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## ORIGINAL ARTICLE

## Work practices and childhood agricultural injury

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**Objective:** To evaluate whether children's agricultural work practices were associated with agricultural injury and to identify injury and work practice predictors.

**Design:** Analyses were based on nested case-control data collected by the Regional Rural Injury Study-II (RRIS-II) surveillance study in 1999 and 2001 by computer-assisted telephone interviews.

**Subjects:** Cases ( $n = 425$ ) and controls ( $n = 1886$ ) were persons younger than 20 years of age from Midwestern agricultural households. Those reporting agricultural injuries became cases; controls (no injury) were selected using incidence density sampling.

**Main outcome measures:** Multivariate logistic regression was used to estimate the risks of injury associated with agricultural work, performing chores earlier than developmentally appropriate, hours worked per week, and number of chores performed.

**Results:** Increased risks of injury were observed for children who performed chores 2–3 years younger than recommended, compared to being "age-appropriate" (odds ratio (OR) = 2.6, 95% confidence interval (CI) = 1.4–4.5); performed any agricultural work (3.9 (2.6–5.6)); performed seven to ten chores per month compared to one chore (2.2 (1.3–3.5)); and worked 11–30 or 31–40 h per week compared to 1–10 h (1.6 (1.2–2.1) and 2.2 (1.3–3.7), respectively). Decreased risks of injury were observed for non-working children compared to children performing what are commonly considered safe levels of agricultural work.

**Conclusions:** This study demonstrated elevated risks of agricultural injury among children who perform developmentally inappropriate chores. Results suggest that the efficacy of age restrictions for preventing the occurrence of childhood agricultural injuries warrants further evaluation.

Agricultural families are exposed to machinery, livestock, chemicals, and other agricultural-related hazards that potentially put them at a higher risk of injuries.<sup>1</sup> In 2004, in the United States (US), the fatal and disabling injury rates per 100 000 agricultural workers were 29.2 and 5000, 8.35 and 1.67 times greater, respectively, than the rates for all occupations combined.<sup>2</sup> Between 1995 and 2000, children younger than 20 years of age averaged 116 agricultural fatalities per year (annualized rate: 9.3 per 100 000 youth).<sup>3</sup> In 2001, youth visiting, living on, or hired to work on US agricultural operations incurred an estimated 22 648 injuries; 16 851 of which (15.7 injuries/1000 household youth) were incurred by youth living on farms.<sup>4</sup>

Children are commonly expected to participate in agricultural-related work; however, family operations are exempt from federal labor and safety standards. Parents regulate their children's occupational exposures in the agricultural environment, often assigning children tasks beyond their developmental ability.<sup>5–8</sup> To help parents assess the developmental readiness of children aged 7–16 years to perform agricultural work, the *North America Guidelines for Children's Agricultural Tasks* (NAGCAT) were developed to provide voluntary age guidelines for 62 common tasks.<sup>9</sup>

Agricultural work practice decisions are often "framed within an economic model where the costs of possible injury outcomes are not weighted heavily",<sup>10</sup> thus contributing to the perception that economic and developmental benefits of childhood agricultural work outweigh its risks.<sup>5 11 12</sup> This framework also justifies the exemptions of family operations from the Fair Labor Standards Act<sup>13</sup> and of operations employing fewer than 11 workers from the Occupational Safety and Health Act.<sup>14</sup> To better understand the risk of work practice decisions and to inform injury prevention efforts, we evaluated the associations

between children's work practices and childhood agricultural injury.

## METHODS

## Study design and subjects

This study was based on nested case-control data collected in the Regional Rural Injury Study-II (RRIS-II) surveillance studies in 1999 and 2001. The RRIS II, Phase 1 and 2 studies were designed to identify the incidence and consequences of and risk factors for children's agricultural injuries and are described elsewhere.<sup>15 16</sup> RRIS-II materials are available at <http://enhs.umn.edu/riprc/riprc.html>. Approval was obtained from the University of Minnesota, Institutional Review Board, Human Subjects Committee.

A random sample of 16 000 agricultural operations (3200 from each participating state: Minnesota, Wisconsin, North Dakota, South Dakota, and Nebraska) was generated from the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) Master ListFrame of Agricultural Operations for each data collection year. Households were eligible if, as of 1 January 1999 or 1 January 2001, they actively farmed or ranched, included children younger than 20 years of age in residence, and had produced at least \$1000 of agricultural goods in the prior year or participated in a Conservation Reserve Program (CRP).

Cases ( $n = 425$ ) and controls ( $n = 1886$ ) were children younger than 20 years of age identified from the RRIS-II database. Children with agricultural injuries reported in the ascertainment period were selected as cases. Children with no reported agricultural injuries were selected as controls using an incidence density sampling scheme based on the months contributing person-time at risk. Respondents were asked about both fatal and non-fatal agricultural injuries; two fatal

injuries were reported. Agricultural injuries were defined as events incurred as a result of performing, or being associated with, an activity related to the agricultural operation that resulted in one or more of the following: restriction from normal activities for 4 or more hours; loss of consciousness or awareness, or amnesia for any length of time; or use of professional health care.

### Data collection

Computer-assisted telephone interviews were conducted by NASS interviewers for each 6-month period of each study year to ascertain injury incidence and relevant consequences. Case exposures were ascertained for the month prior to injury occurrence; control exposures were ascertained for a random 1-month period within the study period, based on an algorithm of expected injury occurrence.<sup>16 17</sup>

### Measures

Four work practice exposures were evaluated.

#### Performing work

A dichotomous variable (yes/no) based on parents' responses to the question, "During the {prior month} did {your child} work in any type of activity or do chores related to your operation?"

#### Number of chores

The summed number of the different types of agricultural chores each child performed in the previous month, out of a possible 18 chore types. Possible chore types included all chores performed by 10% or more of the children in the study: working with beef and dairy cattle (calving, feeding, cleaning, herding), swine, horses, and poultry; operating vehicles (tractor, car, truck, motor cycle, ATV, snowmobile, other large equipment); using hand and/or power tools; and working in storage structures or with agricultural chemicals.

#### Average hours worked per week

The hours per week children worked on their agricultural operations reflected weekly employment patterns: <11 h, 11–30 h, 31–40 h, 41–60 h, and more than 60 h.

#### Working early

Children performing tasks when younger than recommended were designated as working "early". The NAGCAT age recommendations for task performance with intermittent supervision<sup>9</sup> were used as the standard for developmentally appropriate work for most tasks. The minimum age for calving, working with bulls, small power tools, and handling chemicals was set at 16 years, based on their inclusion in the *Hazardous Occupations Order for Agriculture* (HOOA).<sup>13</sup> The minimum age for operating motor vehicles was 15 years, based on state motor vehicle licensing requirements.

Differences between the age recommended for task performance and children's actual age were calculated as measures of the developmental gap between each task and children's physical, cognitive, and behavioral maturity. Task-specific risk scores were summed for each child and divided by the number of chores performed. The averaged scores were grouped into seven categories: not working; performing age appropriate work; and working an average of 2 years, >2 to ≤3 years, >3 to ≤4 years, >4 to ≤6 years, or >6 years younger than recommended.

Parent-related covariates included averaged ages, mother's highest level of education, number of children in household, and hours per week worked on their agricultural operation. Child-related covariates included age, gender, and self-control and size for age.

### Self-control

Because existing instruments were too long to include as embedded scales, the self-control items were based on items from widely used child behavior assessment instruments (the Parent Observation of Child Adaptation (POCA),<sup>18</sup> Child Behavior Checklist,<sup>19</sup> BASC Monitor for ADHD,<sup>20</sup> and multi-dimensional personality scales<sup>21</sup>). The behavioral characteristics in children older than 5 years were summed. Parents responded to four-point Likert scales, with options of (1) *almost never* through (4) *almost always* to rate whether a child: "paid attention", "had good concentration", "was cautious", "worked hard", "was easily distracted", "broke rules", "was impulsive", and "acted without thinking" (the last four items were reverse scored). Chronbach's alpha = 0.78 was calculated for the self-control scale, indicating high internal reliability based on the inter-item correlation.

### Size for age

Percentile values for height for age and body mass index (BMI) were generated, comparing each child against national measurements of children of the same age and gender.<sup>22</sup> The height percentiles were grouped into "short" (≤5<sup>th</sup>) and "not short" (>5<sup>th</sup> to 100); BMI percentiles were grouped into "underweight" (≤5<sup>th</sup>), "normal" (>5<sup>th</sup> to 85<sup>th</sup>), "at risk of overweight" (>85<sup>th</sup> to 95<sup>th</sup>), and overweight (>95<sup>th</sup> to 100).<sup>23</sup>

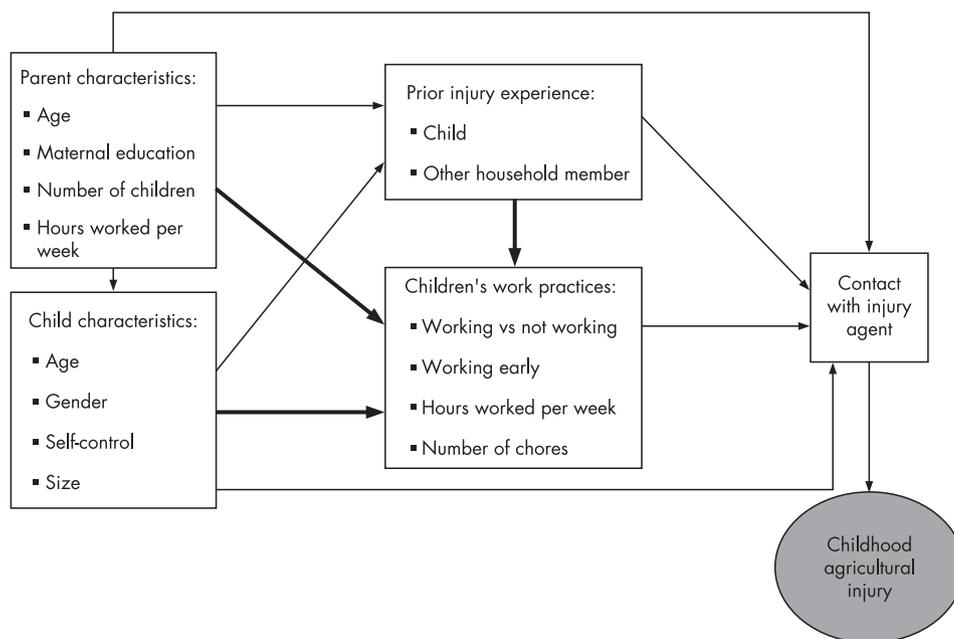
*Prior injuries* indicated prior agricultural injuries experienced by the child or by household members, other than the child.

### Data analysis

A causal model based on hypothesized associations between agricultural work practices, relevant covariates, and childhood agricultural injury served as the basis for data analysis (fig 1). Selection of covariates for statistical models were guided with directed acyclic graphs.<sup>24</sup> Because work practice frequencies differed by year of participation, a year of participation indicator was included in all multivariate analyses to minimize variance and to adjust for factors represented by declines, between 1998 and 2001, in the rate of agricultural injuries to males aged 0–19 years and in the number of injuries to all youths living on US operations.<sup>4</sup>

The relationship of each exposure variable to the logit of the outcome was assessed for linearity. Odds ratios (ORs) and 95% confidence intervals (95% CI), estimating the risk of agricultural injury and "performing agricultural work" were calculated for each exposure using multivariate logistic regression. Interaction terms were constructed for each work practice-covariate pair and tested for significance. Because this study is among the first to evaluate factors associated with children's work practices and injury, the results of both the statistical models estimating the main exposure effects and those estimating the effects of the interaction terms are presented. Multivariate linear regression was used to evaluate the association between injury work practices and child and parent characteristics.

Overall, 16 940 (53%) of the 32 000 agricultural operations sampled in the data collection years were identified as ineligible, based on the study's participation criteria. Of the 8810 (28%) operations identified as eligible, 7420 (84%) participated in the full study. Non-response bias was controlled by inversely weighting responses by estimated probabilities of response,<sup>25</sup> estimated as a function of household characteristics (state, type of operation, annual revenue by quintiles) from the U.S. Department of Agriculture's National Agricultural Statistics Service database. The unknown eligibility among non-respondents was controlled by down-weighting each sample member by the estimated probability of ineligibility among the respondents with the same characteristics.<sup>26</sup>



**Figure 1** Conceptual model: children's work practices and childhood agricultural injury. Bold line = effect of variable at arrow head is modified by the variable at the arrow tail. Note: year of participation (1999/2001) is included in all statistical models, but is not shown here.

To examine the potential efficacy for reducing the risk of childhood agricultural injuries by raising the minimum age recommendations from 16 to 18 years, the minimum age of task performance was re-set to 18 years, legal adulthood, for the chores included in the early measure, and the data were re-analyzed to assess sensitivity to the original assumptions.<sup>27</sup>

## RESULTS

Participant and parent characteristics, based on case-control status, are available at <http://ehs.umn.edu/riprc/riprc.html>. As shown in Table 1, children performing chores 2–3 years younger than recommended were at increased risk of injury; 93% of these children were aged 12–13 years. When the minimum age for task performance was re-set to 18 years, 12–13-year-olds still experienced the highest risk of injury (OR = 2.7, 95% CI = 1.3–5.4). However, an increase in injury risk was also found for 14–15-year-olds (1.7 (0.9–3.2)) and for 16–17-year-olds (1.5 (0.9–2.7)) who performed chores early. Before re-setting the minimum age, the developmental ability of 16–17-year-olds had been equated to an adult's; thus, the potential risks incurred by those performing chores for which they were not developmentally ready could not be examined.

Children had an increased risk of injury if they performed agricultural work at all, worked 11–30 or 31–40 h per week, or performed seven to ten types of chore per month (Table 1). Significant interactions were observed for working early and experiencing prior agricultural injuries; number of hours children worked and number of siblings; number of chores children performed and hours parents worked; and performing agricultural work and children's age. The highest injury risks were seen for children: working 2–3 years "early" from households incurring one or six or more prior injuries; working 11–40 h per week from households with three or more siblings (OR<sub>11–30 h</sub> = 1.9, 95% CI = 1.01–3.4 and OR<sub>31–40 h</sub> = 5.3, 95% CI = 1.9–14.4); and performing three or more chores when parents worked 60 h or more per week (OR<sub>3–6 chores</sub> = 3.6, 95% CI = 0.97–12.9 and OR<sub>7+ chores</sub> = 5.1, 95% CI = 1.2–22.3).

Boys, compared with girls, and 12–13-year-olds, compared with 16–19-year-olds, were at increased risk of injury (Table 2), even after adjusting for hours worked; additional linear regression results are located at <http://ehs.umn.edu/riprc/riprc.html>. Children aged 12–13 years compared to those aged

16–19 years, were more likely work at all and work early, but worked fewer hours, and performed fewer chores. Children who "almost never" or "sometimes" displayed self-control worked less than children who "almost always" displayed self-control; but those with the least self-control were at higher risk of injury. Children's stature was not associated with injury but, compared to children of normal stature, shorter and underweight children worked less and worked fewer hours while children at risk of obesity worked more and performed more chores.

Having prior agricultural injuries, compared to having had no injuries, increased the risk of injury and the likelihood of performing farm work. Each additional sibling increased the risk of injury and the likelihood of working early or at all. Compared with children whose parents worked full-time (40–60 h per week), children whose parents worked 60 or more hours per week were at higher risk of injury; children whose parents worked less than full-time worked less and were at lower risk of injury. As parents' average age increased, children were at decreased risk of injury and less likely to work early but more likely to work at all, work more hours, and perform more chores.

## DISCUSSION

We observed an increased risk for injury among children performing agricultural tasks at ages younger than recommended. These findings were consistent with the reduced risk found for NAGCAT dissemination on preventable injuries in a randomized controlled trial<sup>28</sup> and with descriptive analyses suggesting that age guideline adherence was potentially preventive for injuries.<sup>29–31</sup>

Our results support the assumption that performing age-appropriate tasks prevents injury. However, an increased risk of injury was found for 16–17-year-olds (compared to 18–19-year-olds) when performing tasks that were developmentally appropriate for an adult. Additionally, RRIS-II respondents of all ages performed many tasks prohibited in the *Hazardous Occupations Order for Agriculture (HOOA)*,<sup>13</sup> (eg. calving, handling chemicals, working with bulls and small power tools). Taken together, these findings justify further examination of whether current age guidelines are sufficiently conservative and complete.

**Table 1** Children's agricultural work practices: distribution and association with childhood agricultural injury (n = 2311)

Child work practices	No. (%) of respondents		Odds ratio* (95% confidence interval)
	Case events (n = 425)	Controls (n = 1886)	
<b>Performed agricultural work</b>			
Did not work	48 (11.8)	745 (40.7)	Reference
Worked	359 (88.2)	1087 (59.3)	3.9 (2.6 to 5.6)
Interaction term: performing work × children's age			Wald $\chi^2 = 4.3$ , 1 d.f., p-value = 0.04
<b>Work performed "early"†</b>			
Did not work	48 (11.8)	744 (40.7)	0.2 (0.1 to 0.4)
Did not work early	107 (26.3)	407 (22.3)	Reference
Worked: 1 to ≤2 years early	66 (16.2)	189 (10.3)	1.1 (0.7 to 1.8)
Worked: >2 to ≤3 years early	51 (12.5)	67 (3.7)	2.6 (1.4 to 4.5)
Worked: >3 to ≤4 years early	33 (8.1)	72 (3.9)	1.4 (0.7 to 2.6)
Worked: >4 to ≤6 years early	46 (11.3)	137 (7.5)	0.9 (0.5 to 1.6)
Worked: >6 years early	56 (13.8)	213 (11.6)	0.7 (0.4 to 1.4)
Interaction term: working early × household agricultural injuries			Wald $\chi^2 = 16.5$ , 7 d.f., p-value = 0.02
<b>Hours children worked on own operation</b>			
Did not work	48 (11.8)	745 (40.8)	0.3 (0.2 to 0.4)
1 to 10	163 (40.1)	641 (35.1)	Reference
11 to 30	140 (34.5)	323 (17.7)	1.6 (1.2 to 2.1)
31 to 40	31 (7.6)	49 (2.7)	2.2 (1.3 to 3.7)
41 to 60	15 (3.7)	48 (2.6)	1.0 (0.5 to 2.0)
60+	9 (2.2)	21 (1.1)	1.4 (0.5 to 3.6)
Interaction term: hours children worked × number of siblings			Wald $\chi^2 = 13.2$ , 6 d.f., p-value = 0.04
<b>Number of types of chore</b>			
Did not work	49 (12.0)	775 (42.3)	0.3 (0.2 to 0.4)
1 chore	45 (11.1)	165 (9.0)	Reference
2 chores	30 (7.4)	168 (9.2)	0.6 (0.4 to 1.1)
3 chores	43 (10.6)	129 (7.0)	1.2 (0.7 to 2.0)
>4 to ≤6 chores	105 (25.8)	359 (19.6)	1.1 (0.7 to 1.7)
>7 to ≤10 chores	123 (30.2)	200 (10.9)	2.2 (1.3 to 3.5)
>10 chores	12 (2.9)	36 (2.0)	1.0 (0.4 to 2.2)
Interaction term: number children's chores × hours parent's worked			Wald $\chi^2 = 15.2$ , 7 d.f., p-value = 0.03

\*Separate multivariable logistic regression analyses were performed for each exposure and interaction product. The statistical models adjusted for: missing values, non-response, year participated, age, gender, BMI, being short, self-control, prior child injuries, prior injuries to household members, parents' ages, maternal education, children in household, hours per week parents worked.

†The difference between the child's actual age and the age recommended for task performance.

Associations between child and parent characteristics and injury and work practices were assessed to generate future research hypotheses and to identify potential targets for intervention. Boys, compared with girls, and 12–13-year-olds, compared with 16–19-year-olds, were at higher risk of injury regardless of hours worked. The association between gender and agricultural injury is well established in the literature,<sup>32–35</sup> although it may be partially explained by differential hours worked<sup>15</sup> or the nature of the assigned tasks. Potential age-related mechanisms include the absence of supportive parenting during periods of vulnerability,<sup>36</sup> parental overestimation of children's abilities, or the inclination of young adolescents to take risks.

Behavior and stature may influence adult perceptions about children's competence and readiness to work. Children who almost never exhibited self-control had a higher risk of injury and a lower risk of working, suggesting a potential behavioral pathway related to injury (via poor self-control) and a possibility that parents respond to child behaviors by assigning less work. Being shorter and underweight reduced the likelihood of performing work and being injured. Parents potentially estimated the developmental readiness of smaller children more conservatively, thus, assigning them less risky tasks or supervising them more.

Children of older parents had a lower risk of injury and working early, but were more likely to work at all, work more hours, and perform more chores. That being an older parent is potentially associated with protective parenting practices, such as assigning developmentally appropriate work, warrants further examination. The risk of injury for the number of chores children performed varied by how much parents worked on the operation. For children with parents working more than

60 h per week, performing three or more chores was associated with higher injury risk, possibly due to decreased supervision or increased hazardousness of chores assigned. That parents' less-than-full-time work was associated with decreased injury risk is potentially explained by children's exposure to agricultural hazards being influenced by off-farm child care options<sup>37</sup> or reduced exposure to agricultural hazards.

Although children with additional siblings were at higher risk of injury, the risk was highest for children who worked 11–40 h per week with three or more siblings. This may be partially explained by the association between parents' and children's work hours. Children who work more may need more supervision, while parents who work more may be more distracted or may assign siblings to monitor younger children. Previous associations between larger families and exposure to hazardous agricultural tasks<sup>6</sup> and injury<sup>38</sup> were linked to inadequate supervision.

The risk of injury for working early varied by the number of prior injuries among household members other than the child. The highest risks were seen for children working 2–3 years "early" in households that experienced six or more prior injuries. This is potentially explained by shared economic pressures or hazardous environments, intra-familial risk-taking behaviors, or children assuming hazardous tasks when family members are injured.

Limitations of this analysis include using self-reported injury and exposure data collected during the same interview. Recall bias was minimized by limiting recall of injury events to the previous 6 months<sup>15–39</sup> and recall of exposures to a 1-month period within the previous year.<sup>40</sup> The results were also subject to the following assumptions. The "early" measure represented the "averaged" match between a child's development and the

**Table 2** Characteristics associated with childhood agricultural injury and agricultural work (results of multivariable logistic regression,  $n = 2311$ )

	Childhood agricultural injury**	Perform farm work (yes/no)**
	OR (95% CI)	OR (95% CI)
<b>Data collection year</b>		
1999 respondents	Reference	Reference
2001 respondents	0.8 (0.6 to 0.9)	0.8 (0.7 to 1.02)
<b>Child characteristics</b>		
<b>Gender</b>		
Female	Reference	Reference
Male	1.9 (1.5 to 2.3)	2.5 (2.0 to 3.0)
<b>Age groups*</b>		
0–5	0.5 (0.3 to 0.7)	0.1 (0.6 to 0.1)
6–9	0.6 (0.4 to 0.9)	0.7 (0.5 to .99)
10–11	0.8 (0.5 to 1.1)	1.3 (0.9 to 1.9)
12–13	1.8 (1.3 to 2.5)	1.5 (1.1 to 2.2)
14–15	1.2 (0.8 to 1.7)	1.7 (1.2 to 2.5)
16–19	Reference	Reference
<b>Self-control†</b>		
Almost never	1.7 (0.99 to 3.1)	0.5 (0.3 to 0.8)
Sometimes	0.5 (0.2 to 0.9)	0.8 (0.5 to 1.3)
Often	1.3 (0.9 to 1.7)	1.1 (0.8 to 1.5)
Almost always	Reference	Reference
<b>Height for age (percentile groups)‡</b>		
Short (<5)	0.8 (0.5 to 1.2)	0.6 (0.4 to 0.8)
Not short (5–100)	Reference	Reference
<b>Body mass index for age (percentile groups)§</b>		
Underweight (0 to <5)	0.7 (0.4 to 1.2)	0.6 (0.4 to 0.9)
Normal (5 to <85)	Reference	Reference
Overweight risk (85 to <95)	1.3 (0.9 to 1.7)	1.3 (0.95 to 1.7)
Overweight (95 to 100)	0.9 (0.6 to 1.2)	0.8 (0.6 to 1.04)
<b>Prior child injuries</b>		
No prior injury	Reference	Reference
1	1.7 (1.2 to 2.4)	2.8 (1.8 to 4.5)
2	7.2 (3.7 to 13.9)	5.0 (1.1 to 21.8)
3 to 4	4.7 (2.0 to 11.5)	1.8 (0.4 to 7.0)
>5	3.3 (1.1 to 10.2)	2.1 (0.2 to 20.1)
<b>Parents' characteristics</b>		
Parents' average ages (5-year increments)*	0.9 (0.8 to 0.98)	1.1 (1.01 to 1.2)
<b>Maternal educational status¶</b>		
Not high school graduate	0.8 (0.3 to 2.0)	0.5 (0.2 to 1.1)
High school graduate	Reference	Reference
Technical school	1.0 (0.7 to 1.4)	1.04 (0.8 to 1.4)
College	1.2 (0.9 to 1.5)	0.7 (0.6 to 0.9)
Number of children in household*	1.4 (1.2 to 1.5)	1.1 (1.01 to 1.2)
<b>Hours per week parents worked on own operation*</b>		
0	–	0.1 (0.02 to 0.6)
1 to 10	0.3 (0.2 to 0.6)	0.3 (0.2 to 0.4)
11 to 30	0.6 (0.5 to 0.8)	0.7 (0.5 to 0.9)
31 to 40	0.8 (0.6 to 1.1)	0.5 (0.4 to 0.7)
41 to 60	Reference	Reference
60+	1.6 (1.1 to 2.3)	1.5 (0.96 to 2.2)
<b>Prior injuries to members of the household</b>		
No prior injury	Reference	Reference
1	1.0 (0.7 to 1.4)	1.4 (1.06 to 1.9)
2	1.4 (0.9 to 2.0)	1.3 (0.9 to 1.8)
3 to 5	2.7 (1.9 to 3.7)	1.9 (1.4 to 2.7)
>6	3.5 (2.4 to 4.9)	1.6 (1.1 to 2.3)

\*Less than 5% of the data were missing.

†Data on self-control were missing for 12.5% of the cases and 19.1% of the controls.

‡Data on size for age were missing for 4.5% of the cases and 8.5% of the controls.

§Data on body mass index for age were missing for 3.8% of the cases and 8.3% of the controls.

¶Data on maternal educational were missing for 3.8% of the cases and 6.5% of the controls.

\*\*Separate multivariable logistic regression analyses were performed for each dependent variable; the statistical models are specified as follows:

*Year of data collection* – adjusted for: missing values, non-response, age, gender.

*Gender* – adjusted for: missing values, non-response, year participated, age, parents' ages, maternal education, children in household, hours per week parents worked.

*Child's age* – adjusted for: missing values, non-response, year participated, gender, parents' ages, maternal education, children in household, hours per week parents worked.

*Self-control* – adjusted for: missing values, non-response, year participated, gender, age, parents' ages, maternal education, children in household, hours per week parents worked.

*Short-for-age* – adjusted for: missing values, non-response, year participated, gender, age, parents' ages, maternal education, children in household, hours per week parents worked.

*Body-mass index (BMI) for age* – adjusted for: missing values, non-response, year participated, gender, age, parents' ages, maternal education, children in household, hours per week, parents worked.

*Prior child injuries* – adjusted for: missing values, non-response, year participated, gender, age, BMI, short, self-control, parents' age, maternal education, children in household, hours per week parents worked, prior injuries to household members.

*Parents' ages* – adjusted for: non-response, year participated.

*Maternal education* – adjusted for: missing values, non-response, year participated, parents' ages, hours per week parents worked, children in household.

*Children in household* – adjusted for: missing values, non-response, year participated, parents' ages, maternal education, hours per week parents worked.

developmental requirements of the tasks they performed. The measure's limitations include that it was based on age, a crude indicator of children's "developmental readiness" and assumed supervision equivalent to being checked every 10–30 min. Lastly, the measure averaged potentially important task-specific risks; although the small numbers of task-specific cases precluded stratified analyses, this would be an important focus of future research.

## CONCLUSIONS

This study is the first to use population-based data to evaluate the risk of childhood agricultural injury associated with performing developmentally inappropriate chores. Although positive associations between injury and work practices were expected, our study found an increased risk of injury for levels of work typically considered "safe". Results underscore the importance of a developmental approach for understanding mechanisms of childhood agricultural injury and suggest that the efficacy of age restrictions for preventing the occurrence of childhood agricultural injuries warrants further evaluation.

## IMPLICATIONS FOR PREVENTION

This study found increased risks of agricultural injury for levels of agricultural work typically considered "safe" for children. Of note, an increased risk of injury from performing developmentally inappropriate agricultural chores was observed for 12–13-year-olds; this age group may be an appropriate target for injury prevention programs. Although prohibited in the *Hazardous Occupations Order for Agriculture* (HOOA), children performed many tasks such as calving, handling chemicals, working with bulls, and using small power tools. These activities should be evaluated for future inclusion in voluntary agricultural work guidelines.

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### Key points

- This study is the first to use population-based data to evaluate the risk of childhood agricultural injury associated with performing developmentally inappropriate chores.
- Increased risks of agricultural injury were found for levels of agricultural work typically considered "safe" for children.
- An increased risk of injury from performing developmentally inappropriate agricultural chores was observed for 12–13-year-olds.
- Although prohibited in the *Hazardous Occupations Order for Agriculture* (HOOA), children performed many tasks such as calving, handling chemicals, working with bulls, and using small power tools.
- Results underscore the importance of a developmental approach for understanding mechanisms of childhood agricultural injury and suggest that the classifications of age restrictions for preventing the occurrence of childhood agricultural injuries warrant further evaluation.

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