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# Associations of neighborhood contexts and family-level hair cortisol concentration within Mexican immigrant families

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ABSTRACT

Many Mexican American immigrant families live in socioeconomically disadvantaged neighborhoods, which are recognized as risk factors influencing residents' stress. However, how neighborhood contexts can impact physiological stress at the family level, as indicated by hair cortisol concentration (HCC), particularly among Mexican immigrant family members remains unclear. Using a person-centered approach, the current study identified distinct patterns of family-level HCC and examined their associations with neighborhood contexts (i.e., Hispanic/immigrant concentration, socioeconomic disadvantage, affluence). Participants included 398 adolescents (56.5 % female, $M_{age} = 13.26$) and their mothers and fathers. Two profiles emerged and suggested that families living in neighborhoods with higher Hispanic/immigrant concentration and lower affluence were more likely to be in the *high family-level HCC* group compared to the *low family-level HCC* group. No group differences were found for neighborhood socioeconomic disadvantage. These results highlight the importance of including multiple family members (child and parents) to provide a more comprehensive understanding of how biological stress crossover within families. Our findings also emphasize the importance of integrating neighborhood contexts in shaping the physiological stress levels of Mexican American immigrant families.

## 1. Introduction

There is a growing number of Hispanics immigrating to the United States (U.S.), with Mexicans accounting for the largest origin group (U.S. Census Bureau, 2021). Influenced by the consequences of structural racism (e.g., residential racial segregation and anti-immigrant sentiment), a large proportion of Mexican American immigrants are disproportionally concentrated in socioeconomically disadvantaged neighborhoods (Aiken et al., 2021). Social disorganization theory (Kubrin and Mioduszewski, 2019; Shaw and McKay, 1969) suggests that marginalized neighborhoods characterized by racial heterogeneity and residential instability are likely to experience disruptions in community cohesion and social solidarity. These disruptions can lead to elevated levels of physical disorders (e.g., the presence of garbage and poorly maintained buildings) and social disorders (e.g., open drug use and crime). Indeed, existing studies suggest that residents in such neighborhoods are more prone to feeling unsafe and experience long-lasting self-reported psychological stress (Foell et al., 2021; Lambert et al., 2015). This stress can be reflected in physiological stress biomarkers, such as hair cortisol concentration (HCC, Russell et al., 2012). Moreover, family members may perceive and respond to neighborhood disorders in different ways (Côté-Lussier et al., 2015). The stress experienced by one family member can spill over to another, thereby affecting the entire family unit (Bowen, 1993). However, most neighborhood-related research has only examined the experiences of children and parents separately (e.g., Miliauskas et al., 2022). Given that family members share the same living environment, it is crucial to simultaneously examine physiological stress levels across family members. This is particularly important during adolescence—a developmental stage marked by increasing autonomy and shifting family dynamics, which

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can influence stress responses within the family system (Zimmer-Gembeck and Collins, 2006). Thus, the current study aimed to employ a person-centered approach to identify *family-level HCC profiles* and examine how neighborhood contexts related to each emerging family-level HCC profile.

According to family systems theory (Bowen, 1993), the family unit is a complex social system in which family members' feelings, thoughts, and behaviors can interact with each other. Consequently, stress experienced by one family member can resonate with other members, due to frequent communication, close interdependency, and mutual care (Robinson, 1997). An empirical study that recruited 30 mother-adolescent dyads from socioeconomically disadvantaged neighborhoods in Australia demonstrated that mothers' hair cortisol levels are strongly and positively associated with the hair cortisol levels of their children (Olstad et al., 2016). Similarly, salivary cortisol levels were also found to covary between partners in a study involving 40 married couples in Germany (Doerr et al., 2018). Hence, biological stress levels of family members may influence each other, suggesting the need for closer examinations of cortisol levels within the family unit and their relations to how biological stress can be transmitted within the family. This is especially salient for Mexican-immigrant families who strongly endorse familism—characterized by family cohesion and family-centered values—highlighting the importance of examining stress from a family system perspective (Lopez et al., 2023). Moreover, given the strong emphasis on gender roles within Mexican immigrant families (Updegraff et al., 2014), where mothers typically act as caregivers and fathers are responsible for financial stability and family safety, it is likely that mothers and fathers experience different stress levels due to varying stressors in their shared environment. In addition, as adolescents undergo drastic psychological and physical changes (Tottenham and Galván, 2016), they may experience heightened stress while gradually adapting to and navigating the complexities of society. Therefore, examining the family as a whole could provide a nuanced understanding of the diverse stress patterns driven by different family members in Mexican immigrant families. To this end, our study simultaneously incorporated the HCC of fathers, mothers, and children among a sample of Mexican American immigrant families, using latent profile analysis to capture the complex associations of family-level HCC profiles. We focus specifically on language-brokering immigrant families, where adolescents help their English-limited parents navigate life in the U.S. through tasks such as translating household bills and medical documents. This involvement makes them particularly attuned to their parents' stressors (Shen et al., 2014).

Furthermore, social disorganization theory suggests that neighborhood play a crucial role in shaping residents' stress levels (Sampson and Groves, 1989). Specifically, neighborhood contexts, such as neighborhood affluence, socioeconomic disadvantage, and immigrant concentration are the three widely studied contexts that are found to have implications for immigrants' stress levels (e.g., Morenoff et al., 2007). These factors are particularly relevant for Mexican American immigrant families, who often reside in neighborhoods with high immigrant population density and significant socioeconomic disadvantages (Aiken et al., 2021). In this study, we specifically examine both neighborhood affluence and socioeconomic disadvantage as they capture distinct aspects of neighborhood environment. Socioeconomic disadvantage reflects primarily economic challenges, while affluence encompasses not only socioeconomic advantages but also additional resources, such as greater social control, improved educational opportunities, and safer environments (Browning and Cagney, 2003). Affluent neighborhoods are more likely to provide a stable and less stressful environment for residents, which can contribute to lower self-reported psychological stress levels (Browning and Cagney, 2003). Conversely, neighborhoods with high immigrant population density and socioeconomic disadvantages are often associated with structural racism, including discriminatory loan policies, unequal access to educational opportunities, and biased criminal justice practices (Riley, 2018). These systemic inequities are likely to create a stressful environment for Mexican American immigrant residents (Farley et al., 2005), and families in these neighborhoods have been found to report higher levels of psychological stress (Foell et al., 2021; Lambert et al., 2015). However, from a cultural-developmental neighborhood perspective, Mexican immigrant families living in neighborhoods with higher Hispanic concentration are likely to form "ethnic enclaves", fostering strong social cohesion that can help reduce residents' psychological stress levels (Ip et al., 2024; Portes and Manning, 2006). While emerging studies have acknowledged the importance of considering the impact of neighborhood contexts on residents' stress levels, few studies have explored the "under-the-skin" impacts at the physiological level. Thus, our study employed hair cortisol, a biomarker of a chronic physiological stress response, emphasizing the biological mechanisms influenced by neighborhood contexts.

Collectively, the current study has two research aims. First, we aimed to use a person-centered approach to identify distinct patterns of family-level HCC (i.e., adolescent HCC, mother HCC, and father HCC). HCC is a reliable measure of long-term cortisol exposure, capturing chronic physiological stress (Russell et al., 2012), making it well-suited for examining family-level stress at the biological level. Based on the family systems theory and prior research (Tottenham and Galván, 2016; Updegraff et al., 2014), we hypothesized that five profiles would emerge: *high family-level HCC,* characterized by elevated HCC levels across all family members; *low family-level HCC*, characterized by low HCC level across all family members; *mother-high HCC*, where mothers exhibit higher HCC levels compared to other family members; *father-high HCC*, where fathers exhibit higher HCC levels compared to other family members; and *adolescent-high HCC*, where adolescents exhibit higher HCC levels compared to their parents. Second, we examined whether neighborhood immigrant concentration, socioeconomic disadvantage, and affluence influenced membership in the family-level HCC profiles. For neighborhood immigrant concentration, we specifically examined Hispanic/immigrant concentration because Hispanics constitute the largest immigrant population in the state of Texas (Funk and Lopez, 2022), where the data collection took place. Drawing from social disorganization theory and the cultural-developmental neighborhood perspective, we tested competing hypotheses. Based on social disorganization theory, we hypothesized that higher neighborhood Hispanic/immigrant concentration would be stress-inducing, increasing the likelihood of families being in the high family-level HCC or father/mother-high HCC groups. Conversely, based on the cultural-developmental perspective, we hypothesized that higher Hispanic/immigrant concentration would be stress-reducing, increasing the likelihood of families being in the low family-level HCC group. Additionally, given that neighborhood socioeconomic disadvantage is considered a risk factor, while neighborhood affluence is regarded as a promotive factor for residents' stress levels (Browning and Cagney, 2003; Farley et al., 2005), we hypothesized that families residing in communities with higher neighborhood socioeconomic disadvantage would be more likely to be in *high family-level HCC* or *father/mother-high HCC* group compared to *low family-level HCC* group. Conversely, families residing in communities with higher neighborhood affluence were more apt to be in *low family-level HCC* group.

## 2. Method

### 2.1. Participants and procedures

Data were drawn from a two-wave longitudinal dataset of low-income Mexican immigrant families in central Texas from 2012 to 2016. To be eligible for participation, parents needed to be of Mexican origin (99 % were born in Mexico) and have a middle school-aged child who served as a translator for at least one parent. At Wave 1, data were collected from adolescents in grade six through eight ($N = 604$; $M_{age} = 12.41$, $SD = 0.97$). Wave 2 data were collected about one year later

($N$ = 483; $M_{age}$ = 13.26, $SD$ = 0.94). Among the 483 families who participated in Wave 2 data collection, 398 families provided hair samples, forming the final analytical sample, with 398 adolescents, 397 of their mothers, and 148 of their fathers. Overall, our study included 50 neighborhoods and 398 families, averaging 8 families per neighborhood, with a range from 1 to 35 families per neighborhood. The medium and mode parental highest education level is finished middle school or junior high school, while the median and mode of household income fall within the range of $20,001–$30,000 at Wave 1. The demographic information of these 398 families is presented in Table 1. For adolescents, mothers, or fathers whose HCC fell below or above three standard deviations from the mean, their HCC values were winsorized ($n$ = 16).

Survey data were collected during the home visit at Wave 1 and 2, and hair samples were collected during the home visit at Waves 2. Research assistants cut strands of hair using sterilized scissors as close to the scalp as they could from a posterior vertex position. The aim was to obtain around 100 hair strands, each at least 3 cm long, from every participant. Hair samples were placed on aluminum foils, with the segment closest to the scalp marked. A compensation of $20 was offered to each family for hair collection and $60 (at Wave 1) or $90 (at Wave 2) for participating in the survey. Attrition analyses were conducted to compare families with and without fathers' HCC data across demographic variables (i.e., age, parental education, gender, nativity; see Supplementary Table 1). We found only two significant results: families with fathers' HCC data tend to have higher parental education level ($t$ (396) = -5.473, p < .001) and the adolescent child tend to be male ($\mathscr{X}^2(1) = 11.059$, p < .001). Therefore, we included parental education and adolescent gender as covariates in all the models. In addition, our results suggested that missingness in fathers' HCC is not related to other family members' HCC.

## 3. Measures

### 3.1. Hair cortisol

Hair samples were trimmed to 3 cm to assess cortisol levels over three months. Following the protocol of Davenport et al. (2006), the hair segment was washed in a 10 ml glass container with 2.5 ml isopropanol and rotated for three minutes, repeated twice. It was then dried for at least 12 hours and weighed, with a 7.5 mg sample transferred to a 2 ml cryovial. 1.5 ml pure methanol was introduced, followed by an 18-hour cortisol extraction. After centrifuging at 10,000 rpm for 2 minutes, 1 ml supernatant was transferred to a 2 ml glass vial and evaporated under nitrogen at 50°C until samples dried completely. Subsequently, 0.4 ml water was added, and the tube vortexed for 15 seconds. A 50 µl sample was used from the vital for cortisol measurement with commercially available immunoassays with chemiluminescence detection (CLIA, IBL-Hamburg, Germany), with intra-assay coefficients of variation (CVs) between 4.0 % and 6.7 % and inter-assay CVs between 7.1 % and 9.0 %. Log-transformed cortisol values were used in analysis.

### 3.2. Neighborhood contexts

We extracted measures of neighborhood Hispanic/immigrant concentration, socioeconomic disadvantage, and affluence from the National Neighborhood Data Archive (NaNDA) (https://nanda.isr.umich.edu/) at Wave 2. These data were sourced from the US Census Bureau's American Community Survey (ACS), reflecting the socioeconomic status and demographics for each ZIP Code Tabulation Areas (ZCTA) based on the 5-year estimates from 2013 to 2017, which closely matches the duration during which the data for this study were collected. Since policy efforts are typically aimed at larger geographic areas, we conceptualized neighborhoods at the ZCTA level rather than the census tract level to better identify targets for intervention. Thus, neighborhood indices were integrated into our study through a ZIP code to ZCTA crosswalk. Geospatial information for each ZCTA was obtained from the TIGER/Line shapefiles, released in 2019 by the US Census Bureau, to ensure consistency with similar datasets from NaNDA (Melendez et al. 2020). *Neighborhood Hispanic/immigrant concentration* was calculated as the average of the proportion of Hispanic-origin residents and the proportion of foreign-born residents. Neighborhood socioeconomic status factors were derived using principal factor analysis with orthogonal varimax rotation on seven census indicators (log-transformed to account for positive skew), following the methodology described by Morenoff et al. (2007). *Neighborhood socioeconomic disadvantage* was calculated by averaging the following four indices: a) proportion of female-headed families with children, b) proportion of households with public assistance income or food stamps, c) proportion of families with income below the federal poverty level, and d) proportion of population age 16 + unemployed. *Neighborhood affluence* was measured by averaging the following three indicators: proportion of households with income greater than $75 K, proportion of population age 16 + employed in professional or managerial occupations, and proportion of adults with Bachelor's Degree or higher.

### 3.3. Covariates

Adolescent age, gender (0 = *male*,1 = *female*), nativity (0 = *US-born*, 1 = *Mexico-born*), and parental education (from 1 = *no formal schooling* to 11 = *finished graduate degree*) at Wave 2 were included as covariates.

**Table 1**
Descriptive statistics and bivariate correlations of study variables.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Adolescent sex (0 =male, 1 =female) | – | | | | | | | | | |
| 2. Adolescent nativity (0 =U.S., 1 =Mexico) | −.054 | – | | | | | | | | |
| 3. Adolescent age | −.026 | .146 * * | – | | | | | | | |
| 4. Parental education[a] | −.070 | .065 | −.047 | – | | | | | | |
| 5. Neighborhood Hispanic/immigrant concentration | .016 | .005 | .037 | −.109 * | – | | | | | |
| 6. Neighborhood socioeconomic disadvantage | −.033 | .041 | .084 | −.185 * * | .800 * ** | – | | | | |
| 7. Neighborhood affluence | .036 | −.007 | −.050 | .137 * * | −.844 * * | −.803 * ** | – | | | |
| 8. Adolescent HCC | −.140 * * | .039 | .015 | −.010 | .007 | −.019 | −.007 | – | | |
| 9. Mother HCC | −.051 | .021 | −.014 | −.022 | −.049 | −.038 | −.005 | .448 * ** | – | |
| 10. Father HCC | −.102 | −.038 | .018 | .020 | .090 | .034 | −.145 | .517 * ** | .618 * ** | – |
| *Min* | 0 | 0 | 11 | 1 | 0.060 | 0.035 | 0.033 | −2.300 | −1.630 | −1.390 |
| *Max* | 1 | 1 | 16 | 11 | 0.716 | 0.329 | 0.679 | 4.790 | 5.360 | 6.000 |
| *M* | 0.565 | 0.256 | 13.257 | 5.570 | 0.350 | 0.124 | 0.337 | 0.770 | 0.831 | 1.447 |
| *SD* | 0.496 | 0.437 | 0.940 | 2.214 | 0.121 | 0.045 | 0.121 | 1.216 | 1.273 | 1.494 |
| *N* | 398 | 398 | 397 | 398 | 398 | 398 | 398 | 392 | 387 | 128 |

*Note*: HCC = hair cortisol concentration. All cortisol levels represent nmol/L. *$p$ < .05, * *$p$ < .01.
[a] from 1 = No formal schooling to 11 = Finished graduate degree

### 3.4. Analysis plan

Data analyses were conducted in two steps. First, we did latent profile analyses (LPA) to identify distinct family-level HCC profiles using adolescents', mothers', and fathers' HCC levels. A series of models were specified (i.e., 1–5 profiles). Several statistical indicators were compared to determine the optimal solution, including lower values of AIC, BIC, and ABIC indicating better outcomes, an entropy greater than 0.8 being preferable, and a significant *p*-value of LMR adjusted LRT suggesting meaningful differences between models with distinct profiles. Second, given that families are nested within neighborhoods, the cluster function was used. In addition, R3STEP analysis was applied to compare differences in neighborhood contexts across family-level HCC profiles after families were classified into different profiles according to LPA results. The effects of neighborhood contexts (i.e., neighborhood Hispanic/immigrant concentration, socioeconomic disadvantage, and affluence) were tested in three separate models. Missing data was handled by full information maximum likelihood (FIML).

## 4. Results

### 4.1. Latent profile modeling of family-level HCC

Model fit indices of latent profile analyses are presented in Table 2. The 2-profile solution was identified as the optimal solution for family-level HCC. Specifically, the AIC, BIC, and ABIC values started to level off after the 2-profile solution. The 2-profile solution had an entropy greater than 0.8 and a *p*-value of LMR adjusted LRT smaller than 0.05. Fig. 1 presents a graphical summary of the family-level HCC profiles. The largest group was characterized by low HCC across adolescents, mothers, and fathers (labeled "*Low family-level HCC*"; $n = 363$, 91 % of participants), while families in another group (labeled "*High family-level HCC*") had high HCC across adolescents, mothers, and fathers ($n = 35$, 9 % of participants). Notably, in both profiles, fathers exhibited significantly higher HCC compared to those of mothers and adolescents ($F$ (2, 820) $= 11.93$, $p < .001$ for *low family-level HCC* group and $F$(2, 81) $= 9.54$, $p < .001$ for *high family-level HCC* group).

#### 4.1.1. Neighborhood contexts across family-level HCC profiles

As mentioned in the analysis plan, three separate models were run to examine the effects of neighborhood contexts (i.e., affluence, socioeconomic disadvantage, and Hispanic/immigrant concentration). Results from the current study demonstrated that families living in areas with higher levels of Hispanic/immigrant concentration were more likely to be in the *high family-level HCC* group ($b = 0.035$, OR = 1.036, 95 % CI [1.001, 1.072]), while higher neighborhood affluence was associated with profiles that had lower family-level HCC ($b = -0.041$, OR = 0.960, 95 % CI [0.921, 0.999]; see Table 3). However, there was no significant prediction effect for neighborhood socioeconomic disadvantage across the two groups ($b = 0.064$, OR = 1.066, 95 % CI [0.979, 1.162]).

### 4.2. Sensitivity analyses

To examine the robustness of the results given the missing data on fathers' HCC, we restricted the sample to those families with valid father HCC data ($N = 128$) and reran the latent profile analyses. Similar to the main analyses, results identified two profiles as the optimal solution: *Low family-level HCC* ($N = 113$, 88 % of participants) and *High family-level HCC* ($N = 15$, 12 % of participants; see Supplementary Table 2).

In examining the association between profile membership and neighborhood characteristics with the restricted sample, no significant results were found; however, the trends and coefficients was similar to the results with the main analyses (see Supplementary Table 3). The null results in the restricted sample were likely due to the significant drop in sample size. Future studies with larger sample sizes across family members are encouraged to replicate these findings.

## 5. Discussion

Past research has demonstrated that family members' cortisol levels are implicated not only by genetic factors, but also by shared environmental characteristics (Schreiber et al., 2006).

Especially for Mexican immigrant families, neighborhood factors such as neighborhood affluence and socioeconomic disadvantage are likely linked to family members' cortisol levels; however, the links between neighborhood factors and family members' physiology is an understudied area of work. The present study therefore examined hair cortisol concentration in a sample of Mexican immigrant families. Partially consistent with some existing literature (Doerr et al., 2018; Olstad et al., 2016), we found that family members generally showed congruence in their cortisol levels: we identified a high family-level HCC profile and a low family-level HCC profile that showed either congruently high or low levels of HCC across mothers, fathers and their adolescent children. More importantly, we demonstrated how neighborhood contexts (including neighborhood affluence and Hispanic/immigrant concentration) are linked with family profiles of HCC. Specifically, residing in neighborhoods with high Hispanic/immigrant concentration or low affluence were linked to being in families with high (vs. low) HCC levels; however, neighborhood socioeconomic disadvantage was not linked to family-level HCC profile membership.

We identified two family HCC profiles that showed relative congruence in family members' levels of hair cortisol (i.e., a high family-level HCC profile and a low family-level HCC profile). Given that cortisol is secreted in response to environmental stimuli, it is not surprising that family members who reside in the same household also showed similar cortisol levels across family members (Schreiber et al., 2006). Our findings are generally in line with conceptual models including family systems theory (Bowen, 1993), which suggest family members' physiological indicators of stress likely inter-relate. Interestingly, we point out that fathers in our study showed higher HCC than mothers and adolescents, which might be a product of work stress due to their role as the primary breadwinner in the family (see gender role theory; Updegraff et al., 2014). Nevertheless, these findings are largely consistent with work that has demonstrated cortisol synchrony among couples and mother-child pairs, with some research attributing this similarity to shared family characteristics (Papp et al., 2009; Pauly et al., 2021). Here, we extend the literature beyond dyadic research that has focused only on husband-wife or mother-child relationships, by also demonstrating potential triadic associations amongst father-mother-child's physiological stress. Our findings highlight that biophysiological stress

**Table 2**
Model fit indices for latent profile analysis of family-level hair cortisol concentration ($N = 398$).

| | Log-likelihood | N of parameters | AIC | BIC | ABIC | Entropy | *p* of LMR adj. LRT | Distribution |
|---|---|---|---|---|---|---|---|---|
| 1 profile | −1506.726 | 6 | 3025.451 | 3049.37 | 3030.332 | N/A | N/A | 398 |
| **2 profiles** | **−1378.502** | **10** | **2777.005** | **2816.869** | **2785.139** | **0.945** | **0.0017** | **363–35** |
| 3 profiles | −1360.824 | 14 | 2749.649 | 2805.459 | 2761.036 | 0.957 | 0.3947 | 361–12–25 |
| 4 profiles | −1350.049 | 18 | 2736.098 | 2807.854 | 2750.74 | 0.939 | 0.0637 | 358–9–19–12 |
| 5 profiles | −1337.908 | 22 | 2719.815 | 2807.517 | 2737.71 | 0.726 | 0.1282 | 154–206–11–8–19 |

*Note*: The optimal solution is bolded.

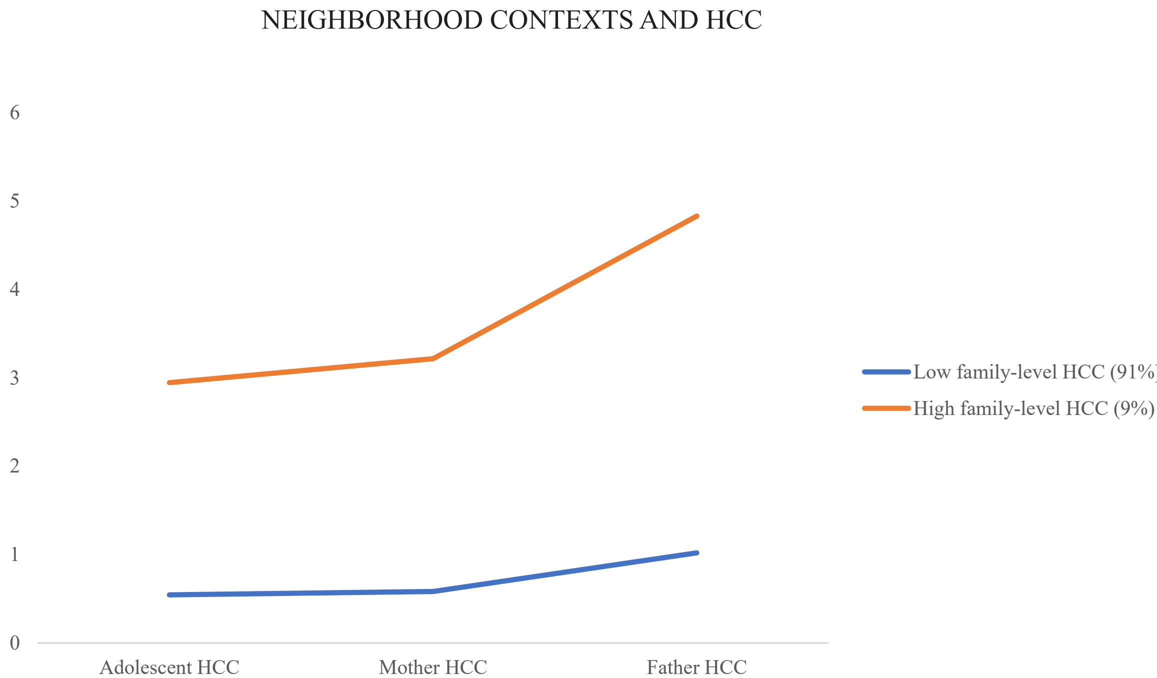


**Fig. 1.** Family-level hair cortisol concentration (HCC) profiles. Across the two emerging profiles, the HCC of adolescents ($t$ (390) = -10.34, $p < .001$), mothers ($t$ (385) = -10.75, $p < .001$), and fathers ($t$ (126) = -15.49, $p < .001$) are significantly higher in the *high family-level HCC* profile compared to those in the *low family-level HCC* profile.

**Table 3**
Logistic regression predicting family-level hair cortisol concentration profile memberships by neighborhood contexts ($N$ = 398).

| | High HCC vs. Low HCC | | |
|---|---|---|---|
| | *b* | OR | OR 95 % CI |
| Neighborhood Hispanic/immigrant concentration | **0.035*** | **1.036** | **(1.001, 1.072)** |
| Neighborhood socioeconomic disadvantage | 0.064 | 1.066 | (0.979, 1.162) |
| Neighborhood affluence | **−0.041*** | **0.960** | **(0.921, 0.999)** |

*Note.* HCC = hair cortisol concentration. Significant findings are in bold. Low family cortisol profile is the reference group. The coefficients reported are unstandardized. Covariates included adolescent age, sex, nativity, and parental education. * $p < 0.05$

could be transmitted within immigrant families; perhaps through environmental mechanisms such as neighborhood factors (see below for elaboration), but likely also via parents' behavior and their coping mechanisms, which is a critical avenue for study in future work. Given that Mexican immigrant families often bear the brunt of health disparities (Vega et al., 2009), including limited access to healthcare, higher exposure to neighborhood and environmental stresses, and greater prevalence of psychosocial stress due to discrimination and acculturation challenges, our findings suggest the need for family-centric interventions.By designing interventions that target the family unit holistically, we can address these varied stressors comprehensively, potentially mitigating elevated HCC levels observed among Mexican immigrant families and improve overall health outcomes. Critically, our work here demonstrates how neighborhood factors are linked with family members' HCC levels. Our findings that individuals who live in affluent neighborhoods tend to be in the families with low family-level HCC is consistent with research suggesting that neighborhood affluence contributes to greater community resources and amenities (e.g., better schools, healthcare facilities, green spaces, job opportunities) and greater social control that buffer against economic insecurity and limited access to essential services, while promoting access to healthier lifestyles (King et al., 2011). Over time, living in stable and less stressful neighborhoods can regulate Mexican immigrants' physiological stress levels at the family level and contribute to lower levels of chronic stress, or HCC levels (Browning and Cagney, 2003). We note that experimental work such as the Moving to Opportunities study has demonstrated that the move to more affluent neighborhoods can positively relate to adults and adolescents' socioemotional function and buffer against short-term psychological distress (although more so for adults than for youths; see Ludwig et al., 2013). However, while living in affluent neighborhoods has been associated with reduced chronic stress and improved socioemotional functioning, the efficacy and feasibility of relocating familiesequires careful consideration. Rather than focusing solely on relocation, our research suggests the importance of enhancing community resources and supports in existing neighborhoods to reduce physiological stress levels of Mexican-origin families. This approach not only circumvents the challenges of relocation but also benefits a larger portion of the Mexican-origin community.

In addition, we found that families residing in areas with high Hispanic/immigrant concentration were more likely to show membership in the high family-level HCC profile. High Hispanic/immigrant concentration is generally seen as adaptive for immigrant families because it may suggest the presence of a close-knit neighborhood of people with similar fates coming together. However, largely consistent with social disorganization theory (Sampson and Groves, 1989), immigrant families are also likely to experience heightened competition for limited resources and opportunities within the same community. Increased social strain due to competition for jobs, housing, and educational resources might exacerbate chronic stress and manifest in higher cortisol levels as families navigate these challenges. At the same time, neighborhoods with high Hispanic/immigrant concentration may also experience unique stressors beyond competition for resources. For instance, these areas could serve as points of entry or transit for recent immigrants, potentially creating instability and uncertainty as families settle. Additionally, such neighborhoods may experience heightened police presence, possibly linked to immigration enforcement or perceptions of crime. For immigrant families, especially those with undocumented members, fear of deportation or legal scrutiny can intensify chronic stress and lead to heightened vigilance and biological stress responses (Miliauskas et al., 2022). While some literature have linked high Hispanic/immigrant concentration with community violence and safety concerns (Foell et al., 2021; Cadenas et al., 2022), it is important to note that these neighborhoods are not uniformly characterized by crime or danger. Rather, the diversity of experiences within these communities may insinuate that other factors, such as systemic discrimination, fear of law enforcement, or instability associated with recent immigration, may play a more prominent role in driving cortisol levels. Future research should further explore these nuanced pathways to better understand how structural and environmental factors influence family stress biology in immigrant communities. Future public health interventions might also focus on improving resource distribution, enhancing legal support, and increasing community policing practices to build trust and reduce fears associated with law enforcement. Such targeted strategies could mitigate the unique stressors faced by immigrant communities, providing a more practical and immediate avenue for intervention than relocation.

Interestingly, we had hypothesized for detrimental links between neighborhood socioeconomic disadvantage and family HCC levels, yet we found no difference in family HCC levels and neighborhood socioeconomic disadvantage. A possible explanation for our null findings may be related to person-environment fit frameworks, which suggests that the greater the (mis)fit of neighborhood characteristics and of its residents, the more likely that residents will have (un)favorable adjustment (Caplan, 1987). For instance, researchers have found only weak associations between neighborhood socioeconomic disadvantage and stressful experiences among Mexican-origin youths (Roosa et al., 2010) and that Latine concentration, rather than concentrated poverty, predicts better psychological well-being among Mexican-origin adolescents (White et al., 2018). Considering that we recruited a relatively homogeneous sample of low-income Mexican immigrant families, our findings may suggest these effects extend beyond adolescents and implicate other members within the family (i.e., fathers and mothers), and influence biological markers of stress. It may be that participants in our study (despite their disadvantages) perceived good fit with their neighborhood environments, which may then wash out some of the negative effects of neighborhood socioeconomic disadvantage (see also Roosa et al., 2009). We suggest the need for more research to (1) investigate and replicate the links between neighborhood socioeconomic disadvantage and Mexican immigrant families' physiological health, (2) compare between neighborhood affluence and socioeconomic disadvantage, to help us comprehensively understand the links between Mexican immigrant families' neighborhood contexts and their influence on Mexican immigrant households' chronic markers of stress in future work. This knowledge can contribute to community-level interventions that increase Mexican immigrant families' resilience and help us understand how they can remain steadfast in the face of disadvantage.

The strengths of our study include the community sample, extending beyond cross-sectional designs, investigations of cortisol at the family level with the inclusion of novel father-reported data—an area often understudied—and the integration of census-based neighborhood data with individual data. There are, however, important limitations that need to be highlighted. For one, we recruited a relatively homogenous sample of Mexican immigrant families from only one location (i.e., central Texas), so our findings may not generalize to other populations such as non-immigrants and those of middle- and high-income families. It would be important for future work to incorporate representation across other racial/ethnic and non-immigrant groups to provide a more comprehensive understanding of the role of neighborhood effects in explaining disparities in physiological stress. Similarly, future studies with participants from diverse neighborhood backgrounds could use latent profile analysis to identify distinct neighborhood configurations and further disentangle the relative influences of various neighborhood characteristics on HCC outcomes. Moreover, a key limitation of this study is the relatively low proportion of fathers who participated within each family. While this study provides novel insights into family-level biological stress by incorporating reports from both parents (fathers and mothers) and the adolescent child among Mexican immigrant families, the low father participation poses challenges for drawing robust conclusions. Future research should include larger and more balanced samples of family members to replicate and validate these findings, thereby enhancing the trustworthiness and generalizability of the results. In addition, we measured neighborhood socioeconomic disadvantage and their links with HCC; given that HCC captures individuals' chronic stress over an extended period, we cannot rule out the possibility that outside of neighborhood factors, (1) stressors such as parenting stress and other adolescent behavioral challenges can exacerbate, while (2) protective factors such as coping strategies and family cohesion can buffer, Mexican immigrant family members' HCC levels. We were not able to examine these factors in the current study and suggest the need for future work to examine these potential stressors and buffers. Moreover, while policy efforts typically target larger geographic areas and research has demonstrated similarities between ZCTA-level and census tract-level measures in predicting well-being (Berkowitz et al., 2015), variations in findings based on the level of geographic granularity may still exist and warrant further exploration. Relatedly, it may be important for future work to incorporate psychological markers of stress to complement the present findings as variations in HCC may not always directly correspond to psychological stress due to factors such as coping strategies, genetics, or even preexisting health conditions (Petrowski et al., 2010). Inclusion of subjective psychological markers of stress may provide more context, helping researchers interpret family-level cortisol data more accurately.

In sum, our findings revealed distinct patterns of families, with one exhibiting consistently high levels of cortisol across all family members and the other displaying consistently low levels. We noted that the high (versus low) family-level HCC group was disproportionately situated in neighborhoods characterized by higher Hispanic/immigrant concentration and lower affluence, underscoring the critical role of neighborhood environments in shaping physiological stress responses within immigrant families. Our findings suggest the need for targeted interventions addressing the unique stressors faced by Mexican immigrant families, particularly for those residing in neighborhoods with higher Hispanic/immigrant density and lower socioeconomic status. By understanding the interplay between neighborhood contexts and physiological stress responses, policymakers and practitioners can develop more effective strategies to support the health and well-being of immigrant families, ultimately fostering stronger and more resilient communities. Further research is warranted to elucidate the underlying mechanisms driving these associations and to inform comprehensive interventions aimed at mitigating physiological stress-related disparities among Mexican immigrant families.

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## CRediT authorship contribution statement

**Chen Shanting:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Xu Yongyong:** Writing – original draft, Formal analysis. **Sim Lester:** Writing – review & editing, Writing – original draft. **Wen Wen:** Writing – review & editing. **Ip Ka:** Writing – review & editing. **Clendinen Cherita:** Writing – review & editing. **Kim Su Yeong:** Writing – review & editing, Project administration, Funding acquisition, Data curation.

## Declaration of Competing Interest

None.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.psyneuen.2025.107426.

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