ORIGINAL ARTICLE

Evaluation of a policy to reduce youth tractor crashes on public roads

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Figures 1 and 3 and table 2 can be found on our website.

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Objective: Evaluate the effectiveness of a United States state law, Wisconsin Act 455, in reducing highway tractor crashes involving youth operators.
Design: Policy outcome evaluation involving review of a retrospective case series.
Setting: Youth highway tractor crashes from Wisconsin for the years 1994–2003 that resulted in a fatality, injury, and/or property damage.
Subjects: One hundred and forty six tractor crash cases involving operators younger than 16 years.
Methods: Describe and model the tractor crash patterns before and after enactment of the law, and examine the relation between the contributing circumstances identified in the crash reports and the content covered in the mandated tractor certification course.
Results: There was neither a significant change in the number of youth tractor crashes after the law was passed, nor any reduction in the proportion of crashes where the youth operator was designated at fault. The tractor certification course did not cover the major factors contributing to youth tractor crashes on public roads.
Conclusions: No significant effect of the law was detected and crash rates at the end of the study period were similar to those before Wisconsin Act 455. The authors' findings should not be construed to suggest that public policy, in general, is an ineffective strategy for the prevention of pediatric agricultural injuries. Negotiating a balance in public policy debates will be a challenge, but it is clear that future policy initiatives need to identify and implement the right policy for the right problem.

Public policy has rarely been employed as a prevention strategy for pediatric agricultural injuries. In the United States, children on family farms are exempt from occupational safety regulations[1] and child labor regulations.[2] Therefore, the work performed by children of any age on family farms is largely unregulated, despite the fact that farm children continue to experience high rates of premature mortality,[3–5] morbidity,[6 7] and disability[8] as a result of agricultural injuries.

Farm tractors remain a leading occupational priority for childhood agricultural injury prevention in many countries.[5 9–12] In the US, farm tractors account for the majority of fatal injuries to youth working in agriculture.[4 13 14] In North America, tractors are also an important source of non-fatal trauma to youth on farms.[15] However, there are no data available on the number of injuries or fatalities that occur when youth are operating tractors on public roads.

In 1994, Wisconsin (US) enacted a state law aimed at reducing youth tractor crashes on public roads. Effective 1 July 1997, Wisconsin Act 455 (Act 455) (see box 1) prohibits any child younger than 16 years from operating a farm tractor on the highway unless the child has successfully completed a tractor certification course that is equivalent to the requirements under the federal child labor regulations.[16 17] Wisconsin is the only state to pass such a law and the effectiveness of this regulation has not been formally evaluated.

The overall goal of this research was to evaluate the effectiveness of Act 455 by examining the pattern of tractor highway crashes involving youth operators. Our objectives were to (1) describe the characteristics of tractor crashes involving youth operators before and after enactment of Act 455, (2) examine the relation between the contributing circumstances cited in the crash report and the content covered in the mandated tractor certification course, and (3) examine trends in crashes over time and their relation to Act 455.

METHODS

Study design

This study employed a retrospective case series design. The primary data consisted of vehicle crash reports from the Wisconsin Department of Transportation during the years surrounding the introduction of Act 455.

Ethical considerations

The Institutional Review Board of Marshfield Clinic Research Foundation approved this study in accordance with the

Box 1 History of Wisconsin legislation affecting youth operating tractors on public roads

ACT 455 (28 April 1994)
After 30 April 1996 all youth under 16 years of age must complete a tractor certification course in order to operate tractors and farm machinery on public roads.[16]
ACT 194 (3 April 1996)
Amended start date to 1 July 1997 to provide sufficient time for youth to be certified.[17]
ACT 178 (27 April 1998)
Specified that youth must be 12 years old to enroll in the tractor certification course.[18]

Abbreviations: Act 455, Wisconsin Act 455; ROPS, rollover protection structures.

Department of Health and Human Services' Regulations for the Protection of Human Subjects.

Data sources

We obtained the computerized portion of motor vehicle accident reports from the Wisconsin Department of Transportation for the period from 1994 through 2003 (only years available). These data included fields for age of the operator and vehicle type which allowed us, for example, to subset crashes involving tractor operators younger than 16 years. The numbers of students completing the certification course annually from 1994 to 2002 were obtained from the University of Wisconsin Center for Agricultural Safety and Health. Population estimates were obtained from the 1990[19] and 2000[20] censuses. Public Use Microdata Sample[21 22] household and person files provided estimates of the proportions of Wisconsin youth 12–15 years of age living on and off farms. Farms were defined for our purposes as ⩾10 acres in size with sales of agricultural products ⩾$10,000 (US) in the previous year. The proportion of farm youth in the sample was applied to the census population count of all Wisconsin youth to obtain an estimate of the total number of Wisconsin farm youth. This procedure was completed independently for 1990 and 2000.

Data abstraction and coding

Demographic and descriptive information about each tractor crash was abstracted directly from the electronic files. These electronic data for the years 1994 to 2003 were used to assign driver fault and determine whether contributing circumstances attributed to the tractor driver or vehicle were covered in the tractor certification course.

Driver fault was not included as a specific data element on the motor vehicle accident report form.[23] Therefore, we developed a fault glossary specifying the criteria and methodology that would be used to assign fault. Briefly, a vehicle operator was considered to be at fault if the investigating officer listed one or more contributing circumstances or crash related citations for that vehicle on the accident report form. Each crash was then coded to one of the following unique fault categories: (1) only the tractor driver was at fault, (2) only the other driver was at fault, (3) both drivers were at fault, or (4) unable to determine fault. A single coder applied the above fault methodology to a set of electronically generated case report forms and completed the coding. This coding was validated by computer using the contributing circumstances and citation variables from the electronic files.

The student manual, *Safe operation of agricultural equipment* by Silletto and Hull,[24] is used in all Wisconsin tractor certification courses and is the main source of information provided to class participants during the 24 hour program. The manual was used to judge whether a tractor driver or vehicle contributing circumstance was covered in the tractor certification course. We used the following definitions: ''covered'' meant more than a single phrase or sentence was present in the student manual and it included some discussion of the subject, ''not covered'' meant there was no reference in the student manual or the topic was mentioned briefly in a single phrase or sentence without any discussion of the information, and ''unknown'' was used whenever a contributing circumstance was specified as ''other''. The coding was straightforward based on the above definitions and was completed by a single coder.

Data quality assurance

Electronic data files were subjected to various programming checks and individual record review to ensure that they had been transferred and loaded into the study database correctly. Data manually abstracted and coded were completely validated for correct entry. All data reported from the final study database were subjected to tabular and graphical review to check for consistency and gross errors.

Data analysis

Data analyses were largely descriptive with primary interest in whether trends over time may have resulted from the implementation of Act 455. Summary tables and graphical displays were used to evaluate the numbers of tractor crashes among youth and key characteristics of those crashes over time. Tabulated results are presented in three time periods reflecting conditions before passage (1994–95), during implementation (1996–98), and after implementation (1999–2003) of Act 455.

Although Act 455 initially applied to all youth less than 16 years of age, the 1998 amendment prohibited those under 12 years from enrolling in the certification course. The anticipated effect of the law would therefore be different for those under 12 than for those aged 12–15. There were relatively few tractor crashes among youth under 12 years in any case (12 in our entire study period), so this subset was summarized separately and removed from consideration when evaluating effects over time.

It was assumed that the full effect of Act 455 would not be realized immediately, but would develop as tractor drivers aged 12–15 were certified. Based on the available certification data (see http://www.injuryprevention.com/supplemental for fig 1), by the end of 1998 it appeared that the backlog of youth needing certification was overcome and that youth were being certified at a relatively constant rate. Therefore, we assumed that in the presence of an effective law the underlying rate of tractor crashes among youth aged 12–15 would begin declining in 1996 to a new rate in 1999 under the full effect of Act 455.

Unfortunately, existing data sources were limited to crash numbers without a direct measure of exposure as required to calculate true rates. In the absence of a measure of the extent to which youth were operating tractors on public roads, population data were used to adjust the raw crash numbers before fitting a statistical model. Population estimates were then used to standardize crash rates to a 1998 basis, expressed as numbers of crashes per time period for a fixed population size (the 1998 estimate of 20 500 farm youth). Analyses were repeated without this population adjustment to assess sensitivity and showed very similar results (data not shown).

In 1996, the reporting limit for crashes involving only property damage was increased from $500 to $1000 (US). As damage estimates were not available for individual crashes, we made a correction to adjust for this difference in reporting. The change from 1994–95 to 1996–97 in the proportion of tractor crashes for all ages (1128 total crashes, data not shown) that involved only property damage was used to estimate the number of crashes in 1994–95 that would subsequently have gone unreported because they involved property damage of <$1000 (US). The youth property damage crash numbers for 1994–95 were then reduced accordingly before modeling. The vast majority of reported tractor crashes involve property damage of at least $1000 (US), and the reduction was only 9.6%. In addition, the primary data analyses were repeated for the subset involving injuries and fatalities, because these accidents would not have been affected by the property reporting change, but our conclusions were unchanged (data not shown).

Poisson regression analysis[25 26] was used to model the rate of youth tractor crashes over the study period. The raw data input to the model were the crash numbers per quarter,

weighted by the number of days and the number of farm children estimated for Wisconsin in that quarter. Quarters were defined seasonally in keeping with known changes in farm activity, such that the three months of greatest tractor operation (June to August) were taken together. The model included an indicator for the quarter that accounted for much of the expected seasonal variability in the data.

We assumed that the introduction of Act 455 would at a minimum result in some reduction in crash risk, even if the magnitude of the effect was very small. Given this assumption and limits on statistical power due to relatively low crash numbers, emphasis was placed on estimating the magnitude of the effects and evaluating the practical implications in terms of the potential for Act 455 to reduce crash rates. Model results are presented as estimated rate ratios with confidence limits and large sample test results (p values). The rate ratio represents the estimated proportional change in the crash rate due to a specific term in the model (for example, a rate ratio of 0.5 corresponds to halving the rate and 2.0 corresponds to doubling the rate).

RESULTS

Demographics

For the entire study period, there were 146 crashes involving youth tractor operators less than 16 years of age (table 1). Operator and crash characteristics were consistent across the study timeframe. Most youth tractor operators were male and two thirds were either 14 or 15 years old. The majority of crashes involved property damage only and few crashes involved fatalities. Making a left turn was the most frequent tractor driver action. The remainder of this report will focus on the subset of 134 cases involving youth tractor operators between 12 and 15 years.

Citations

Overall, there were only 18 crash related citations issued to tractor operators aged 12–15 (see http://www.injuryprevention.com/supplemental for table 2). Although the percentage of citations more than doubled from 8.3% to 17.7% during the study period, the change was not statistically significant ($p = 0.244$) and may have been subject to changes in reporting. Since the law was enacted, only two citations have been issued for violation of *Act 455* (traffic citation unit, Wisconsin Department of Transportation, ''personal communication'', 30 June 2004).

Fault designation

Fault designation for youth tractor operators and other drivers involved in the crashes is shown in table 3. In all time periods, youth tractor operators were more frequently designated solely at fault than were the drivers of the other vehicles.

Contributing circumstances

The percentage of crashes with at least one contributing circumstance attributed to either operator increased only slightly over the study period (table 4). The most commonly cited circumstances for the tractor operators were failure to yield, improper turn, and inattentive driving. Tractor vehicle contributing circumstances such as malfunctioning tail lamps or turn signals were rarely cited.

Tractor certification course

When comparing the tractor certification course content to contributing circumstances attributed to the youth tractor operator (table 5), only ''left of center'', cited in just 6% of crashes, was addressed in the student manual and therefore considered covered in the course. Most contributing circumstances involving the tractor itself were covered in the course, but few of these were cited as factors in the crashes.

Tractor crashes over time

Figure 2 displays the numbers of tractor crashes in four age groups over the study period. All numbers shown have been adjusted for the 1996 change in the level of reportable property damage and have been standardized to a 1998 basis to adjust for farm population changes. Act 455, if effective, should have differentially affected ages 12–15 (lowest line in fig 2). However, all age groups show similar trends over time, and instead of diverging under the effect of the law, the numbers for ages 12–15 actually tend to converge with those for other ages toward the end of the study period.

Table 1 Description of youth aged 7–15 years involved in highway tractor crashes

	1994–95 (n = 39), n (%)	1996–98 (n = 39), n (%)	1999–2003 (n = 68), n (%)	Total 1994–2003 (n = 146), n (%)
Sex				
Male	36 (92.3)	37 (94.9)	66 (97.1)	139 (95.2)
Female	3 (7.7)	2 (5.1)	2 (2.9)	7 (4.8)
Age (years)				
7–11	3 (7.7)	3 (7.7)	6 (8.8)	12 (8.2)
12	2 (5.1)	6 (15.4)	5 (7.4)	13 (8.9)
13	7 (17.9)	6 (15.4)	12 (17.6)	25 (17.1)
14	9 (23.1)	14 (35.9)	25 (36.8)	48 (32.9)
15	18 (46.2)	10 (25.6)	20 (29.4)	48 (32.9)
Severity of crash				
Fatality	1 (2.6)	2 (5.1)	2 (2.9)	5 (3.4)
Injury	14 (35.9)	11 (28.2)	21 (30.9)	46 (31.5)
Property damage	24 (61.5)	26 (66.7)	45 (66.2)	95 (65.1)
Tractor driver action				
Making left turn	22 (56.4)	27 (69.2)	39 (57.4)	88 (60.3)
Going straight	11 (28.2)	10 (25.6)	19 (27.9)	40 (27.4)
Making right turn	2 (5.1)	1 (2.6)	3 (4.4)	6 (4.1)
Stopped in traffic	2 (5.1)	0	1 (1.5)	3 (2.1)
Slow/stopping	1 (2.6)	0	0	1 (0.7)
Merging	0	0	1 (1.5)	1 (0.7)
Negotiating curve	0	0	1 (1.5)	1 (0.7)
Illegally parked	0	0	1 (1.5)	1 (0.7)
Backing	0	0	1 (1.5)	1 (0.7)
Other	0	1 (2.6)	1 (1.5)	2 (1.4)
Unknown	1 (2.6)	0	1 (1.5)	2 (1.4)

Table 3 Fault designation for youth tractor operator (aged 12–15 years) and other driver

	1994–95 (n = 36), n (%)	1996–98 (n = 36), n (%)	1999–2003 (n = 62), n (%)	Total 1994–2003 (n = 134), n (%)
Fault				
Youth tractor operator	14 (38.9)	13 (36.1)	25 (40.3)	52 (38.8)
Other driver	7 (19.4)	6 (16.7)	14 (22.6)	27 (20.1)
Both tractor operator and other driver	7 (19.4)	14 (38.9)	17 (27.4)	38 (28.4)
Not able to determine	8 (22.2)	3 (8.3)	6 (9.7)	17 (12.7)

Table 4 Operator and vehicle contributing circumstances cited in crash reports involving youth aged 12–15 years

	1994–95 (n = 36), n (%)	1996–98 (n = 36), n (%)	1999–2003 (n = 62), n (%)	Total 1994–2003 (n = 134), n (%)
Crashes with one or more driver contributing circumstances				
Tractor operator	18 (50.0)	25 (69.4)	34 (54.8)	77 (57.5)
Other driver	13 (36.1)	19 (52.8)	31 (50.0)	63 (47.0)
Tractor operator contributing circumstances				
Failure to yield	9 (25.0)	6 (16.7)	15 (24.2)	30 (22.4)
Improper turn	6 (16.7)	4 (11.1)	9 (14.5)	19 (14.2)
Inattentive driving	3 (8.3)	5 (13.9)	7 (11.3)	15 (11.2)
Left of center	1 (2.8)	4 (11.1)	3 (4.8)	8 (6.0)
Failure to control	2 (5.6)	3 (8.3)	1 (1.6)	6 (4.5)
Speed too fast for conditions	0	1 (2.8)	0	1 (0.7)
Exceeding speed limit	0	1 (2.8)	0	1 (0.7)
Disregarding traffic control	0	1 (2.8)	0	1 (0.7)
Other	2 (5.6)	6 (16.7)	6 (9.7)	14 (10.4)
Tractor vehicle contributing circumstances				
Tail lamps	1 (2.8)	1 (2.8)	7 (11.3)	9 (6.7)
Turn signals	3 (8.3)	2 (5.6)	3 (4.8)	8 (6.0)
Mirrors	1 (2.8)	1 (2.8)	1 (1.6)	3 (2.2)
Stop lamps	0	0	1 (1.6)	1 (0.7)
Other	1 (2.8)	2 (5.6)	4 (6.5)	7 (5.2)

Model estimates for youth aged 12–15 are presented in table 6, and the observed and predicted crash rates over time are displayed graphically by quarter in figure 3 (see http://www.injuryprevention.com/supplemental). Crashes were highly seasonal, with the lowest rates in the winter and early spring, and much higher rates in June through August. The estimate for an underlying trend over time was small (about a 1% increase per quarter) and not significant ($p = 0.437$). The overall effect of the law was not significant ($p = 0.280$), and the crash rates at the end of the study period were very similar to those before Act 455.

Table 5 Contributing circumstances covered in tractor certification manual (1996–2003)

	Covered in the student manual	
	Yes	No
Tractor operator contributing circumstances		
Failure to yield		X
Improper turn		X
Inattentive driving		X
Left of center	X	
Failure to control		X
Speed too fast for conditions		X
Exceeding speed limit		X
Disregarding traffic control		X
Other	Unknown	Unknown
Tractor vehicle contributing circumstances		
Tail lamps	X	
Turn signals	X	
Mirrors	X	
Stop lamps	X	
Other	Unknown	Unknown

DISCUSSION

Our findings show there was no reduction in the proportion of crashes where the youth tractor operator was designated at fault, nor in the type or number of contributing circumstances attributed to the youth tractor operator. There was also no significant change in the number of youth tractor crashes occurring on public highways following enactment of Act 455. Finally, while there was an increase in the number of youth certified, with few exceptions the tractor certification course did not cover the major factors contributing to youth tractor crashes on public roads.

Potential explanations for our findings

We examined legislative documents associated with the proposal and passage of Act 455 that suggest several explanations for our findings.

A low priority problem was selected

This legislation was drafted by the Special Committee on Farm Safety, established by a Senate joint resolution in 1992 to identify ways to reduce the high number of farm related fatalities in Wisconsin, more than half of which were

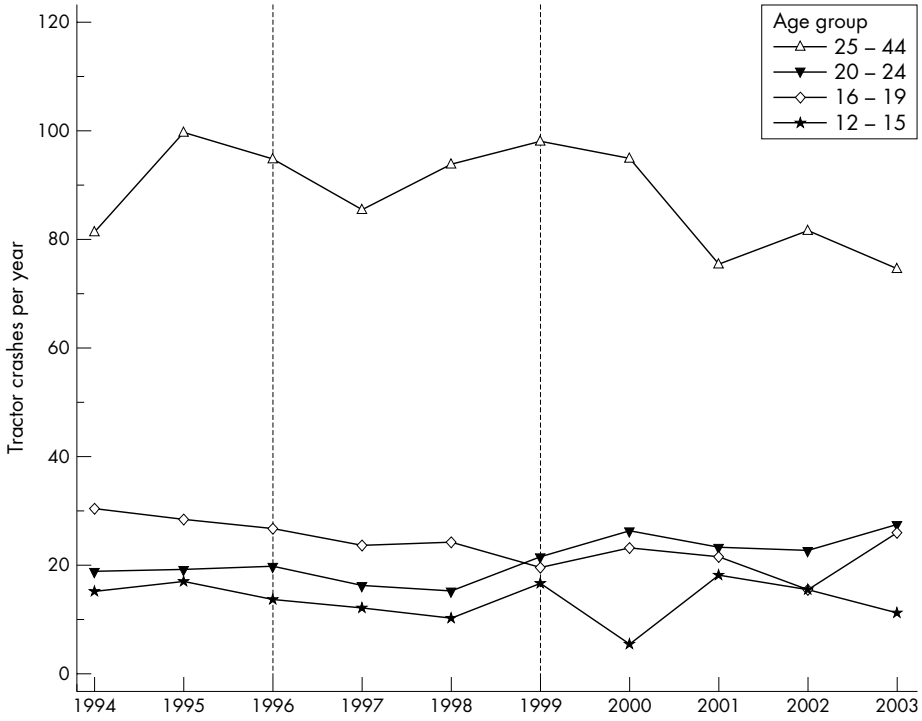

Figure 2 Tractor crashes per year by age group (adjusted counts).

attributed to tractors and farm machinery.[27] The fatality data gathered by the Committee showed that the leading cause of farm deaths were overturns of tractors not equipped with rollover protection structures (ROPS) and public testimony garnered by the Committee identified the need for ROPS as a key safety concern.[27] In contrast, highway crash data obtained from the Department of Transportation during Committee deliberations showed that very few of the tractor operators involved in crashes on public roads were younger than 15 years.[28] Clearly, the need for ROPS on tractors was a higher priority problem than youth tractor crashes on public roads, yet the youth tractor policy was passed.

The intervention was not tailored to the problem selected

Although public policy is a novel intervention for prevention of childhood agricultural injuries, Act 455 simply mandates an educational approach that has been deemed an ineffective strategy for promoting farm safety.[29] Furthermore, the tractor certification course required by this policy was not designed to prevent youth tractor crashes on public roads, but rather to meet federal exemption requirements under the Fair Labor Standards Act-Hazardous Occupations Order for Agriculture.[2] Only one chapter of the certification manual covers safety on public roads and it does not address the leading factors contributing to youth tractor crashes on public roads.

Table 6 Rate ratios from the model for youth tractor crashes over the study period*

Parameter	Rate ratio	95% confidence limits	p Value
Season			
Dec-Feb	0.66	0.34 to 1.26	0.209
Mar-May	0.61	0.31 to 1.19	0.144
Jun-Aug	2.83	1.75 to 4.56	<0.001
Sep-Nov (referent)	1.00		
Underlying time trend per quarter	1.01	0.98 to 1.05	0.437
Full law effect (after 3 years)	0.58	0.21 to 1.57	0.280

*Results from Poisson regression analysis modeling youth tractor crashes over time. Rate ratios show the relative change in the crash rate due to model terms for season, underlying changes over time, and Act 455. The effect of Act 455 was incorporated in the model as a gradual change in the rate over the three years from 1996–98 as the proportion of youth who were certified to drive tractors increased.

There was no incentive to comply with the law

Since enactment, only two citations have been issued for violation of Act 455. Although this could suggest that most youth operating tractors on the roadway had been certified, it most likely means that the law has been rarely enforced. In addition, the monetary fines for violating the law are quite modest ($20 for first offense, $50 for second offense)[16] and are unlikely to serve as a deterrent.

Strengths and limitations

This study is one of the first to examine the impact of regulatory policy on the reduction of injuries to children on family farms. It fills an urgent need for evaluative research and examines public policy, a rarely used pediatric farm safety intervention.

Our study retrospectively investigated a case series of youth tractor crashes and there are recognized limitations to this approach. The data were collected for other purposes and we relied on others for the accuracy and completeness of the data. The relatively small number of crashes involving youth tractor operators, coupled with substantial variability over time, limited our ability to statistically discern any effect of the law, even though a relatively large reduction in the number of crashes (about 40%) was temporarily observed after 1995. However, the small number also limits the potential impact of the law. We could not determine which, if any, youth involved in crashes had been certified and therefore could only examine certification effects as reflected in overall crash numbers. Further, true exposure data do not exist, so we relied on population estimates as an indirect measure of exposure.

Key points

- Farm tractors remain a leading occupational priority for childhood agricultural injury prevention in many countries.
- Regulatory policy is increasingly seen as a promising intervention strategy.
- Wisconsin Act 455 is a regulatory approach to the prevention of youth tractor crashes on public roads that had not been formally evaluated.
- This policy outcome evaluation found no significant change in the number of youth tractor crashes following the enactment of Wisconsin Act 455.
- Future policy efforts aimed at pediatric agricultural injury prevention need to focus on identifying and implementing the right policy for the right problem.

CONCLUSIONS

With the continued high numbers of tractor fatalities and injuries to farm children and the fact that education[29] and engineering controls have fallen short,[30 31] regulatory policy is seen as a promising intervention strategy.[32] Our study findings should not be construed to suggest that public policy, in general, is an ineffective strategy for the prevention of pediatric agricultural injuries. Policy initiatives require compromise and it appears that in the case of Act 455, the negotiated compromise was the selection of a low priority problem coupled with an intervention that was palatable to farmers and cost effective for policymakers. Clearly, this type of compromise can limit the effectiveness of public policy. Negotiating a balance in public policy debates around pediatric agricultural injury prevention will be a challenge, but it is clear that future policy initiatives need to focus on identifying and implementing the right policy for the right problem.

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