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Heat-Related Illness Among Latinx Child Farmworkers in North Carolina: A Mixed-Methods Study

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Abstract

Children as young as ten are legally hired for farm work. In North Carolina, many of these hired children are Latinx; they often work long hours during hot and humid summer conditions. Heat-related illness occurs along a continuum of severity ranging from heat cramps and rashes to heat exhaustion and heat stroke, which can be fatal. The literature on the negative health effects of occupational heat exposure is growing; however, few studies have examined this exposure and health outcomes among child agricultural workers. To understand Latinx child farmworkers' experiences of working in heat, we conducted in-depth interviews (n = 30). To estimate the prevalence of heat-related illness symptoms and associated factors, we conducted survey interviews (n = 165). Heat-related illness is common among these child farmworkers. While children often understand the dangers of working in heat, work organization often prevents their taking precautions. Formal workplace protections to prevent heat-related illness are limited.

Keywords

heat-related illness; child labor; migrant and seasonal farmworkers; occupational health; Latino/Hispanic; health equity; health disparities; agricultural health

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Introduction

Heat-Related Illness and Farmworkers

Heat-related illness (HRI) is a burgeoning global public health topic. Global climate change leading to greater frequency and intensity of extreme heat events increases HRI risk, making vulnerable populations and outdoor workers especially exposed.[1–3] HRI occurs along a continuum of severity ranging from heat cramps and rashes to heat exhaustion and heat stroke, which can be fatal (see Figure 1, adapted from National Institute for Occupational Safety and Health[4]). An analysis of national data of heat-related deaths from 1992 to 2006 calculated that crop workers had an average annual mortality rate nearly twenty times greater than that of all U.S. civilian workers.[5] During this period, deaths in California, Florida, and North Carolina accounted for 57 percent of all crop-worker deaths, and North Carolina had the highest annualized rate.[5]

Farmworkers are at an elevated risk for occupational injury and illness, including HRI, due to limited safety regulations, substandard housing conditions, long work hours, limited access to healthcare, social vulnerability due to guest-worker or immigration status, and working during peak summer heat.[6–13] Hired Latinx children constitute an especially vulnerable population within the larger farmworker community.[14,15]

Findings from research with farmworkers and other outdoor workers are concerning, given the prognosis of higher global temperatures due to climate change.[1,16] Using surveys, biomonitoring, and environmental sampling, studies have begun to delineate the relationship between the various risk factors and outcomes of HRI among farmworkers. Research in North Carolina, Florida, Georgia, Oregon, and California has documented high prevalence of HRI and other heat-related conditions among farmworkers.[9,13,17–22] In addition to the health risks of HRI, recent reviews observed increased occupational injury risk in high temperatures among young workers, male workers, and agricultural workers.[23,24] The percent of farmworkers who are women has increased substantially since 2001,[25–27] and research is documenting factors related to HRI among women workers.[28] Tobacco is a major agricultural crop in North Carolina, along with Kentucky and Virginia, and presents the risk of green tobacco sickness for farmworkers.[29] Green tobacco sickness and HRI symptoms overlap (dizziness and nausea).

Child Farmworkers and Exposure to Heat

Current standards for children working in agriculture in the United States date back to the Fair Labor Standards Act of 1938, which exempted agriculture from many child labor provisions. In 2019, children aged sixteen or older can hold any farm job, hazardous or not, for unlimited hours. Children aged ten to fifteen can be hired for any nonhazardous farm job outside of school hours, but parental permission is required for children under age 14, and those under age 12 are only allowed to work on small farms. There are no age restrictions for children working on farms owned or operated by their parents.[30] It is unknown how many children aged seventeen and under work as hired U.S. farm labor. The best available estimates are drawn from the National Agricultural Workers Survey and the Childhood

Agricultural Injury Survey. These estimates place the number of hired child farmworkers between 30,000 and 79,325 annually between the years 2005 and 2016.[31,32]

Existing research on children's heat exposure has primarily focused on the context of HRI and heat fatalities in youth sports.[33–35] The American Academy of Pediatrics cited undue physical exertion, insufficient recovery between repeated exercise events, and inappropriate clothing as modifiable HRI risk factors in youth sports.[33,36] Factors outside the control of child farmworkers such as the intensity and pace of farm work tasks, long work hours, limited control over their work environment, and lack of regulatory frameworks in agriculture increase their risk of HRI.[15,37–39]

Summers are extremely hot and humid in North Carolina (Table 1).[40] The findings from a recent study of Latinx child farmworkers in North Carolina indicate that children experience considerable exposure to working in peak summer heat. A third (34 percent) of child workers reported working forty-one to sixty-nine hours during the last week they worked.[41] Farm work is organized in a way that further exacerbates children's vulnerability due to the crew leader system and children's unique developmental characteristics, which may make them reticent to speak out against unsafe conditions.[37] Many farmworkers are paid piece rate wages, which incentivizes productivity and can make workers less likely to take breaks and more likely to work at an unsafe pace.[42–46] Previous research with Latinx child farmworkers in North Carolina found that they perceived low levels of work safety culture and climate in farm work.[47,48] Qualitative research with Latinx child farmworkers demonstrated that children generally understand that their parents want them to stay safe, but that their supervisors and coworkers do not uniformly value safety.[38] The geographic isolation of agricultural fields creates a dangerous situation in which workers may not receive adequate or timely medical care should they experience HRI complications. Latinx child farmworkers have additional barriers to healthcare seeking and access due to family immigration status or low knowledge levels about how to seek care.[15]

Physiologically, there are several important differences between children and adults relevant to HRI risk. Children's greater life expectancy increases their total environmental hazard exposures, compared to adults. The long-term effects of chronic heat exposure are unknown. A recent review, however, postulated that chronic heat exposure among agricultural workers in several world regions is one contributing risk factor for high morbidity of chronic kidney disease.[49] Research with adult farmworkers in California and Florida found biomarkers suggestive of acute kidney injury associated with increasing outdoor temperatures and limited hydration.[21,50]

In contrast to adults, children have a greater body surface area-to-mass ratio. Levels of radiation that children absorb from the sun are distributed to less tissue, raising core body temperature and increasing HRI risk.[51] Children's greater body surface area-to-mass ratio also creates a potential for increased absorption of chemicals. Pre-pubertal children generally produce less sweat than post-pubertal children and adults, due to the smaller size of sweat glands and a relative lack of sensitivity to heat.[52] This makes children's bodies less efficient at cooling through evaporative heat loss.[51]

Using data from a large, multicomponent study of hired Latinx child farmworkers in North Carolina, this study uses a mixed-methods analysis to address three objectives. It describes how Latinx children perceive heat hazards based on data from thirty in-depth interviews with Latinx child farmworkers. It reports the frequencies of HRI symptoms and protective behaviors among a sample of 165 Latinx child farmworkers. Finally, it examines associations between personal characteristics and experiences of HRI symptoms and protective behaviors among these children.

Methods

Overview

We report 2016 in-depth interview and 2017 baseline survey interview data from a longitudinal Community-Based Participatory Research study examining the health and safety of Latinx child farmworkers.[41] We have discussed the study design in detail in Arcury et al.[41] and Quandt et al.[37] Therefore, we provide a brief overview of methods here for brevity. Community partners for this study included Student Action with Farmworkers, North Carolina Migrant Education Program, community field interviewers, and representatives from other farmworker health and advocacy organizations. The program of Student Action with Farmworkers for Latinx youth farmworkers, the *Levante* Leadership Institute, serves as the youth advisory board.[53] The institutional review board at Wake Forest School of Medicine approved all study procedures (approval number: IRB00036403).

Participant Recruitment

Semi-structured in-depth interviews.—We worked with community organizations in order to recruit thirty Latinx child farmworkers from June to September 2016.[37] To be eligible for the in-depth interview, participants had to be between ten and seventeen years old; have worked in agriculture in the last twelve months; be fluent in English or Spanish; and self-identify as Hispanic or Latino. All participants completed signed youth assent and their parents completed signed parental permission. The Institutional Review Board approved an exemption of parental permission for individuals who were living in North Carolina unaccompanied by a parent or legal guardian.

Baseline survey interviews.—We collaborated with bilingual study staff to recruit 202 participants in twenty counties across North Carolina from May to November 2017.[41] Data in this analysis were limited to a subset of 165 participants who reported working in extremely hot weather in the last year. To be eligible, participants had to be between ten and seventeen years old; have worked in farm work in the last three months; be fluent in English or Spanish; and self-identify as Hispanic or Latino. Prior to a child's enrollment in the study, staff explained the study and received signed parental permission and signed youth assent. The Institutional Review Board approved an exemption of parental permission for individuals who were living in North Carolina unaccompanied by a parent or legal guardian.

Data Collection

Semi-structured in-depth interviews.—Experienced and trained bilingual interviewers conducted audio-recorded in-depth interviews. The guide included questions regarding

children's experiences of working in hot conditions and related illnesses. Interviews lasted approximately sixty minutes and participants received a $25 incentive. Interviewers used probes to draw out the participants' views of working in the heat as well as their perceptions of strategies to protect themselves from the heat.

Survey interviews.—The survey interviews collected information on participant's experiences of HRI symptoms and protective behaviors; these measures were developed for previous studies with adult farmworkers.[9,20] We pilot tested the instrument with the youth from the *Levante* Leadership Institute and incorporated their feedback on content, language, and question wording.[53]

We identified possible field interviewers through community contacts and organizations who have direct contact with farmworkers in different North Carolina regions. Interviewers completed Collaborative Institutional Training Initiative on the protection of human subjects training[54] and a one-on-one training with the project manager on the research protocol.

After recruiting participants, interviewers completed face-to-face interviews with participants in their preferred language (English or Spanish) in their homes. Participants received a $20 incentive for completing the interview, which took approximately forty-five minutes to complete. Data were entered in real time during the interviews using Research Electronic Data Capture. Research Electronic Data Capture is hosted at Wake Forest School of Medicine through the Clinical and Translational Science Institute, and this system provides secure, web-based applications for a variety of types of research.[55]

Survey interview measures.—Personal characteristics measures include gender (male, female); age range (ten to thirteen years, fourteen to fifteen years, and sixteen to seventeen years); farmworker status (migrant, meaning they moved from state to state to do farm work; seasonal, meaning that they did not change state of residence throughout the year in order to do farm work); years of farm work experience (one to two years, three or more); working with older nonsibling relatives (parents, uncles, aunts); pay structure (paid by piece, hour, or combination); recipient of pay (parents, child); and housing (trailer, house). Questions assessing HRI symptoms occurring while working in extremely hot weather in the last year included responses (yes/no) to any of the following: dizziness; sudden muscle cramps; hot, dry skin; nausea or vomiting; confusion; and fainting. The occurrence of symptoms was summed; participants reporting at least one or more symptom were considered to have experienced HRI. Protective behaviors were also assessed and included drinking extra water, taking breaks in shaded areas, taking extra breaks, changing work hours, going to air-conditioned places during or after work, and changing work tasks.

Analysis

Semi-structured in-depth interviews.—A professional transcription and translation company transcribed verbatim the audio recordings of interviews. We verified all transcripts to ensure accuracy. We used ATLAS.ti (version 7.2) text analysis software to manage and code the data. We performed iterative and recursive data analysis beginning with the first interview in order to identify areas to explore and clarify in subsequent interviews. Based on these analyses, we created a codebook reflecting emergent topics and assigned codes to each

section of text. Participants' descriptions of working in the heat were primarily contained within the codes "farm work experience," "work-related risk behavior," "occupational injury," "work organization," and "safety culture." In order to summarize participants' descriptions of heat, we isolated all quotations that broadly discussed heat. We then subcategorized all quotations into emergent topics. We include age, gender, and participant identification numbers with each quotation in order to demonstrate the diversity of participants quoted.

Survey interview.—We report frequencies of job characteristics, personal characteristics, HRI symptoms, and protective behaviors. We used chi-square tests to examine associations between participant characteristics and HRI as well as protective behaviors and HRI among participants who worked in extremely hot weather. We conducted analyses using SAS version 9.4 (SAS Institute, Cary NC), and p values of less than .05 were considered statistically significant.

Results

Semi-Structured In-Depth Interviews

Participants included seventeen boys and thirteen girls. Nine participants were aged ten to thirteen years old; eleven were aged fourteen to fifteen years old; and ten were aged sixteen to seventeen years old. The majority preferred to complete the interview in English. About half (n = 16) of participants worked in farm work seasonally and lived in North Carolina year-round, eleven migrated for farm work with their parents, and three migrated for farm work without a parent. Eight participants were in their first season of working for pay at the time of the interview. Participants had worked in a variety of crops, with the most common consisting of tomatoes, tobacco, and blueberries. Heat and HRI emerged as a topic at the forefront of how the children perceived their jobs. Major themes were heat and negative aspects of farm work, acclimatization, HRI prevention strategies including workplace supervision, breaks, and hydration, individual experience of HRI, and coworker experience of HRI.

Negative aspects of farm work.—The majority of participants cited working in the heat as the primary negative aspect of doing farm work. For example, when asked about what she did not like about working in the tobacco fields, a sixteen-year-old girl replied, "The sun. It's hot. That's the only thing. Because, I mean, working in the field is easy, but it's only the sun. The sun and the tobacco juice and stuff like that" [#30]. A fifteen-year-old boy stated, "I get hot and you sweat a lot there … and you also have to take another shirt so that you can change" [#7]. A sixteen-year-old boy working in tobacco described the heat, work pace, and harsh supervision as negative aspects:

> Well it's hot. It's really hot, and you have to work with everybody's pace so you won't be left behind. And if you're left behind, the boss man will like scream at you and just tell you to go faster or if not then he's going to replace you with someone else.
>
> [#28]

Acclimatization.—Several participants believed that becoming accustomed to the heat was important, and that those who were unaccustomed to the heat would face greater risk. For example, a thirteen-year-old girl who worked picking peas said, "… if it's the first day, you might feel the hotness … You might think you're gonna die in there, but you're not. You can survive" [#15]. Similarly, a fifteen-year-old boy working in tobacco commented,

> I mean you don't really feel it because you get used to it, I guess. But if it's really, really hot like above 95, 100, I mean you do feel it and it's sweating a lot. It's pouring and you take more breaks.
>
> [#29]

A seventeen-year-old girl working in tobacco emphasized the importance of work pace and supervisors on experience of the heat:

> It's not hard when you go, like, every year. But when you first go, it's hard. People sometimes, they're used to it, so they go fast, and it depends on the supervisor if, like, some—the first year I went with my uncle and I would go slow. They would help you and everything. And then all these years I went with this lady, and it would go fast. [The crew-leader] wouldn't help you. They wouldn't let you drink.
>
> [#22]

Several of the migrant participants described being accustomed to the heat in comparing the North Carolina heat to other places they had worked. A seventeen-year old boy picking tomatoes, bell peppers, and eggplant said,

> Well, I mean, of course it's hotter in Florida—way hotter. But here, I mean, the only hot months is July and June. August is a little hot, but after that, it starts getting a little cold, and it just starts freshening up.
>
> [#27]

Another fourteen-year-old boy harvesting tomatoes similarly thought about the heat in the context of comparing it to Florida, "I'm used to it, 'cause here, like, when it's a really hot day, it's not really nothing, 'cause in Florida it gets hotter, like, 100 and something" [#10]. And another fifteen-year-old boy compared it to the places they stopped to work while following the tomato harvest: "… it's not as hot as Moultrie [Georgia] or Florida …" [#11]. A fourteen-year-old girl compared it to her home state of Texas, "Well, I actually get more used to it because in [Texas], it's double the hotness from here" [#3]. Despite their comparisons, many of these same participants went on to describe their own experiences of HRI in North Carolina.

HRI prevention: Supervision, breaks, hydration.—Participants held different perspectives on how much supervisors cared for their safety relative to heat exposure. Several described a positive supervisory environment for HRI prevention strategies, like taking breaks and providing water. A few stated that they were allowed to take breaks whenever they needed and reported leaving early if it was too hot. A fourteen-year-old migrant boy working in tomatoes described a flexible, but limited break system:

> you can take a break whenever you want, like, not for a long time, you know, ‘cause then you’re not really working. But, like, if you wanna get a drink of water only for a couple of minutes, three or five, maybe, you can take it whenever you want.
>
> [#10]

A sixteen-year-old girl working in tobacco described a set break schedule and the ability to leave early if the weather was hot:

> They give you three breaks. One at 10:30, the other one at 12:00, and the other one at 3:30. [Interviewer: And so you would do that same schedule for–?] Every day. And, like, when it was really hot—when it felt really hot, we came home early.
>
> [#30]

A sixteen-year-old boy working in tobacco described a work environment in which the crew leader primarily cared about the quantity of the work, but that the grower seemed to care about worker safety,

> I think he [the grower] cared because when it was hot he would always come to the field and tell us, “If you want to leave y’all can leave. I know it’s hot and if y’all want to leave y’all can leave.”
>
> [#28]

The same participant described another situation where collective action by the workers sometimes persuaded the crew leader to let the people vote on ending work early. The participant continued,

> sometimes we would get off early because people complained that it was too hot and they couldn’t work anymore and so we just got off early. [Interviewer: And so whose decision was it to let you off early?] It was the people’s. It was our decision. If we complained then he’d be like, “All right, raise your hand if you want to leave,” and, if people raised their hand, then we would leave.
>
> [#28]

An eleven-year-old boy working in blueberries commented on how his father would allow him to take breaks,

> since we are kids, our dad tells us that, if we are tired or the sun is too strong for you, you can sit down in the shade to rest for some five minutes since the sun is very hot.
>
> [#19]

A fifteen-year-old boy stated,

> So I actually had a few times where all that hot would make me want to faint and—but I have always had a water bottle with me to like cool me down or sometimes I’ll sit down under, like, the [tobacco and blueberry] bushes for a few minutes to cool down and then go back to work.
>
> [#21]

Others described a much more negative environment. A sixteen-year-old girl working in tobacco discussed feeling stressed when she could not take a break,

> Well, if they're rushing you, then you will feel stressed out. It's like, you need a break. Or you'll pass out or something. You feel like if you don't take a break, you're going to pass out. There were times where the [other workers] would get mad and be like, they have things to do; they ain't got time for us to take a break. So they would just let you drink water and keep working.
>
> [#17]

A sixteen-year-old girl described a situation in which breaks were withheld until a particular task was completed,

> If your schedule is your 10:30 break, they don't want you to take it because they want you to finish the field … the farmers come and say, "I need this field by 12:00 so you need to finish," so we can't take a break …
>
> [#30]

Most, but not all, participants reported that their supervisors provided water (but participants did not appear to know that law required it). A seventeen-year-old boy with multiple seasons of experience described the condition at several different farms, and noted that water was not always available:

> the first two supervisors that we worked with, like, they'll put water out in the field for us, they'll leave a huge cooler of water. And then, the first owner I worked with, he would always make sure that I, I either brought my own water, or he had water in the house for me kind of thing. Like, he asked me if I was thirsty, and if I didn't have no more water, he would bring me out a bottle of water kind of thing. Our most recent owner, the one we've been working this year, since he's not around a lot, he doesn't leave water out in the field. But whenever he does show up, he'll ask us, "Hey, are you all thirsty?"
>
> [#23].

Several participants reported that they would bring their own water because the water the supervisors provided was not always clean. A fifteen-year-old boy stated, "They do give us some, but I don't like to drink it from there-… maybe there's germs or something there that —I don't want to get any diseases" [#7]. A sixteen-year-old boy described the water the supervisor provided as "… nasty and it wasn't clean water. It tasted different" [#28].

A few participants held beliefs about drinking water that could actually increase risk for HRI. A fifteen-year-old boy said, "I never drink water. I always drink sodas, all that" [#7]. Similarly, another fifteen-year-old boy stated,

> I drink lots of water. But sometimes you can't drink water the whole day. It starts hurting your stomach. So you have to drink at least one soda … you get tired of the water, and the grown-ups, the older people, they drink a little, like, beer 'cause they get tired of the soda and the water.
>
> [#11]

A sixteen-year-old boy believed that drinking too much water would make you sick,

> Well, pretty much you can drink around two cups, less than two cups ‘cause if you drink too much, your stomach will be kind of too much water, so when you start picking again, it’s gonna be hard for you to breathe or something.
>
> [#24]

When probed about whether this was only the case for water or other drinks too, he responded, “… if you drink Red Bull—your heart starts beating faster … or Monsters, stuff like that, [energy drinks]. I mean Gator [ade] is probably ok” [#24].

Child workers’ personal experience of HRI symptoms.—Many children described their own experience of HRI symptoms. The most common symptoms that participants discussed were dizziness, headaches, and nearly fainting. A sixteen-year-old girl said, “But you get dizzy. You get overheated. You just want to feel the cold air. It makes you get in a bad mood and stuff like that” [#30]. A seventeen-year-old boy described a day when the temperature was above 95 degrees and feeling like he was on the verge of fainting, “… I started feeling so, so dizzy that when I got to the car, I just stayed there, and I couldn’t go back to work. Like, I just stopped for the rest of the day” [#23]. A seventeen-year-old girl commented, “The first day I would go in the tobacco I would feel like fainting ‘cause of the hotness” [#22]. A twelve-year-old boy working at a nursery described feeling distressed by the heat,

> I felt tired. Well, like tired and frustrated because, I don’t know, when I had the headaches I felt like I was going to get frustrated and throw a plant to the ground but I never did that but I felt like it. It was like—my—I don’t know—my head was like another world or something.
>
> [#13]

A fifteen-year-old girl discussed her experience of nearly passing out, “Like, sometimes I—not dehydrate, but, I feel like I’m really dizzy because of the sun. And there was—last year, the first day we got here, I got really, really dizzy, and I was going sideways. So I had to step out” [#6]. A fourteen-year-old girl working in blueberries commented, “… because of the hotness, my head will be hurting sometimes” [#5].

Child workers’ observation of HRI in the workplace.—Several children also described the distress they felt when they witnessed other workers fainting in the fields. A thirteen-year-old girl recalled,

> It was actually my grandparents. When we were working with them, she fainted. I got scared, because I was kind of small. I would say she was dead. She kind of just passed out, and we were all freaking out. She got hurt by one of the branches, because when she fell, there was a branch there, and she got hurt on her arm.
>
> [#16]

A seventeen-year-old girl described her experience of seeing someone who fainted in the tobacco fields,

> It was kind of bad seeing the person on the ground. Because—but I don't know—nobody even noticed it because of the big leaves … But then somebody just saw her and I went and I saw her. And so I got scared also. I don't like seeing people right there on the floor. Like they're dead or something.
>
> [#18]

A fifteen-year-old boy who had been going to the fields since he was six-years-old described the experience of other workers fainting as relatively routine, something he would "[see] only once or twice a year" [#21].

Survey Interview Results

Participant and job characteristics.—Survey interview participants were nearly two-thirds (64.2 percent) male (Table 2). One-fifth (20.6 percent) were aged ten to thirteen, 31.5 percent were aged fourteen to fifteen and nearly half (47.9 percent) were aged sixteen to seventeen. The majority (86.1 percent) of participants were seasonal workers, but nearly 14 percent were migrant. Fifty-nine percent reported one to two years of farm work experience, and 41.2 percent reported three or more years of experience. Many (57.6 percent) worked with at least one older relative. The majority (63.6 percent) of children were paid by the hour at their last farm job. A quarter (25.5 percent) were paid by the piece and 6.7 percent received a combination of hour and piece rate pay. Four percent did not specify or know their pay structure in the interview. Nearly 21 percent reported that their parents received their pay; while about 80 percent of children received the pay themselves. Three-quarters (74.6 percent) lived in a trailer and the other quarter lived in a house.

Participants reported working in a variety of crops in the last week they did farm work. The most common crops were tobacco (64.2 percent), berries (24.9 percent), sweet potatoes (14.6 percent), and tomatoes (11.5 percent). The most common tasks within the different crops included topping tobacco (57.0 percent), harvesting or picking (46.7 percent), and pulling weeds or cultivating (41.8 percent). Nearly a quarter (23.0 percent) were involved in loading/packing/dumping/transporting, and 13.9 percent planted crops (results not included in table).

HRI symptoms and protective behaviors.—Among children who performed farm work in extremely hot weather in the previous twelve months, close to one-third (29.1 percent) experienced dizziness and over one-fifth (21.8 percent) had sudden muscle cramps (Table 3). Hot, dry skin was reported by 17.6 percent, 8.5 percent reported nausea or vomiting, and 6.1 percent reported confusion. Three participants (1.8 percent) reported fainting while at work. Nearly half (47.8 percent) of participants reported experiencing at least one HRI symptom, and 22 percent experienced at least two symptoms.

Common behaviors protective against HRI were drinking extra water (90.9 percent) and taking rest breaks in the shade (87.9 percent). Taking extra breaks was reported by 55.8 percent and changing the work schedule to start earlier in the morning or leaving earlier in the afternoon was reported by 43 percent. Slightly more than one-third (34.6 percent) reported going to air-conditioned places during breaks or after work. Few (10.9 percent)

participants were able to change their work tasks, such as doing easier tasks or working in the shade.

Associations between HRI, personal characteristics, and protective behaviors.—While there was some variation in experience of HRI based on personal characteristics, the only significant association was age (Table 4). Older participants were more likely to report HRI symptoms than younger participants (60.8 percent of sixteen to seventeen year olds; 44.2 percent of fourteen to fifteen year olds; and 23.5 percent of ten to thirteen year olds).

Those reporting protective behaviors had lower levels of HRI, with a few exceptions. Taking extra breaks significantly decreased HRI (62.0 percent vs. 39.7 percent). Counterintuitively, those reporting going to air conditioned places during rest breaks or after work reported higher HRI levels (59.6 percent vs. 41.7 percent) and this difference was significant.

Discussion

This mixed-methods study of Latinx child farmworkers expands our knowledge of the experience and prevalence of HRI as an occupational health outcome among vulnerable worker populations. The in-depth interviews revealed that Latinx child workers considered that working in the heat was the primary negative aspect of their farm work jobs. Many discussed their experiences of HRI symptoms and attributed the cause of symptoms to working in the sun and heat. They most commonly experienced dizziness, headaches, and feeling as if they might faint. Participants described a work environment in which HRI was relatively commonplace among other workers. A series of Human Rights Watch reports also cited heat exposure as a concern for child farmworkers, but did not quantify HRI symptoms or conditions.[56,57]

We could not identify any child agricultural worker studies to compare our quantitative survey results. However, an expanding body of literature has documented HRI among adult farmworkers through self-reported symptoms and biomonitoring. Comparison between studies is difficult due to differing reporting periods and case definitions of HRI. Further, children have physiological differences, such as developing self-regulatory systems, which make comparison with adults difficult.[37,38] Our findings of 47.9 percent of child workers experiencing HRI are slightly greater than other cross-sectional studies in North Carolina. Using the same measures as the present study, but with a shorter recall time (last three months), Arcury et al.[9] estimated HRI prevalence among 101 North Carolina migrant farmworkers at 35.6 percent. Mirabelli et al.[20] with a longer recall time (any previous year working in U.S. agriculture) found 40 percent of 281 North Carolina farmworkers reported HRI symptoms. Kearney et al.[19] estimated an HRI prevalence of 72.3 percent among 158 North Carolina farmworkers, but included more HRI symptoms in the classification. In a Georgia study, Fleischer et al.[18] found that one-third of 405 farmworkers experienced at least three HRI symptoms in the previous week. Another Georgia study in 2019 reports that 28 percent of 101 farmworkers experienced one or more HRI symptoms in the last week.[22] A 2013 study in Oregon of one hundred farmworkers found that 64 percent experienced one

HRI symptom and 11 percent experience three or more symptoms in the previous work week.[17]

Similar to the present study, other studies that measured HRI prevention strategies found that the great majority of workers drink more water when working in hot weather. The in-depth interviews revealed that child workers generally understand the importance of hydration, but that some may lack adequate knowledge about the importance of drinking water rather than sugar-sweetened beverages. Further, several children described an environment where water was not always provided by the supervisor or grower, which appears to be in violation of Occupational Safety and Health Act's field sanitation standards.[58] When supervisors provided water, several children still opted to bring their own because they did not know or trust the source of water provided by the supervisor.

Forty-three percent of child farmworkers who completed the survey interview reported changing work hours, compared with 25 to 30 percent in the other North Carolina studies[9,20] and 21 to 63 percent in the Georgia studies.[18,22] The in-depth interviews elicited that child workers generally had the ability to leave work early in extreme temperatures, but it largely depended on the crew-leader or grower and whether or not their adult coworkers came to a consensus. Fewer child farmworkers (10.9 percent) reported changing work tasks, compared with 20 to 30 percent in the other North Carolina studies,[9,20] and 23 to 64 percent in the Georgia studies.[18,22] This may demonstrate that child workers have less control over their work environment.[37] Most work in harvesting, for which there are few alternative tasks available. The majority of workers in the present and other North Carolina studies reported taking rest breaks in shaded areas (73%–88%),[9,20] while the Georgia studies found that only 20 to 23 percent reported taking breaks in the shade.[18,22] Children who completed in-depth interviews described taking breaks in the shade, but it appears that employers rarely provided shade structures and sometimes participants needed to improvise. For example, a few described sitting under tobacco leaves or blueberry plants for shade or that access to shade depended on whether the fields were located near trees. Our finding that 35 percent of child workers went to air-conditioned places during rest breaks or after work was consistent with what Arcury et al.[9] found in North Carolina (30 percent) and Fleischer et al.[18] in Georgia (38 percent); however, in the other North Carolina study, Mirabelli et al.[20] found that very few workers reported access to air-conditioning.

A significant finding from our study is that older children (aged sixteen to seventeen) were more likely to report HRI symptoms than younger children (aged fourteen to fifteen and ten to thirteen). There are several possible explanations for this finding. First, older children may be more likely to work at a pace similar to their adult counterparts, which raises body temperature. Biomonitoring with adult farmworkers demonstrated that fast work pace increases HRI risk.[43,44,59] Older children we interviewed described feeling pressure to keep up with their adult coworkers, even though they would sometimes receive help if they fell behind. Second, older children may work longer hours than younger children, which increases physical exertion and exposure time to hot environments. Our survey interview only collected data on work hours in the past week, but the recall period for HRI is twelve months, so we cannot test this hypothesis. However, in the in-depth interviews, older children described working long hours while the younger children described that their

parents monitored them closely and allowed more flexibility in breaks. Third, it is possible that older children have more capacity for accurate self-report of HRI symptoms than younger children. In addition, older children may better recognize HRI symptoms—the fact that younger children may not recognize HRI symptoms may increase their health risk.

In this study, taking extra breaks significantly reduced HRI. A little over half (56 percent) of children who completed the survey interview reported taking extra breaks. Child workers may not always have the capacity to know when to take breaks and may not always feel comfortable to ask for a break, as demonstrated by the qualitative findings.[37] Several children who completed the in-depth interview described that some crew-leaders would not allow breaks to deviate from a set schedule and others would even withhold breaks until a particular task was completed. The pressure of keeping up with other workers was also cited as a factor that may reduce child workers' ability to take breaks. Periods of rest are critical in lowering an elevated body temperature and breaks are important for creating a safer work environment in extremely hot weather.[4]

Our finding that children who reported going to air-conditioned places during rest breaks or after work experienced higher levels of HRI (59.7 percent vs. 41.7 percent) is somewhat perplexing and difficult to interpret. While very few (2 percent) workers reported going to air-conditioned places in the Mirabelli et al.[20] study, those who did also had an increased risk of HRI. Contrarily, Arcury et al.[9] found that spending time after work in an extremely hot house was associated with increased HRI. Periods of cooling are highly recommended as an HRI prevention strategy,[4] though the relationship between air-conditioned places during rest breaks or after work and HRI in this sample is unclear. One possibility is that air-conditioned rest areas were reserved for those experiencing symptoms; however, air-conditioned rest areas are uncommon in this work context. Better measures to distinguish between the location, quality, and time spent in air conditioning as well as the implication for acclimatization would help further delineate this relationship. Migrant farmworkers often have very little control over their housing conditions.[60,61] In a study of common and sleeping rooms in farmworker camps, Quandt et al.[60] recorded dangerous heat indexes in most rooms. Overall, air-conditioning was rare and usually only present in bedrooms, but it did serve to reduce the overall heat index.[60] Children in farmworker families likely have distinct experiences, as they do not generally live in housing provided by their employers. Nevertheless, many farmworker children and their families live in poverty and often live in poorly insulated housing. In this sample, three-fourths reported living in trailers, but we did not detect significant differences in HRI levels between participants living in houses versus those living in trailers.

Our findings on HRI and pay structure (hour vs. piece) differ from studies with adult farmworkers. We found that those who were paid only by the piece had slightly lower HRI levels than those who were only paid by the hour at their last farm work job (38.1 percent vs. 51.4 percent). Focus groups with farmworkers in South Carolina and California highlighted that workers feel pressure to work faster for longer hours and take fewer breaks when they are paid piece rate, and that this can increase HRI risk.[42,45] Studies in California and Washington showed that workers paid piece rate, relative to those paid hourly or salary, had higher physical activity levels,[43] higher core body temperature readings,[44] higher levels of

acute kidney injury,[21] and higher odds of HRI symptoms.[46] Our findings could demonstrate that child workers feel less financial pressure to maximize earnings by working at a dangerous pace in the heat than their adult counterparts. Another possibility is that those paid by the hour are pressured to continue working at a fast pace and take fewer breaks by their employer. Several children who completed the in-depth interview described that their breaks were withheld while being paid by the hour.

Strengths and Limitations

This study has several strengths. It is one of the only studies examining HRI among child farmworkers. Our inclusion of in-depth interview findings of children's experiences of heat deepens and contextualizes the quantitative findings. They allowed child workers to describe their feelings in their own words and allowed interviewers to probe further on topics not fully captured by structured survey interviews. Even so, we used the emergent qualitative findings to strengthen the structured survey instrument. The participation of young Latinx students with experience in farm work in an advisory role helped strengthen our instruments and tailor the research to the study population.[53] We recruited a geographically dispersed sample throughout twenty counties in North Carolina and enrolled a largely hidden and hard-to-reach group of Latinx child farmworkers at a time where the political climate made families fearful to participate in research.

This study also has limitations, and the results should be interpreted with caution. We asked participants to self-report HRI symptoms and behaviors during the previous year so the potential for recall bias is present. Some of the symptoms of HRI resemble other occupational illness symptoms such as green tobacco sickness[62] and acute pesticide poisoning (e.g., dizziness, nausea), so there is a potential confounding effect. Some participants were interviewed early in the agricultural season (May and June) prior to the hottest months, so it is likely that we missed experiences of HRI that happened later in the season for children who were in their first work season. The results are cross-sectional and limited to North Carolina, so they are not generalizable to HRI among child farmworkers in other states or years.

Conclusion

This research highlights the need for greater attention to protect child workers from HRI. Latinx child farmworkers often recognize the dangers of working in the heat, but they do not always possess the knowledge or workplace control to intervene effectively on their situation. The majority of research on HRI among adolescent children has focused on youth sports and recreation. While this is of high importance, recreational sports offer a much more controlled and regulated environment than agricultural fieldwork with considerably less exposure time to environmental heat than full time jobs. It raises the question of whether this type of work environment is appropriate for young children. Nearly half of child farmworkers reported experiencing at least one HRI symptom while working in extreme heat in the previous twelve months. The most severe HRI of heat stroke (when an individual's body temperature rises above 104 degrees Fahrenheit) can be fatal if not treated. HRI symptoms can increase risk for other occupational injuries.

The only states to pass HRI prevention legislation are California, Washington, and Minnesota.[63–65] In 2018, advocacy groups began campaigns to pass federal heat standard legislation that would mandate HRI prevention provisions such as hydration, shade, and rest breaks in workplaces.[66] The results from the present study and others elucidate the urgent need to protect workers from the effects of extreme heat hazards in a time of global warming. Further research on HRI among Latinx child farmworkers in other regions will help delineate the magnitude of this issue and possible avenues to reduce HRI. Educational campaigns targeted at Latinx youth can increase knowledge and prevention strategies of HRI; however, they are difficult to sustain and do not go far enough in protecting young workers.[22,67,68] A federal heat standard is needed to protect workers from HRI. States that have passed heat standards need to continually evaluate their effectiveness and use evidence-based strategies to refine them. California evaluated their heat illness prevention campaign and observed improvements in worker safety as well as opportunities to enhance effectiveness.[69,70] At the same time, if these standards are ignored and not enforced, the results can be tragic. In 2008, seventeen-year-old Maria Isabel Vasquez Jimenez died in the hospital after collapsing from heat stroke while working in a California vine-yard.[71] A state investigation found that the labor contractors were in violation of multiple provisions of the heat standard.[72]

Article 32 of the Convention on the Rights of the Child states that children have the right “to be protected from economic exploitation and from performing any work that is likely to be hazardous or to interfere with the child’s education, or to be harmful to the child’s health or physical, mental, spiritual, moral or social development.”[73] The United States has signed, but not ratified the Convention.[74] Federal heat standard legislation should include provisions to ensure special protections for the rights of vulnerable child workers. Lawmakers need to revisit the appropriateness of the current age limits in agriculture, one of the most hazardous industries, by examining the age limits in every other industry in place to protect child workers.

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Illness	Description	Symptoms
Heat stroke	Body temperature rises above 104 degrees (potentially lethal emergency)	Confusion, altered mental status, slurred speech, loss of consciousness (coma), hot and dry skin or profuse sweating, seizures, possible death
Heat exhaustion	Occurs after extended exposure to high temperatures and lack of fluids	Headache, nausea, dizziness, heavy sweating, irritability, weakness
Heat Syncope	Occurs with prolonged standing, dehydration, and lack of acclimatization	Fainting, dizziness, lightheadedness
Heat cramps	Muscle pains or spasms that happen during heavy exercise	Tightness or spasm of muscles (usually in abdomen, arms, or legs)
Heat rash	Skin irritation from excessive sweating	Rash on skin

Figure 1.
Heat-related illness: Descriptions, symptoms, and severity.[4]

Table 1.

Monthly Average of Daily Maximum Temperature and Monthly Maximum Heat Index in the Twenty North Carolina Counties of Data Collection, 2017.

	Average maximum daily temperatures (F°)	Average monthly maximum heat index[a] (F°)
May	80.6	92.0
June	85.4	97.5
July	90.1	107.0
August	86.6	104.4
September	82.3	94.1
October	76.0	93.0
November	64.0	78.4

[a]Missing data for Greene and Wilson counties.

Table 2.

Participant Characteristics of Those Working in Hot Weather (n = 165).

Participant characteristics	N	Percent
Gender		
Male	106	64.2
Female	59	35.8
Age		
10–13	34	20.6
14–15	52	31.5
16–17	79	47.9
Farmworker status		
Migrant	23	13.9
Seasonal	142	86.1
Years of farm work experience		
1–2	97	58.8
3 or more	68	41.2
Work with older relative(s)		
Yes	95	57.6
No	70	42.4
Pay structure		
Piece only	42	25.5
Hour only	105	63.6
Combination of piece and hour	11	6.7
No pay structure identified	7	4.2
Recipient of pay		
Parents	34	20.6
Child	131	79.4
Housing		
Trailer	123	74.6
House	42	25.4

Table 3.

Individual Heat-Related Illness Symptoms, Number of Symptoms, Protective Behaviors, and Number of Behaviors Among Participants Who Reported Working in Hot Weather in Last Twelve Months (n = 165).

	N	Percent
Symptoms		
Dizziness	48	29.1
Sudden muscle cramps	36	21.8
Hot, dry skin	29	17.6
Nausea or vomiting	14	8.5
Confusion	10	6.1
Fainting	3	1.8
Number of symptoms reported		
0	86	52.1
1	43	26.1
2	23	13.9
3	5	3.0
4	4	2.4
5	4	2.4
6	0	0
Heat-related illness	79	47.9
Protective behaviors		
Drink extra water	150	90.9
Take breaks in shaded areas	145	87.9
Take extra breaks	92	55.8
Change work hours	71	43.0
Go to air-conditioned places during breaks or after work	57	34.6
Change tasks	18	10.9
Number of behaviors reported		
0	0	0
1	11	6.7
2	30	18.2
3	56	33.9
4	48	29.1
5	18	10.9
6	2	1.2

Table 4.

Associations Participant Characteristics, Protective Behaviors, and HRI Symptoms (n = 165).

	No HRI symptoms n = 86		Any HRI symptoms n = 79		
Participant characteristics and protective behaviors	**N**	**Percent**	**N**	**Percent**	***p* value**
Gender					.8070
Male	56	(52.8)	50	(47.2)	
Female	30	(50.8)	29	(49.2)	
Age					.0011
10–13	26	(76.5)	8	(23.5)	
14–15	29	(55.8)	23	(44.2)	
16–17	31	(39.2)	48	(60.8)	
Farmworker status					.1788
Migrant	9	(39.1)	14	(60.9)	
Seasonal	77	(54.2)	65	(45.8)	
Years of farm work experience					.2758
1–2	54	(55.7)	43	(44.3)	
3 or more	32	(47.1)	36	(52.9)	
Work with older relative(s)					.8785
Yes	50	(52.6)	45	(47.4)	
No	36	(51.4)	34	(48.6)	
Pay structure					.4922
Piece only	26	(61.9)	16	(38.1)	
Hour only	51	(48.6)	54	(51.4)	
Combination of piece and hour	5	(45.4)	6	(54.6)	
No pay structure identified	4	(57.1)	3	(42.9)	
Recipient of pay					.6222
Parents	19	(55.9)	15	(44.1)	
Child	67	(51.2)	64	(48.9)	
Housing					.4987
Trailer	66	(53.7)	57	(46.3)	
House	20	(47.6)	22	(52.4)	

Participant characteristics and protective behaviors	No HRI symptoms n = 86 N	Percent	Any HRI symptoms n = 79 N	Percent	*p* value
Protective behaviors					
Extra water					.3243
Yes	80	(53.3)	70	(46.7)	
No	6	(40.0)	9	(60.0)	
Breaks in shade					.4518
Yes	74	(51.0)	71	(49.0)	
No	12	(60.0)	8	(40.0)	
Extra breaks					.0045
Yes	57	(62.0)	35	(38.0)	
No	29	(39.7)	44	(60.3)	
Hours changed					.5303
Yes	39	(54.9)	32	(45.1)	
No	47	(50.0)	47	(50.0)	
Go to air-conditioned places during breaks or after work					.0279
Yes	23	(40.4)	34	(59.6)	
No	63	(58.3)	45	(41.7)	
Tasks changed					.4186
Yes	11	(61.1)	7	(38.9)	
No	75	(51.0)	72	(49.0)	
Number of behaviors					.6213
2 or fewer	20	(48.8)	21	(51.2)	
3 or more	66	(53.2)	58	(46.8)	

HRI = heat-related illness.