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To compensate for insufficient resources, many child protection agencies use screening instruments to prioritize reports of abuse for investigations. Like most risk assessment instruments, however, the variables included in the screens are selected on the basis of clinical observations. Because an empirically derived screen may lead to more-accurate predictions, this article identifies predictors of injury severity caused by physical abuse from information included in the abuse reports. Subjects included one physically abused child from 789 families. The criterion variable had four levels: no, mild, moderate, and severe injury. Predictors included child, report, perpetrator, and maternal characteristics. Results of an ordinal probit regression analysis identified that a model with four predictors (perpetrator identity, reporter identity, severity of allegations, and season report was made) and two interaction terms (child's age by mother's age and child's age by child's gender) successfully predicted whether a child was injured.

Key words: **child abuse; child protection; ordinal probit regression; risk assessment; screening instrument**

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Since 1980 child protection services (CPS) programs have experienced substantial increases in reports of abuse (American Humane Association, 1988) without concomitant increases in funding. As a result, many programs lack sufficient staff to investigate in a timely manner every report they receive. To address this disparity between work and resources, some agencies prioritize reports for investigation based on a screening instrument (Wells, Downing, & Fluke, 1991). However, existing screening instruments could be improved.

Screens, like most other risk assessment tools, include variables selected on the basis of clinical judgment. Decisions about how quickly to investigate abuse might be improved if they were driven by empirically derived criteria for predicting the probability of injury severity and immediate recurrence of abuse. Despite this need, little systematic research has addressed prediction of injury severity. This article reports results from a study that used ordinal probit regression to develop a model for predicting severity of child abuse injury from information included in abuse reports to CPS.

LITERATURE REVIEW

This literature review, presented in greater detail elsewhere (Hegar, Zuravin, & Orme, 1994), was a systematic search of several databases from various disciplines. Twenty-one articles were identified. Four studies used multivariate analytic techniques to predict severity of child abuse injury (Daley & Piliavin, 1982; Hampton, 1987; Rosenthal, 1988; Seaberg, 1977), whereas the remainder used bivariate techniques, descriptive procedures, or both. The authors also reviewed the unpublished papers of the ongoing Risk Assessment Roundtable sponsored by the American Public Welfare Association and American Humane Association (see Tatara, 1991). This overview emphasizes study findings; it does not detail methodological variations and differences relative to definition of severity (Hegar et al., 1994).

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Age of Abused Child

Age of the abused child is one of the most frequently explored variables and one about which there is most agreement. Many researchers have found young children to be at greater risk for severe child abuse injury (American Humane Association, 1988; Creighton, 1985; Daley & Piliavin, 1982; Jason & Andereck, 1983; Rosenthal, 1988; Seaberg, 1977). Although young children may be at greater risk for severe injury, these findings could mean that less-severe abuse is more difficult to detect in young children because they are less visible to concerned adults than are school-age children. Thus, underreporting of minor injuries to young children may help explain their overrepresentation in the categories of more severe injury.

Gender

The relationship between severity of abuse injury and gender of the child is much less clear. Although gender was explored in each multivariate study reviewed, only one reported positive findings. Rosenthal (1988) found that boys were more severely injured when other variables were controlled. Gender of the perpetrator has been linked more clearly and consistently to severity of injury, with victims of male perpetrators suffering more serious injury (Anderson, Ambrosino, Valentine, & Lauderdale, 1983; Bergman, Larsen, & Mueller, 1986; Daley & Piliavin, 1982; Jason & Andereck, 1983; Rosenthal, 1988). There is also some support for an interaction between perpetrator and victim gender. Rosenthal (1988) found that men tend to abuse boys, whereas women tend to abuse girls, an interaction that may be due to family role division in discipline.

Ethnicity and Income

Two reanalyses of Gil's (1979) child abuse data found victims of nonwhite perpetrators to be at increased risk for severe injury (Daley & Piliavin, 1982; Seaberg, 1977). Daley and Piliavin (1982), suspecting that Seaberg's findings might be attributed to uncontrolled economic factors, found that income did not alter the relationship between race and severity. Consistent findings are reported by Hampton (1987), who found that severity of injury adds statistically significant power in discriminating between white and black families at both low- and higher-income levels. In studies of hospital admissions and known child abuse fatalities, black children also are overrepresented (Greenland, 1987; Jason & Andereck, 1983; Johnson & Showers, 1985). For a variety of reasons, findings concerning the race of injured children must be interpreted with caution. Some results may reflect failure to control for socioeconomic status or a greater willingness of professionals to attach stigmatizing labels to families of color (Hampton & Newberger, 1985; Wells, 1988).

Report Characteristics

Little research attention has been paid to relationships between injury severity and report characteristics such as severity of allegations, identity of reporter, or time of report (month, day, and so forth). One study concluded that anonymous reports are more likely to be judged unfounded, but if substantiated, these reports are as severe as those by professional and nonprofessional reporters (Zuravin, Watson, & Ehrenschaft, 1987). Other authors found anonymous reports to be frequently unfounded (Abramczyk & Sweigart, 1985; Jackson, 1983), and at least one additional study found them to be less severe (Adams, Barone, & Tooman, 1982). Others concluded that reports from professionals are substantiated more frequently than those from nonprofessionals, without addressing severity of injury (American Humane Association, 1988; Eckenrode, Powers, Doris, Munsch, & Bolger, 1988; Jason & Andereck, 1983).

Timing

The timing of child abuse reports has a possible relationship to injury severity. Although researchers have explored seasonality as a factor in other violent behavior (Abel, Strasburger, & Zeidenberg, 1985; Michael & Zumpe, 1986), attention in the child abuse literature has been limited to patterns of reporting without regard to severity (Lobb & Strain, 1984). Severity might vary seasonally due to increased serious abuse or decreased reporting of minor incidents during some times of the year.

METHODS

Data Source

This study was conducted on a subset of observations from a database of physical child abuse reports made to the Baltimore City Department of Social Services (BCDSS), Division of Child Protective Services, from January 1 to December 31, 1984. In 1984 Maryland Family Law Article 5-701 defined child abuse as "the sustaining of physical injury by a child as a result of cruel or inhumane treatment or as a result of a malicious act by any parent or other person who has permanent or temporary care or custody or responsibility for supervision of a child under circumstances that

indicate that the child's health or welfare is harmed or threatened thereby" (Maryland Family Law, 1984).

Database. The data set includes selected variables on 1,947 (66 percent) of the 2,944 physical abuse reports made to BCDSS during 1984. These reports were not randomly selected from the full population of 2,944 reports; instead, they include those reports for which we were able to access (around mid-1985) written copies of both the initial complaint taken by the screening worker and the disposition report completed by the investigating caseworker. Without data on the reports that were missing, it is impossible to assess with certainty whether findings are biased and, if so, how. However, comparison of the distribution of reports by month and season for 1984 with comparable data from 1987 (prepared by BCDSS from all reports made in 1987) reveals an identical pattern.

Most data were abstracted by graduate social work students from the screening workers' written reports of complaints and the investigating caseworkers' written summaries of findings and disposition. Three steps were taken to ensure high levels of interrater reliability among the abstractors: (1) A detailed manual was developed, (2) students were trained to 80 percent interrater reliability, and (3) rater agreement was checked in 20 percent of the reports. Interrater reliability for study variables ranged from 80 percent to 100 percent.

The 1,947 physical abuse reports represent 1,781 families. Ninety-two percent of these families were reported once for physical abuse during 1984, and 8 percent were reported two or more times. The report for 14 percent of the families included allegations of abuse for more than one child.

Selection of Reports for Severity Study. A report was included in the study if it was substantiated (that is, if the investigating caseworker found evidence that confirmed or suggested that at least one child had been physically abused). A report was excluded if the perpetrator was a foster parent or a school or day care staff member. For the 53 families with more than one substantiated report of physical abuse, only the first report was selected. The remaining reports were excluded because many appeared to be re-reports of the first incident. When more than one child in a family was abused, we included data only on the youngest child. Because the literature suggests an inverse relationship between child's age and injury severity, this strategy should enhance the ability to predict severity.

Of the 1,947 reports of physical abuse, 896 (46 percent) met all criteria. Because severity data were missing for 107 of the 896 reports, 789 were used in the analysis. Thus, this study focuses on predicting severity of injury for 789 physically abused children from the same number of families.

Definitions

Levels of severity of injury are modifications of those developed by Magura and Moses (1986). A child was assigned a severity code on the basis of the most severe injury sustained, regardless of the total number of injuries (see Daley & Piliavin, 1982). For ***no injury*** the child was the victim of unacceptable modes of physical discipline or aggression that endangered his or her well-being but did not result in physical injury. Relevant behaviors included hitting with a fist, kicking, choking, smothering, dropping, and being held under water. ***Mild injuries*** include welts, cuts, abrasions, bruises, and first-degree burns localized in one or two areas of the body and involving two or fewer separate injuries in each area. ***Moderate injuries*** include sprains, mild concussions, broken teeth, cuts requiring sutures, second-degree burns, cigarette burns, finger or toe fractures, and more than two mild injuries on any area of the body. ***Severe injuries*** include third-degree burns, brain and spinal cord injury, eye injuries, fractures of bones other than fingers or toes, severe concussions, deep wounds or puncture wounds, and internal injuries. Some of the severely injured children died.

Severity Predictors

Because this study used an existing data set, selection of predictors was constrained by the availability of information and the number of reports with missing data. Given the inconsistency of recording by different caseworkers, a substantial number of reports were missing data for important predictors. For example, only about half of the reports included data about family socioeconomic status (defined as recipient of Aid to Families with Dependent Children). With these constraints in mind, the selection of predictors was driven by four criteria. First, to ensure that findings are clinically meaningful, a characteristic was selected only if it had a very high probability of being known about at the time the initial report was taken. This criteria is particularly important because it bars using many characteristics that clinicians consider important (for example, parental substance use, domestic violence, previous history of child maltreatment, and socioeconomic status), because information is frequently not available. Second, to build knowledge about the predictors of injury severity, a predictor was selected if findings from prior research were contradictory. Third, to enhance prediction accuracy, a variable was selected if prior research consistently found it

to be associated with injury severity. Fourth, to take advantage of the characteristics of the report itself or its content, report variables were included as predictors. Nine variables met these criteria, including three report characteristics (season the report was made, source of the report, and severity of the allegations), three child characteristics (gender, age, and race), two perpetrator characteristics (gender and relationship to the child), and one maternal characteristic (age).

Source of the report includes an "anonymous" category for individuals who refused to identify themselves. Known reporters were categorized as either nonprofessionals (for example, neighbors, friends, relatives, parents, foster parents, and victims of abuse), nonmedical professionals (for example, teachers, day care providers, social workers in nonmedical settings, police), or medical professionals (for example, private practitioners and staff of health care facilities, including social workers).

Severity of the allegations made by reporters often is the basis for designating investigations as emergencies. Despite this fact, the nature of the allegation as a predictor of injury severity has not been established empirically. This variable was divided into three levels on the basis of reviewing allegations from 200 randomly selected reports. For *low-risk behaviors* the reporter alleged that a caretaker spanked, slapped, hit, punched, or beat the child but did not cause injuries. For *high-risk behaviors* the reporter alleged that a caretaker attempted to drown, suffocate (for example, placing infant in a plastic bag, holding pillow over child's head), or poison or threatened with a gun, knife, or other object classified as a weapon, but no injury resulted to the child. *Reported physical injury* involves allegations that a child was bruised, cut, burned, or otherwise injured by inappropriate and excessive discipline or aggression by a caretaker. This category also included adverse reactions from a caretaker forcing a child to consume alcohol, household cleaning products, or illicit drugs.

Perpetrator relationship to child is divided into four levels: (1) unknown perpetrators (that is, caseworker was unable to identify who perpetrated the abuse), (2) nonrelatives (for example, baby-sitters, neighbors, adult friends of the primary caretakers, and any other nonrelated individuals who were acting in the capacity of temporary caretaker of the child), (3) relatives (for example, aunts, uncles, grandparents, and cousins), and (4) parent figures (mothers and fathers, as well as stepmothers and stepfathers). Examining this predictor could show possible differences in the nature of relationships between adults and children of varying degrees of kinship or acquaintance.

Ordinal Probit Regression

Ordinal probit regression (OPR) is better suited than ordinary least squares (OLS) regression to the analysis of dependent variables with a limited number of ordered categories, such as severity of injury (Maddala, 1983; McKelvey & Zavoina, 1975; Miller, 1991; Muthen & Short, 1985; Orme, Zuravin, & Hegar, 1992; Winship & Mare, 1984; Xie, 1989). However, OPR and OLS regression are similar in a number of ways. Both yield a regression slope for each predictor and a test of statistical significance for each slope. In both methods the regression slope indicates the predictor's independent contribution to the prediction of the dependent variable, and the sign of the slope indicates the direction of the relationship. The same methods are used for coding predictor variables (for example, dummy coding, effect coding); predictor variables can be entered hierarchically in sets, and product terms are used to test interactions. Overall model fit can be tested, as can the incremental improvement in a model brought about by the addition or deletion of predictors, although R^2 is used with OLS regression and a likelihood-ratio χ^2 test is used with OPR. Finally, observed and predicted values of the dependent variable are compared to determine model fit, although the two methods use different means of comparison: OLS regression relies on the squared correlation between observed and predicted values (another way to conceptualize R^2), whereas OPR relies on the degree of agreement (for example, percentage of agreement, or kappa, which is preferable because it is a chance-corrected measure).

Several differences between OLS and OPR are notable. In particular, OPR explicitly recognizes the ordinal nature of dependent variables with a limited number of categories and nonequidistant scale steps. It also assumes that the ordinal dependent variable is an indicator of an underlying continuous normal variable. This latent dependent variable, inferred from the observed dependent variable, is regressed on the observed independent variables. The OPR model is developed for the latent variable, and the OLS regression assumptions are assumed to hold for this latent variable as related to the observed independent variables. Consequently, an OPR slope indicates the predicted change in a latent dependent variable with a standard deviation of one, which is associated with a unit change in a predictor variable, when controlling for other predictors in the model.

Study Limitations

Despite some methodological improvements, this study is not without limitations. One major source of

problems for this as well as many past efforts stems from use of a retrospective design involving collecting data from the case recordings of screening and investigative caseworkers. Inherent in this strategy are problems that could affect overall prediction accuracy as well as identification of predictors. However, such confounding is minimized by two design characteristics: (1) careful attention to interrater reliability during training and throughout the data abstraction phase of the study and (2) blindness of the abstractors to study hypotheses.

Second, because case record narratives vary by both type of information recorded and degree of detail, selection of predictors is constrained by what is available and can be abstracted reliably. Important omissions from this study's group of predictors as well as those of earlier efforts are family structure (single-parent versus two-parent family) and various contextual characteristics such as proportion of neighborhood residents whose income is below the poverty level, level of violent crime, and household transiency. Studies by Gelles (1989) and Gelles and Wolfner (1991) have found that some of these variables are associated with severe violence toward children. Socioeconomic status, parental substance use, child mental health problems, and other family characteristics that may be excellent severity predictors are not good candidates for inclusion in a screening tool because pertinent information is not uniformly available on every complaint made to the screening unit.

Third, the variable quality of case record narratives, in addition to causing problems for model specification, impedes the ability of raters to make reliable distinctions among reports for some predictors. For example, we were able to abstract reliably only three levels for the predictor "severity of allegations" (low-risk and high-risk caretaker behavior and reported physical injury).

RESULTS

Univariate Descriptive Data

Of the nine predictors, five had missing values. Missing data ranged from 0.3 percent to 7.0 percent. For three variables the percentage was 1 or less. For perpetrator gender the percentage was 6.3 and for mother's age, 7.0. Given the small percentage of missing data, substitute values were assigned so the entire sample could be analyzed. Cases were grouped according to the severity of injury (0 = no injury, 1 = mild, 2 = moderate, 3 = severe). Within each group, a case with a missing value was assigned the value of that variable for the preceding case in the data set. Because cases were not ordered within severity groups, this method involved the random substitution of values within categories of the dependent variable. This method is preferred because it does not reduce the variance of a variable, as would the substitution of a constant such as the mean, and it does not attenuate the relationship of the dependent and independent variables (Gibson, 1992).

Severe injury was found to be a rare phenomenon (4.6 percent) (Table 1). Most common were mild injuries (44.5 percent).

Ordinal Probit Regression

Predictor Variable Coding. Child's age and severity of allegations were treated as quantitative variables. Dichotomous variables were coded as 0 or 1 in the following manner: child's gender and perpetrator's gender (0 = female, 1 = male) and child's race (0 = other, 1 = African American). Perpetrator's relationship to the child, type of reporter, and season were effect coded. Effect coding involves coding a nominal level variable having g categories, using $g - 1$ variables, where each variable represents a particular category with subjects in that category coded 1, subjects in the excluded category coded −1, and subjects in the remaining categories coded 0 (Cohen & Cohen, 1983).

The regression slopes for the effect-coded variables indicate the difference in the mean severity for a category of a variable from the mean severity for all categories of that variable (for example, the difference between the mean severity of reports during the summer and the mean severity across all seasons) (Cohen & Cohen, 1983). Estimates of slopes for all categories of the effect-coded variables were obtained by estimating the regression model twice, each time omitting a different category of the variable.

Model Comparisons. We hypothesized that each predictor variable would be related to severity when controlling for all other predictor variables. We also hypothesized that the effect of the child's age would be different depending on the mother's age and the child's gender (that is, interactions between child's age and mother's age and between child's age and gender) and that the effect of the perpetrator's gender would be different depending on the child's gender (that is, an interaction between perpetrator's gender and child's gender). In all cases nondirectional tests were used because results in either direction were considered important.

Interactions are tested with OPR in much the same way they are tested with OLS regression. First, three interaction variables were created: (1) child's age multiplied by mother's age, (2) child's age multiplied

TABLE 1—Descriptive Data and Severity Predictors (*N* = 789)

Variable	%	*n*	*M*	*SD*
Severity of injury				
No injury	37.0	292		
Mild injury	44.5	351		
Moderate injury	13.9	110		
Severe injury	4.6	36		
Child's gender				
Female	47.7	376		
Male	52.3	413		
Child's race				
African American	71.6	565		
Other[a]	28.4	224		
Child's age, years			8.33	5.50
Perpetrator's gender				
Female	58.6	462		
Male	41.4	327		
Perpetrator's relationship to child				
Unknown	6.3	50		
Nonrelative	11.5	91		
Relative	6.5	51		
Parent figure	75.7	597		
Mother's age, years			30.67	7.81
Type of reporter				
Anonymous	8.1	64		
Nonprofessional	26.7	211		
Other professional	34.5	272		
Medical professional	30.7	242		
Season[b]				
Fall	19.3	152		
Winter	26.9	212		
Spring	29.7	234		
Summer	24.2	191		
Allegations				
Low-risk behavior	25.6	202		
High-risk behavior	5.1	40		
Reported physical injury	69.3	547		

NOTES: Percentages do not add to 100 due to rounding. Missing data ranged from 0.3 percent to 7.0 percent. Substitute values were assigned by grouping the cases by severity of injury and assigning each missing case the value of the preceding case in the data set.
[a]Eighty-three percent were white.
[b]Fall includes September, October, November; winter includes December, January, February; spring includes March, April, May; summer includes June, July, August.

by child's gender, and (3) perpetrator's gender multiplied by child's gender. Second, the three interaction variables and the original nine predictor variables were regressed simultaneously on the severity of injury, and estimates of the interaction effects were obtained from this analysis. Third, a main-effects-only model was estimated that constrained the interaction effects to equal zero, and estimates of the main effects were obtained with this analysis. Finally, the model with the estimated interaction effects was compared to the main-effects-only model to determine whether the latter model resulted in a statistically significant reduction in fit. This proved to be the case ($\chi^2[3] = 8.43$, $p = .038$), so the interaction variables were retained in the model.

Agreement between Observed and Predicted Values of the Dependent Variable. The degree of agreement between predicted and actual cases of injury (no injury versus mild, moderate, or severe injury) is very good (kappa = .62; $t = 17.50$, $p \leq .001$; 95 percent confidence interval = .56 to .68), and the percentage of false-negative cases is 5 and false-positive cases is 12. The agreement between predicted and actual cases of moderate or severe injury (versus no or mild injury) is relatively low (kappa = .25; $t = 8.58$, $p \leq .001$; 95 percent confidence interval = .17 to .35), and the percentage of false-negative cases is 14 and false-positive cases is 3. There were no predicted cases of severe injury (versus no, mild, or moderate injury), and so it was impossible to compute a kappa value for this situation. The percentage of false-negative cases is 5 and false-positive cases is 0.

Effects of Individual Variables. Severity is greater when the perpetrator is unknown, when the report is from a medical professional, and when the allegations are more severe (Table 2). Severity is less when the perpetrator is a parent, when the report is anonymous or from a nonprofessional, and when the report is made in the summer. In general these effects range from small to moderate, except for the effect of the severity of the allegations. A one-point increase in the severity of the allegations was associated with a standard deviation increase in severity of nearly one (that is, $b = .92$).

There are interactions between child's age and mother's age and between child's age and child's gender, although these variables do not have independent main effects on severity. The interaction between child's age and mother's age indicates that the older the child the less severe the injury, and the older the mother the stronger this inverse relationship. The interaction indicates that age did not influence the severity with which girls were injured, but severity was greater for younger boys than for older boys. Finally, child's race and perpetrator's gender did not have statistically significant independent main effects on severity, and there was not a statistically significant

TABLE 2—Ordinal Probit Regression Results

Variable	Slope	z	p (two-tailed)
Child's gender	.152	1.69	.091
Child's race	.174	1.71	.088
Child's age	.000	.00	1.000
Mother's age	−.015	−1.88	.061
Perpetrator's gender	.105	1.06	.289
Perpetrator's relationship to child			
Unknown	.414	3.00	.003
Nonrelative	−.107	−.96	.335
Relative	−.060	−.38	.701
Parent figure	−.248	−2.92	.004
Type of reporter			
Anonymous	−.239	−2.21	.027
Nonprofessional	−.293	−3.57	≤.001
Other professional	.000	.00	1.000
Medical professional	.533	6.66	≤.001
Season[a]			
Fall	.029	.36	.717
Winter	.035	.45	.649
Spring	.109	1.51	.130
Summer	−.173	−2.16	.033
Allegations	.919	15.07	≤.001
Child's age × mother's age	−.002	−2.00	.046
Child's age × child's gender	−.039	−2.44	.015
Perpertrator's × child's gender	.094	.52	.604

[a]Fall includes September, October, November; winter includes December, January, February; spring includes March, April, May; summer includes June, July, August.

interaction between perpetrator's gender and child's gender.

DISCUSSION

Failure to predict severe abuse injury as well as relatively poor ability to predict moderate and severe injury is disappointing, because CPS staff need most to identify these outcomes. Although we cannot pinpoint the specific reasons for failure, it is important to underscore that rare events like severe injury are difficult to predict. Although it may be impossible to predict this level of injury with great accuracy, such a pessimistic view is premature. With larger samples, better specified models, and more-precise measurement of variables, prediction ability may improve.

Our results regarding race and perpetrator gender differ from those of earlier efforts. Unlike prior multivariate efforts, neither child's race nor perpetrator's gender were retained in the model. The most likely explanation is that the information provided by these predictors was redundant with that provided by other predictors.

Also, we found an interaction between gender and age in the same general direction as Rosenthal (1988). This critical interaction should be included in future efforts to predict severity.

Further, even though only one other study (Rosenthal, 1988) examined perpetrator identity, the consistency of the two sets of results (that is, situations where the identity of the perpetrator is unknown) suggests that this predictor is also important to include in future studies.

Finally, the significant ability of a medical reporter to predict severity of injury can be explained by three possibilities: (1) the size and injury risk status of the child population seen daily by the medical profession, (2) their greater knowledge of abuse signs and symptoms, and (3) their heightened suspicion of injuries. Also, although it seems like belaboring the obvious to stress the importance of the predictive ability of severity of allegations, it is important to note that the obvious is not always borne out by research. That this predictor is the best of all studied confirms the importance of taking allegations of injury seriously.

CONCLUSION

Predicting injury severity is of practical value for public CPS programs. A prediction protocol can be used to identify reports that require immediate investigation, particularly for those agencies that have a high volume of reports and limited investigational resources. Even a screening tool with moderate ability to predict risk is valuable, because it allows professionals to identify efficiently those who are most likely to benefit from the available services (Balassone, 1991; Milner, 1986). Consequently, if the overwhelmed CPS agency is to make the best use of its scarce resources to protect children, social work researchers must be willing to step in and help them develop the empirically derived risk protocols that are desperately needed. ■

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