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Children's Behavioral Traits and Risk of Injury: Analyses from a Case-Control Study of Agricultural Households

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ABSTRACT

Problem: Children on family agricultural operations have high risk of injury. The association between children's behavioral traits and their risk of injury is not well understood. **Method:** Data from the Regional Rural Injury Study-II were used to assess behavioral risk factors for injury to children ages six to <20 years. A total of 379 injury events (cases) and 1,562 randomly selected controls were identified. Adjusted odds ratios (OR) and 95% confidence intervals (CI), calculated using logistic regression, were used to estimate injury risk in reference to behavioral traits. **Results:** Injury risks were greater for children with high levels of depressive symptoms (OR = 1.9, CI = 1.0–3.7) and aggression (OR = 1.6, CI = 0.9–2.7), and low levels of careful/cautious behavior (OR = 1.8, CI = 1.1–2.9). Children with low levels of self-regulation had reduced risks (OR = 0.4, CI = 0.2–0.8). **Discussion:** Results suggest that children's behaviors affect their risk of agricultural injury. Additional research could elucidate mechanisms and inform interventions. **Impact on industry:** The development of multifaceted, sustainable approaches for prevention is necessary for this unique population. These findings suggest a need for interventions that incorporate specific behavior-related risk factors in the context of family farms and ranches.

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1. Problem

Agriculture is among the most hazardous industries in the United States, with rates of fatal injuries more than nine times greater than all occupations combined (National Safety Council, 2007). Unlike other industrial settings, the overlap between occupational and household environments on agricultural operations contributes to high rates of pediatric mortality, morbidity, and disability among agricultural families (Goldcamp, Hendricks, & Myers, 2004; Hendricks, Layne, Goldcamp, & Myers, 2005; Rivara, 1997). Sociocultural characteristics of the rural agricultural population, such as the perceived economic (Kim & Zepeda, 2004a,b) and developmental (Kim & Zepeda, 2004a,b; Lee, Jenkins, & Westaby, 1997) importance of children's agricultural work, are also important factors that contribute to these elevated rates.

Exposures to specific environmental hazards, such as tractors, machinery, and various types of animals, have been shown to increase children's risk of injury on agricultural operations (Gerberich et al., 2001). Behavioral risk factors, however, have not been well characterized in this population. Prior research has shown behavioral traits, such as distractibility or impulsivity, to be positively associated with risk of injury among children (Bijur, Stewart-Brown, & Butler, 1986; Jaquess & Finney, 1994; Schwebel & Plumert, 1999). Traits such as overactivity, inattentiveness, aggression, and impulsivity have been found to be independent risk factors for injury among people of all ages (Bijur et al., 1986; Davidson, 1987; Jaquess & Finney, 1994; Wazana, 1997). How such behaviors might influence risk of agricultural injury among members of farm and ranch families is unknown.

In recent years, the study of behavioral risk factors has subsided in favor of a more resolute focus on environmental hazards and passive interventions. However, given that this approach has had limited success in the agricultural community (DeRoo & Rautiainen, 2000; Hartling, Brison, Crumley, Klassen, & Pickett, 2004), with its unique values and work traditions (Elder & Conger, 2000), a multifaceted approach to children's agricultural injury is warranted. Improved knowledge of the role of children's behaviors on their risk of

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agricultural injury could enhance current and future intervention efforts. The purpose of the current study was to analyze associations between reported behavioral traits among children ages six to <20 years and their risk of agricultural injury on family farming and ranching operations.

2. Method

2.1. Overview

This study was based on combined data from Phase 1 (January–December, 1999) and Phase 2 (January–December, 2001) of the Regional Rural Injury Study–II (RRIS–II). The RRIS–II involved prospective, population-based cohort studies of agricultural households in Minnesota, North Dakota, South Dakota, Nebraska, and Wisconsin. For the current analysis, data from the two cohorts involving all ages, as well as nested case-control studies involving children less than 20 years of age, were used. The Institutional Review Board, Human Subjects Committee, at the University of Minnesota approved the protocol for both study phases and the current analyses.

2.2. Study population

The U.S. Department of Agriculture (USDA) National Agricultural Statistics Service Master ListFrame of Farming Operations provided the roster of farming and ranching operations. For each phase, random samples of 3,200 agricultural operations were selected for each of the five states, providing a total of 16,000 selected operations per year. To be eligible for the study, operations had to: (a) have a household associated with the operation that included children <20 years of age in residence as of January 1st of the respective study year; (b) produce at least \$1,000 of agricultural goods in the year prior to each study year, or be involved in a Conservation Reserve Program (CRP); and (c) be actively farming/ranching as of January 1st of the respective years.

2.3. Data collection

Subsequent to an introductory mailing in January of each study year, telephone interviews were conducted, using a computer assisted telephone interview (CATI) instrument, to obtain informed consent, establish eligibility, and enroll eligible households that were willing to participate in the study. Eligible participating households were mailed comprehensive packets of information containing: (a) cover letters from the study investigators and respective state USDA offices; and, (b) booklets with detailed information to facilitate telephone interviews, and logs to maintain ongoing information about injury events between January 1st and June 30th. Comparable mailings were implemented for the second six months of data collection (July 1st – December 31st) in each study year.

Full-length CATI interviews began in July of each year (1999 and 2001), and January of the following years, to collect data for the respective prior six-month periods. The female head of household was the preferred informant for the collection of demographic, behavioral, and injury data, while the male head of household was preferred for operation information. Consent was requested to collect personal exposure information, including farming- and ranching-related work activities, directly from children who were 12 years of age and older; 21% of case-control children were their own respondents. The preferred respondent for children less than 12 years of age, and for children 12 and older for whom consent was not received (63%), was the female head of household.

2.4. Case and control selection

Cases were all agricultural injury events associated with their own operation and sustained during the study years (1999 for Phase 1; 2001 for Phase 2) by children <20 years of age. An agricultural injury

event had to result from farm- or ranch-related work activities or objects, and lead to restriction of normal activities for four hours or more, loss of consciousness or awareness, or amnesia, for any length of time, and/or treatment by a health professional. Case events were identified for each six-month reporting period prior to the full-length interviews (January – June, and July – December, of each year).

The case-control interviews, nested within the full-length interviews, collected behavior and exposure data for the month before the month of injury for cases, and the month before an agricultural injury-free month for controls. The sampling of controls occurred during each of the full-length interviews and was based on an incidence-density sampling scheme. An algorithm was pre-programmed into the CATI system to ensure a minimum ratio of three controls per case. This was done by using injury incidence rates from the most recent, similar study to estimate the number of controls that should be sampled per month: Phase 1 selection was based on data from the Regional Rural Injury Study – I (RRIS–I) (Gerberich et al., 1993) while Phase 2 selection was based on Phase 1 data (Gerberich et al., 2003).

2.5. Behavioral items and scales

For case and control children ages six to <20 years, responses were elicited for 18 behavioral items adapted from commonly used, validated inventories; most were from the Parent Observation of Child Adaptation (POCA) checklist (Ialongo, Kellam, & Podusk, 1999). Questions were in the form of a four-point Likert scale and addressed behaviors considered either desirable (completed work/chores; followed rules; worked hard; planned carefully before going ahead; was cautious; paid attention; had good concentration) or undesirable (acted without thinking; got into fights; was impulsive; broke rules; couldn't sit still; was easily distracted; was irritable; left the house or farm without permission; looked sad or down; bullied or was mean to others; had low energy).

These items were used to form behavioral scales relevant to the agricultural population. Hypothesized *a priori* constructs, based on POCA scales from which items were selected, were modified based on results of exploratory factor analysis (Field, 2000; Floyd & Wideman, 1995). Maximum likelihood analyses with promax oblique rotations were performed using SPSS version 12.0 for Windows (SPSS, 2003). Resulting factors with eigenvalues greater than 1.0 and items with absolute values greater than 0.40 for factor loadings were retained for subsequent, iterative analyses. Cronbach's alphas were used to test internal consistency for resulting scales (Cronbach, 1951).

Five scales were developed using this approach: (a) *Depression*: Child looked sad or down; had low energy; was irritable (Cronbach's alpha = 0.58); (b) *Aggression*: Child broke rules; got into fights; was impulsive (alpha = 0.51); (c) *Self-Regulation*: Child was easily distracted; paid attention; had good concentration; worked hard (alpha = 0.78); (d) *Careful/Cautious*: Child was careful; was cautious (alpha = 0.58); and (e) *Responsible Conduct*: Child completed work; followed rules (alpha = 0.60).

The individual behavioral items were dichotomized to allow comparisons of children who almost always/often exhibited the behavior and those who almost never/sometimes did. For the five scalar constructs, responses to the desirable behavioral items were reverse coded. Scores were then categorized to compare children with the least desirable level of the behavior (to the extent possible, those within the 10th percentile tail) to those with more moderate (10th to <50th percentile) and desirable (50th to 100th percentile) levels.

2.6. Data analysis

Multivariable logistic regression was used to estimate risk of children's agricultural injury, in reference to behavioral items and scales, while controlling for potentially confounding variables (Breslow & Day, 1987). Odds ratios (OR) and 95% confidence intervals (CI)

were calculated using logistic regression. Two models were analyzed: one estimated children's risk of injury while controlling for age and gender, and the second included additional potential confounders. To identify potential confounders, a causal model was used as a basis for the design and use of directed acyclic graphs (DAGs), following the methods described by Greenland, Pearl, and Robins (1999) and illustrated by Hernán, Hernández-Díaz, Werler, and Mitchell (2002). In short, the DAGs identified known or assumed causal associations between variables, thereby enabling specification of the most parsimonious statistical models. The DAGs also facilitated exclusion of covariates that could introduce bias if included in the models. The risk estimates for each behavioral item or scale were also adjusted for the other behavioral items or scales.

Odds ratios were adjusted for within-household correlation using generalized estimating equations (GEEs; Liang, & Zeger, 1986). Potential selection bias from non-participation was controlled by inversely weighting observed responses with stratum-specific probabilities of response (Horvitz & Thompson, 1952), estimated as a function of characteristics available from the NASS database (state in which the operation was located; type of operation; annual revenue by quintile). To account for unknown eligibility among non-respondents, probability of eligibility was estimated for these same characteristics and used to adjust weights (Mongin, 2001). Descriptive and regression analyses were performed with SAS version 9.1 for Windows.

3. Results

Based on comparable population characteristics and response rates between Phase 1 (1999) and Phase 2 (2001) of the RRIS-II (Gerberich et al., 2003, 2004), these data were combined for the current study. A

Table 1
Characteristics of cases and controls six to <20 years of age: Regional Rural Injury Study – II (RRIS-II)

Characteristic	Cases (n = 379)		Controls (n = 1,562)	
	n	(%)	n	(%)
Gender				
Male	262	(69.1)	873	(55.9)
Female	117	(30.9)	689	(44.1)
Age (years)				
6 – <10	55	(14.5)	306	(19.6)
10 – <14	138	(36.4)	419	(26.8)
14 – <20	186	(49.1)	834	(53.4)
Missing/Unknown/Refused	0	(0.0)	3	(0.2)
Hours Worked/Week on Operation				
<10	131	(34.6)	962	(61.6)
10 – <20	88	(23.2)	233	(14.9)
20 – <30	74	(19.5)	149	(9.5)
30 – <40	22	(5.8)	60	(3.8)
40 +	45	(11.9)	103	(6.6)
Missing/Unknown/Refused	19	(5.0)	55	(3.5)
Parents' Average Age				
<35 years	32	(8.4)	113	(7.2)
35 – <45 years	234	(61.7)	786	(50.3)
45 – <55 years	101	(26.7)	581	(37.2)
55+ years	12	(3.2)	79	(5.1)
Missing/Unknown/Refused	0	(0.0)	3	(0.2)
Number of Children in Household				
1	61	(16.1)	472	(30.2)
2	137	(36.2)	546	(35.0)
3	101	(26.7)	346	(22.2)
4+	80	(21.1)	195	(12.5)
Missing/Unknown/Refused	0	(0.0)	3	(0.2)
Type of Operation Requiring Most Time				
Beef cattle	110	(29.0)	422	(27.0)
Dairy cattle	81	(21.4)	201	(12.9)
Other animals	47	(12.4)	154	(9.9)
Field, forage, specialty crops; conservation reserve	131	(34.6)	740	(47.4)
Program (CRP); or nothing during month of inquiry				
Missing/Unknown/Refused	10	(2.6)	45	(2.9)

Table 2

Risk of agricultural injury among children aged six to <20 by behavioral items: Regional Rural Injury Study – II (RRIS-II)

Behavioral Item	Cases n = 379		Controls n = 1,562		Multivariable Model† OR* (95% CI)
	n	(%)	n	(%)	
Acted Without Thinking					
Almost Always/Often	36	(9.7)	151	(9.9)	0.8 (0.5–1.3)
Almost Never/Sometimes	336	(90.3)	1372	(90.1)	Referent
Was Impulsive					
Almost Always/Often	35	(9.4)	138	(9.1)	0.9 (0.5–1.5)
Almost Never/Sometimes	336	(90.6)	1383	(90.9)	Referent
Liked to Plan Carefully					
Almost Never/Sometimes	165	(44.4)	580	(38.1)	1.3 (0.9–1.7)
Almost Always/Often	207	(55.6)	942	(61.9)	Referent
Was Cautious					
Almost Never/Sometimes	88	(23.7)	289	(19.0)	1.6 (1.1–2.3)
Almost Always/Often	284	(76.3)	1235	(81.0)	Referent
Couldn't Sit Still					
Almost Always/Often	56	(15.1)	230	(15.1)	0.9 (0.6–1.3)
Almost Never/Sometimes	316	(84.9)	1293	(84.9)	Referent
Was Easily Distracted					
Almost Always/Often	37	(9.9)	151	(9.9)	0.9 (0.6–1.6)
Almost Never/Sometimes	335	(90.1)	1375	(90.1)	Referent
Paid Attention					
Almost Never/Sometimes	45	(12.1)	216	(14.2)	0.7 (0.4–1.1)
Almost Always/Often	327	(87.9)	1310	(85.8)	Referent
Had Good Concentration					
Almost Never/Sometimes	57	(15.4)	261	(17.1)	0.8 (0.5–1.3)
Almost Always/Often	314	(84.6)	1263	(82.9)	Referent
Followed Rules					
Almost Never/Sometimes	46	(12.4)	141	(9.2)	1.5 (0.9–2.5)
Almost Always/Often	326	(87.6)	1386	(90.8)	Referent
Broke Rules					
Almost Always/Often	13	(3.5)	32	(2.1)	2.0 (0.9–4.4)
Almost Never/Sometimes	359	(96.5)	1495	(97.9)	Referent
Left the Farm/House					
Almost Always/Often	14	(3.8)	27	(1.8)	1.4 (0.6–3.2)
Almost Never/Sometimes	358	(96.2)	1482	(98.2)	Referent
Completed Work/Chores					
Almost Never/Sometimes	27	(7.3)	154	(10.1)	0.9 (0.5–1.6)
Almost Always/Often	342	(92.7)	1367	(89.9)	Referent
Worked Hard					
Almost Never/Sometimes	36	(9.7)	242	(15.9)	0.6 (0.3–0.9)
Almost Always/Often	336	(90.3)	1282	(84.1)	Referent
Got Into Fights					
Almost Always/Often	17	(4.6)	39	(2.6)	1.9 (0.9–3.8)
Almost Never/Sometimes	355	(95.4)	1482	(97.4)	Referent
Bullied Others					
Almost Always/Often	6	(1.6)	19	(1.2)	0.6 (0.2–2.2)
Almost Never/Sometimes	366	(98.4)	1506	(98.8)	Referent
Had Low Energy					
Almost Always/Often	14	(3.8)	38	(2.5)	1.7 (0.7–3.9)
Almost Never/Sometimes	357	(96.2)	1488	(97.5)	Referent
Looked Sad or Down					
Almost Always/Often	9	(2.4)	22	(1.4)	1.8 (0.7–5.1)
Almost Never/Sometimes	362	(97.6)	1502	(98.6)	Referent
Was Irritable					
Almost Always/Often	24	(6.5)	86	(5.6)	0.9 (0.5–1.8)
Almost Never/Sometimes	348	(93.5)	1440	(94.4)	Referent

* Adjusted for within-household correlation using GEEs (Liang and Zeger, 1986) and weighted for non-response (Horvitz and Thompson, 1952; Mongin, 2001).

† Models included gender, age, body mass index, number of hours worked on operation, parents' average age, parents' highest education level, number of children in household, operation state, operation type, operation income, and 17 remaining behavioral items.

total of 8,810 (28%) of the farms/ranches were found to be eligible. Of those, 7,420 (84%) participated in the respective full study. In total, 379 eligible cases (95%) and 1,562 eligible controls (97%), ages six to <20, participated and were included in the analyses.

3.1. Participant characteristics

Demographic and exposure characteristics of cases and controls are presented in Table 1. Case versus control children were more likely

to be males (70% vs. 56%, respectively), have parents between the ages of 35 and 44 (62% vs. 50%) as opposed to 45 and 54 (27% vs. 37%), reside in households with four or more children (22% vs. 13%), and reside in households associated with dairy cattle operations (22% vs. 13%). Control children tended to work fewer hours than cases, with 63% versus 36% working <10 hours/week, 14% versus 23% working 10 to <20 hours per week, and 9% versus 19% working 20 to <30 hours per week. No significant differences were observed in state of residence, children's body-mass index, parents' educational status, or operation income.

3.2. Regression analyses

3.2.1. Behavioral items

Results of multivariable regression analyses for behavioral items are presented in Table 2. Results were comparable between the model controlling for age and gender (data not shown), and the full multivariable model. Increased risks were identified for children who almost never/sometimes liked to plan carefully (OR=1.3, CI=0.9–1.7), were cautious (OR=1.6, CI=1.1–2.3), or followed rules (OR=1.5, CI=0.9–2.5); as well as for children who almost always/often broke rules (OR=2.0, CI=0.9–4.4) or got into fights (OR=1.9, CI=0.9–3.8). Reduced risks were observed for children who almost never/sometimes worked hard (OR=0.6, CI=0.3–0.9) or paid attention (OR=0.7, CI=0.4–1.1).

3.2.2. Behavioral scales

Four behavioral scales (depression, aggression, self-regulation, and careful/cautious) were associated with children's risks of agricultural injury (Table 3). Children with high, versus low, levels of depressive

symptoms had nearly twice the risk of injury (OR=1.9, CI=1.0–3.7) as did those with low levels of careful/cautious behavior (OR=1.8, CI=1.1–2.9). High scores for aggression also appeared to be associated with elevated risk (OR=1.6, CI=0.9–2.7). Contrarily, low and medium levels of self-regulation were associated with reduced risks of injury (OR=0.4, CI=0.2–0.8 and OR=0.7, CI=0.5–1.0, respectively).

4. Discussion

Rural agricultural households comprise a unique population due to distinct socio-cultural factors, hazardous exposures, and high rates of occupational injury, particularly among children. While previous studies have identified behavioral traits as potential risk factors for injury, this study is distinct in that it explores behavioral factors that may contribute to the risk of agricultural injury among children in farming and ranching households.

Results showed that children's behaviors were associated with their risk of agricultural injury, though not always in the predicted direction. Increased risks of injury were identified for children who were less cautious, less likely to plan carefully, or less likely to follow rules. Reduced risks were observed for those who were less likely to work hard or pay attention. Elevated risks were also identified for children with high levels of depressive symptoms, aggression, and self-regulation, and for those with low levels for being careful/cautious.

Though some of the behavioral constructs examined appeared to play a unique role in this population, these results were generally consistent with prior studies of behavior and injury. Across past studies, aggression has been shown to be positively associated with risk of injury, particularly among children (Bijur et al., 1986; Manheimer & Mellinger, 1967). For example, a study of medically-treated, unintentional injuries among nearly 12,000 preschool children showed those in the 90th percentile of aggression scores to have elevated risks for hospitalized and non-hospitalized injuries (Bijur et al., 1986). In the current study, children who exhibited high levels of aggression had increased risk for agricultural injury, compared to children with low aggression levels. This association may be due to increased risk-taking among those with aggressive personalities (Zuckerman & Kuhlman, 2000) which, on agricultural operations, could lead to more high-risk exposures than among children with lower tolerance for risk.

An interesting finding from this study was the association between agricultural injuries and symptoms of depression. Children in the highest 10th percentile of depression-related scores had twice the risk as children with the lowest scores (50th to 100th percentile). Depressive symptoms have been shown to be associated with poor safety practices in an agricultural population (Stallones & Beseler, 2004). To date, though, there has been limited statistical evidence of associations between depression and risk of unintentional injury. One exception is a study by Park et al. (2001), which found that depressive symptoms were associated with risk of agricultural injuries among male principal farm owners. The current finding, pertinent to children of farming and ranching families, is notable and should be taken into context with the documented prevalence of depressive symptoms in the agricultural population (Linn & Husaini, 1987; Scarth, Stallones, Zwerling, & Burmeister, 2000; Stallones, Leff, Garrett, Criswell, & Gillan, 1995).

While not considered in this study, there is a current, growing interest in the associations between adolescent sleep and health, including injury. Prior studies have shown inadequate sleep and variant sleep patterns to be associated with increased risks of injury among children and adolescents (Koulouglioti, Cole, & Kitzman, 2008; Valent, Brusaferrro, & Barbone, 2001), including those residing on family farms (Stallones, Beseler, & Chen, 2006). Sleep and sleepiness have also been shown to be associated with children's behaviors (Gregory, Eley, O'Connor, & Plomin, 2004; Lavigne et al., 1999) and

Table 3
Risk of agricultural injury among children aged six to <20 by behavioral scales: Regional Rural Injury Study – II (RRIS-II)

Behavioral Scale (items included)	Cases n = 379		Controls n = 1,562		Multivariable Model [†] OR* (95% CI)
	n	(%)	n	(%)	
Depressive Symptoms (looked sad or down; had low energy; was irritable)					
High	25	(6.7)	67	(4.4)	1.9 (1.0–3.7)
Medium	137	(36.8)	583	(38.2)	1.2 (0.9–1.5)
Low	210	(56.5)	876	(57.4)	Referent
Aggression (broke rules; got into fights; was impulsive)					
High	30	(8.1)	84	(5.5)	1.6 (0.9–2.7)
Medium	125	(33.6)	486	(31.8)	1.0 (0.7–1.4)
Low	217	(58.3)	957	(62.7)	Referent
Self-Regulation (was easily distracted; had problems paying attention; had good concentration; worked hard)					
Low	34	(9.1)	167	(10.9)	0.4 (0.2–0.8)
Medium	133	(35.8)	591	(38.7)	0.7 (0.5–1.0)
High	205	(55.1)	769	(50.4)	Referent
Careful/Cautious (was careful; was cautious)					
Low	80	(21.5)	239	(15.7)	1.8 (1.1–2.9)
Medium	127	(34.1)	554	(36.3)	1.0 (0.7–1.4)
High	165	(44.4)	733	(48.0)	Referent
Responsible Conduct (completed work; followed rules)					
Low	34	(9.1)	135	(8.8)	1.2 (0.7–2.1)
Medium	123	(33.1)	448	(29.3)	1.2 (0.8–1.6)
High	215	(57.8)	944	(61.9)	Referent

* Adjusted for within-household correlation using GEEs (Liang and Zeger, 1986) and weighted for non-response (Horvitz and Thompson, 1952; Mongin, 2001).

[†] Models included gender, age, body mass index, number of hours worked on operation, parents' average age, parents' highest education level, number of children in household, operation state, operation type, operation income, and four remaining behavioral scales.

could potentially confound identified associations between behavioral traits and injury. Therefore, it would be worthwhile to explore the interrelatedness of these factors, potentially controlling for sleep quantity and quality in future studies of behavior and injury among children.

Individual items as well as the averaged score for careful/cautious behavior were strongly associated with reduced risks of agricultural injury. These results were not surprising, since prior research suggests that children who are “planful,” or controlled and deliberate in their actions, are less likely to engage in impulsive, risk-taking behavior (Caspi & Silva, 1995). On agricultural operations, children with conscientious, or careful/cautious, personalities might have decreased risks for a multitude of reasons. For example, these children might make use of current educational materials aimed at reducing risk of agriculture-related injury.

Though conclusions have been highly inconsistent, hyperactivity has been examined readily as a potential risk factor for children's injury (Davidson, 1987). Four items that comprise many hyperactivity scales (couldn't sit still; impulsive; acted without thinking; had good concentration) did not factor together in the current analyses, which suggests a distinct construct for these items within the agricultural community. The fact that the four individual items were not associated with injury seems to be consistent with most recent findings. While prior studies have shown activity-related measures to be associated with children's injury (Bijur et al., 1986; Langley, McGee, Silva, & Williams, 1983; Manheimer & Mellinger, 1967), findings from a more recent, prospective cohort study found no association between injury and hyperactivity (Davidson, 1992).

On the contrary, factor analysis identified four items (child was easily distracted; had problems paying attention; had good concentration; worked hard) that were strongly related, with a Cronbach's alpha of 0.78; this factor was referred to as children's self-regulation. A novel and important finding from this study was that children with low levels of self-regulation were at half the risk of agricultural injury as children with high scores for this construct. This is counter to previous suggestion that poor self-regulation is associated with risk-taking (Steinberg, 2004), and a past study showing poor self-control to be associated with injury (Manheimer & Mellinger, 1967). Reasons for this surprising finding may include that parents supervise children with poor attention skills more closely, or that parents, aware of attention problems in their children, assign less hazardous or challenging work to children they know to be distractible. Concomitantly, parents may be more likely to entrust children with good attention skills to chores they believe require better concentration.

Further findings in this paper appear to reflect children's differential assignment to farm or ranch chores. For example, the item “child worked hard,” appeared to play an important and distinct role in this particular study population. Working hard is, in general, a positive trait and was therefore expected to be inversely associated with injury. Interestingly, a direct association was observed; children who almost never/sometimes worked hard had reduced risks of injury. While work hours were controlled in the regression analysis, residual confounding due to differential work pace or work exposures might explain this association. Nonetheless, agricultural operations appear to present a unique context in which parent perceptions of individual child behavior, and the nature of work available to children, interact in complex ways. Future research examining potential associations between children's behavioral traits and their specific environmental exposures could further elucidate the causal pathway between children's behaviors and injuries.

4.1. Strengths and limitations

While this study addresses a deficiency in current knowledge about children's behavioral traits and agricultural injury, results should be interpreted in light of study limitations. Analyses of behavioral items and injury data may have been susceptible to recall

bias. This issue is relevant to results pertinent to depression, given that these symptoms are commonly a result of injury (Keogh, Nuwayhid, Gordon, & Gucer, 2000); but, concern may also extend to other behavioral items and scales. To address this potential bias, along with further measurement and selection issues, multiple measures were taken. Based on prior validation efforts (Braun, Gerberich, & Sidney, 1994; Gerberich et al., 1990), injury data were collected for six-month windows to limit information bias. Additionally, behavior-related items were measured in reference to the months prior to the injury events for cases, or randomly selected months for controls. Limited data pertinent to agricultural operation state, size, and annual revenue by quintile were also used in aggregate form to identify and adjust for differences in response among households.

While the multivariable analyses controlled for a number of important potential confounders, including operation type, operation income, parents' education levels, and number of hours worked on the operation, the potential for an additional, unmeasured confounder cannot be ruled out. For example, parenting factors, such as supervision, could explain some children's behaviors and also affect their risk of injury (Morrongiello, Corbett, McCourt, & Johnston, 2006). Unfortunately, some variables that would be useful for the current analyses, such as parental supervision, or children's sleep quality, could not be included in the survey instrument due to the length of administration time. These potential confounders should be evaluated in future studies.

Given that a main intent of the RRIS-II was to serve as a tool for surveillance of environmental risk factors for agricultural injury, the behavioral items measured also had to be limited in scope and number. The 18 items used were selected based on their deemed relevance to work and safety on agricultural operations. The *a priori* constructs, based mostly on the questionnaires from which the items were adapted, were modified based on results of exploratory factor analyses to yield the scales that were used. However, apart from self-regulation, Cronbach's alphas for each scale were relatively low. Low alphas may have resulted in part from the limited number of items included in each scale, but may also indicate limited interpretability of these latent behavioral constructs.

5. Summary

To date, there has been limited understanding of the impact of children's behavioral characteristics on their risk of unintentional injury. This study identified several behaviors as potential risk factors for injury and, paradoxically, showed that children with attention and concentration problems (low self-regulation) had decreased risks. This and other findings imply that assignment of work to children on farms and ranches may be related to children's behavior. Future research on the procedures by which children are assigned certain chores on family operations, specifically, the role of behavioral and developmental differences in parents' decision-making about when particular children are ready to work, the chores they are ready to perform, and the levels of supervision they require, could enhance intervention efforts.

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