related characteristics. The variables were the same as in Table 2, with the exception that wage was not included since it was plausibly jointly determined with sanitation access. This may be because employers have economic incentives to offer both lower wages and less field sanitation, all else equal, due to the costly nature of the provision of both compensation and high quality work conditions, thus leading to a positive correlation between these variables. Table 2 suggested that higher paying jobs were also those with better field sanitation access in two of the three sanitation definition cases.

The impact of legal status (for naturalized citizens, for workers with Green Card or other work authorization, and for undocumented workers) was relative to the excluded category of the U.S. born. Piece rate and hourly were relative to workers who were either salaried or combination (piece rate and hourly) paid. Crop categories of field crops, fruit crops, horticulture, and vegetables were relative to the category of miscellaneous crops. Likewise, farm tasks of preharvest work, harvest, postharvest, and semi-skill were relative to the excluded category of supervisors and others. The regional reference category was the state of California. The time trend incremented linearly from the start of the survey in fiscal year 1989.

Overall, we found that men, workers with less education, workers who do not speak English well (self-reported), and those who are from Mexico were systematically more likely to be at risk than are other workers, all else equal. We also found patterns with job-related characteristics. Particularly, specific crop, task, region, and the time trend were statistically significant. These variables were also more economically significant (of a higher magnitude in terms of changes in probability) in many cases. This was expected, given the time and regional variation documented in Figure 1 and Table 1, respectively. We found that workers in fruit, horticulture, and vegetable crops were most likely to have access to the various field sanitation measures whereas the opposite was true of field crops.

The model also documented strong relationships between regional indicators and access to field sanitation. Since California was the excluded category and regional coefficients are all negative, this indicated that Californian workers were at lowest risk associated with remaining gaps in sanitation all else equal. Each alternate region had lower estimated probabilities of access relative to California.

Discussion

Nationally representative data on the availability of basic sanitary necessities for farmworkers (i.e., clean drinking water, hand washing stations, and bathroom facilities), which we analyzed and documented in this article, suggested that basic access to sanitation has increased substantially over time and is approaching (but has not yet achieved) full coverage. Despite this national trend, there are persistent regional differences in coverage. This suggests that the aforementioned standards may not always be practiced fully, nor fully enforced.

Although patterns suggest low risk overall in the current period, the definitions of what constitutes field sanitation in the data were limited and provided insight on basic access only, as opposed to usage and quality. This points to a continued need to examine sanitation practice in the U.S. agricultural sector as a way to protect agents (i.e., workers and consumers) in the food economy, and suggests that there still remains potential for substantial public health risks resulting from less sanitary conditions on U.S. farms.

Time and geographic differences may relate to variation in enforcement of regulatory standards or in local customs pertaining to migrant farmworkers. Alternately, these differences may be due to systematic reporting propensities that vary across time and/or region (e.g., if workers in one area are more likely to report low access due to differences in the interpretation of the questions). Overall, however, there is evidence that field sanitation access has in fact improved over time though that it is still not complete in all areas. Multivariate analysis allowed us to net out the effect of the increasing trend toward higher levels of reported field sanitation over time while isolating the impacts of other observable demographic and work-related characteristics.

Analysis of socioeconomic characteristics of U.S. farmworkers indicated that some remaining differences in access may be systematic. This is relevant for the development of targeted labor market, regulatory, and public welfare-related policies. Differences in access

by demographic characteristics such as nativity and English-language-speaking ability while holding constant specific work attributes, for example, allude to specific additional worker vulnerabilities that may be relevant from public policy perspectives. Furthermore, stark regional differences suggest that regional targeting of enforcement of existing regulations may be relevant. We encourage the reader however, to interpret these conclusions with caution, as we found many of the marginal effects of field sanitation access to be very small in magnitude.

Our work reveals the necessity for more attention to how questions about field sanitation are asked in surveys. We found that the NAWS survey, while commendable for its reach in many areas, is inadequate to precisely measure issues of field sanitation. The questions merely probe for the existence of sanitation measures (hand washing and drinking stations, toilet facilities, etc.). To get a true understanding of issues of field sanitation, information is needed that relates to the access and use of the available facilities. Knowing that a toilet is available within a quarter-mile walk of the farmworker tells little about how often and how easily such a facility is accessed. The survey is, therefore, incomplete in terms of extent of compliance (e.g., Are toilets available in all work locations or just in one spot on the farm, and what is the quality of existing facilities?) and in terms of common practice (e.g., Do workers routinely use the provided resources?). Furthermore, the timeframe to which the question is pertaining is unspecified, leading to the chance of past experiences influencing the answers to the current round of questioning.

As data are federally funded and collected, we recommend expanded data collection efforts with specific attention to margins identified in this study. Additional data collection could include detailed infrastructure observations by the surveyor (e.g., standardized details of the facilities offered) and observations of usage (e.g., observations as to the extent of compliance) by the surveyor in addition to more detailed respondent survey questions. Surveyor observation coupled with respondent information should minimize survey bias concerns (e.g., social desirability bias associated with hand washing and other sanitation use questions which have been raised by Walton et al.[11] and others).

Conclusion

Earlier literature suggested that negative field sanitation exposures were widespread4–7 and that regulations in early periods were inadequate.[8,10] We conclude here that substantial risk associated with field sanitation persists despite the higher proportions of survey respondents reporting access to basic sanitation over time as documented in this article. We specifically note that features of the survey questions may lead to bias in the responses. Most particularly, more detail about facilities and their characteristics are necessary for further understanding about remaining gaps in access to field sanitation on U.S. farms, and measures of field sanitation used in the analysis are imperfect indicators at best of the specificity of field sanitation standards imposed by the federal regulations noted earlier in this article. We document here that negative field sanitation exposure is a continued possibility in the current period.

Although these data in their current form provide insight into relationships underlying agricultural health and safety risk as it relates to vulnerable workers in the United States, examination of the data identifies several future research needs especially the collection of data across regions on sanitation practice in addition to availability. Future fieldwork and observational studies may be relevant for ascertaining necessary details.

Another consideration suggesting further study is that H-2A workers were excluded by design in the survey used in this article. Whalley et al.[10] suggested there were potentially substantial differences in field sanitation conditions available to different types of workers by this definition. As such, new data collection of H-2A workers relative to non H-2A workers is warranted.

Finally, we also might be interested in how specific sanitation exposures impact economic outcomes such as farm and labor productivity and earnings for agricultural employers and employees through health effects and compensation packages. Significant differences between the wages of those with access to field sanitation and to those without access were documented in Table 2. Further analysis of these questions is beyond the scope of this study due to the data constraints and the scope of this article, and is therefore left for future work.

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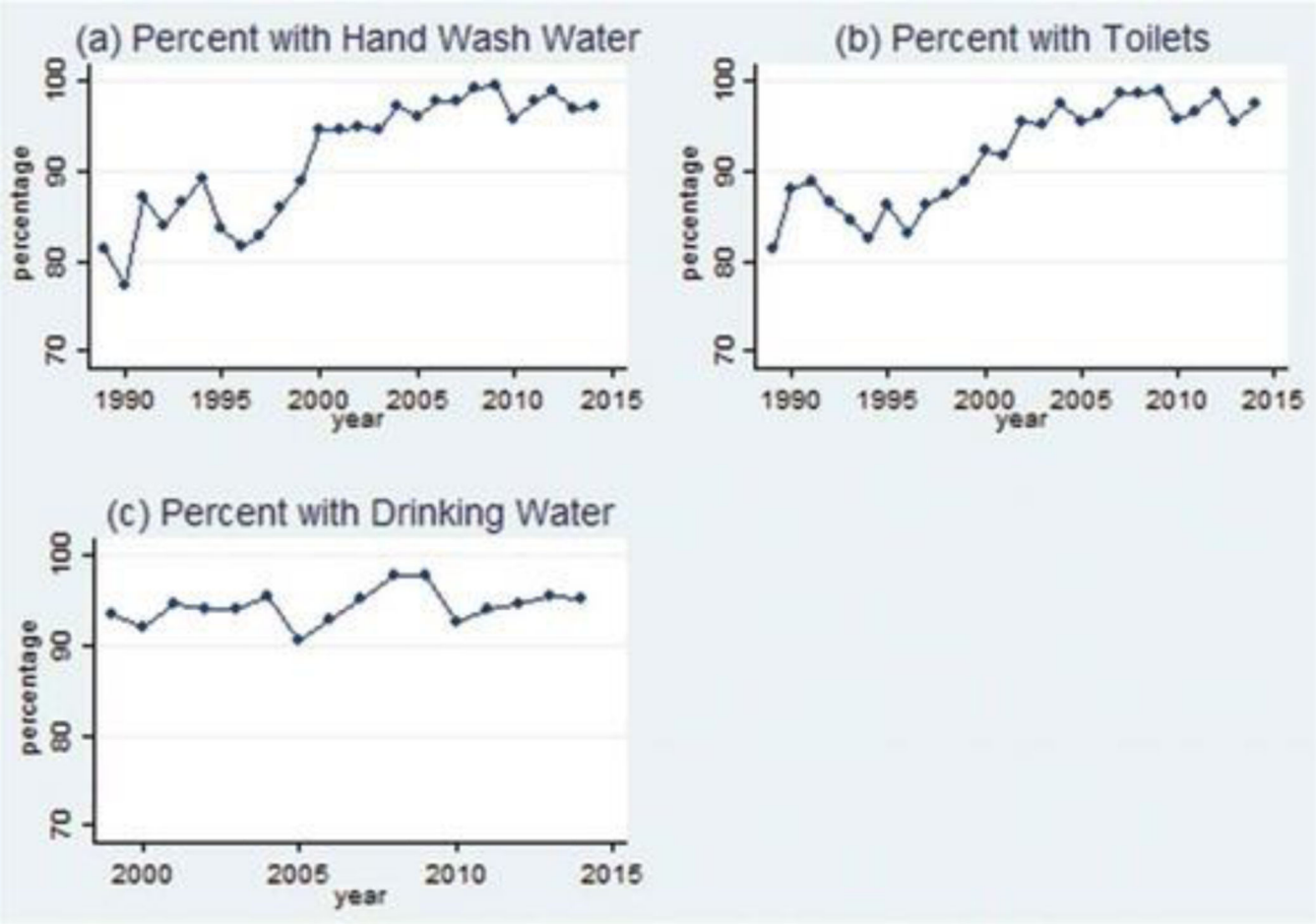

Figure 1.
Farmworker access to basic sanitation over time, national averages. [Source: NAWS and authors' calculations, survey-weighted means of individual responses converted to percentages.].

Table 1.

Regional variation in reported sanitation access, survey-weighted percentages of the total sample.

	(1)	(2)	(3)
	Reported having water for hand washing	**Reported having toilet**	**Reported having drinking water**
Observations (N)	60,949	61,101	38,628
East	86.3	81.7	94.2
Southeast	84.9	83.5	93.2
Midwest	90.8	93.5	92.2
Southwest	87.0	84.0	85.9
Northwest	92.1	96.5	94.0
California	96.4	97.8	97.9

Table 2.

Group means tests of demographic and work-related characteristics of U.S. farmworkers, by sanitation-access categories.

	Access to water for hand washing?			Access to toilets?			Access to drinking water?		
	yes	**no**	**Signif. diff?**	**yes**	**no**	**Signif. diff?**	**yes**	**no**	**Signif. diff?**
Observations (N)	50,028	4,343		50,330	4,176		34,273	2,402	
DEMOGRAPHIC VARIABLES									
Female = 1	0.24	0.15	**	0.24	0.10	**	0.25	0.16	**
	(0.00)	(0.01)		(0.00)	(0.01)		(0.01)	(0.02)	
Age (years)	33.80	30.89	**	33.70	31.70	**	34.80	36.70	**
	(0.11)	(0.34)		(0.11)	(0.34)		(0.14)	(0.52)	
Education (years)	7.51	6.51	**	7.49	6.64	**	7.75	7.61	
	(0.04)	(0.10)		(0.03)	(0.10)		(0.05)	(0.19)	
Farm Experience (years)	10.49	7.94	**	10.41	8.72	**	11.30	12.41	*
	(0.08)	(0.27)		(0.08)	(0.27)		(0.11)	(0.42)	
Tenure (years)	4.68	3.18	**	4.65	3.50	**	5.28	5.93	*
	(0.04)	(0.14)		(0.04)	(0.15)		(0.06)	(0.27)	
Has Spouse in U.S. = 1	0.41	0.28	**	0.41	0.26	**	0.44	0.45	
	(0.00)	(0.01)		(0.00)	(0.01)		(0.01)	(0.02)	
Children (number)	0.81	0.66	**	0.82	0.56	**	0.83	0.86	
	(0.01)	(0.06)		(0.01)	(0.04)		(0.01)	(0.07)	
U.S.-born = 1	0.23	0.15	**	0.22	0.18	**	0.24	0.23	
	(0.00)	(0.01)		(0.00)	(0.01)		(0.01)	(0.02)	
Naturalized Citizen = 1	0.042	0.029	**	0.042	0.042		0.04	0.05	
	(0.00)	(0.00)		(0.00)	(0.01)		(0.00)	(0.01)	
Green Card or Other Auth. = 1	0.27	0.27		0.27	0.24	*	0.22	0.26	*
	(0.00)	(0.01)		(0.00)	(0.01)		(0.00)	(0.02)	
Undocumented = 1	0.47	0.56	**	0.47	0.54	**	0.51	0.47	
	(0.00)	(0.01)		(0.00)	(0.01)		(0.01)	(0.02)	
Speaks English = 1	0.34	0.24	**	0.33	0.26	**	0.34	0.35	
	(0.00)	(0.01)		(0.00)	(0.01)		(0.01)	(0.02)	
from Mexico = 1	0.71	0.78	**	0.72	0.75	**	0.71	0.73	
	(0.00)	(0.01)		(0.00)	(0.01)		(0.01)	(0.02)	
CURRENT JOB-RELATED VARIABLES									
Wage (2014USD)	9.58	9.11	**	9.59	8.94	**	9.86	9.80	
	(0.02)	(0.01)		(0.02)	(0.11)		(0.03)	(0.14)	
Piece rate = 1	0.14	0.30	**	0.15	0.22	**	0.11	0.07	**
	(0.00)	(0.01)		(0.00)	(0.01)		(0.00)	(0.02)	
Hourly = 1	0.81	0.66	**	0.80	0.73	**	0.83	0.84	
	(0.00)	(0.01)		(0.00)	(0.01)		(0.00)	(0.02)	
Salary or Combo Pay = 1	0.05	0.04		0.05	0.05		0.06	0.08	
	(0.00)	(0.01)		(0.00)	(0.01)		(0.00)	(0.01)	

	Access to water for hand washing?			Access to toilets?			Access to drinking water?		
	yes	**no**	**Signif. diff?**	**yes**	**no**	**Signif. diff?**	**yes**	**no**	**Signif. diff?**
Field Crops = 1	0.14	0.31	**	0.13	0.46	**	0.14	0.28	**
	(0.00)	(0.01)		(0.00)	(0.01)		(0.00)	(0.02)	
Fruit Crops = 1	0.36	0.27	**	0.36	0.22	**	0.35	0.22	**
	(0.00)	(0.01)		(0.00)	(0.01)		(0.01)	(0.02)	
Horticulture = 1	0.19	0.06	**	0.19	0.05	**	0.21	0.22	
	(0.00)	(0.01)		(0.00)	(0.01)		(0.01)	(0.02)	
Vegetables = 1	0.27	0.30	*	0.28	0.20	**	0.25	0.20	**
	(0.00)	(0.01)		(0.00)	(0.01)		(0.01)	(0.02)	
Misc. Crops = 1	0.05	0.07		0.05	0.07	*	0.04	0.08	**
	(0.00)	(0.01)		(0.00)	(0.01)		(0.00)	(0.01)	
Preharvest = 1	0.22	0.18	**	0.22	0.20	*	0.24	0.24	
	(0.003)	(0.01)		(0.00)	(0.01)		(0.01)	(0.02)	
Harvest = 1	0.29	0.42	**	0.30	0.34	**	0.25	0.17	**
	(0.00)	(0.01)		(0.04)	(0.01)		(0.01)	(0.01)	
Postharvest = 1	0.14	0.09	**	0.14	0.09	**	0.14	0.11	
	(0.00)	(0.01)		(0.00)	(0.01)		(0.00)	(0.01)	
Semi-skill = 1	0.23	0.25		0.22	0.29	**	0.22	0.28	**
	(0.00)	(0.01)		(0.00)	(0.01)		(0.00)	(0.02)	
Supervisor or Other Task = 1	0.12	0.07	**	0.12	0.086	**	0.15	0.19	**
	(0.00)	(0.01)		(0.00)	(0.01)		(0.00)	(0.02)	

Source: NAWS and author calculations.

Notes: Survey-weighted means with standard errors in parentheses; for binary variables (noted as " = 1" above), these means are interpreted as proportions; wages are converted to 2014 dollars using the Consumer Price Index; difference in group means test

** $p < 0.01$,

* $p < 0.05$

Table 3.

Marginal effects of demographic and work-related characteristics of U.S. farmworkers on the probability of sanitation access.

	(1)	(2)	(3)
	Prob(Access to water for hand washing)	**Prob(Access to toilet)**	**Prob(Access to drinking water)**
Female = 1	0.01	0.02**	0.02**
	(0.00)	(0.00)	(0.00)
Age (10s years)	0.00	0.00	−0.00*
	(0.00)	(0.00)	(0.00)
Education (10s years)	0.02**	0.02**	0.00
	(0.01)	(0.00)	(0.01)
Farm Experience (10s years)	0.00	−0.00	0.00
	(0.00)	(0.00)	(0.00)
Tenure (10s years)	0.00	0.00	−0.00
	(0.00)	(0.00)	(0.00)
Has Spouse in U.S. = 1	0.01	0.01**	0.00
	(0.00)	(0.00)	(0.00)
Children (number)	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)
Naturalized Citizen = 1	0.01	0.00	−0.01
	(0.01)	(0.01)	(0.01)
Green Card or Other Auth. = 1	0.00	0.01	−0.02
	(0.01)	(0.01)	(0.01)
Undocumented = 1	−0.01	0.00	−0.01
	(0.01)	(0.01)	(0.01)
Speaks English = 1	0.01*	0.01*	−0.00
	(0.00)	(0.00)	(0.01)
From Mexico = 1	−0.01**	−0.02**	−0.01
	(0.01)	(0.00)	(0.01)
Piece rate = 1	−0.03**	−0.00	0.01*
	(0.01)	(0.01)	(0.01)
Hourly = 1	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)
Field Crops = 1	−0.04**	−0.04**	0.00
	(0.01)	(0.01)	(0.01)
Fruit Crops = 1	0.01*	0.02**	0.03**
	(0.01)	(0.01)	(0.01)
Horticulture = 1	0.04**	0.04**	0.03**
	(0.01)	(0.00)	(0.01)
Vegetables = 1	0.01	0.03**	0.03**

	(1)	(2)	(3)
	Prob(Access to water for hand washing)	**Prob(Access to toilet)**	**Prob(Access to drinking water)**
	(0.01)	(0.00)	(0.01)
Preharvest = 1	−0.01 *	−0.01	−0.00
	(0.01)	(0.01)	(0.01)
Harvest = 1	−0.01	−0.00	0.01 *
	(0.01)	(0.00)	(0.01)
Postharvest = 1	0.00	0.01	0.01
	(0.01)	(0.00)	(0.01)
Semi-skill = 1	−0.03 **	−0.03 **	−0.01
	(0.01)	(0.01)	(0.01)
East = 1	−0.11 **	−0.18 **	−0.06 **
	(0.01)	(0.01)	(0.01)
Southeast = 1	−0.12 **	−0.17 **	−0.08 **
	(0.01)	(0.01)	(0.01)
Midwest = 1	−0.12 **	−0.10 **	−0.10 **
	(0.01)	(0.01)	(0.01)
Southwest = 1	−0.15 **	−0.20 **	−0.15 **
	(0.01)	(0.02)	(0.02)
Northwest = 1	−0.07 **	−0.04 **	−0.07 **
	(0.01)	(0.01)	(0.01)
Time Trend (10s years)	0.06 **	0.04 **	0.01 *
	(0.00)	(0.00)	(0.00)
Observations (N)	55,786	55,927	37,443

Source: NAWS and author calculations.

Notes: Probit marginal effects with robust standard errors in parentheses;

** $p < 0.01$,

* $p < 0.05$