Journal of Pediatric Psychology, Vol. 23, No. 3, 1998, pp. 197–205

Effects of Maternal Intelligence, Marital Status, Income, and Home Environment on Cognitive Development of Low Birthweight Infants

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Objective: To examine direct and mediated effects of maternal IQ, marital status, family income, and quality of the home environment on the cognitive development of low birthweight infants.
Methods: Secondary analyses on a large dataset using hierarchical regression identified factors correlated with cognitive outcomes in children at 3 years of age who were born at low birthweight.
Results: Maternal IQ was a critical variable, because it was highly correlated with child IQ and because maternal intelligence influenced patterns of relationships among other predictor variables including marital status, income level, and home environment on child IQ. Analyses revealed that effects of these variables on child IQ interacted with maternal IQ.
Conclusions: Early childhood intervention programs should target those low birthweight infants most at risk for impaired cognitive development. Children at greatest risk are those living with unmarried, low IQ mothers.

Key words: *cognitive development; low birthweight infants; maternal IQ; marital status; family income; home environment.*

Premature low birthweight (LBW) is the leading risk indicator for infant mortality and morbidity. Census data from 1995 reveal that 285,152 newborns were LBW (<2500g) (Ventura, Martin, Curtin, & Mathews, 1997). As a group, survivors are at highly elevated relative risk for subsequent and long-term health, cognitive, social, and other problems (Baumeister & Bacharach, 1996; Breslau et al., 1994; Escobar, Littenberg, & Petitti, 1991; Hack, Klein, & Taylor, 1995).

Premature LBW is an enormously complex constellation of causes and effects, implicating biological as well as social factors. Causes and effects have proven difficult to disentangle. But it is necessary to move beyond simple descriptive, typically bivariate, studies to grasp the interlocking features of this complex biosocial risk profile in order to design improved preventive or ameliorative interventions.

Effects of premature LBW on cognitive outcome have long been known to be associated with factors such as maternal age, maternal intelligence, socioeconomic status (SES), and race among others conditions (e.g., Baumeister, Kupstas, & Woodley-Zanthos, 1993; Hack et al., 1995; Starfield, 1992). Furthermore, various studies have shown that LBW children are more likely than normal birthweight (NBW) children to live in high-risk social environ-

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ments but that when both LBW and NBW children are exposed to high-risk environments the effect is greater on the LBW children (McGauhey, Starfield, Alexander, & Ensminger, 1991). The question now becomes one of how environmental risks differentially affect LBW children. Results of several studies indicate that detrimental effects of LBW can be attenuated when LBW children are exposed to conditions that promote cognitive development, including maternal competence (e.g., Wilson, 1985). In this regard, infants born to mothers with IQs below average (IQ < 85) are also at greater relative risk for delayed cognitive development (Ramey & Ramey, 1992; Reed & Reed, 1965).

The present study focuses on children who, on a population basis, are at differentially high risk arising from both LBW and low maternal intelligence. Cumulative effects of LBW and diminished maternal IQ on cognitive development have seldom been examined extensively (Ramey & Ramey, 1992). Furthermore, the assumption is that LBW infants of low-IQ mothers are particularly vulnerable to socioeconomic and biological risks that predispose all children to impaired cognitive development. This study was designed to examine comparative and cumulative influences of socioeconomic and biological risk factors on cognitive development of premature LBW children born to mothers with average and subaverage intelligence.

The analytical rationale for this study derives from the "new morbidity" model for prevention of children's health and behavior disorders (Baumeister et al., 1993). This multivariate conceptualization delineates ways that cognitive development among premature LBW infants might be influenced by biological, socioeconomic, and psychological risk factors alone or in concert. A contextual model is employed that includes "predisposing" factors (such as maternal age, marital status, and sex of child), "catalyzing" variables (e.g., poverty), and "resource" variables (personal and social resources of children and families). The child is regarded as a biological system in interaction and transaction with a network of family, community, social, service, economic, and political influences. Numerous studies have shown that the predisposing variables emphasized by Baumeister et al. (1993) are associated with delayed cognitive development in LBW children. For example, child intellectual development is related to maternal age (Liaw & Brooks-Gunn, 1993). In addition, young maternal age confers increased relative risk of premature LBW independent of other sociodemographic considerations (Fraser, Brockert, & Ward, 1995). Aspects of family structure have also been linked to intellectual development (Ricciuti & Scarr, 1990; Sameroff, Seifer, Barocas, Zax, & Greenspan, 1987). Poverty, as measured by SES or family income, also conditions cognitive development (Duncan, Brooks-Gunn & Klebanov, 1994; Thompson et al., 1994). The relationship between resource variables, such as the quality of the home environment, and cognitive development has been documented in other studies (Bradley & Casey, 1992; Lee & Barratt, 1993; Liaw & Brooks-Gunn, 1993).

Maternal IQ is related to home environment, which in turn mediates the connection between maternal and child intelligence (Bradley et al., 1993). Presumably parents with greater intelligence generate more stimulating home experiences. It is also well established that family income level and marital status condition child intellectual development (Baumeister & Bacharach 1996; Campbell & Ramey, 1994).

The predictive advantage of a bioecological model is that it postulates an hierarchical structuring of variables influencing cognitive development in a specific population of at-risk children. Variables can be ordered according to casual priority providing a scheme to examine direct and indirect contributions to cognitive development of biological, socioeconomic, and psychological factors (Lee & Barratt, 1993). Because the new morbidity model is specific to a population of children who are often the subject of various types of intervention programs (e.g., Field, Widmayer, Stringer, & Ignatoff, 1980; Infant Health and Development Program, 1990; Scarr-Salapatek & Williams, 1973), it can be employed to establish risk profiles for identification of children who would most benefit from such programs.

The new morbidity model predicts that income or SES should mediate effects of predisposing variables, such as maternal age and marital status, on cognitive development. Income or SES should also have a direct bearing on cognitive development. Resource variables are hypothesized to have direct impact on cognitive development in this group of at-risk children.

Because maternal IQ appears to be the strongest single predictor of a child's cognitive development, separate analyses were conducted for low-IQ and average-IQ mothers on the assumption that the magnitude of the effects of variables that predispose children to risk might differ for these two groups. Detrimental effects of LBW on cognitive development interact with numerous other variables. Because maternal IQ is such a potent predictor of child cognitive development and because maternal IQ is associated with rearing environment, children born to average-IQ mothers should be less vulnerable to other risk factors than children born to mothers with low IQ.

Infant Health and Development Program (IHDP)

Secondary analyses were performed on archival data from the IHDP (1990). The IHDP was a multisite randomized clinical trial study of the effects of intensive intervention on the intellectual development of preterm, low birthweight infants (<37 weeks gestational age, <2500 g). Infants selected to participate in the study were assigned at random to treatment or follow-up (control) groups. Children in the treatment condition received a package of services including home visitation beginning with discharge from the hospital and, at 12 months, parent group meetings, and center-based education services. Children in the follow-up group did not receive any of the intervention benefits. Data were collected on a large number of variables including maternal IQ, maternal age, and mother's marital status at the birth of her child, family income, and quality of the home environment. Details of the IHDP can be found in numerous publications (e.g., Brooks-Gunn, Klebanov, Liaw, & Spiker, 1993; IHDP, 1990; Gross et al., 1992; Gross, Spiker, & Haynes, 1997).

Methods

Participants

The sample studied in this analysis included 453 children who were assigned to the follow-up group in the IHDP and on whom there was a complete set of data for each of the following predictor variables: (a) maternal age at childbirth; (b) family income determined when the child was 1 year of age (these values were originally obtained by category; following the procedure reported by Duncan, Brooks-Gunn, and Klebanov [1994], values were converted to dollar amounts corresponding to the midpoints of each category; (c) marital status of mothers at childbirth (married or single head of household); and (d) total scores on the Infant-Toddler version of the Home Observation for Environment Inventory (HOME) scores (Caldwell & Bradley, 1984) obtained when the children were 12 months of age. Thirty-six-month Stanford-Binet IQ scores were available for all children in the sample. At the time of IQ assessment the most recent revision of the Stanford-Binet was not available.

Approximately 52% of the mothers in the follow-up sample were Black, 9% were Hispanic, and 39% were categorized as "White, Asian or Other." The sample included mothers from a wide range of socioeconomic backgrounds. Mothers as a whole were poorly educated (34% had not completed high school) and had low incomes (47% with incomes below $15,000). Birthweights of children in this sample ranged from 540 g to 2500 g (M = 1796.96 g; SD = 458.03 g).

The primary analysis is based on data from the follow-up group because these families did not receive an intervention designed to alter the developmental course of the children. Because of the intense intervention, the cohort of treatment children and their mothers would not be representative of the population of primary interest in the present study. However, a comparable analysis was conducted on the treatment group in order to determine whether the pattern of relationships would be influenced by the intervention.

Assessment

The Peabody Picture Vocabulary Test-Revised (PPVT-R) was chosen by the IHDP investigators to assess maternal IQ (Brooks-Gunn & Benasich, 1992). The PPVT-R was the only measure of maternal intelligence available for this study and, despite its well-established validity for predicting WAIS and Stanford-Binet scores, perhaps is best regarded as an indicator of receptive verbal ability. The PPVT-R was administered to participating mothers when their children were 18 months of age. Other trained assessors administered the HOME inventory. Children's IQs at 36 months of age were assessed using the Stanford-Binet Intelligence Scale Form L-M, 3rd edition. Child IQ scores were corrected for gestational age (IHDP, 1990).

Analytic Strategy

Hierarchical regression analyses were conducted to examine contributions of the predictor variables to child IQ variance. Order of entry was determined with reference to the Baumeister et al. (1993) model and by related logical considerations of causal priority (e.g., maternal age was entered before marital status). One method for examining interactions is to regress the dependent variable on the predictor variables separately for each level of a categorical variable (Cohen & Cohen, 1983; Kleinbaum, Kupper, & Muller, 1988). This approach was employed because an interaction was hypothesized between maternal IQ and the predictor variables as a set. Separate analyses were conducted on data from samples of children born to low-IQ mothers (equal to or less than 85) and to mothers with higher IQs (greater than 85).

Results

Summary statistical values for variables examined in this study can be found in Table I (the follow-up group). Data for the treatment group are presented in Table II. Zero-order correlation coefficients among the variables in the study can be found in Tables III and IV for the follow-up and treatment groups, respectively. The estimated relative risk of having an IQ score below 76 for a child born to a low-IQ mother in the follow-up group was 3.95 (95% confidence interval [CI] = 2.42, 6.43).

Table I. Descriptive Statistical Values of Variables in the Model for Participants in the Follow-up Group

Variables	Total (n = 453)	Low maternal IQ sample (n = 274)	Average maternal IQ sample (n = 179)
Child IQ	86.6 (19.5)	79.15 (14.4)	97.95 (20.7)
Maternal IQ	82.3 (21.7)	67.84 (10.6)	104.39 (14.6)
Maternal age	25.11 (5.9)	23.06 (5.2)	28.26 (5.7)
Home	33.97 (6.1)	31.72 (5.9)	37.41 (4.7)
Income (k)	21.65 (16.8)	14.82 (11.8)	32.10 (18.0)
Marital status (% married)	52.5	37.2	76.0

Table II. Descriptive Statistical Values for Variables in the Model for Participants in the Treatment Group

Variables	Total (n = 293)	Low maternal IQ sample (n = 184)	Average maternal IQ sample (n = 109)
Child IQ	94.87 (18.9)	88.60 (15.9)	105.44 (18.8)
Maternal IQ	81.08 (20.0)	68.39 (9.7)	102.50 (13.6)
Maternal age	24.60 (5.8)	23.16 (5.4)	27.05 (5.6)
Home	33.74 (6.2)	31.82 (6.2)	36.99 (4.9)
Income (k)	20.29 (17.5)	13.85 (13.0)	31.16 (18.6)
Marital status (% married)	42.70	29.30	65.10

Average-Maternal IQ Sample

A regression analysis was accomplished using data from the subsample of children in the follow-up group whose mothers had IQs greater than 85. The adjusted R^2 for the complete model was .31, $F(4,174) = 21.2$, $p < .001$. Statistically significant ($p < .001$) direct effects for marital status (r_p = .17), income (r_p = .31), and HOME scores (r_p = .25) were observed. There were statistically significant (p <.01) total effects associated with age (r_p = .21), marital status (r_p = .39), and income (r_p = .34). Table V shows the R^2 change as each variable was entered in the regression equation. (Comparable date for the treatment group are presented in Table VI.)

Low-Maternal IQ Sample

A second regression analysis was accomplished using data from the low-maternal IQ subsample. The adjusted R^2 for the complete model was .09, $F(4,269) = 7.6$, $p < .001$. Statistically significant direct effects were associated with age ($r_p = -.13$, p = .03), income (r_p = .15, p = .01), and quality of the home environment (r_p = .21, $p < .001$). The total effect for marital status was significant (r_p = .13, p =

Table III. Zero Order Correlation Coefficients for Variables in the Model for Participants in the Follow-up Group

Variables	Maternal IQ	Maternal age	Marital status	Income (k)	Home
Child IQ	.47	.26	.37	.52	.46
Maternal IQ		.43	.38	.50	.46
Maternal age			.38	.42	.30
Marital status				.48	.43
Income (k)					.44

All values statistically significant, $p < .01$.

Table IV. Zero Order Correlation Coefficients for Variables in the Model for Participants in the Treatment Group

Variables	Maternal IQ	Maternal age	Marital status	Income (k)	Home
Child IQ	.43	.22	.26	.32	.45
Maternal IQ		.33	.35	.48	.40
Maternal age			.39	.34	.37
Marital status				.41	.39
Income (k)					.42

All values statistically significant, $p < .01$.

.04), as was the total effect for income (r_p = .19, p = .001). Table VII shows the R^2 change as each variable was entered in the regression equation. (Data for the treatment group are presented in Table VIII.)

Marital Status

Although there was ample reason to anticipate that marital status would be related to LBW and cognitive development (e.g., Ahmed, 1990; Chomitz, Cheung, & Lieberman, 1995), the magnitude of the effect was unexpected. Therefore, several auxiliary analyses were pursued exploring different aspects of this variable. First, marital status had greater impact on cognitive outcome for children born to average-IQ mothers than for children born to low-IQ mothers (age-adjusted *b*s = 18.89 and 3.88, respectively). The difference between these partial regression coefficients was statistically significant, z = 2.99, $p < .01$.

Another way to examine this difference is to compare age-adjusted mean IQs as a function of marital status for the two groups of mothers. The mean IQ for children born to married, low-IQ mothers in the follow-up condition was 81.0, n = 102; the value for children born to unmarried, low-IQ mothers was 77.8, n = 172; respective values for average-IQ mothers were 102.8, n = 136 and 82.5, n = 43. This interaction was statistically significant, $F(1,448) = 24.7$, $p < .001$.

Not only were low-IQ mothers less likely than average-IQ mothers to be married at the birth of their children, but 22% of the low-IQ mothers who were married at the time of parturition no longer had husbands in the household by 24 months. At 24 months, husbands were in the households of 93% of the average-IQ mothers.

The Treatment Group. The major thrust of this analysis and its conclusions are based on the follow-up families. Those in the treatment condition are, in effect, unique in that they received a highly structured and intense intervention, the effects of which could be to nullify or distort the natural pattern of correlations. The sample was also much smaller. In addition there is an important initial difference between groups. Although families were randomly assigned to conditions, significantly fewer of the mothers in the treatment condition (about 10% fewer) were married. Nevertheless, it may be instructive to examine how the treatment

Table V. Partial Unstandardized Regression Coefficients and Standard Errors for Variables in Model by Order of Entry in Regression Equation for Average IQ Mothers in the Follow-up Group

Variables	Step 1	Step 2	Step 3	Step 4
Age	.78 (.27)	.43 (.26)	.04 (.25)	.008 (.25)
Marital status		18.89 (3.39)	11.68 (3.53)	8.17 (3.58)
Income (k)			.42 (.09)	.37 (.09)
Home				1.04 (.31)
R^2	.05	.19	.28	.33
Constant	75.85	71.43	74.20	40.41

All R^2 changes, p values < .01.

Table VI. Partial Unstandardized Regression Coefficients and Standard Errors for Variables in Model by Order of Entry in Regression Equation for Average IQ Mothers in the Treatment Group

Variables	Step 1	Step 2	Step 3	Step 4
Age	.56 (.32)	.43 (.34)	.38 (.35)	.11 (.34)
Marital status		2.04 (2.02)	1.56 (2.12)	−.10 (2.06)
Income (k)			.08 (.10)	.01 (.10)
Home				1.42** (.39)
R^2	.02	.04	.04	.15*
Constant	90.23	93.17	92.27	49.52

*Significant change in R^2, $p < .001$.
**Significant coefficient, $p < .001$.

Table VII. Partial Unstandardized Regression Coefficients and Standard Errors for Variables in Model by Order of Entry in Regression Equation for Low IQ Mothers in the Follow-up Group

Variables	Step 1	Step 2	Step 3	Step 4
Age	−.24 (.17)	−.24 (.17)	−.37 (.17)	−.37 (.17)
Marital status		3.88 (1.86)	2.20 (1.90)	.83 (1.90)
Income (k)			.25 (.08)	.19 (.08)
Home				.53 (.15)
R2	.007	.02*	.06**	.10***
Constant	84.59	85.49	83.20	67.64

*p of R^2 change: $p < .05$.
**$p < .01$.
***$p < .001$.

Table VIII. Partial Unstandardized Regression Coefficients and Standard Errors for Variables in Model by Order of Entry in Regression Equation for Low IQ Mothers in the Treatment Group

Variables	Step 1	Step 2	Step 3	Step 4
Age	.09 (.22)	.01 (.23)	−.02 (.23)	−.18 (.22)
Marital status		1.85 (1.33)	1.39 (1.36)	.55 (1.32)
Income (k)			.16 (.09)	.08 (.09)
Home				.79** (.20)
R^2	.001	.01	.02	.11*
Constant	86.53	89.18	87.52	66.69

*Significant change in R^2, $p < .001$.
**Significant coefficient, $p < .001$.

produced effects different from those observed among the follow-up families.

Marital status and income were more highly correlated with child IQ in the follow-up condition. These correlations may have been moderated by the intervention, although it is also the case that there was a smaller percentage of married mothers in the treatment cohort. This suggests the possibility of some difference between mothers in the two groups not reflected in Tables I and II. Examination of Tables V and VI reveals that HOME was the only variable in the regression model accounting for a significant proportion of child IQ variance in the treatment group. The effect of the treatment on HOME was not, however, reflected in improved mean scores relative to the follow-up for either maternal IQ group (Tables I and II).

In addition, mothers in the treatment condition were more likely than follow-up mothers to be employed for longer periods of time, although this effect interacted with birthweight (Brooks-Gunn, McCormick, Shapiro, Benasich, & Black, 1994). That is, the difference appeared among mothers of lighter birthweight infants (<2000 g). Free high-quality day-care for vulnerable children might be expected to influence employment. Concerning controlling for employment, mothers in the intervention group also were more likely to receive public assistance, possibly reflecting the impact of the home visitation component of the intervention package. In view of these and other considerations (Baumeister & Bacharach, 1996), for the purpose of sorting through risk factors for poor cognitive outcome the follow-up group is more representative of the population of LBW infants and their mothers.

Discussion

It is clear from the analysis presented here that factors influencing IQs of LBW children interact with maternal IQ. There are two sources of evidence for such interactions. One derives from the large difference in effect size for the low-IQ mothers' model compared with the model for the average-IQ mothers. Variables in the average-maternal IQ model accounted for approximately three times more of the children's IQ variance than the variables in the low-maternal IQ model.

Another indication of the interactive effect is the distinctly different pattern of relationships among the variables in the two models. The patterns differ in two ways: (a) with respect to the sources of mediation and (b) with respect to the magnitude of effect sizes. For example, maternal age was found to be directly linked to child IQ when data from the low-maternal IQ sample were examined; effects of maternal age were not mediated by other variables. In contrast, data from the average-maternal IQ sample revealed that family income and home environment mediated the contribution of maternal age to child IQ. There was no direct effect of maternal age on children's cognitive development in this sample.

In addition to differing with respect to structure, the models diverged with respect to the strength of links between the predictor variables and children's IQs. For example, the relationship between IQ and income was greater for children born to average-IQ mothers than for children born to low-IQ mothers.

It could be argued that these structural and effect size differences result from range restriction associated with the low-IQ mother sample. It is not possible to equivocally rule out this interpretation. However, a range restriction interpretation would fail to account for effects such as those associated with age in which a difference exists for the low-IQ sample but not for the average-IQ sample.

Other studies have shown that parental marital status (or father's presence in the home) is related to infant and childhood cognitive development (Featherstone, Cundick,& Jensen, 1992; Ricciuti & Scarr, 1990; Sameroff et al., 1987). However, the pervasiveness and size of the marital status effect were unexpected.

Regardless of the sample analyzed (in the follow-up group), marital status influenced children's IQs. Marital status had a large total effect on the cognitive development of these LBW children, partially mediated by both family income and quality of the home environment. Even with these variables controlled, a substantial direct effect of marital status was observed.

However, marital status is probably best viewed as a proxy variable for a complex web of correlations affecting family structure and other social support resources. Additional factors not included in the present analysis undoubtedly mediate effects of marital status on cognitive outcome. Given the types of information collected by IHDP, it was impossible to explore systematically the many possible hypotheses regarding the locus of the marital status effect.

On the other hand, as a practical matter, marital status is a strong predictor of cognitive outcome among LBW children. This variable could be useful for screening children for intervention programs and for generating socially supportive relationships and buffers through specialized services (Dunst, Trivette, & Cross, 1986; Feldman, 1994).

Clearly, preterm LBW children born to low-IQ mothers present a much greater risk of impaired cognitive development than LBW children born to average-IQ mothers. Although some maintain that cognitive intervention programs should be broadly targeted (Scott & Carren, 1987), results from the present study, along with those presented by McGauhey et al. (1991), suggest that a more realistic alternative is judicious targeting for intervention based on established risk factors, factors that differ across subgroups—for instance, the pathway from low SES to poor health differs for Black and Caucasian children (Starfield, 1992).

Results of the present analyses have other implications for cognitive intervention programs for at-risk children. The new morbidity model identifies variables that contribute significantly to IQ variance of children born to average-IQ mothers. However, for children of low-IQ mothers the model fits less well and fails to identify variables that contribute to IQ variance among these children. Given that the variables in the model are fairly standard representatives (e.g., income and quality of home environment) of the class generally thought to mediate maternal IQ effects on child IQ, the finding that they accounted for so little (10%) of IQ variance among children of the low-IQ mothers was unexpected. The present analyses suggest that interventions directed at children of mothers with low IQ (or by proxy, poorly educated mothers) need to focus on other variables. Data from the IHDP (1990) point to the same conclusion.

To the extent that the IHDP interventions influenced child IQ, the effect was limited to heavier birthweight infants. Given that overall effects of broadly conceived educational intervention on intelligence are small, transient, and restricted to children who are not seriously at risk to begin with, there is reason to question whether a standardized intervention is appropriate for all LBW infants (Baumeister & Bacharach, 1996). Differing risk profiles must be taken into account and interventions adjusted accordingly (McGauhey et al., 1991). Factors that contribute to individual differences among one group of children (e.g., children born to high-IQ mothers) may not contribute to individual differences among other groups of children (e.g., children born to low-IQ mothers) (Rowe, 1997).

Participants for cognitive intervention should be identified on the basis of the extent to which different variables are related to cognitive development. Analyses such as those performed here on the IHDP data can be used for risk assessments that are high in sensitivity and specificity. A more sensitive selection strategy would be to include marital status as a selection criterion. Furthermore, given the profile of risk factors examined here, there may be more to be gained clinically from an individually tailored intervention based on enhancing parenting skills and accessing support resources than on early preschool education. Although the current emphasis was on cognitive development of LBW children, not on prevention of LBW, counseling should also be directed at family planning in that one the most potent predictors of LBW is a prior pregnancy that resulted in a LBW child (e.g., Skjaerven, Wilcox, & Russell, 1988).

Although in the present analyses the emphasis has been on theoretical and technical implications, one important result is consistent with an increasingly large number of long-term follow-up studies of LBW infants who are not extremely small and/or premature, who do not present clear neurological handicap, and who are reared in reasonably supportive environments. As a group, these children will have approximately the same IQ as average weight, full-term infants.

Acknowledgments

Dr. Bacharach thanks the Department of Psychology and Human Development and the John F. Kennedy Center at Vanderbilt University for their hospitality during his study leave and the Department of Psychology at Appalachian State University for supporting the leave.

Received April 7, 1997; accepted December 9, 1997

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