BRIEF REPORT

A Prospective Study of Effects of Prenatal Maternal Stress on Later Eating-Disorder Manifestations in Affected Offspring: Preliminary Indications Based on the Project Ice Storm Cohort

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ABSTRACT

Background: Research associates maternal stress exposures (especially when occurring late in gestation) with heightened risk of subsequent emotional and behavioral problems in affected offspring. However, as yet, no study has examined the association between prenatal maternal stress (PNMS) and affected children's risk of anorexia- or bulimia-type eating disturbances.

Objective: To study the influences of PNMS on later disordered eating in exposed offspring.

Method: We used the Eating Attitudes Test (EAT)-26 to measure eating attitudes and behaviors in 54 thirteen-year olds whose mothers had been exposed, while pregnant with these children, to the 1998 Quebec Ice Storm—a natural disaster regarded as a model of exposure to severe environmental stress. Mothers' stress was measured shortly after exposure to the storm using established indices of objective and subjective stress.

Results: Hierarchical multiple linear regression analyses indicated that once variance owing to children's body mass index and sex was accounted for, stress exposures during the third trimester of pregnancy predicted elevated EAT-26 scores in affected children—perhaps even more so when levels of objective stress were high.

Discussion: Third trimester exposure to PNMS, especially when objectively severe, seems to be associated with increased eating-disorder-linked manifestations in affected early adolescents.

Keywords: eating disorders; maladaptive eating; risk factors; environmental stress; prenatal maternal stress

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Introduction

Maternal stress during pregnancy can have adverse effects on fetal neurodevelopment, and the later mental and physical status of exposed offspring.[1,2] Stress exposures during later stages of pregnancy are reported to be especially detrimental to subsequent emotional adjustment in affected children.[3–6] Suggesting that intrauterine stress can influence eating disorder (ED) development, obstetric complications have been linked to risk of EDs in exposed children.[7,8] However, to date, no study has examined the influence of prenatal maternal stress (PNMS) on children's later risk of developing ED-like symptoms.

Project Ice Storm[1] assessed children carried by women who were pregnant when a series of severe ice storms hit southern Quebec in January 1998. The Insurance Bureau and Environment Canada rate the 1998 ice storm as Canada's most devastating and costly natural disaster. Project Ice Storm has generated a small but very unique cohort, allowing for prospective study of effects on developmental outcomes in exposed children of mothers' random exposures, during pregnancy, to this independent natural stressor. Availability of data on a cohort of ice-storm-affected children, and a

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questionnaire-based assessment including a measure of maladaptive eating attitudes and behaviors conducted when these children reached the age of $13\frac{1}{2}$ years, provided us with a unique opportunity to carry out a prospective study of effects of the severity and timing of mothers' environmental stress exposures on ED-related outcomes in the affected children. This opportunistic dataset allowed us to view mother-to-child transmission of effects of stress exposure in a context that approximated a random exposure, objective aspects of which would (arguably) be quite independent of trait variations (e.g., specific genetic tendencies) in the mother. Hence, the specific aim of this study was to determine the extent to which PNMS and its timing explained variance in disordered eating in Project Ice Storm children. This is the first longitudinal study on the potential influence of intensity and timing of PNMS on later development of disordered eating in affected children.

Method

Participants

Women who were pregnant in January 1998 and lived in the area most harshly affected by the ice storm were invited (5 months after the storm hit) via a mailed invitation to take part in the project. A total of 224 women responded to the questionnaire, of whom, 178 consented to further contact. A variety of follow-up assessments have since been carried out with these women and their children.[9–12] At a $13\frac{1}{2}$-year follow-up (the object of this report), 54 children who had been conceived prior to the ice storm hit participated.

Measures

Eating Disorder Symptomatology. We used the Eating Attitudes Test (EAT-26)[13] to measure presence of ED-like symptoms and concerns. On the total EAT-26 score, a cutoff of 20 reliably differentiates clinical and nonclinical populations. The EAT-26 has good internal consistency ($\alpha = .86$) and test–retest reliability ($r = .87$), and its validity for use with adolescent populations is well supported.[14–16]

Body Mass Index. Anthropometric measures of height and weight (kg/m^2) were used to compute each child's body mass index (BMI) at the age of $13\frac{1}{2}$ years.

Objective Stress. The original Ice Storm Project utilized a face-valid questionnaire to reflect objective ice storm stress, quantifying such experiences as "days endured without electricity," "danger due to falling ice," etc. The original 32-item scale (dubbed Storm32) contained four subscales: loss, scope, threat, and change.[17] Six-year test–retest data obtained in a subgroup of the study's mothers supported the reliability of scope ($r = .80$), change ($r = .83$), and loss ($r = .69$) subscales, but less so of threat ($r = .43$).[17] Hence, we dropped the threat subscale to yield a 24-item scale, renamed Storm24.

Subjective Distress. We assessed the severity of mothers' subjective, storm-induced stress symptoms using the 22-item Impact of Event Scale—Revised (IES-R),[18] adapted to capture reactions specifically to the ice storm during the preceding 7 days. The IES-R has good internal consistency ($\alpha = .93$) and satisfactory test–retest reliability ($r = .76$).[19]

Timing of Ice Storm Exposure. We calculated the number of days between the beginning of pregnancy and peak of the ice storm (January 9, 1998). We then created a continuous variable reflecting number of days into pregnancy and categorical variables differentiating Trimester 1 (0–90 days of pregnancy), Trimester 2 (91–195 days of pregnancy), and Trimester 3 (196 and more days).

Data Analysis and Results

Data on sample characteristics are shown in **Table 1**. Overall, participating mothers tended to be relatively well-educated and to have upper-middle socioeconomic status. Although most children's EAT-26 scores were in the "subthreshold" (score < 20) range, three children, all girls, had above-threshold scores, suggesting possibility of a clinically significant eating problem. In all the three cases, mothers had been in the third trimester of gestation at the time of the ice storm hit.

Given limits of our sample size, and to avoid over-parameterizing any one statistical model, we conducted a series of separate hierarchical regression analyses to study predictors of children's EAT-26. Results of the main series, shown in **Table 2**, tested effects of prime interest—namely of stress (objective stress in one analysis and subjective stress in another), trimester of stress exposure (comparing exposure during Trimesters 1 and 2 with that during Trimester 3), and the stress by trimester interaction.

The analysis involving Objective Stress (Storm24 scores) showed that, together, BMI and sex explained 20% of the variance in children's EAT-26 scores [$F_{(2,\ 51)} = 6.41$, $p = .003$]. The entry of objective stress and trimester in Step 2 added a nonsignificant incremental 6.1% to variance explained [$F_{(2,\ 49)} = 2.0$, $p = .14$], whereas the inclusion of the stress by trimester interaction in Step 3 added a significant 6.1% to variance explained [$F_{(1,\ 48)} = 4.36$,

TABLE 1. Sample characteristics, showing means (±SDs) for continuous variables or frequencies (and percentages) for categorical variables

Characteristics	Full Sample ($n = 54$)	Girls ($n = 26$)	Boys ($n = 28$)
Mother's age at birth of child (years)	30.3 (±4.74)	30.2 (±3.87)	30.5 (±5.49)
Mother's education level (years)	15.3 (±2.45)	15.4 (±2.14)	15.1 (±2.74)
Highest household SES (Hollingshead)[a]	27.36 (±11.95)	28.9 (±12.1)	26.5 (±11.91)
Lower class	1 (1.85%)	1 (3.85%)	0
Lower middle class	1 (1.85%)	0	1 (3.57%)
Middle class	15 (27.78%)	9 (34.62%)	6 (21.43%)
Upper middle class	28 (51.85%)	12 (46.15%)	16 (57.14%)
Upper class	9 (16.67%)	4 (15.38%)	5 (17.86%)
Trimester at January 9th[b]			
First trimester	19 (35.18%)	9 (34.62%)	10 (35.71%)
Second trimester	18 (33.33%)	8 (30.77%)	10 (35.71%)
Third trimester	17 (31.48%)	9 (34.62%)	8 (28.57%)
Number of days of pregnancy at January 9th[c]	139 (±84.78)	140.77 (±86.64)	137.46 (±84.57)
Length of gestation (weeks)	39.4 (±1.95)	39.3 (±2.06)	39.5 (±1.87)
Birth weight (g)	3,351 (±549.45)	3,327 (±570.2)	3,373 (±538.92)
Weight at age 13 (kg)	58.0 (±18.1)	52.6 (±8.99)	62.6 (±22.42)
Height at age 13 (cm)	162.9 (±7.20)	160.7 (±5.16)	164.9 (±8.16)
BMI at age 13[d]	21.6 (±5.33)	20.3 (±3.05)	22.6 (±6.57)
Storm24	9.85 (±3.82)	9.58 (±3.94)	10.1 (±3.84)
IES-R	11.35 (±11.44)	11.11 (±11.60)	11.57 (±11.49)
EAT-26 Total	5.66 (±6.12)	7.92 (±7.65)	3.55 (±3.15)

[a]Socioeconomic status scores, which were determined from maternal and paternal education and occupation using the Hollingshead Index.
[b]First trimester corresponds to due dates falling between 0 and 90 days of gestation, second trimester to 91 and 195 days of gestation, and third trimester corresponds to due dates falling between 196 and 280 days of pregnancy.
[c]Smaller numbers indicate earlier exposure in pregnancy.
[d]Data imputation using mean value for BMI was used to substitute missing data for three participants who could not be weighed or measured at age 13½.

$p = .04$]. The incremental r^2 value for the trimester × stress interaction corresponded to a small effect size. Results indicate that, controlling for BMI and sex, and taking into account main effects of stress and trimester, the stress by trimester interaction contributes further to the explanation of children's disordered eating.

In the parallel analysis involving subjective stress (IES-R scores), BMI and sex again explained a significant proportion of EAT-26 score variance. The addition of subjective stress and trimester in Step 2 explained a marginally significant incremental 8% of the variance [$F_{(2,\ 49)} = 2.92$, $p = .06$], mainly attributable to a medium effect of the trimester variable. Later inclusion of the stress by trimester interaction (in Step 3) did not add significantly to variance explained [$F_{(1,\ 48)} = .34$, $p = .56$]. Again, results show that third trimester exposure to stress predicts greater likelihood of elevations in children's EAT-26 scores.

A second series of regressions (see Supporting Information Table S1) indicated that analyzing

TABLE 2. Predictors of EAT-26 Total Score with timing of storm as a dichotomous variable (Trimester 3 vs. Trimesters 1 and 2). Standardized beta coefficients, standard errors, semipartial correlations, variance, incremental variance, and F-change are presented

	Objective Stress (Storm24)							Subjective Stress (IES-R)						
	Step 1		Step 2		Step 3			Step 1		Step 2		Step 3		
Variable	β	SE	β	SE	β	SE	sr^2	β	SE	β	SE	β	SE	sr^2
BMI	0.27[a]	0.15	0.26[a]	0.15	0.28[a]	0.15	.03	0.27[a]	0.15	0.31[a]	0.15	0.30[a]	0.15	.03
Sex	0.42[b]	1.55	0.40[b]	1.53	0.40[b]	1.48	.17	0.42[b]	1.55	0.40[b]	1.50	0.39[b]	1.53	.17
Stress			0.04	0.20	−0.12	0.23	.00			−0.17	0.07	−0.11	0.09	.01
Timing			0.25[a]	1.62	−0.38	4.23	.06			0.29[a]	1.63	0.37[c]	2.44	.08
Stress × timing					0.67[a]	0.42	.06					−0.13	0.14	.00
R^2	.20		.26		.32			.20		.29		.29		
ΔR^2	.20		.06		.06			.20		.08		.00		
ΔF	6.42[b]		2.02		4.36[a]			6.42		2.92†		0.34		

†$p < .1$.
[a]$p < .05$.
[b]$p < .01$.

timing as a continuous variable produced results compatible with those involving the categorical (trimester-based) measure (shown in **Table 2**), except for the fact that the objective stress × timing interaction was now reduced to a trend ($p = .091$). The main effect of the timing variable was, however, still significant. A third series included sex as a predictor, to rule out the possibility that sex interacted with stress and timing variables in predicting disordered eating (see Supporting Information Table S2). Sex did not interact with these other variables.

Discussion

This prospective study assessed the impact of mothers' experiences while pregnant of an environmental stressor on the later development of maladaptive eating behaviors in a cohort of children who had been exposed during the gestational process. Overall, our results suggest that mothers' exposure to ice storm stress in the latter (third trimester) phase of pregnancy was associated with heightened EAT-26 total scores in affected offspring, over and above the component explained by sex (being female) and BMI (having a higher body mass). Furthermore, we obtained some evidence of interaction between stress and timing of exposure, suggesting that late pregnancy may be a "window of vulnerability" during which the more severe was a mothers' objective hardship from the ice storm, the more likely was her child to eventually develop disordered eating. Indications that mothers' stress exposures during late pregnancy may be especially detrimental to later signs of disordered eating in exposed children "echo" other findings, indicating that third trimester stress can have special impact on later emotional adjustment in children exposed to gestational stress in utero.[3–6] In this respect, our findings add to a body of evidence suggesting that PNMS is a risk factor for mental health outcomes, and may have various implications for etiological modeling and prevention in general and in the EDs area. We also emphasize that predictive effects of objective stress observed are intriguing, given that objective stress would have been relatively independent of any idiosyncratic traits in mothers that could have contributed to children's later eating symptoms through a genetic or environmental learning-based pathway. The preceding would be compatible with presence of fetal programming effects owing directly to PNMS. In light of a limited sample size available here, replication will be needed to ensure that such results are stable. Nonetheless, as we have noted, effects pointing to a particular influence of third trimester exposures on mental health outcomes in affected children are already precedented. Further work will also be needed to determine the extent to which any effects of the type observed are conducive to generalized maladjustment, or produce specific risk of maladaptive eating, and to isolate pathway(s) that may mediate any such prenatal stress effects.

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