Salivary Cortisol and Posttraumatic Stress Disorder in a Low-Income Community Sample of Women

Elizabeth A. Young, Richard Tolman, Kristine Witkowski, and George Kaplan

Background: *Studies of male combat veterans with posttraumatic stress disorder have demonstrated a profile of low cortisol. Studies with women with posttraumatic stress disorder (PTSD) have focused on childhood sexual abuse and holocaust survivors, both of whom experienced trauma during development, which could be different than adult trauma exposure.*

Methods: *Using an epidemiologic sample of low-income women from an urban area in Michigan, we conducted structured psychiatric interviews and saliva cortisol collection on a subsample of women with exposure to trauma but never PTSD (n = 72), recent PTSD (n = 29), and past PTSD (n = 70). Saliva cortisol was collected at awakening, 30 minutes later, at bedtime, and during a clinic visit.*

Results: *Recent trauma exposure but not past trauma exposure led to an increase in saliva cortisol. Neither recent PTSD nor past PTSD resulted in any saliva cortisol changes compared with the trauma exposed, never PTSD group. Recent major depression (past 12 months) demonstrated a weak effect (p = .08) on bedtime saliva cortisol.*

Conclusions: *While recent trauma exposure can increase saliva cortisol, neither recent nor past PTSD affected saliva cortisol in our community sample of women. Our data do not support saliva cortisol changes associated with PTSD.*

Key Words: Stress, trauma, PTSD, cortisol, HPA axis, major depression

The hypothalamic-pituitary-adrenal (HPA) axis is the main hormonal system activated by stress. Dysregulation of this system has been associated with psychiatric diseases, particularly major depressive disorder (MDD) and posttraumatic stress disorder (PTSD). While both diseases show abnormalities in the cortisol system, studies to date indicate that these abnormalities are in the opposite direction, with MDD showing increased urinary free cortisol (UFC), plasma cortisol, and saliva cortisol (Carroll et al 1976a, 1976b; Rubin et al 1987; Halbreich et al 1985; Young et al 2000, 2001), while PTSD is associated with low UFC and low plasma cortisol (Mason et al 1986; Yehuda 2002). The most comprehensive studies of PTSD by Yehuda and colleagues (Yehuda 2002) have assessed male combat veterans and found low UFC, lower plasma cortisol, enhanced suppression to dexamethasone, and a higher number of lymphocyte glucocorticoid receptors in veterans with PTSD compared with normal controls or combat controls. Furthermore, the presence of comorbid MDD does not change the neuroendocrine picture. The main criticism of this body of work is the nature of the sample: male combat veterans. Since women are most likely to experience PTSD in the community, male combat veterans are not representative of the community where this psychiatric disease is most likely to occur (Breslau et al 1991, 1999; Kessler et al 1995).

A number of studies have sought to address this problem by using nonveteran subjects recruited from clinics and the community. The majority of these studies have examined women with childhood sexual abuse. While some studies have demonstrated increased UFC (Lemieux and Coe 1995), others have demonstrated similar plasma cortisol (Rasmusson et al 2001) and still others have found lower cortisol and enhanced suppression to dexamethasone (Stein et al 1997). Furthermore, the issue of comorbid depression in this population has not been well addressed, although studies have examined the impact of childhood sexual abuse in subjects with MDD (Heim et al 2001), demonstrating greater stress responsiveness.

Community based samples focusing on natural disasters have examined exposure only with high and low PTSD symptoms (Davidson and Baum 1986; Fukuda et al 2000; Anisman et al 2001) but without diagnostic information. The exception was the study of Maes et al (1998), which looked at PTSD subjects recruited from community disasters and demonstrated increased UFC in PTSD; however, in that study, no attempt was made to obtain a representative sample. In addition to the issue of exposure to trauma, the persistence of the neuroendocrine changes following recovery from PTSD is unclear. In an early study, Yehuda et al (1995) reported that holocaust survivors with past but not current PTSD demonstrated normal UFC, while later studies of offspring of holocaust survivors (Yehuda et al 2002a, 2002b) suggested that changes in cortisol may persist beyond the duration of the symptoms and thus may be a marker of underlying vulnerability to PTSD.

Thus, much of the biological work on PTSD done with samples of male combat veterans may be limited in explaining the elevated vulnerability for women that is suggested by the epidemiologic data. Civilian studies of PTSD using biological measures have typically come from treatment-seeking patients or respondents recruited through advertisements. These may also represent unique populations that could differ in important ways from community samples. In addition, these samples focused on childhood sexual abuse, which may differ from exposure to trauma in adulthood only. Further, since low-income women may be particularly at risk of exposure to trauma and vulnerability to PTSD when exposed (Breslau et al 1999; Kessler et al 1999), it is important to examine the biology of PTSD among this vulnerable population.

Our analysis addresses research questions by using both biological and survey data collected from respondents originally sampled for the Women's Employment Study (WES). The WES

From the Department of Psychiatry and Mental Health Research Institute (EAY); School of Social Work (RT, KW); and Department of Epidemiology (GK), University of Michigan, Ann Arbor, Michigan.

Address reprints requests to Dr. Elizabeth A. Young, 205 Zina Pitcher Place, Ann Arbor, MI 48109-0720.

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collected information from a longitudinal community sample of women drawn from an urban county in Michigan who were receiving cash assistance from the state. We present data here on saliva cortisol collected in both clinical and home environments. The specific questions we focused on were: 1) Does exposure to trauma affect cortisol? 2) Do cortisol levels differ in subjects with PTSD from those exposed to trauma? 3) Does past PTSD show a similar saliva cortisol to current PTSD? 4) Does comorbid major depression affect the cortisol level in subjects with and without PTSD? Finally, we explored the effects of childhood versus adult trauma on cortisol measures.

Methods and Materials

Sample

We used data from the Women's Employment Study, a longitudinal study of a random sample of women receiving Temporary Assistance to Needy Families (TANF) benefits in one urban county of Michigan in February 1997. The sample included recipients aged 18 to 54 who were African American or White and were listed as single parents. In the first wave of WES, conducted in 1997, 753 interviews were completed, a response rate of 86% of the original sample. The second wave of interviews was completed in fall 1998 with 693 respondents, and the third wave was completed in late 1999 with 632 respondents. The third wave sample represented 72% (632/875) of the original sample. All subjects gave informed consent for both the interviews and saliva collection, and these studies were approved by the University of Michigan School of Public Health Institutional Review Board.

Psychiatric Assessment

Posttraumatic stress disorder was measured using a modification of the University of Michigan-Composite International Diagnostic Inventory (UM-CIDI) (Kessler et al 1994), which determines the lifetime prevalence of PTSD based on women's responses to the most upsetting traumatic events. If symptoms from the most upsetting event persisted into the 12 months before an interview, we classified the respondent as having recent PTSD. Our modification included an expansion and limited rewording of the trauma event checklist.

Using the trauma events checklist from the UM-CIDI PTSD measure, we also constructed variables indicating exposure to various categories of trauma. Using reports of timing of events, we classified whether respondents had experienced these traumas in the past 12 months, in adulthood, or in childhood. We created measures of interpersonal violence trauma to the respondent (forced to have sex or raped, sexually molested or sexually abused, physically attacked or assaulted, threatened with a weapon, or kidnapped or held captive), other trauma (car accident, disaster, witness to violent event, sudden death of close friend/relative, serious illness, other severe shock, or other noninterpersonal trauma), and childhood abuse (physical abuse while growing, rape or sexual molestation before age 16, seriously neglected, or witnessed family violence while growing up). We also created a variable combining these categories into any childhood trauma (any trauma event before age 16), any childhood abuse (physical abuse, sexual abuse, or neglect), any adulthood trauma (any trauma after age 16), and any recent trauma (any trauma event in the past 12 months). Retrospective data from all three waves of the WES were used to edit reporting inconsistencies. For instance, a person is said to have experienced a childhood trauma if she reported this trauma in any wave.

Additionally, we used a modified version of the Conflict Tactics Scale (CTS) (Straus 1979) to measure domestic violence. Women were asked to report if they had ever experienced various types of abuse by an intimate partner and if they had experienced these acts in the past 12 months. For this article, we classified women as having experienced domestic violence if they reported their intimate partner had done any of the following: hit you with a fist, hit you with an object that could hurt you, beaten you, choked you, threatened to or used a weapon against you, or forced you into any sexual activity against your will. While these same acts may have been reported by women on the trauma event checklist as physical or sexual assault in adulthood, we include this measure to provide more specific trauma classification. Further, some women who reported domestic violence on the CTS measure did not report physical assault on the trauma event checklist.

We used the World Health Organization-Composite International Diagnostic Inventory-Short Form (WHO-CIDI-SF) (Kessler et al 1998) to measure whether or not the respondent met criteria for major depression, social anxiety disorder (SAD), generalized anxiety disorder (GAD), or drug dependence and alcohol dependence within 12 months before their interviews. These diagnostic screening scales are based on the National Comorbidity Study (NCS), the first nationally representative survey to administer a structured psychiatric interview (Kessler et al 1994). The CIDI-SF scales correctly classified between 77% and 100% of CIDI cases and between 94% and 99% of CIDI noncases in the NCS. The classification accuracy for MDD was 93% to 99% for GAD (Kessler et al 1998).

Salivary Cortisol

In June 2000, following completion of the third wave of WES data collection, a special health supplement (WES-HS) was administered to the WES survey respondents. There were 632 respondents to the third wave of WES data collection. Of these, 298 completed the WES-HS. Excluding those who had moved out of the county (19) or could not be located (35), the response rate was 52% (298/578). Demographic characteristics (age, race, number of children in household, and education) of the respondents in the health supplement were quite similar to the full wave 3 WES sample, although they were slightly younger (30.0 vs. 31.4 years, $p < .05$). A comparison of the cortisol subsample ($n = 190$) with the full WES wave 3 sample is shown in Table 1. One cortisol sample was drawn during a clinic visit, and three additional samples were collected by subjects over a 1-day period. Subjects were asked to collect a sample on awakening, 30 minutes after awakening, and at bedtime, using salivettes. Subjects were instructed to delay breakfast until after the second sample.

Samples were returned by mail to the data tracking center and frozen at −20°C until assay. Samples were thawed and spun in the laboratory immediately before assay. They were assayed using DPC Coat-a-Count tubes (Diagnostic Products Corporation, Los Angeles, California) and 200 μL of saliva per tube, following manufacturer's directions. Interassay variability was 10%. All cortisol values were log transformed before analysis; however, all values presented in figures and tables are not transformed (i.e., unlogged). Subjects with saliva cortisol readings greater than 2.0 μg/dL were deleted from analyses (outliers). In all, we collected at least one cortisol sample from 190 women. These cortisol measures were drawn from 163 clinic samples, 170

Table 1. Mean Cortisol ± Standard Error (μg/dL) by Diagnostic Group

Group	Awakening	AM	Bedtime	Clinic
Never Exposed $n = 16$	.39 ± .05	.43 ± .08	.15 ± .05	.31 ± .07
Exposed, Never PTSD $n = 72$	.47 ± .03	.57 ± .04	.18 ± .02	.34 ± .03
Recent PTSD $n = 29$	.45 ± .05	.50 ± .05	.26 ± .07	.35 ± .04
Past PTSD $n = 70$	.43 ± .04	.48 ± .03	.25 ± .07	.33 ± .04
Recent PTSD, No MDD $n = 17$	.46 ± .07	.49 ± .07	.17 ± .05	.35 ± .06
Recent PTSD, Recent MDD $n = 12$	.44 ± .08	.51 ± .12	.38 ± 14	.35 ± .05
Past PTSD, No MDD $n = 56$	.44 ± .04	.48 ± .04	.18 ± .03[a]	.39 ± .04
Past PTSD, MDD $n = 14$	.41 ± .10	.48 ± .06	.21 ± .06	.45 ± .11

PTSD, posttraumatic stress disorder; MDD, major depressive disorder.
[a]Significantly different ($p < .05$) from all recent MDD group, ($n = 22$) and from past PTSD, recent MDD group at trend level ($p = .08$).

waking samples, 173 second-morning samples, and 166 bedtime samples.

Data Analysis

We collected data for both PTSD and MDD from 624 WES respondents. Of these, only 42 had never experienced trauma. The 187 cases with UM-CIDI and cortisol data from the health supplement cohort represent our study's analytical sample. Of these, only 16 had never experienced trauma.

Using ordinary least squares (OLS) regression and repeated-measures mixed models (Singer 1998), we tested for significant psychiatric factors that affect absolute levels and circadian patterns of cortisol, while controlling for data collection characteristics. Ordinary least squares regression was used to model absolute cortisol levels of clinical, waking, and bedtime samples. Repeated-measures mixed models were used to model the fall in cortisol levels between waking and bedtime samples (i.e., individual growth curves), as well as "average" cortisol levels of all collected samples. We defined statistical significance as $p \leq .05$, unless otherwise noted.

While times of waking and bedtime were ascertained for the day when respondents collected their circadian samples, we did not collect information on the time of waking for the day when the clinic sample was collected. For our clinic sample, collection time was controlled by including an indicator for the number of minutes after 6:00 AM that the sample was taken. In modeling waking samples, we controlled for the number of minutes after waking that the sample was taken. For bedtime samples, we controlled for the number of minutes after waking that a respondent went to bed and the number of minutes before bed that the sample was taken.

Pooling data from the waking and bedtime samples, we constructed a model for the "fall between waking to bedtime" in cortisol levels. Controlling for collection time, we included three continuous variables for number of minutes after waking that the sample was taken, number of minutes before bed that the sample was taken, and number of minutes after waking that a respondent went to bed.

Pooling data from all cortisol samples (i.e., clinic, waking, 30-minute, and bedtime samples), we constructed a model for "average" absolute cortisol levels. Controlling for collection time, we created four dummy variables indicating whether any of the samples were drawn 0 to 14 minutes after waking (omitted reference group), 15 to 29 minutes after waking, 30 to 44 minutes after waking, and 45 to 59 minutes after waking. We also included a continuous variable indicating the number of minutes after waking for samples drawn after 60 minutes. Finally, we included a dummy for "clinic" sample to account for measurement error stemming from the lack of waking time data.

In addition to the tendency to collect samples at the inappropriate time, a significant proportion of the subjects (38%) collected the second saliva sample following breakfast rather than before eating. Only in the "absolute waking" model and the "fall between waking to bedtime" model do we control for whether the respondent ate before the waking sample collection. All respondents had eaten before their bedtime samples, while no such information was collected for the clinic saliva sample.

Given the high rates of smoking and its potential effect on the quality of our cortisol data, we also controlled for the likelihood of smoking a cigarette before collecting a sample. This variable was constructed using information about whether a person currently smoked and when they usually had their first cigarette of the day (1 = smoker who is likely to have early morning cigarette; 0 = nonsmoker or smoker who is not likely to have early morning cigarette). We assumed that all smokers had a cigarette before their evening sample. Finally we controlled for age, pregnancy status, and work schedule to account for extraneous biological factors affecting cortisol levels. Since cortisol levels follow a circadian pattern, we controlled for variations stemming from work patterns: currently unemployed (reference group), day shift, evening shift, and mixed shift. Measures of age, pregnancy, smoking behavior, and work patterns were drawn from wave 3 survey data. These data were collected approximately 3 to 6 months before cortisol data.

Results

Comparison of Subset to Entire WES Sample

Overall, there were few demographic differences between the cortisol subsample and the entire WES sample. In comparison with the entire wave 1 sample, the women in the cortisol subsample were more likely to be white, older, have more years of education, and have more years of prior welfare receipt. The cortisol subsample did not differ from the entire wave 1 sample in terms of MDD and PTSD. The cortisol subsample was more likely to have experienced trauma as an adult before the last year. There were no differences between the subsample and original sample in experiences of trauma in the last year (i.e., recent adult trauma). Childhood trauma was present in a higher proportion of the cortisol subsample at a trend level ($p < .1$).

Psychiatric Diagnoses and Trauma Experiences

As expected, higher rates of psychiatric comorbidity were found among those with lifetime PTSD than the nonexposed and exposed, never PTSD groups. Those with past or recent PTSD were significantly most likely to meet criteria for major depression (41% in recent and 29% in past), to have GAD (31% recent

Table 2. Impact of Specific Traumas on Cortisol Levels (μg/dL)

Factor	Presence	*n*	Clinic Cortisol	AM Cortisol	PM Cortisol	Average Cortisol	*p*
Domestic Violence	Yes	17	.35	.46	.25	.38	*ns*
	No	170	.33	.44	.19	.36	
Childhood Abuse	Yes	89	.36	.44	.19	.37	*ns*
	No	98	.31	.45	.19	.36	
Recent Trauma	Any Recent Trauma	70	.36	.48	.23	.40	*a*
	No	117	.32	.43	.17	.34	
Past Adult Trauma $n = 117^b$	Yes	67	.30	.43	.14	.33	*ns*
	No	50	.34	.42	.21	.36	

[a]Those recently experiencing any recent trauma have significantly higher average 4-sample cortisol levels.
[b]Those who experienced recent trauma ($n = 70$) deleted.

and 16% past), and to be dependent on drugs (10% recent vs. 6% past). In the sample, women with recent and past PTSD were significantly more likely to have been abused as children (72% and 56%, respectively) than those not manifesting PTSD (40%). Rates of any childhood trauma (70% trauma exposed sample), any adult trauma (66% trauma exposed sample), and recent adult trauma (41% trauma exposed sample) did not differ between PTSD and trauma exposed, never PTSD groups.

Saliva Collection Adequacy

To estimate the potential amount of measurement error and analytical bias in the cortisol data, we compiled information regarding compliance with sample collection procedures and provision of sample collection data (i.e., complete information provided on times of waking, sample collection, and eating). Mean awakening time was 8:02 ± 9 minutes (SEM). For those providing data collection information, the first saliva sample was collected, on average, 15 ± 1 minute (SEM) following awakening. The second saliva sample was collected 99 ± 9 minutes (SEM) following awakening, rather than 30 minutes later as instructed. The bedtime samples were collected at bedtime 23:16 ± 11 minutes. Thus, 50% of respondents had "unbiased" waking samples, 24% had "unbiased" second-morning samples, and 72% had "unbiased" bedtime samples.

Using time from awakening, we were able to model a morning rise in the subjects who properly collected samples at awakening and 30 minutes later. Those who followed collection procedures had an average waking cortisol level of .41 μg/dL, with a steep increase in their 30-minute cortisol levels (average of .62 μg/dL). Those who did not follow procedures tended to have slightly elevated waking cortisol levels that were equal, on average, to their 30-minute sample. (.49 μg/dL for both waking and 30-minute cortisol levels). Due to the small number of subjects who properly collected the second morning sample, we chose not to model further the circadian rise in cortisol between our two morning samples. There was little difference between these two groups in average bedtime cortisol levels (.19 and .20 for those following and not following procedures, respectively).

Relationship of Cortisol to Psychiatric Diagnosis and Trauma History

Table 1 shows the cortisol levels (by collection time) for women who were unexposed to trauma, exposed to trauma but never developed PTSD, met criteria for current PTSD at the time of interview (recent PTSD), and who had PTSD in the past but were recovered at the time of interview (past PTSD). Individuals who met criteria for major depression were present in all groups (Table 1) but particularly the PTSD groups. There was an overall significant circadian difference with bedtime samples showing lower cortisol levels than waking samples; however, there was no significant difference in absolute cortisol or delta scores for morning and evening samples among groups. Exposure to trauma had no significant effect on saliva cortisol. As can be seen, active PTSD ($n = 29$) and past PTSD ($n = 70$) show similar levels of cortisol.

The influence of recent (past year) comorbid depression on recent PTSD is also shown in Table 1. In the absence of comorbid major depression, individuals with past or current PTSD show identical levels of saliva cortisol. The comorbid MDD-PTSD subjects appear to show relatively higher evening cortisol levels than MDD alone, with average levels of .38 and .20, respectively; however, this difference is not statistically significant. Multivariate analyses indicated a weak effect of recent MDD on evening cortisol compared with past PTSD ($n = 56$, logged coefficient of −.90; $p = .05$). The recent MDD, past PTSD group ($n = 14$) also shows higher cortisol than the past pure PTSD subgroup ($n = 56$), which is significant at the trend level ($p = .08$). The small sample size of the comorbid depression groups in both current and past PTSD may affect the ability to find a significant effect of depression.

No significant differences in cortisol levels were found when comparing women who were abused as children ($n = 89$) versus those who were not abused ($n = 98$) (Table 2). We further explored whether the type of trauma experienced in childhood, i.e., physical abuse ($n = 49$), neglect ($n = 39$), rape ($n = 35$), molestation ($n = 56$), other interpersonal violence ($n = 71$), noninterpersonal trauma (i.e., car accident) ($n = 39$), and no childhood trauma ($n = 68$), affected saliva cortisol, and no differences were found.

We performed analyses to determine the effects of trauma in adulthood on saliva cortisol (Table 2). Women with recent trauma (past 12 months) had significantly higher cortisol levels (four-sample average; logged coefficient of +.20; $p = .04$; $n = 70$) than those not recently traumatized ($n = 117$). We found no significant differences in cortisol levels when comparing women with recent assaultive violence ($n = 20$) versus women without assaultive violence ($n = 167$). Small sample size may have affected our ability to detect a significant difference. Past (greater than 1 year) adult exposure to trauma or interpersonal violence was not related to cortisol secretion.

Discussion

First, this study demonstrates the feasibility of collecting saliva cortisol from a poor, low-income community sample. While respondents generally complied with cortisol sampling overall, the timing of the cortisol samples tended not to be as requested. Thus, it is extremely important to collect information on actual timing of the saliva samples in epidemiologic studies. Recent studies have suggested that the morning rise in cortisol is reflective of overall levels of stress (Pruessner et al 1999; Wust et al 2000). However, only 24% of the sample was able to follow through and collect a second sample 30 minutes after awakening, and consequently, it was difficult to use the 30-minute sample data for analysis. We were able to observe the expected circadian decline in cortisol samples over the remaining course of the day.

To summarize the findings, in this study we observed an effect of recent trauma exposure on increasing saliva cortisol but no effect of past trauma exposure (either adulthood or childhood) on saliva cortisol. We found no changes in cortisol with recent PTSD compared with exposed, never PTSD subjects and no difference between recent and past PTSD on saliva cortisol measures. We did observe a small effect of recent MDD on evening saliva cortisol and only in comparison with the past PTSD group. Within the past PTSD group, those with recent MDD showed a trend level increase in evening cortisol.

These data, using a community-based epidemiologic sample of low-income women, demonstrate extremely high rates of trauma exposure. In fact, the small number of subjects without lifetime trauma exposure is the greatest limitation of this study. Furthermore, these individuals differ on multiple other factors from the individuals exposed to trauma, so it is difficult to address the effects of lifetime exposure on saliva cortisol with this sample. We were able to demonstrate a significant effect of recent exposure to trauma (past year), suggesting that exposure per se may have an effect but that the effect is transient, since effects of past adult trauma on cortisol were not observed, irrespective of whether the trauma exposure involved interpersonal violence or not. In addition, our data do not support a long-lasting effect of childhood trauma on cortisol levels in adulthood, since again we saw no difference in saliva cortisol between those with childhood trauma and those without; however, it is possible that continued exposure to trauma masked an effect of childhood trauma on cortisol, since recent trauma exposure did elevate cortisol.

As reviewed in the introduction, studies of cortisol in PTSD have demonstrated contradictory results, with several studies failing to confirm that PTSD subjects demonstrate low cortisol in comparison with normal controls or exposed controls (Lemieux and Coe 1995; Rasmusson et al 2001; Maes et al 1998) and some studies demonstrating increased cortisol in individuals with PTSD (Lemieux and Coe 1995; Maes et al 1998). While this sample is not well suited to answer the question of the impact of exposure, it does include a large number of exposed individuals who did not experience PTSD ($n = 72$), as well as recent ($n = 29$) and past PTSD cases ($n = 70$). Furthermore, since it is drawn from an epidemiologic sample, it does not have ascertainment biases introduced by advertising or clinic recruitment. Also, it focuses on women, who constitute the majority of cases in the community. Our comparisons of the saliva cortisol subsample with the sample at large indicate few significant differences on a number of demographic, psychiatric, and socioeconomic status (SES) factors, so this subsample appears to be sufficiently representative of the entire sample; however, the lag time between interview and saliva collection (3 to 6 months) limits our knowledge about who had active PTSD symptoms at the time of the saliva collection but enables us to compare recent PTSD and past PTSD. These data demonstrate that past PTSD and recent PTSD show similar saliva cortisol levels and that these do not differ from levels in persons exposed to trauma without development of PTSD, particularly when subjects with recent MDD are removed from the analysis (Table 1). Thus, our data present evidence for normal baseline HPA axis functioning in both recent and past PTSD.

In this sample, we were unable to observe any further significant effect of comorbid MDD on the HPA axis profile of recent PTSD, but we were greatly limited by sample size ($n = 12$) to address this question; however, individuals with past PTSD who are not depressed do show lower evening cortisol than individuals with recent MDD without recent PTSD. Thus, there does appear to be some enduring effects of recent major depression on saliva cortisol, in agreement with a previous study demonstrating increased cortisol in women with past major depression (Young et al 2000) compared with women who never experienced MDD. In another study examining urinary cortisol in an epidemiologic sample with exposure to trauma and lifetime MDD and PTSD information, we observed an increase in evening UFC in women with the lifetime comorbid MDD and PTSD (Young and Breslau, in press). The data presented here are in agreement with those data demonstrating that PTSD per se has no effect on UFC, but that individuals with lifetime MDD comorbid with lifetime PTSD show elevated UFC. Unfortunately, we do not have data on MDD beyond the past year in the current study to address lifetime MDD; consequently, the current analysis is limited to recent MDD. But overall in this study, the effect of comorbid PTSD and MDD on saliva cortisol is not different than the effect of MDD itself. Finally, since this study was a sample of women only, we cannot address possible gender differences in the effects of PTSD on cortisol.

The high rates of exposure to trauma in this sample and the high rates of PTSD in these low SES women have significant public health implications, suggesting trauma is affecting mental health. Other biological measures from the sample suggest a high burden of medical disease, as well as significant psychiatric burden. These data suggest a need for more extensive psychiatric services for these populations.

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Anisman H, Griffiths J, Matheson K, Ravindran AV, Merali Z (2001): Posttraumatic stress symptoms and salivary cortisol levels. *Am J Psychiatry* 158:1509–1511.

Breslau N, Chilcoat HD, Kessler RC, Davis GC (1999): Previous exposure to trauma and PTSD effects of subsequent trauma: Results from the Detroit area survey of trauma. *Am J Psychiatry* 156:902–907.

Breslau N, Davis GC, Andreski P, Peterson E (1991): Traumatic events and posttraumatic stress disorder in an urban population of young adults. *Arch Gen Psychiatry* 48:216–222.

Carroll BJ, Curtis GC, Mendels J (1976a): Neuroendocrine regulation in depression: I. Limbic system-adrenocortical dysfunction. *Arch Gen Psychiatry* 33:1039–1044.

Carroll BJ, Curtis GC, Mendels J (1976b): Neuroendocrine regulation in depression: II. Discrimination of depressed from non-depressed patients. *Arch Gen Psychiatry* 33:1051–1058.

Davidson LM, Baum A (1986): Chronic stress and posttraumatic stress disorders. *J Consult Clin Psychol* 54:303–308.

Fukuda S, Morimota K, Kanae M, Maruyama S (2000): Effect of the Hanshin-Awaji earthquake on posttraumatic stress, lifestyle changes, and cortisol levels of victims. *Arch Environ Health* 55:121–125.

Halbreich U, Asnis GM, Schindledecker R, Zurnoff B, Nathan RS (1985): Cortisol secretion in endogenous depression. I. Basal plasma levels. *Arch Gen Psychiatry* 42:909–914.

Heim C, Newport DJ, Bonsall R, Miller AH, Nemeroff CB (2001): Altered pituitary-adrenal axis responses to provocative challenge tests in adult survivors of childhood abuse. *Am J Psychiatry* 158:575–581.

Kessler RC, Andrews G, Mroczek D, Üstün TB, Wittchen H-U (1998): The World Health Organization Composite International Diagnostic Interview Short Form (CIDISF). *Int J Methods Psychiatr Res* 7:171–185.

Kessler RC, McGonagle KA, Zhao S, Nelson CB, Hughes M, Eshelman S, et al (1994): Lifetime and 12-Month prevalence of DSM-IIIR psychiatric disorders in the United States: Results from the national comorbidity survey. *Arch Gen Psychiatry* 51:8–19.

Kessler RC, Sonnega A, Bromet E, Hughes M, Nelson CB, Breslau N (1999): Epidemiological risk factors for trauma and PTSD. In: Yehuda R, editor. *Risk Factors for Posttraumatic Stress*. Washington, DC: American Psychiatric Press.

Kessler RC, Sonnega A, Bromet E, Nelson CB (1995): Posttraumatic stress disorder in the National Comorbidity Survey. *Arch Gen Psychiatry* 52:1048–1060.

Lemieux AM, Coe CL (1995): Abuse-related posttraumatic stress disorder: Evidence for chronic neuroendocrine activation in women. *Psychosom Med* 57:105–115.

Maes M, Lin A, Bonaccorso S, van Hunsel F, Van Gastel A, Delmeire L, et al (1998): Increased 24-hour urinary cortisol excretion in patients with post-traumatic stress disorder and patients with major depression, but not in patients with fibromyalgia. *Acta Psychiatr Scand* 98:328–335.

Mason JW, Giller EL, Kosten TR, Ostroff RB, Podd L (1986): Urinary-free cortisol levels in posttraumatic stress disorder patients. *J Nerv Ment Dis* 174:145–159.

Pruessner JC, Hellhammer DH, Kirschbaum C (1999): Burnout, perceived stress, and cortisol responses to awakening. *Psychosom Med* 61:197–204.

Rasmusson AM, Lipschitz DS, Wang S, Hu S, Vojvoda D, Bremner JD, et al (2001): Increased pituitary and adrenal reactivity in premenopausal women with posttraumatic stress disorder. *Biol Psychiatry* 50:965–977.

Rubin RT, Poland RE, Lesser IM, Winston RA, Blodgett N (1987): Neuroendocrine aspects of primary endogenous depression. I. Cortisol secretory dynamics in patients and matched controls. *Arch Gen Psychiatry* 44:328–336.

Singer JD (1998): Using SAS PROC MIXED to fit multilevel models, hierarchical models, and individual growth models. *J Educ Behav Stat* 24:323–355.

Straus MA (1979): Measuring intrafamilial conflict and violence: The conflict tactics (CT) scale. *J Marriage Fam* 45:75–78.

Stein MB, Yehuda R, Koverola C, Hanna C (1997): Enhanced dexamethasone suppression of plasma cortisol in adult women traumatized by childhood sexual abuse. *Biol Psychiatry* 42:680–686.

Wust S, Federenko I, Hellhammer DH, Kirschbaum C (2000): Genetic factors, perceived chronic stress, and the free cortisol response to awakening. *Psychoneuroendocrinology* 25:707–720.

Yehuda R (2002): Current status of cortisol findings in post-traumatic stress disorder. *Psychiatr Clin North Am* 25:341–368.

Yehuda R, Bierer LM, Schmeidler J, Aferiat DH, Breslau I, Dolan S (2002a): Low cortisol and risk for PTSD in adult offspring of holocaust survivors. *Am J Psychiatry* 157:1252–1259.

Yehuda R, Halligan SL, Bierer LM (2002b): Cortisol levels in adult offspring of holocaust survivors: Relation to PTSD symptom severity in the parent and child. *Psychoneuroendocrinology* 27:171–180.

Yehuda R, Kahana B, Binder-Byrnes K, Southwick SM, Mason JW, Giller EL (1995): Low urinary cortisol excretion in holocaust survivors with posttraumatic stress disorder. *Am J Psychiatry* 152:982–986.

Young EA, Aggen SH, Prescott CA, Kendler KS (2000): Similarity in saliva cortisol measures in monozygotic twins and the influence of past major depression. *Biol Psychiatry* 48:70–74.

Young EA, Breslau N (in press): Cortisol and catecholamines in posttraumatic stress disorder: An epidemiological community study. *Arch Gen Psych*.

Young EA, Carlson NE, Brown MB (2001): 24-hour ACTH and cortisol pulsatility in depressed women. *Neuropsychopharmacology* 25:267–276.