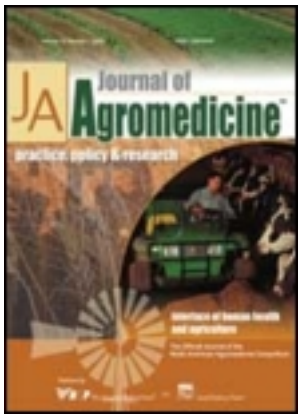

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Safety and Health Hazard Observations in Hmong Farming Operations

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Safety and Health Hazard Observations in Hmong Farming Operations

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ABSTRACT. Agricultural workers have a high risk of occupational injuries, illnesses, and fatalities. However, there are very few standardized tools available to assess safety and health in agricultural operations. Additionally, there are a number of groups of agricultural workers, including Hmong refugees and immigrants, for which virtually no information on safety and health conditions is available. This study developed an observation-based methodology for systematically evaluating occupational health and safety hazards in agriculture, and pilot-tested this on several small-scale Hmong farming operations. Each observation assessed of range of safety and health hazards (e.g., musculoskeletal hazards, dust and pollen, noise, and mechanical hazards), as well as on factors such as type of work area, presence of personal protective equipment, and weather conditions. Thirty-six observations were collected on nine farms. The most common hazards observed were bending at the back and lifting <50 pounds. Use of sharp tools without adequate guarding mechanisms, awkward postures, repetitive hand motions, and lifting >50 pounds were also common. The farming activities observed involved almost no power equipment, and no pesticide or chemical handling was observed. The use of personal protective equipment was uncommon. The results of this assessment agreed well with a parallel study of perceived safety and health hazards among Hmong agricultural workers. This study suggests that small-scale Hmong farming operations involve a variety of hazards, and that occupational health interventions may be warranted in this community. The study also demonstrates the utility of standardized assessment tools and mixed-method approaches to hazard evaluation.

KEYWORDS. Hazard assessment, Hmong farming, injury risk, safety and health

INTRODUCTION

Agricultural work is dangerous; workers in this industry have among the highest rates of fatalities[1,2] in the United States. Work in agriculture involves exposures to a variety of hazards, including dust, noise, thermal stress, pesticides and other chemicals, and ergonomic

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risk factors. As a result, agricultural workers have elevated rates of injuries and illnesses[3,4] compared with other US workers.

Despite the hazardous nature of agricultural work, surveillance of occupational health hazards and health outcomes in this industry has been inadequate. The National Occupational Research Agenda of the National Institute for Occupational Safety and Health calls for additional occupational health and safety research on workers who are more susceptible to injury or illness, as well as improved data collection on safety and health disparities among vulnerable workers.[5] Both of these situations apply to agricultural workers, and as a whole agricultural workers are in need of additional health and safety surveillance and occupational health interventions.[6] The lack of adequate surveillance of occupational health among agricultural workers is due at least in part to the transient, migrant agricultural workforce in the United States.[7] An additional barrier is presented by the exclusion of agricultural workers from many occupational safety and health regulations and reporting requirements.[2] There have been a number of studies published on occupational health in certain groups of agricultural workers (e.g., Latinos[8,9]). However, most of these studies have focused specifically on pesticides, and have not characterized other safety and health hazards.

One group for which there is a paucity of data is Hmong agricultural workers in the United States. The Hmong migrated from South China into Vietnam, Laos, and Thailand where they lived as marginalized populations. During the Vietnam War, the US government recruited the Hmong in efforts to fight against communist regimes. In the years following the war, over 100,000 Hmong were resettled in the United States as they sought to escape persecution."[10] In the United States, there are several established Hmong populations in California, the Midwest, and the Pacific Northwest, and many Hmong families rent land to operate small-scale, family-run farms, which are typically underserved from an occupational health perspective. Hmong agricultural workers in the United States may be at increased risk of occupational injury and illness, similar to other vulnerable groups of workers such as immigrant Latino agricultural workers[11] and undocumented day laborers.[12] Child labor practices[13] and difficult economic conditions[14] among Hmong agricultural workers in the United States may increase the likelihood of injuries and illness to the population. The Hmong did not have a written language until the 1950s, making it likely that at least a fraction of older Hmong do not use written language, and suggesting that traditional written safety and health training materials may not be universally acceptable or useful.[13] In the Pacific Northwest, Hmong agricultural workers predominantly grow flowers and vegetables, but the specific health and safety hazards associated with growing these crops do not appear to have been described previously.

One barrier towards conducting a comprehensive health and safety hazard evaluation in agricultural settings, including but not limited to small-scale Hmong farms, is the lack of standardized tools with which to conduct such an evaluation.[15–17] One approach that has been used in some studies is a checklist based on walkthroughs through work areas with dynamic operations, such as agricultural[18,19] and construction[20,21] sites. This approach shows promise in identifying the presence and degree of a range of hazards, but requires further evaluation before it can be widely adopted, particularly in agricultural work, which involves a wide range of crop- and process-specific tasks and equipment.

Our study had two goals. The first was to develop an observational tool to assess the presence of a wide range of agricultural health and safety hazards. The second was to pilot the use of this tool to document these hazards among workers at Hmong-operated farms near Seattle, Washington, USA. The research described here complements and helps validate a parallel qualitative study of safety and health concerns among Hmong agricultural workers that we conducted using participatory approaches,[22] and can therefore be considered as part of a mixed-method approach to exposure assessment.

METHODS

Our study was divided into two segments. The first was the development of a

semiquantitative observational tool to characterize safety and health hazards. The second was the application of the tool to several Hmong-operated, small-scale farms to conduct a pilot hazard assessment. All research procedures and methods were reviewed and approved by the University of Washington Human Subjects Division.

Development of the Observational Tool

The tool (Appendix A) was developed with the goal of being accessible to, and useful for, individuals with minimal safety training. We drew specific items used in the tool from previous studies[19] (www.farmsafewa.org, accessed January 8, 2012; http://safemanitoba.com/uploads/farm_family_safety_checklist.pdf, accessed February 12, 2012) where possible. The survey consisted of 10 sections: (1) musculoskeletal factors; (2) mechanical hazards; (3) pesticides; (4) chemical hazards; (5) falls; (6) noise; (7) dust and pollen; (8) thermal and weather conditions; (9) clothing and use of personal protective equipment (PPE); and (10) other factors. Exposure frequency to each of the assessed factors was assigned into one of three categories: "frequent" (worker performed the action for more than half of the observation period); "occasional" (worker performed the action for less than half of the observation period); and "never" (worker did not perform the action during the observation period). If exposure was observed for over half of the observation period, then it was considered frequent. If exposure was observed for less than half of the observation period, then it was considered occasional.

Below are the specific parameters assessed for each of the 10 factors.

1. *Musculoskeletal factors*. Awkward postures; high hand force; repetitive hand motions; lifting of loads judged to be >50 and <50 pounds; bending at the knees, back, and/or neck; squatting or kneeling; pushing or pulling heavy items; and presence of a constant hand grip.
2. *Mechanical hazards*. The assessment tool addressed the use of equipment and tools, including hand tools designed for cutting, scraping, or digging and power tools designed for drilling, sawing, and cutting weeds. Items related to tractor use were included, such as use of a power takeoff (PTO), whether or not the worker added or removed tractor attachments, the type of operation ("plowing," "seeding," or "transporting"), the presence of a rollover protection system (ROPS), the presence of additional riders beyond the operator, and the use of occupant restraints by all riders. Aspects of loading and transporting heavy equipment were also assessed, including the method of transport ("truck bed," "trailer," "towing"), presence of proper vehicle restraints, use of loading aids ("ramps" or "winch"), and potential for crushing. Use of small powered equipment was also documented ("mower," "sprayer," "chipper," and "rototiller"). Finally, the presence of machine guards, pinch points, and conveying equipment was included, as was any cleaning or repairing of machinery by workers.
3. *Pesticide*s. Pesticides are a major cause of morbidity among agricultural workers.[23] The tool contained a number of items evaluating the presence of powder or liquid pesticides, as well as whether or not workers were involved in pesticide mixing and/or application. Where pesticides were applied, the application method ("mechanical," "handthrown," or "spray") was recorded. The presence of field hand washing stations was also documented, along with the possibility of contact with pesticide residue on equipment or crops.
4. *Chemical hazards*. Workers' contact with fuels, lubricants, degreasers/solvents, and "other" chemicals was documented through the use of one item specific to each of these categories of chemicals.
5. *Falls from heights.* A single item addressed the potential for a fall from an elevated height of 4 feet or more.
6. *Noise*. A single item addressed the presence or absence of "loud noise." We have demonstrated that perceived exposures to

noise are reasonably accurate when compared with measured levels.[24,25]

7. *Dust and pollen*. A single item was used to assess whether the work involved high exposure to dust and/or pollen.
8. *Weather and thermal conditions*. Weather conditions (including the presence and form of any precipitation) were documented at the time of observation. Quantitative temperature and humidity levels at the observation location and time were later determined from data available from the National Weather Service.
9. *Clothing and PPE*. The presence of a long-sleeved shirt and long pants was evaluated. Additional items addressed the presence of gloves; head coverings or hats; work boots; coveralls; eye protection; respiratory protection; and hearing protection.
10. *Other conditions*. Other factors assessed included start and stop time of the observation; crop type; approximate worker age (judged as >18 years old, ≤ 18 years, or unclear); work task (collected descriptively via a free field); and whether the worker was working alone or with others. We also assessed the type of area in which workers were observed: farm, market, storage area, and confined space/silo.

Observational Procedure

We converted the final version of the tool to a tablet survey form using Open Data kit software (http://opendatakit.org/). We then installed this survey form on a handheld digital device (Samsung Galaxy Tab 7"; Samsung Electronics America, Ridgefield Park, NJ, USA). We also created a data dictionary describing the meaning of each observation item and all response categories to supplement the observation tool, and the research observer had a copy of this dictionary available during all observations. All observation data were downloaded and saved on a secure server, using an encrypted connection. The data were then exported to a comma-separated values (CSV) file for analysis.

Observations were specified to last approximately 2 minutes. Our research observer entered the observed location and made observations on every worker in the order they were encountered. Each observation included all of the items in the tool observed on a single individual over that 2-minute period. Once an evaluation on a single worker was completed, the research observer began an observation on the next nearest participating worker. We have successfully used this approach to characterize occupational health and safety hazards in a variety of industries, including aircraft maintenance[26] and scrap metal recycling.[27] We also took nonidentifiable photographs of observed workers to document working conditions and specific health and safety hazards and to facilitate postobservation review.

Application of Observational Tool

Participants were recruited by the project's Hmong community liaison via direct contact or by direct mail advertisement fliers. At a start of growing season workshop conducted for the purposes of our parallel study,[22] the project team described the observational procedures and asked participants for permission to visit their farm sites over the course of the growing season. The farm sites were either owned or rented by the project participants. During the growing season (March through December of 2012), the community liaison regularly contacted participants to schedule times for observational visits and determine where the participant would be working during that time. Only the project participants were observed, although other family members may have been working at the same time, and Hmong farmers not participating in the study were seen working on neighboring plots.

The community liaison accompanied the research observer during all observations. The liaison and observer did not stay for extended periods when it appeared that workers were very busy, that the observation process might serve as a distraction or hinder work, or when it was judged likely that workers would be doing the same activity throughout the entire day.

All observations were conducted by the same research observer (J.K.), a masters-level trained environmental health specialist. We used a single observer to eliminate the potential for interobserver variability. Although interobserver

variability is an important issue with any observational tool administered by multiple users, given the pilot nature and limited resources involved in this evaluation, we deemed this an acceptable approach. After observations were made, the observation data and corresponding photographs were shared with an experienced occupational hygienist (RN) for review. This review cannot be considered a validation of the study methods or results, but was intended to provide an indication as to the repeatability and accuracy of the data recorded by the research observer.

Analyses

Descriptive statistics were computed across all observation variables. We did not apply tests of significance or inferential modeling techniques due to the small sample size. We conducted all analyses in Stata Intercooled 12.1 (Stata Corporation, College Station, TX, USA).

TABLE 1. Descriptive Statistics for Observations ($N = 36$)

Variable	Category	*n*	%
Work area	Farm	28	77.8
	Market	3	8.3
	Confined space	4	11.1
	Storage	1	2.8
Worker type	Adult	36	100.0
	Child	0	0.0
Working alone		12	33.3
Clothing	Long-sleeved pants	35	97.2
	Long-sleeved shirt	35	97.2
	Hat	29	80.6
	All of the above	28	77.8
Personal protective equipment	Work boots	25	69.4
	Gloves	31	86.1
	All of the above	25	69.4
Weather	Rainy	4	11.1
	Sunny	19	52.8
	Overcast/cloudy	13	36.1
		Mean	*SD*
Air temperature (°F)		63.6	9.4
Humidity (%)		62.9	14.6

RESULTS

We visited nine participating farms on 13 sampling days between May and September 2012, making one to five visits to each farm. We also conducted observations on two market days. The time spent on each visit ranged from 1 hour to a half-day, and a total of 36 observations were made over the course of the growing season.

Overall results are shown in Table 1. The vast majority of observations (78%) were made on farms. All observed workers were adults, and the vast majority—about 66%—of observed workers worked alongside others. More than 80% of observed workers were wearing long pants, a long-sleeved shirt, and a hat, and nearly 70% were wearing work boots and some type of gloves. One worker worked barefoot, and three workers wore flip-flops. Of the 31 workers observed wearing gloves, 17 (55%) wore latex gloves rather than work gloves, and these gloves were usually too large for the workers' hands. No workers wore respirators. However, one (2.8%) worker wore a dust mask, and four (11.2%) others wore bandanas over their faces, although whether this was for sun protection or an attempt to reduce dust exposure was unclear. We never observed workers wearing hearing or eye protection. Only one field handwashing station was observed. Workers were generally noted to have access to water and other liquids to ensure adequate hydration.

A slight majority of observed days (about 53%) featured sunny weather (Table 1). The average temperature during observations was about 63.0°F, and only 1 day exceeded 80°F (maximum temperature 87°F). Humidity averaged about 63%, with a high of 82%. Most observations ($n = 26$, or 72%) were made between the hours of 11 AM and 5 PM; four (9%) were made before 11 AM, and six (17%) were made after 5 PM.

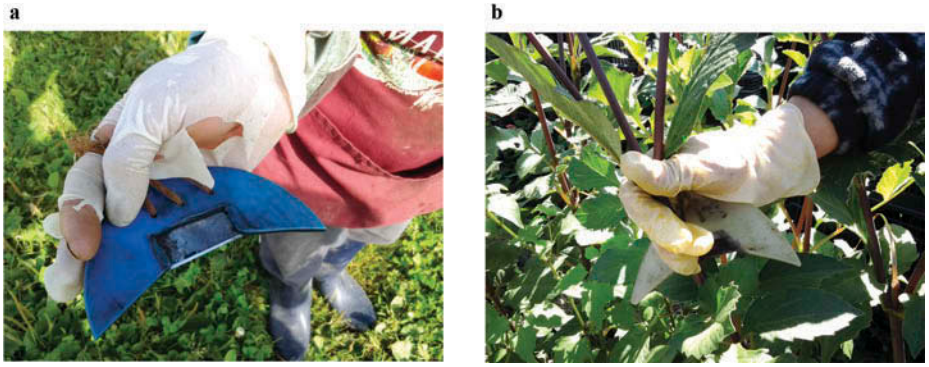
We observed a variety of hazard types (Table 2). The most common hazards observed to occur "frequently" were musculoskeletal in nature: bending (about 56% of all observations, with the vast majority of these being bending at the back) and constant hand grip (about 42% of all observations). Other common hazards that we observed "frequently" were

TABLE 2. Observed Hazards ($N = 36$)

Hazard type	Factor	Frequency			
		"Frequent"		"Occasional"	
		n	%	*n*	%
Musculoskeletal	Awkward postures	11	28.9	4	10.5
	Repetitive hand motions	6	16.7	—	—
	Lifting >50 pounds	2	5.6	2	5.6
	Lifting <50 pounds	11	30.6	3	8.3
	Constant hand grip	15	41.7	8	22.2
	Bending	20	55.6	8	22.2
	Knee	7	19.4	—	—
	Back	19	52.8	8	22.2
	Neck	—	—	1	2.8
	All of the above	3	8.3	0	
	Squatting or kneeling	5	13.9	1	2.8
	Pushing or pulling	2	5.6	12	33.3
Mechanical*	Hand tools				
	Sharp blade	11	30.6	10	27.8
	Small power equipment	1	2.8	—	—
Pesticides and chemicals*	Used nearby	2	5.6	—	—
	Potential residue contact	2	5.6	—	—
Fertilizers		1	2.8	—	—
Potential for falls		1	2.8	—	—
Noise		1	2.8	—	—
Dust and pollen		4	11.1	5	13.9

*Tractors, pesticides, and chemicals (fuels, lubricants, degreasers/solvents) were never used directly by subjects.

FIGURE 1. (a) Example of one improvised stem cutting tool and inadequate protective equipment. (b) Example of different stem cutting tool in use, again with inadequate protective equipment.



use of sharp blades and lifting <50 pounds (about 31% of observations each) and awkward postures (about 29% of observations). We observed many participants using a tool traditionally used for cutting rice in Southeast Asia, and adapted for cutting flower stems (Figure 1a). This cutting tool is popular because it is efficient, but it also presents a substantial laceration hazard—particularly when cutting woody stems, which require the application of a great deal of force (Figure 1b). Anecdotal information from workers suggested that many people cut themselves when learning to use this tool.

FIGURE 2. Example of a disabled machine guard (guard at rear of rototiller tied up rather than contacting ground).

We did not observe any workers using chemicals or pesticides, although two observations (about 6%) noted potential exposures from nearby pesticide application or residual pesticide on crops. Although pesticides were not observed being used, containers of glyphosate (an herbicide) and metaldehyde (a molluscicide) were observed at various locations, suggesting that store-bought pesticides are used at least occasionally. When chemicals were discussed, one worker said that they felt dizzy when they applied pesticides, but did not wear any personal protective equipment.

Exposures to noise, dust and pollens, and potential fall hazards were infrequently observed, as was use of powered equipment. We observed one worker pushing a powered rototiller over uneven ground with great difficulty due to her short stature in relation to the handle of the rototiller. The guard on the rototiller, designed to prevent ejection of rocks and other objects, was disabled with a rope, increasing the likelihood of injury when using this tool (Figure 2). No workers were directly observed using tractors. However, occasionally tractors were present at the participating farm

TABLE 3. Observed Hazards by Work Area ($N = 36$)

Hazard type	Factor	Confined space ($n = 4$)		Farm ($n = 28$)		Market ($n = 3$)		Storage area ($n = 1$)	
		n	%	*n*	%	*n*	%	*n*	%
Musculoskeletal	Awkward postures	2	50	12	42.7	1	33.3	—	—
	Repetitive hand motions	1	25	4	14.3	1	33.3	—	—
	Lifting >50 pounds	1	25	2	7.1	1	33.3	—	—
	Lifting <50 pounds	2	50	10	35.6	1	33.3	1	100
	Constant hand grip	1	25	12	42.9	2	66.7	—	—
	Bending	3	75	20	71.2	3	100	1	100
	Knee	—	—	7		—	—	—	—
	Back	4	11.1	19	52.8	3	8.3	1	2.8
	Neck	—	—	1		—	—	—	—
	All of the above	—	—	3		—	—	—	—
	Squatting/kneeling			5	17.9	1	33.3		
	Pushing or pulling	—	—	2	7.1	—	—	—	—
Mechanical*	Hand tools	2	50	16	57.1	—	—	—	—
	Sharp blade	2	50	9	32.1	—	—	—	—
	Small power equipment	—	—	1	3.5	—	—	—	—
Pesticides and chemicals*	Used nearby	—	—	2	7.1	—	—	—	—
	Potential residue contact	—	—	2	7.1	—	—	—	—
Fertilizers		—	—	1	3.5	—	—	—	—
Potential for falls		—	—	1	3.6	—	—	—	—
Noise		—	—	1	3.6	—	—	—	—
Dust and pollen		2	50	7	26.0	—	—	—	—

*Tractors, pesticides, and chemicals (fuels, lubricants, degreasers/solvents) were never used directly by subjects.

and not being operated, or were operated by workers not under direct observation. ROPS systems were never present on any of the tractors observed.

Table 3 presents hazards observed to occur "frequently" or "occasionally" in the observed types of work areas (e.g., farm, market, confined space, or storage). Lifting <50 pounds and bending at the back were noted across all four work areas. Awkward postures, repetitive hand motions, lifting >50 pounds, bending, and constant hand grip were noted in three areas (farm, confined space, and market). Dust and pollen and use of sharp blades were noted in two areas (confined space and farm). These data suggest that musculoskeletal hazards are present in all aspects of Hmong agricultural operations.

We identified a number of hazards associated with different work areas and activities (data not shown). Bending at the back and neck, squatting, and stooping were associated with planting seeds and bulbs (14 of 24 observations) and weeding (4 of 4 observations). Weeding was done manually, either by hand or with the use of a tool with a sharp edge, such as a hoe or machete. These tools usually had short handles that encourage bending and stooping (Figure 3), and the handles were often crudely constructed and made the tools difficult to grip firmly. Anecdotal evidence indicates that many of these hand tools are imported from Southeast Asia and are preferred because workers feel they provide better control over the tool. Bending at the back was observed during market activities (3 of 3 observations). Use of sharp tools was noted during weeding (4 of 4 observations) and harvesting crops (5 of 5 observations). Market work was associated with lifting objects >50 pounds (1 of 3 observations)—typically buckets filled with flowers and water and crates and boxes of vegetables—and improper lifting techniques (e.g., not bending at the knees and twisting while lifting). Farming activities were also associated with lifting objects under 50 pounds (10 of 28 observations). Finally, awkward postures and constant hand grips were relatively common in

FIGURE 3. Example of a short-handled hoeing tool and bending at the back resulting from tool use.

farm work (each factor was noted 12 times out of 28 observations).

DISCUSSION

Our study developed an agricultural safety and health hazard observation tool, and pilot-tested it with Hmong-operated, small-scale farms in the Pacific Northwest. The observational approach we developed, in combination with the tool itself, represents a useful step forward for hazard assessment in the agricultural industry. The adoption and use of standardized assessment tools will allow for a more thorough evaluation of safety and health risks in both small- and large-scale agricultural operations. This will also provide the ability to conduct "apples-to-apples" comparisons of injury and illness risk factors in different sectors of the agricultural industry, which will allow for more precise characterization of risk and prioritization for occupational health interventions.

The most common hazards we observed were musculoskeletal in nature and involved bending at the back and lifting <50 pounds. These hazards were observed at all four work areas (farm, confined space, market, and storage) and across a variety of tasks. Use of sharp tools, awkward postures, repetitive hand motions, and

lifting >50 pounds were also common in three of the four work areas. The farming activities we observed involved almost no power equipment, and we did not observe pesticide or chemical handling or application. However, we did observe a worker who had disabled the guard on a rototiller, the presence of tractors without adequate safety equipment (i.e., ROPS systems), and the presence of pesticides, and heard anecdotal evidence of pesticide application without appropriate PPE and suspected ensuing health effects.

We noted several positive factors—nearly all participants were obviously aware of the hazards presented by sun and heat and wore appropriate clothing and sufficient liquids nearby to stay properly hydrated. We did not survey the observed workers to evaluate their occupational injury and illness experience, but did ask workers to share "stories" about their farmworker history, and received information that suggested injuries from improvised cutting tools were common. Due to human subjects restrictions, we did not observe any children as part of this study; however, we did note children working at the participating farms, which supports prior research, suggesting that children work in some Hmong agricultural operations.[13,28]

The main hazards we observed in this study showed good agreement with those identified in our parallel study of Hmong agricultural workers conducted using qualitative, participatory approaches.[22] Participants in our parallel study identified musculoskeletal disorders as a concern, and specifically noted the extended periods they spent in awkward postures, stooping, bending, and lifting various objects during their agricultural activities. Participants also noted risks associated with the use of sharp tools. The general similarities in results between the observational and participatory approaches suggest that the hazards identified through observations generally agree with those perceived by workers themselves. The few discrepancies between observed and perceived hazards highlight the differences in data collected via observation—which represent a detailed snapshot of particular moments in time—versus data collected via participatory self-report mechanisms, which may provide more integrative but less detailed information. A mixed-method approach, which combines information on hazards from workers with expert judgment, observation data, and quantitative exposure measurements (where possible), is more likely to yield a comprehensive assessment of potential safety and health issues than a single-method approach.[27]

Our findings generally agree with the sparse existing literature on Hmong and other small-scale farming operations. We did not observe any pesticide use on the participating Hmong farms, which is consistent with a study of Hmong agricultural workers in Minnesota in which participants expressed a preference for farming practices that did not include the use of pesticides.[13] This same study found that children performed repetitive and strenuous tasks, including lifting heavy weights and operating rototillers—both hazards that we observed among adults on our own participating farms. A study of indigenous agricultural workers in Oregon found that most did not use appropriate PPE,[29] also consistent with observations in the present study.

We incorporated published safety and health survey items into our observation tool where possible. Most of the tools already developed for use in the United States have focused on hazards presented by use of pesticides, chemicals, and mechanized equipment such as tractors[30] and power takeoffs.[31] As a result, our observational tool featured a number of items specific to these hazards. Although the observation checklist used was extensive, it was not comprehensive, and did not evaluate, for example, specific chemical agents and pesticides. The fact that the participating Hmong farms we observed were largely nonmechanized and did not apply pesticides during any of our visits meant that a large fraction of our tool was not relevant to the activities we observed. This highlights the importance of pilot-testing safety and health tools such as ours; we can use the results of this pilot assessment to better tailor our tool to insure that it adequately addresses small, largely nonmechanized Hmong farming operations, focusing more on the use of improvised tools and additional musculoskeletal hazards.

Data such as those collected in this study can be used to anticipate the injuries likely to be

common among Hmong agricultural workers in the United States. A more robust data set of observations could be used to help guide appropriate and feasible occupational health interventions. These could take several forms, such as simple engineering controls (e.g., modification of improvised cutting tools to include a simple blade guard or blade retraction mechanism, adoption of ROPS systems on tractors, use of tools with ergonomically correct handles, and adoption of standard containers for transporting products).[32] Other interventions could focus on behavioral practices—for example, promoting the correct use of existing guards on rototillers, training workers to adopt ergonomically neutral positions, and training workers to recognize and protect against pesticide exposures. Innovative training interventions have already been shown to be effective among Hmong agricultural workers in the United States.[28] Such interventions must acknowledge the balance between safe working conditions and perceived gains in productivity or efficiency; for example, the worker who had disabled the machine guard on the rototiller did so to gain a better view of the location of the rototiller blade. This action could be more safely accomplished by replacing the existing guard with a transparent Plexiglas guard. Finally, personal protective equipment could be incorporated into various activities, including use of eye protection when working with cutting tools, hearing protection when working with noisy equipment, and cut-resistant gloves (rather than surgical gloves).

LIMITATIONS

Our study had a number of limitations. First, our sample size was small. The results of 36 observations across four different types of work areas and a limited number of work tasks provide little statistical power and cannot be generalized to the broader Hmong farming community in Washington State or beyond. Our data do not, for example, capture the typical frequency or duration of job tasks.

The results of our study were likely affected by selection bias. Farms that participated were known to our community liaison, and may have differed systematically from nonparticipating farms (e.g., they may have been operated by more acculturated Hmong, and may have been safer as a result). Only project participants, and not other nearby workers, were observed, and it is possible that participants performed different tasks, or performed the same tasks differently, than nonparticipants due to greater acculturation. In order to not interfere with workers, we shortened our observation periods when workers appeared to be extremely busy. Although we felt being unobtrusive and avoiding work interference were critical to the success of our observations, this approach may have resulted in our failure to observe unsafe situations that occurred only during high-intensity work periods. It is also possible that we missed tasks that occurred with one worker working alone on a remote section of the participating farms, although this is unlikely.

We found it difficult to visit participating farms regularly, which influenced both our sample size and the range of activities and work areas observed. The most substantial issue was that some participating farms were difficult to reach over the phone and we did not want to arrive unannounced, so we were unable to conduct as many site visits as we had hoped. In addition, the times when work occurred were unpredictable, so it was difficult to know when people could actually be observed working. Our original intent was to conduct observations at each participating farm quarterly or more frequently, and during distinct work periods of the growing season (e.g., planting, harvesting, etc.). However, many of the activities were similar throughout the growing season. It was easier to capture routine activities that took time such as planting or weeding. We did not capture activities that were brief or infrequent, such as loading or unloading equipment from vans and pesticide application. It is possible that workers purposely did not perform these activities when we were visiting. Despite these challenges to scheduling and performing walkthrough observations, repeated walkthroughs proved beneficial because they enabled us to develop relationships with individual agricultural workers.

CONCLUSIONS

Our study demonstrated that a safety and health observation tool can be used to evaluate health and safety hazards among difficult-to-access agricultural worker populations in the United States. We identified a range of hazards, most of them musculoskeletal in nature, which generally agreed well with hazards reported by workers themselves in our parallel participatory research study.[22] These findings demonstrate the utility of mixed-method approaches, which are likely to yield more comprehensive and thorough assessments of safety and health hazards than single methods alone.

The tool we developed may prove useful in the assessment of hazards in other agricultural settings, and represents a step towards a standardized evaluation tool for hazard assessment among agricultural workers that has the potential to dramatically improve and expand our understanding of risk factors for occupational injury and illness in agricultural operations. We encountered a number of barriers in the conduct of this study that hindered our ability to collect data and likely reduced the generalizability of our findings. These included access to a limited number of sites, probable selection bias among both sites and participants, and our need to balance an unobtrusive research presence with our goal of conducting observations that were as comprehensive as possible. To create a data set of observations that are valid and representative of working conditions and safety hazards across different Hmong farms and farming activities, these barriers need to be overcome, possibly through a combination of greater community involvement, Hmong-conducted observations, and a more sustained and intensive observation campaign across a greater number of farms and participants.

Despite the limitations of this study, our preliminary results suggest that additional observations and some simple, culturally appropriate interventions are warranted in the Hmong agricultural community to reduce occupational injuries and improve the health of these vulnerable workers.

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APPENDIX A. AGRICULTURAL WORKER OBSERVATION TOOL

ASSESSING AGRICULTURE SAFETY & HEALTH NEEDS AMONG HMONG FARMERS

Date: _____/_____/_____ **Observation Start Time**: _____:_____ ☐ AM ☐ PM

Observer:_____

Location:_____

Weather: ☐ Sunny ☐ Overcast ☐ Rainy ☐ Windy **Temperature:** _____°F **Humidity:** _____%

Job/Task Observed:_____

Crop Type:_____

A. Worker and Location Information				
1. Work Area	☐ Farm Field	☐ Storage	☐ Roadway	☐ Other
	☐ Market	☐ Workshop		
2. Worker type	☐ Adult	☐ Child	☐ Don't know	
3. Working alone	☐ Yes	☐ No		
4. Clothing/PPE				
a. Long sleeve shirt	☐ Yes	☐ No		
b. Long pants	☐ Yes	☐ No		
c. Gloves	☐ Yes	☐ No		
d. Head covering	☐ Hat	☐ Bandana	☐ Other	☐ None
e. Work boots	☐ Yes	☐ No		
f. Coveralls	☐ Yes	☐ No		
g. Eye protection	☐ Yes	☐ No		
h. Hearing protection	☐ Yes	☐ No		
B. Physical Hazards				
5. Lifting *over* 50 lbs	☐ Frequent	☐ Occasional	☐ Never	
6. Lifting under 50 lbs	☐ Frequent	☐ Occasional	☐ Never	
7. Bending	☐ Frequent	☐ Occasional	☐ Never → ***If never skip to 8***	
a. Where does bend occur?	☐ At knees	☐ At back	☐ At neck	

8. Squatting or kneeling	☐ Frequent	☐ Occasional	☐ Never	
9. Pulling/pushing heavy items	☐ Frequent	☐ Occasional	☐ Never	
10. Hand tool use	☐ Frequent	☐ Occasional	☐ Never → ***If never skip to 11***	
a. Tool type	☐ Cutting	☐ Scraping	☐ Digging	☐ Other
11. Constant grip with hand	☐ Yes	☐ No		
12. Sharp edges/blade use	☐ Frequent	☐ Occasional	☐ Never	
13. Hand power tool use	☐ Frequent	☐ Occasional	☐ Never → ***If never skip to 14***	
a. Tool type	☐ Drill	☐ Saw	☐ Weedwacker	☐ Other
14. Repetitive motion of hands	☐ Frequent	☐ Occasional	☐ Never	
15. Hands in water to wash or clean objects	☐ Frequent	☐ Occasional	☐ Never	
16. Awkward posture	☐ Frequent	☐ Occasional	☐ Never	
17. Loud noise	☐ Frequent	☐ Occasional	☐ Never	
18. Dustiness	☐ High	☐ Low	☐ None	
C. Pesticides				
19. Type used	☐ Powder	☐ Liquid	☐ None → ***If none skip to 24***	
20. Mixing	☐ Frequent	☐ Occasional	☐ Never	
21. Application	☐ Frequent	☐ Occasional	☐ Never	
22. Application method	☐ Mechanical	☐ Handthrown	☐ Spray	☐ Other
23. Cleaning equipment	☐ Frequent	☐ Occasional	☐ Never	
24. Field hand washing station	☐ Available	☐ Not Available		
25. Contact with pesticide residue on equipment or crops	☐ Yes	☐ No	☐ Don't Know	
D. Chemicals				
26. Contact with gasoline/fuels	☐ Frequent	☐ Occasional	☐ Never	
27. Contact with lubricants	☐ Frequent	☐ Occasional	☐ Never	
28. Contact with degreasers/solvents	☐ Frequent	☐ Occasional	☐ Never	
29. Contact with other chemicals	☐ Yes	☐ No		

E. Farm Machinery				
30. Tractor use	☐ Yes	☐ No → ***If no skip to 30***		
a. Use of power take off	☐ Yes	☐ No		
b. Adding or removing attachments	☐ Yes	☐ No		
c. Operation type	☐ Plowing	☐ Seeding	☐ Transporting	☐ Other
d. Rollover protection	☐ Yes	☐ No		
e. Additional riders	☐ Yes	☐ No		
f. All riders properly restrained	☐ Yes	☐ No	☐ Don't Know	
31. Loading and transporting machinery	☐ Yes	☐ No → ***If no skip to 32***		
a. Method of transport	☐ Truck bed	☐ Trailer	☐ Pulling	☐ Other
b. Vehicle properly restrained during loading	☐ Yes	☐ No	☐ Don't Know	
c. Loading aids used	☐ Ramps	☐ Winch	☐ None	
d. Potential for crushing	☐ Yes	☐ No	☐ Don't Know	
32. Small equipment use	☐ Mower ☐ Chipper	☐ Sprayer ☐ Rototiller	☐ Other	☐ None
33. Other equipment use	☐ Conveyor	☐ Wheelbarrow	☐ Other	☐ None
34. Machinery guards on equipment	☐ Yes	☐ No	☐ Don't Know	
35. Pinch points on equipment	☐ Yes	☐ No	☐ Don't Know	
36. Cleaning machinery	☐ Frequent	☐ Occasional	☐ Never	
F. Additional Hazards or Comments				
37. Confined space	☐ Yes	☐ No		
38. Manure pits	☐ Yes	☐ No		
39. Silos	☐ Yes	☐ No		
a. Entrances properly guarded	☐ Yes	☐ No		
40. Potential for fall from elevation	☐ Yes	☐ No		

Observation Stop Time: _____:_____ ☐ AM ☐ PM

GUIDANCE FOR FIELD OBSERVATIONS

Complete and systematic collection of data is needed to determine the potential for occupational exposures among Hmong farmers. Observations with this tool should last *2 minutes*. An observation includes all of the items in the tool observed on a single individual over that 2 minute period.

Frequencies of exposure are defined as follows	
Frequent	Worker performs this action for more than half of the observation period.
Occasional	Worker performs this action for less than half of the observation period.
Never	Worker does not perform this action during the observation period

Description of items

A. Worker and Location Information	
1. Work area	Basic work location in which the observation is performed.
2. Worker age	*Child* If the worker appears to be less than 18 years of age. *Adult* If greater than 18 years of age. *Don't know* if unclear.
3. Working alone	*Yes if* work is performed alone or in an area out of sight of other workers
4. Clothing/ PPE	*Yes* if worker observed is wearing or using the listed clothing article or personal protective equipment (PPE).
B. Physical Hazards:	
5. Lifting over 50 lbs	*Frequency of worker lifting* >50 lbs. Estimation of weight is sufficient.
6. Lifting under 50 lbs	*Frequency of worker* lifting <50 lbs. Estimation of weight is sufficient.
7. Bending	*Frequency of deviation from a neutral body position.*
a. Bending location	*Body location* acting as the pivot point for the bend.
8. Squatting or kneeling	*Frequency of knees bent* from neutral position or resting on one or both knees
9. Pulling/pushing heavy items	*Yes* if moving heavy items without lifting them off the ground.
10. Hand tool use	Hand tools are non-powered tools such as spades, scissors, knives, shovels, saws, etc. *Frequency of use of hand tool* during the observed time.
a. Hand tool type	*Type of hand tool used*
11. Constant grip	*Yes* if worker held the tool in their hand consistently during the observed time.

12. Sharp edges/ blades	*Frequency of use* of knife, scissors, box-cutters, machetes, etc.
13. Power tool use	Power tool is a tool driven by electrical or battery sources. *Frequency of use* of tool during the observed time.
a. Power tool	*Type of tool used*
14. Repetitive motion of hands	*Yes* if hands perform the same motion over and over again during the observed time (i.e. turning a screwdriver by hand, cutting flowers, etc.).
15. Hands in water to wash or clean objects	*Yes* if products (e.g., fruits, flowers, etc) or tools (e.g., shovels, knives, etc) are being cleaned by hand in water.
16. Awkward postures	*Yes* if worker has to position body parts (i.e. hands, limbs, back) in any position other than a straight or neutral position.
17. Loud noise	*Yes* if worker must speak louder than a normal speaking voice in order to be heard by someone that is located close to them. Also *Yes* if worker is using power tools, tractors, or other powered machinery.
18. Dustiness	*High* indicates a high level of particles dispersed in the air during the observed time.
C. Pesticides:	
19. Type used	*Powder* consists of granules or other solid material. *Liquid* is a solvent based (normally water) material
20. Mixing	Pesticides often need to be diluted from a concentrated source prior to application to the crops. They can also be stored in a powder form that needs to be mixed with a liquid (often water) prior to application. *Frequency of pesticide mixing*
21. Application	*Frequency of pesticide application*
22. Application method	*Mechanical* is the use of an apparatus to distribute the pesticide (i.e. broadcast spreaders either on wheels or hand-held). *Hand thrown* is manual application. *Spraying* is distributing the pesticide by a pressurized container.
23. Field hand washing	*Yes* if portable hand washing station or other sources of water/cleaners available in the field for washing hands after pesticide application.
24. Cleaning equipment	*Frequency of cleaning pesticide application equipment*
25. Contact with pesticide residue	*Yes* if worker physically contacted (without use of PPE) surfaces or equipment that were contaminated with pesticides but not cleaned.
D. Chemicals	
26. Gasoline/fuels	*Frequency of contact with gasoline and fuels.* Note that this is only contact with liquid forms.

27. Lubricants	*Frequency of contact with lubricants like oil*
28. Degreasers/solvents	*Frequency of contact with degreasers and solvents*
29. Other chemicals used	*Frequency of contact with other chemicals*
E. Farm Machinery	
30. Tractor	*Yes* if worker is operating or riding on a tractor
a. Use of power take off	This is a method of physically transferring power from the running tractor engine to an attachment. Typically a metal bar is attached from the back of the tractor to the attachment. The drive shaft of the tractor turns the metal bar which mechanically moves the attachment point of operation (the area where work is being done such as blades tilling the soil or blades cutting grass). *Yes* if power take off is present.
b. Adding or removing attachments	Attachments can include sturdy equipment not permanently fixed to the tractor such as plows, blades, buckets, etc. *Yes* if attachments are being added or removed during observation
c. Operation Type	*Plowing* is the clearing the field or creating furrows for seeding. *Seeding* is the distribution of seeds or small plants within the furrows created during plowing. *Transporting* is using the tractor to move equipment or materials from one location to another.
d. Rollover protection	A physical bar or cage attached to the equipment that would is able to withstand the weight of the equipment in the event of a rollover. The rollover protection would allow for the operator to escape the equipment if it were to be upside down. *Yes* if rollover protection apparatus is present around driver's position on tractor.
e. Additional riders	*Yes* if persons are riding the vehicle or equipment in excess of the number of seats on the vehicle or equipment
f. Occupants properly restrained during vehicle operation	*Yes* if all occupants are using proper safety equipment (seat belt, safety harness, etc.) while operating the vehicle
31. Loading and transporting machinery	*Yes* if an automobile, truck, tractor, or trailer is used to transport machinery either from one farm to another or within different locations at the same farm.
a. Vehicle properly restrained during loading	*Yes* if measures have been taken to secure the vehicle so that it does not move or shift during the loading of material or equipment.
b. Loading aids	*Yes* if mechanical mechanisms that aide in the loading/unloading of equipment are used to lessen the amount of manual manipulation.

d. Potential for crushing	*Yes* if potential for machinery or materials of significant weight to fall upon or press body parts against a fixed surface. For example, worker is loading tractor and located between tractor and trailer where they could be crushed.
32. Small equipment use	*Yes* if worker operates fueled or battery driven equipment that is moved via wheels.
33. Other equipment use	*Yes* if worker operates conveyer, chipper, or other powered equipment
34. Machinery guards used	Machine guards are physical barriers that prevent workers from accessing areas of the equipment that can lead to pinching, crushing, cutting, and other hazards. These barriers are permanently attached to the machine and cannot be easily removed or circumnavigated. *Yes* if machine guards are present on small equipment.
35. Pinch points	Pinch points are areas where a body part (normally fingers or hands) are caught between two moving parts or one moving part and a fixed surface. *Yes* if pinch points are present at the worker's location.
36. Cleaning machinery	*Yes* if worker physically removes dirt/pesticide from machinery.
F. Additional Hazards or Comments	
37. Confined space	A confined space is an area that is not intended to be occupied by a worker during normal work activities and can create a hazardous environment due to lack of oxygen, build-up of hazardous gases, or other hazardous conditions. *Yes* if worker is working in a confined space.
38. Manure pits	Large pits that contain manure which is later used for fertilizing purposes. *Yes* if worker is working in a manure pit.
39. Silos	A large structure for containing bulk material such as grain. *Yes* if worker is working in a silo.
a. Properly guarded entrances	*Yes* if silo has doors or other mechanisms to prevent entrance from unauthorized persons or children.
40. Potential for fall from elevation	*Yes* indicates the person is working on a surface that is higher than 4 feet off the ground.