Hypothesis

• Chronic stress-induced dysregulation of daily stress hormone rhythms, and the biological systems they regulate, help to account for both socioeconomic and racial/ethnic disparities in health.

• Stress during childhood and adolescence may be particularly influential for adult stress biology and health outcomes.
Health Disparities

• Socioeconomic = worse health at each step lower in socioeconomic position (measured by income, education, occupational status), across a range of health outcomes

• Race-Based = worse health for disadvantaged and marginalized racial-ethnic minorities (partially due to, but even after taking into account the effects of SES)
Banks, Marmot et al., 2006 (NHANES, ELSA)

Higher income → lower fair/poor health
Higher income $\rightarrow$ lower heart disease
Higher socioeconomic status – lower under 5 mortality
Racial/Ethnic Health Disparities

FAIR OR POOR HEALTH STATUS BY RACE/ETHNICITY AND INCOME, 2007

Share reporting fair or poor health:

- **White, Non-Hispanic**
  - Less than 100% of Poverty: 20.9% 21.0%
  - 100-199% of Poverty: 15.2% 15.1%
  - 200%+ of Poverty: 5.9% 9.1%

- **Hispanic**
  - Less than 100% of Poverty: 22.6%
  - 100-199% of Poverty: 17.7%
  - 200%+ of Poverty: 9.4%

- **African-American, Non-Hispanic**
  - Less than 100% of Poverty: 21.0%
  - 100-199% of Poverty: 15.1%
  - 200%+ of Poverty: 9.4%

NOTES: Respondents assessed their health status as excellent, very good, good, fair, or poor. The federal poverty level for a family of four in 2007 was $21,203 (http://www.census.gov/hhes/www/poverty/threshld/thresh07.html).
DATA: Centers for Disease Control and Prevention/National Center for Health Statistics, National Health Interview Survey.
SOURCE: Health, United States, 2009, Table 57.
Not fully explained by:

- Variation in health care access or quality
- Variations in health behaviors
Low SES and Minority Race/Ethnicity Associated with Stressful Social Conditions

- Greater exposure to violence, threat of violence
- Lower quality and insecurity of food and housing
- Perceived relative deprivation
- Perceived social exclusion
- Overt and perceived discrimination (Awareness of unfair treatment and attitudes)
- Low predictability
- Low perceived control
- Low social support
Psychological Responses to Stressful Social Conditions

Fear and anxiety
Loneliness
Shame
Anger/hostility
Depression
Helplessness/hopelessness

Higher Perceived Stress
Race-Based Stress

- Multiple forms of race-related stress exist
  - Some exist due to confounding of minority race and lower income
    - Stress associated with individual and family poverty
    - Stress associated with impoverished and lower quality neighborhood and school environments
  - Some exist independent of income
    - Specifically due to being a member of a disadvantaged racial/ethnic minority group
    - E.g. Racial discrimination
    - “Race-based stress”
Race-Based Social Stress

• **Perceived discrimination** = the observation or anticipation of unfair treatment based on race/ethnicity
  – In nationally representative data comparing perceptions of discrimination by blacks and whites, 24.8% of blacks believe themselves to “often” be the target of everyday discrimination vs. only 3.4% of whites (Kessler et al., 1999)
  – Racial/Ethnic minority youth aware of discrimination in their environments (Brown & Bigler, 2005)
  – Black and Latino adolescents more likely than their Asian and non-Hispanic White peers to report being the victims of discrimination (Fisher et al., 2000)
Stress is more than a feeling

It sets into motion biological responses in the body that have implications for immediate functioning and long term health and attainment.
Stress Affects Biological Systems

- Multiple interrelated biological stress systems exist
- I focus on a system that:
  - show variations by race/ethnicity
  - show impacts on cognition/learning and health

Hypothalamic pituitary adrenal axis (HPA axis)
- affected by stress, very sensitive to:
  - negative social evaluations
  - social exclusion

Acute stress -> increases in hormone cortisol
Chronic stress -> changes in basal cortisol rhythm
Cortisol Measurement
(Small samples of saliva, across full waking day)
Cortisol Diurnal (Daily) Rhythm and Reactivity

Cortisol Diurnal Rhythm

Cortisol Stress Response

Time of Day

Waketime

Bedtime
Cortisol Response to Chronic Stress
-> Flatter Diurnal Cortisol Rhythm
Adolescent Stress and Flatter Diurnal Cortisol Rhythm

Flattening of diurnal cortisol slope with:
- High Loneliness and Sadness
- High Anger/Frustration
- High Chronic Stress
- Low Parenting Warmth
- Negative Life Events
- High Neuroticism
- Perceived Discrimination
- Low Hours of Sleep

Sampling Time:
- Wake
- Wake + 40 min
- Wake + 3 hours
- Wake + 8 hours
- Wake + 12 hours
- Bedtime

Cortisol (ug/dl)

SES, Race, and Diurnal Cortisol

• Lower SES and minority race/ethnicity both predict flatter diurnal cortisol rhythms

• Developmental histories of exposure to low SES and racial discrimination help account for adult differences in rhythms

• Data from two 20-year longitudinal studies
Cebu Study: Birth cohort of 3,327 mothers and their children born in 1983-1984 in Cebu, the Philippines. 19 rounds of data, including SES from 3rd trimester of pregnancy to early adulthood; cortisol in adulthood.
Results
Bedtime Cortisol by SES

- prenatal
- birth
- toddler
- child
- adol
- current

Categories:
- lowest
- 25-50
- 50-75
- highest
Results
Cumulative SES: Prenatal-Adulthood

Graph showing the relationship between wake-up and bedtime with cumulative SES levels.

- 0-1
- 2 to 3
- 4 to 5
- 6

Northwestern
Racial/ethnic differences in cortisol across the waking day in adolescents

- Flatter diurnal cortisol slopes across the day for blacks and Hispanic adolescents

DeSantis et al., 2007, JAH
Average Racial/ethnic Differences in Cortisol Rhythms across a 5-year Period in Older Adults (DeSantis et al., 2015)
Race-based Stress and Cortisol Rhythms

• Racial differences in cortisol are significant covarying the effects of:
  – Income
  – Health behaviors
  – Life events stress
  – Daily hassles
  – Recent perceived discrimination

• We argue that developmental histories of exposure to discrimination are important
Maryland Adolescent Development in Context Study (MADICS)

• Prospective study of over 1400 adolescents in Prince Georges County, Maryland
  – First recruited in 7th grade: 12 years old
  – Followed for 20 years: age 32 at latest wave
  – 8 waves of data collection

• Subset invited to participate in study of perceived racial discrimination and adult stress biomarkers
  – 124 Participants, selected for high and low histories of perceived racial discrimination
    • 59 Black, 65 White
    • 50 male, 74 female

Differences Between Sub-sample and Larger Sample on Income, Parent Education, %Black, and PRD (Adolescent and Young Adult)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sub-sample</th>
<th>Full sample</th>
<th>t(df)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income Wave 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11.02 (3.84)</td>
<td>9.94 (4.25)</td>
<td>-2.80</td>
<td>.006</td>
</tr>
<tr>
<td>Parent Education Wave 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14.56 (2.58)</td>
<td>13.77 (2.43)</td>
<td>-3.30</td>
<td>.001</td>
</tr>
<tr>
<td>Black (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>44.6% (.50)</td>
<td>68.7% (.46)</td>
<td>4.91</td>
<td>.000</td>
</tr>
<tr>
<td>PRD Adolescent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.36 (.51)</td>
<td>1.49 (.65)</td>
<td>2.28</td>
<td>.024</td>
</tr>
<tr>
<td>PRD Young Adult</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.82 (.58)</td>
<td>1.90 (.72)</td>
<td>1.23</td>
<td>.221</td>
</tr>
</tbody>
</table>
## Sample and Neighborhood Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Full Sample</th>
<th>Black Sample</th>
<th>White Sample</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (or %)</td>
<td>Mean (or %)</td>
<td>Mean (or %)</td>
<td>t</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>SD</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Female (percent)</td>
<td>60.71</td>
<td>49.06</td>
<td>64.00</td>
<td>-0.63</td>
</tr>
<tr>
<td>W1 Income (in 000's of $)</td>
<td>51.21</td>
<td>19.69</td>
<td>46.60</td>
<td>2.26</td>
</tr>
<tr>
<td>Parent Education (percentages)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than HS</td>
<td>21.43</td>
<td>41.28</td>
<td>35.14</td>
<td>-2.81</td>
</tr>
<tr>
<td>HS diploma</td>
<td>23.81</td>
<td>42.85</td>
<td>35.14</td>
<td>-2.20</td>
</tr>
<tr>
<td>Some college</td>
<td>27.38</td>
<td>44.86</td>
<td>16.22</td>
<td>2.06</td>
</tr>
<tr>
<td>College or more</td>
<td>27.38</td>
<td>44.86</td>
<td>13.51</td>
<td>2.60</td>
</tr>
<tr>
<td>W3 friends that are Black*</td>
<td>3.08</td>
<td>1.33</td>
<td>4.08</td>
<td>-8.87</td>
</tr>
<tr>
<td>W3 friends that are White*</td>
<td>2.87</td>
<td>1.29</td>
<td>1.78</td>
<td>11.83</td>
</tr>
<tr>
<td>W3 Neighborhood school quality (scale 1-4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W3 Neighborhood safety (scale 1-3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W3 Percent Black HH in neighborhood</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W4 Percent Black students in school</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W8 Age</td>
<td>32.36</td>
<td>0.44</td>
<td>32.35</td>
<td>0.20</td>
</tr>
<tr>
<td>W8 Income (in 000's of $)</td>
<td>76.34</td>
<td>45.63</td>
<td>77.16</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

*(1=none of them 2=a few of them 3=about half of them 4=most of them 5=all of them)
Longitudinal data collection

Adolescence

Wave 1
- 7th grade
- 1991
- Age 12
- 1 PRD Q's

Wave 3
- 8th grade
- 1993
- Age 13
- 8 PRD Q's

Wave 4
- 11th grade
- 1996-97
- Age 16-17
- 8 PRD Q's

Wave 5
- 1 yr after High School
- 1998, Age 19
- 3 PRD Q's

Wave 6
- 3 yrs after High School
- 2000, Age 21
- 6 PRD Q's

Wave 7
- Age 30
- 2009-2010
- 12 PRD Q's

Wave 8
- Age 32
- 2011-12

Young Adulthood

Demographics
(Race/ethnicity, sex, income, grades)

Perceived Racial Discrimination (PRD) and Ethnic Identity

Biomarker Data, Adult Attainment and Health
PRD Variable Creation

• Perceived Racial Discrimination (PRD)

• Measures the extent to which individuals perceived discrimination based on race
  – Differed by wave due to changing contexts over time

• Example Questions:
  – Wave 4: How often do you feel that you get disciplined more harshly by teachers than other kids because of your race?
  – Wave 6: At work, how often have you experienced what you perceived as racist behavior or treatment?
PRD Variable Creation

• Standardized and averaged items within waves

• Averaged Z-scores across waves
  – Each available wave equally weighted across the waves

• 3 different outcome variables:
  – Cumulative PRD (Waves 3-7)
  – Adolescent PRD (Waves 3-4)
  – Young Adult PRD (Waves 5-7)
PRD Variable Creation

• Standardized and averaged items within waves

• Averaged Z-scores across waves
  – Each available wave equally weighted across the waves

• 3 different outcome variables:
  – Cumulative PRD (Waves 3-7)
  – Adolescent PRD (Waves 3-4)
  – Young Adult PRD (Waves 5-7)
Biomarker Data Collection
(Wave 8, age 32)

• Salivary Cortisol
  – At wakeup, 30 min after waking, bedtime
  – Every day for 7 days
  – Samples assayed for cortisol

• 3 Cortisol Indices Calculated
  – Separately each day, then averaged over 7 days

AUC: area under curve of all cortisol data points
CAR: wake+30 level – waking cortisol level
Cortisol slope: \((\text{bedtime} – \text{waking cortisol})/\text{total time awake}\)
3-Level HLM Analysis

Moment level (Level 1)
- Cortisol predicted by time since waking, its quadratic, and 0/1 CAR variable

\[
\text{Cortisol} = \pi_0 + \pi_1 \text{Time Since Waking} + \pi_2 \text{Time Since Waking}^2 + \pi_3 \text{CAR} + e_i
\]

Day-level (Level 2)
- Day level covariates (e.g. waketime)

Person-level (Level 3)
- Main effects of PRD
- Interactions with race
- Started with Cumulative (W3-7) PRD
- Then examined Adolescent (W3-4) and Early Adulthood (W5-7) PRD to examine developmental timing

- Covariates: gender, income, average sleep length, and daily morning waking time
- Also predicted daily AUC (area under the curve; total cortisol across the day) from person-level variables in a 2-level multilevel model
# Results – Perceived Racial Discrimination (in SD units)

<table>
<thead>
<tr>
<th></th>
<th>Black (N=59)</th>
<th>White (N=65)</th>
<th>Difference</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adolescent Discrimination</td>
<td>.215</td>
<td>-.174</td>
<td>.39 SDs</td>
<td>-2.08</td>
<td>.040</td>
</tr>
<tr>
<td>Young Adult Discrimination</td>
<td>.553</td>
<td>-.446</td>
<td>1.0 SDs</td>
<td>-6.04</td>
<td>.000</td>
</tr>
<tr>
<td>Cumulative Discrimination</td>
<td>.468</td>
<td>-.377</td>
<td>.85 SDs</td>
<td>-4.88</td>
<td>.000</td>
</tr>
</tbody>
</table>

- Examine developmental timing effects -- which matters more:
  - adolescent discrimination
  - young adult discrimination
  - cumulative discrimination
### Results – Perceived Discrimination by Race
#### (Some Adolescent Items)

<table>
<thead>
<tr>
<th>Wave</th>
<th>Question</th>
<th>Scale</th>
<th>Full Sample</th>
<th>Black Sample</th>
<th>White Sample</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>3</td>
<td>At school, how often do you feel that teachers call on you less often than they call on other kids because of your race?</td>
<td>1 (Never) – 5 (Every day)</td>
<td>1.586</td>
<td>0.935</td>
<td>1.825</td>
<td>0.984</td>
</tr>
<tr>
<td>3</td>
<td>At school, how often do you feel that teachers grade you harder than they grade other kids because of your race?</td>
<td>1 (Never) – 5 (Every day)</td>
<td>1.414</td>
<td>0.883</td>
<td>1.575</td>
<td>1.035</td>
</tr>
<tr>
<td>3</td>
<td>At school, how often do you feel that you get disciplined more harshly by teachers than other kids do because of your race?</td>
<td>1 (Never) – 5 (Every day)</td>
<td>1.517</td>
<td>1.010</td>
<td>1.850</td>
<td>1.189</td>
</tr>
<tr>
<td>3</td>
<td>At school, how often do you feel that teachers think you are less smart than you really are because of your race?</td>
<td>1 (Never) – 5 (Every day)</td>
<td>1.356</td>
<td>0.889</td>
<td>1.550</td>
<td>1.085</td>
</tr>
<tr>
<td>3</td>
<td>How often have you felt that teachers/counselors discourage you from taking certain classes because of your race?</td>
<td>1 (Never) – 5 (More than six times)</td>
<td>1.310</td>
<td>0.826</td>
<td>1.475</td>
<td>0.987</td>
</tr>
<tr>
<td>3</td>
<td>How often do you feel like you are not picked for certain teams or other school activities because of your race?</td>
<td>1 (Never) – 5 (Every day)</td>
<td>1.547</td>
<td>0.916</td>
<td>1.300</td>
<td>0.723</td>
</tr>
<tr>
<td>3</td>
<td>How often do you feel that you get in fights with some kids because of your race?</td>
<td>1 (Never) – 5 (Every day)</td>
<td>1.349</td>
<td>0.748</td>
<td>1.325</td>
<td>0.797</td>
</tr>
<tr>
<td>3</td>
<td>How often do you feel that kids do not want to hang out with you because of your race?</td>
<td>1 (Never) – 5 (Every day)</td>
<td>1.581</td>
<td>1.000</td>
<td>1.375</td>
<td>0.838</td>
</tr>
</tbody>
</table>
### Results – Perceived Discrimination by Race (Some Young Adult Items)

<table>
<thead>
<tr>
<th>Item</th>
<th>Agree 1 (Not at all) - 5 (A lot)</th>
<th>Agree 2 (1-2) - 4 (A lot)</th>
<th>Agree 3 (3-4) - 5 (A lot)</th>
<th>Agree 4 (4-5) - 6 (A lot)</th>
<th>Agree 5 (5-6) - 7 (A lot)</th>
<th>Agree 6 (6-7) - 8 (A lot)</th>
<th>Agree 7 (7-8) - 9 (A lot)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much do you think discrimination because of your race/ethnicity has kept you from advancing your career.</td>
<td>1.911 1.220</td>
<td>2.700 1.329</td>
<td>1.274 0.605</td>
<td>7.023 0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much do you think discrimination because of your race/ethnicity has kept you from getting the education you wanted.</td>
<td>1.613 1.089</td>
<td>2.041 1.384</td>
<td>1.274 0.605</td>
<td>3.614 0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much do you think you are discriminated against because of your race/ethnicity?</td>
<td>2.162 1.156</td>
<td>2.837 1.143</td>
<td>1.629 0.854</td>
<td>6.162 0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because of your race, how often have you been treated rudely, disrespectfully, or ignored?</td>
<td>2.589 1.333</td>
<td>3.160 1.299</td>
<td>2.129 1.180</td>
<td>4.348 0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because of your race, how often have you been accused of something or treated suspiciously?</td>
<td>1.857 1.154</td>
<td>2.500 1.313</td>
<td>1.339 0.651</td>
<td>5.712 0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because of your race, how often have others reacted to you as if they were afraid or intimidated?</td>
<td>1.893 1.276</td>
<td>2.760 1.422</td>
<td>1.194 0.474</td>
<td>7.462 0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because of your race, how often have you been treated as if you were stupid or been talked down to?</td>
<td>2.018 1.221</td>
<td>2.700 1.216</td>
<td>1.459 0.905</td>
<td>5.983 0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Results – Perceived Discrimination by Race
(Some More Young Adult Items)

<table>
<thead>
<tr>
<th>Item Description</th>
<th>1 (Never) - 6 (Once a week or more)</th>
<th>1 (Never) - 6 (Once a week or more)</th>
<th>1 (Never) - 6 (Once a week or more)</th>
<th>1 (Never) - 6 (Once a week or more)</th>
<th>1 (Never) - 6 (Once a week or more)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Because of your race, how often have you been treated in an &quot;overly&quot; friendly or superficial way?</td>
<td>2.009 1.225</td>
<td>2.460 1.313</td>
<td>1.639 1.017</td>
<td>3.619 0.000</td>
<td></td>
</tr>
<tr>
<td>Because of your race, how often have you been avoided, with others moving away from you physically?</td>
<td>1.571 0.956</td>
<td>2.000 1.195</td>
<td>1.226 0.493</td>
<td>4.295 0.000</td>
<td></td>
</tr>
<tr>
<td>Because of your race, how often have you been mistaken for someone who serves others?</td>
<td>1.446 0.792</td>
<td>1.800 0.904</td>
<td>1.161 0.549</td>
<td>4.388 0.000</td>
<td></td>
</tr>
<tr>
<td>Because of your race, how often have you been stared at by strangers or considered fascinating or exotic by others?</td>
<td>1.795 1.171</td>
<td>2.320 1.362</td>
<td>1.371 0.773</td>
<td>4.390 0.000</td>
<td></td>
</tr>
<tr>
<td>Because of your race, how often have you been mistaken for someone else of your same race?</td>
<td>2.107 1.365</td>
<td>2.560 1.445</td>
<td>1.742 1.186</td>
<td>3.222 0.002</td>
<td></td>
</tr>
<tr>
<td>Because of your race, how often have you been asked to speak for or represent your entire racial/ethnic group?</td>
<td>1.768 1.090</td>
<td>2.080 1.104</td>
<td>1.516 1.020</td>
<td>2.780 0.006</td>
<td></td>
</tr>
</tbody>
</table>
Results

• Racial differences in waking cortisol and slope are significant
  – lower waking levels and flatter slopes for blacks

• 37% of racial differences in waking cortisol, and 38% of racial differences in diurnal cortisol slope accounted for by PRD
Results. Adolescent Perceived Racial Discrimination and Adult Cortisol (Age 32)
Results. Adolescent Perceived Racial Discrimination and Adult Cortisol (Age 32)

Flatter diurnal cortisol slope in both blacks and whites with high PRD

Low waking and average cortisol in blacks with high adolescent PRD
Results. Adult Perceived Racial Discrimination and Adult Cortisol (Age 32)

Higher cortisol awakening response in low PRD whites.
Why do we care about low, flat cortisol?

Are LOW AUC cortisol, and a flatter diurnal cortisol slope problematic?
Simple Correlations between Adult Cortisol Levels and Adult Academic Attainment/Health outcomes within the MADICS sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>AUC cortisol</th>
<th>Cortisol Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>.325*</td>
<td>-.415**</td>
</tr>
<tr>
<td>College Grad</td>
<td>.355*</td>
<td>-.031</td>
</tr>
<tr>
<td>General Health</td>
<td>.135</td>
<td>-.304*</td>
</tr>
<tr>
<td>Depression</td>
<td>-.054</td>
<td>-.335*</td>
</tr>
<tr>
<td>Anxiety</td>
<td>-.290*</td>
<td>-.433**</td>
</tr>
</tbody>
</table>

+ = \( p < .10 \);  * = \( p < .05 \);  ** = \( p < .01 \)

Plus, meta-analysis of 81 studies supports negative associations with a wide variety of health outcomes (Adam, Gilbert, Quinn, Tavernier and McQuillan, *in preparation*).
Correlation between Flatter Diurnal Cortisol Rhythms and Adverse Outcomes Across Multiple Health Domains: Meta-analytic Summary of N=81 studies and 190 findings
Correlation between Flatter Diurnal Cortisol Rhythms and Adverse Outcomes
Cross-sectional vs. Prospective

(Meta-analytic Summary of N=81 studies and 190 findings)

<table>
<thead>
<tr>
<th>Group by Cross-sectional or Prospective</th>
<th>Study name</th>
<th>Statistics for each study</th>
<th>Outcome</th>
<th>Correlation and 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Correlation</td>
<td>Lower limit</td>
<td>Upper limit</td>
</tr>
<tr>
<td>cross</td>
<td></td>
<td>0.122</td>
<td>0.096</td>
<td>0.148</td>
</tr>
<tr>
<td>prospective</td>
<td></td>
<td>0.147</td>
<td>0.063</td>
<td>0.239</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td>0.124</td>
<td>0.090</td>
<td>0.149</td>
</tr>
</tbody>
</table>

Correlation and 95% CI: -1.00, -0.50, 0.00, 0.50, 1.00
Increased Prospective Risk for Cancer-related and Cardiovascular Mortality Associated with Flatter Diurnal Cortisol Rhythms (5 studies, 3 shown here).
Discussion

• Histories of low SES and high exposure to discrimination are generally associated with a flatter diurnal cortisol slope

• Developmental timing matters
  – Driven strongly by experiences in childhood and adolescence

• Flatter diurnal cortisol slopes associated with wide range of negative health outcomes
Discussion

• Provides initial support for the hypothesis:
  – psychological stress related to experience of lower SES and minority race/ethnicity
  – may activate and alter stress biology in ways that predict negative health outcomes
  – And further, that developmental histories of SES and race-related stress may predict stress physiology and health better than recent or concurrent measures of stress
Extra Slides
(Protective Factors)
Protective factors against low cortisol?

Focus on identifying protective factors against low AUC in blacks (N=49)

What factors protect or reduce the negative effects of PRD on cortisol?
Scales

**Family Tradition Scale** (4 items, $\alpha = .673-.748$)
- E.g. How often do you talk in the family about your racial background

**Racial Importance Scale** (3 items, $\alpha = .632-.745$)
- E.g. How proud are you of your racial background?

**Ethnic Heritage Scale** (4-items, $\alpha = .725-.808$)
- E.g. People of my race/ethnicity have a culturally rich heritage
Adolescent PRD, Adolescent Ethnic Importance

$$\text{AUC}_{\text{mean}} = \text{PRD}_{\text{Adolescent}} + \text{Gender} + \text{Income}_1 + \text{Parent Education} + \text{Ethnic Importance}_{\text{Adolescent}} + \text{Ethnic Importance}_{\text{Adolescent}} \times \text{Ethnic Importance}_{\text{Adolescent}} + e$$

<table>
<thead>
<tr>
<th></th>
<th>$\beta$ (Model 3)</th>
<th>$\beta$ (Model 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRD$_{\text{Adolescent}}$</td>
<td>-.411*</td>
<td>-.208</td>
</tr>
<tr>
<td>Ethnic Imp$_{\text{Adolescent}}$</td>
<td>.412*</td>
<td>.457**</td>
</tr>
<tr>
<td>Interaction</td>
<td>-</td>
<td>-.295+</td>
</tr>
</tbody>
</table>

**Ethnic Importance** includes: Family Traditions, Racial Importance, Ethnic Heritage scales
Adolescent PRD, Adolescent Family Traditions

AUC\text{mean} = \text{Gender} + \text{Income} + \text{Parent Education} + \text{PRD}_{\text{adolescent}} + \text{Family Traditions}_{\text{Adolescent}} + \text{PRD}_{\text{adolescent}} \times \text{Family Traditions}_{\text{Adolescent}} + \epsilon

e.g.: How often do you talk in the family about your racial background

<table>
<thead>
<tr>
<th></th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRD$_{\text{Adolescent}}$</td>
<td>-.362*</td>
</tr>
<tr>
<td>Family Trad$_{\text{Adolescent}}$</td>
<td>.359+</td>
</tr>
<tr>
<td>Interaction</td>
<td>-.286*</td>
</tr>
</tbody>
</table>

n.s. for Adolescent Racial Importance, and n.s. for Adolescent Ethnic Heritage
Adolescent PRD, YA Racial Importance

\[ \text{AUC}_{\text{mean}} = \text{PRD}_{\text{adolescent}} + \text{Gender} + \text{Income}_1 + \text{Parent Education} + \text{Racial Importance}_{\text{YA}} + \text{PRD}_{\text{adolescent}} \times \text{Racial Importance}_{\text{YA}} + e \]

**Example Item:** How proud are you of your racial background?

<table>
<thead>
<tr>
<th></th>
<th>( \beta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRD (_{\text{Adolescent}} )</td>
<td>-.697</td>
</tr>
<tr>
<td>Racial Imp (_{\text{YA}} )</td>
<td>.714*</td>
</tr>
<tr>
<td>Interaction</td>
<td>.057</td>
</tr>
</tbody>
</table>

![Graph showing AUCu for Low PRD34 and High PRD34 with Low and High EthnicHeritage567 lines.](image)
Adolescent PRD, YA Ethnic Heritage

AUC_{mean} = PRD_{adolescent} + Gender + Income + Parent Education + Ethnic Heritage_{YA} + PRD_{adolescent} \times Ethnic Heritage_{YA} + e

**Example Item:** People of my race/ethnicity have a culturally rich heritage

<table>
<thead>
<tr>
<th></th>
<th>( \beta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRD_{adolescent}</td>
<td>-0.288</td>
</tr>
<tr>
<td>Ethnic Heritage_{YA}</td>
<td>0.529**</td>
</tr>
<tr>
<td>Interaction</td>
<td>-0.193</td>
</tr>
</tbody>
</table>

![Graph showing AUCu for Low and High PRD34 with Low EthnicHeritage and High EthnicHeritage](image-url)
Discussion

• Having rich family racial/ethnic traditions in adolescence
• Being proud of one’s race and having a strong racial/ethnic community in young adulthood

-> Have positive effects on cortisol regulation in adulthood, helping to counteract the negative impact of high adolescent racial discrimination on adult cortisol
Immediate policy implications for NU and other campuses

• Promotion of safe spaces on campus where racial/ethnic traditions can be expressed and racial/ethnic communities can gather may have positive effects on stress biology health, and academic attainment.

• May help counteract earlier (adolescent) negative impact of experiences of racial/ethnic discrimination.
THE RDSSC MODEL: RACIAL DISPARITIES IN STRESS AND SLEEP IN CONTEXT

Academic Performance and Attainment

Coping Responses
Devaluation & Disidentification
Emotion Regulation

Developmental History and Recent Race-based Social Stress
Perceived Discrimination, Stereotype Threat

Developmental History and Recent Socioeconomic Status (SES)-based Social Stress
Daily Life Stressors (e.g. Family Conflict, Financial Stress)
Community Stresses (e.g. School and Neighborhood Stress)

Resources
Individual, School, Family and Community
Resources/Social Supports/Role Models

Perceived Stress

Stress Responses

Negative Emotion
Anxiety, anger, sadness

Coping Responses
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Emotion Regulation

Basal Activity and Reactivity of Stress-Sensitive Biological Systems
HPA Axis Activity
Sleep Hours and Quality

Educational Aspirations/Identity/Motivation

Attention/Memory/Executive Functioning

Opportunities
Overt racial and SES-based biases
In Academic Advancement, Admissions, Hiring and Promotion, School Discipline, Law Enforcement, Health care
Social and Career Networks
Economic and Policy Climate

Outcomes

Academic Performance and Attainment
Physical and Mental Health
Educational and Workforce Disparities
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Perceived Stress

Forms of Race-Based Stress:

**Perceived discrimination** or the observation or anticipation of unfair treatment based on race/ethnicity

**Stereotype threat** or the stress of wanting to perform well to overcome negative expectations of one’s racial/ethnic group
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