Investigating potential hormonal associations of grandmaternal care in Jamaica

P Gray, M Samms-Vaughan

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Abstract

There has been increasing scholarly interest in the role of grandmothers in human evolution and cross-culturally. An unaddressed question is the proximate mechanisms associated with human grandmaternal care. Here, we report on results of a naturalistic study conducted in greater Kingston, Jamaica designed to test for between- and within-subject effects of grandmaternal care on women's cortisol, oxytocin, vasopressin, and prolactin levels. We recruited 25 women who lived with and provided care for a biological grandchild aged five or younger (grandmothers) in addition to 20 women of similar ages, socioeconomic status, and health status who did not similarly provide such care (controls). Women were aged 50-67 and postmenopausal. Interviews and biological sample collection took place either in women's homes or a nearby church. While control women participated on a single day, grandmothers participated on two days: one day when they had been caring for their youngest grandchild the previous four hours, and another day when not providing such care the previous four hours. Hormonal data revealed that grandmothers had significantly higher vasopressin levels than control women, but did not exhibit differences in cortisol, oxytocin, and prolactin compared with control women. Results also revealed no significant differences in hormone levels on days grandmothers provided vs. did not provide care the previous four hours. Findings from this first study investigating hormones associated with grandmaternal care can be situated in light of the comparative physiology of affiliative behavior and methodological considerations.

INTRODUCTION

In recent years, scholars have sought to investigate the roles of grandmothers in human evolution[1,2], cross-culturally[3], and as growing segments of the human population[4]. Here, we present findings from a study designed to investigate a novel dimension of grandmothering: the hormones associated with grandmaternal care. We attempt to link the social context of grandmothering in Jamaica with potential hormonal bases of grandmaternal care assessed in a naturalistic study. To do this, we first provide further background on grandmaternal care in Caribbean family contexts, then we present relevant theory and data on hormones and behavior to outline the hypotheses we test.

In Jamaica, like throughout the Caribbean, family household structures are dynamic[5-9]. In Jamaica, half of all children are born to parents who live apart[10-11]. In some of these cases, such "visiting unions" evolve into common-law unions or marriage; in other cases, these unions dissolve, with mothers benefiting from future male mating partners (stepparents) or, importantly for our purposes, maternal kin (especially maternal grandmothers and aunts)[12]. An important consequence of these patterns is that grandmothers frequently play important roles in caring for their grandchildren[6,8].

One recent nationally representative study in Jamaica of 250 households (which was following children 6 years old at the time) found that grandmothers served as the head of the household in 10% of households (Samms-Vaughan, unpublished data). Another recent Jamaican study (which was following children aged 11-12 at the time) found that 7.8% of a sample of 1720 households in the greater Kingston area was headed by grandmothers (Samms-Vaughan, unpublished data). These figures do not include the presence of grandmothers serving as secondary caretakers (e.g., grandmothers living with a daughter and grandchild); such quantitative data are unavailable. However, these data on Jamaican household composition suggest that grandmothers play important roles as heads of households and caretakers.

In this project, we bridge the social context of grandmothering with a complementary set of research in behavioral endocrinology that focuses on the hormonal bases of caregiving[13-16]. Here, growing attention has been given to

the roles of several hormones—oxytocin, vasopressin, prolactin, and cortisol—for which we investigate potential roles in Jamaican grandmothering. Research in both nonhuman animals and humans implicates these hormones in social affiliation broadly and offspring care more specifically. As examples, oxytocin has been implicated in mammalian social behavior, including maternal care[14], just as it has in humans[17-19].

Apart from oxytocin, considerable research has investigated the roles of vasopressin, prolactin and cortisol in caregiving. The vasopressin system has been implicated in vole pair bonding and paternal care, with effects appearing to be more consistent and functional in males rather than females[20-21]. We previously found that the urinary vasopressin levels among a sample of Jamaican men were positively associated with the age of fathers' youngest child[22]. Research on prolactin, conversely, suggests important functions in mammalian offspring care. While administration of a prolactin receptor blocker inhibits rat maternal care[23] and a small study of captive squirrel monkeys revealed higher prolactin levels in aunts and grandmothers relative to unrelated females and males[24], there exist no published studies on the roles of prolactin in human non-maternal caretaking studies. Finally, a body of research on glucocorticoids (cortisol in humans) demonstrates that these stress hormones increase in response to a variety of stimuli in order to adaptively channel energy, focus attention, and enhance memory; however, it is not clear whether grandmaternal care is associated with differential stress responsiveness.

Building on this background, we sought to test the hormonal correlates of grandmothering in Jamaica. We test the hypotheses that grandmothering will be associated with elevated oxytocin and prolactin levels. We also test whether vasopressin and cortisol levels are affected by grandmothering. To facilitate these tests, we focus on postmenopausal grandmothers recruited in a naturalistic study design. Moreover, we investigate both within-subject and between-subject hormonal effects of grandmothering as described in the Methods below. Finally, to provide additional social context, including emic perspectives on women's attitudes toward caregiving, we present qualitative data obtained from interviews.

METHODS

STUDY POPULATION

To test the hypotheses above, 25 postmenopausal grandmothers and 20 control subjects were recruited from greater Kingston, Jamaica. While Jamaica has a population of around 2 million, Kingston is the largest urban area on the island, harboring a socioeconomically diverse population of around 800,000 inhabitants. Approximately 93% of the island's population claims African Caribbean descent, with the remainder a mixture of European, Native Caribbean (e.g., Taino), South Indian, Chinese, and Southwest Asian ancestry.

We limited our study to postmenopausal Jamaican grandmothers for several reasons. The primary reason is that postmenopausal grandmothers are a culturally salient group of caregivers in Jamaica. This makes the study of them culturally normative rather than rare or unusual. Another reason is that a female's reproductive status (pre- vs. postmenopausal) affects oxytocin and prolactin levels[25], meaning that by focusing on strictly postmenopausal women we can remove the potentially confounding effects of female reproductive status on these hormones. To further restrict variation among subjects in this study, we limit our study to postmenopausal grandmothers aged 50-65 who do not have a biological child less than 10 years of age and who co-reside (live in the same dwelling) with at least one putative biological grandchild aged 5 or younger. We sought control subjects of comparable age and socioeconomic backgrounds, but defined controls by virtue of not living with a putative biological grandchild aged 5 or younger. We recruited groups of comparable age and socioeconomic backgrounds by checking for similar age and educational backgrounds of participants during the recruitment phase. Menopause was operationalized as a self-reported cessation of menstruation during the previous 12 months.

According to 2004 data (www.worldbank.org), average lifespan in Jamaica is 70.8 years, meaning that many women reach these upper ages. However, the population has experienced an increase in the incidence of obesity and metabolic diseases such as Type 2 diabetes and hypertension. Accordingly, we included in our sample about half of subjects who have been diagnosed with Type 2 diabetes and/or hypertension. Finally, although completed fertility in Jamaica has fallen to 2.4 children, we encountered few older women who had not previously had children and observed that Jamaican grandmothers continue to serve important roles as caregivers of their grandchildren.

We recruited grandmothers and control women by word of mouth and at two churches in greater Kingston. One of these churches was an Anglican church in urban Kingston, and the

other a Seventh Day Adventist church on the rugged, mountainous outskirts of town. These churches were chosen because one of us (MS-V) maintains active and longstanding ties with one, and because of ties to research personnel in the other case. Subjects were remunerated either $3500 Jamaican (approximately $50 U.S.: grandmothers) or $2000 Jamaican (approximately $30 U.S.: controls). Ethical approval for the study was given by the University of the West Indies Faculty of Medical Science/University Hospital Ethical Committee and University of Nevada, Las Vegas institutional review board. Written informed consent was obtained from participants.

STUDY PROCEDURES

The study design was built around testing both within- and between-subject effects of caregiving on hormones. To test within-subject effects, we performed all study procedures with grandmothers on two days: one day in which the grandmother had spent the previous four hours caring for her youngest grandchild, and a second day in which the grandmother had not been caring for this or other young grandchildren the previous four hours. Potential within-subject effects of caregiving on hormones were expected to be shown on the caregiving day. To test between-subject effects, we recruited control women of similar ages, socioeconomic variation, and health status. All procedures with control participants took place on one day. Data from controls were then compared with the two-day average day of grandmothers in addition to supplemental analyses contrasting controls with grandmothers on caregiving and non-caregiving days respectively.

All study procedures took place either in a subject's home or at one of the same two churches from which participants were recruited. This feature of the study design was meant to capture more naturalistic effects of grandmothering on hormones. In all cases where grandmothers participated at a church, they lived within short walking distances. Since the church serves as a central social activity for many Jamaican women, including those in the sample, conducting procedures in the church enabled use of a familiar environment.

All study procedures took place between 1200 and 1800 hours. One reason for limiting procedures to these times was to reduce potential circadian effects on hormone levels (e.g., most declines in cortisol levels occur within the first few hours after waking). Another reason was to conduct study procedures after grandmothers had been awake for enough hours to have either spent the previous four hours providing care or not of a grandchild. All subjects participated between 28 May 2008 and 18 July 2008. The order of procedures entailed subjects providing informed consent, biological samples, and then responding to interview items.

A central methodological feature of this study was use of minimally invasive sample collection. Saliva samples were collected in order to measure cortisol levels; finger prick blood spot samples were collected to measure prolactin levels; and urine samples were collected to measure oxytocin and vasopressin levels. Procedures of sample collection have been previously published (see [22]). In brief, these procedures entailed collecting biological samples as follows: approximately 1.0 ml of unstimulated saliva was provided through a straw into a cryovial tube; approximately 4 drops of blood were dropped upon filter paper after wiping the finger with an alcohol wipe and pricking it with a safety lancet; and urine samples were provided in specimen collection cups then transferred into polystyrene tubes for long-term storage. After samples were collected, they were kept in a cooler along with freeze packs before transported to a -20C freezer at the University Hospital of the West Indies for storage until shipped back to the U.S. for assay. In addition to collecting these three biological samples during each study visit, we also measured blood pressure using a portable blood pressure monitor (Omron HEB-773AC), measured height and weight to calculate body mass index (BMI: kg/m^2), and engaged in semi-structured interviews.

SEMI-STRUCTURED INTERVIEWS

Interviews were conducted with each control subject and each grandmother on her "non-caregiving" day. Interviews included questions covering basic sociodemographic information such as age, socioeconomic status, and reproductive history. Educational attainment was scored as 1 (none); 2 (primary school); 3 (secondary school); or 4 (post-secondary school). A measure of wealth was indexed as the total number of a possible 11 household items (e.g., refrigerator, cell phone, stereo/VCR/DVD equipment, motor vehicle) present in a subject's household.

To provide further social context on Jamaican grandmothers' lives and caregiving, we asked open-ended questions concerning household structure, broader behavioral context of caregiving, and emic views of caregiving. Examples of these open-ended questions include: How do you feel about providing care for your grandchild(ren)? and What types of support do you provide? We report some of the qualitative

data stemming from these interviews in the Discussion section. Interviews typically lasted between 30 and 60 minutes. Interviews were either conducted by one of us (PG) or trained Jamaican research assistants.

HORMONE ASSAYS

Details concerning salivary, blood spot, and urinary hormone assays have been previously published in[22]. These methods included solid phase extraction for sample purification (SepPak C18 cartridges, Waters, cat# WAT023590) prior to assay. Samples were 1 ml aliquots of urine for each assay and after solid phase extraction the samples dried, resuspended in assay buffer and were applied onto the EIA plates in 100 µl (Assay Designs,Ann Arbor, MI) . Results of the prolactin assays yielded inter-assay coefficients of variation of 13.3% and 8.9% for low and high controls, respectively, and an intraassay coefficient of variation of 8.0%. Interassay coefficients of variation for cortisol were 8.2% and 2.3% for low and high controls, respectively, and an intrassay coefficient of variation of 11.8% Oxytocin coefficients of variation were 6.4% for intrassay and 14.1% for interassay. Vasopressin coefficients of variation were 4% for intrassay and 14% for interassay.

STATISTICAL METHODS

K-S tests indicated that cortisol, vasopressin, and oxytocin levels, but not prolactin levels, differed significantly from a normal distribution ($p<0.05$). Thus, cortisol, vasopressin, and oxytocin concentrations were log(10) transformed. After log transformation, these hormone concentrations no longer deviated from a normal distribution ($p>0.05$). Two prolactin values that were > 3SD above the mean were removed. No log transformed cortisol, oxytocin, or vasopressin levels were > 3SD above the mean.

Hormone analyses included five potential confounding variables: age, BMI, current use of daily medications, time of day, and the location (home vs. church) at which study procedures took place. Initial bivariate analyses relied on either t tests or ANOVA to determine whether these variables were associated with hormone concentrations (Table 1). Results of these bivariate explorations of potential confounding variables suggested several variables that should be controlled. Those variables exhibiting relationships at $p<0.10$ were retained in multivariate models designed to test for effects of caregiving on hormone concentrations. ANCOVA was used for all multivariate models. To test within-subject effects of caregiving on hormones, repeat measure ANOVA was used with hormone concentrations used as the repeat dependent measures and any covariates included. To test for between-subject effects, we used grandmothers/controls as the independent variable, included relevant covariates, and a subject's hormone concentrations were used as the dependent variables. The average of a grandmother's two hormone concentrations (e.g., cortisol on the two days measured) was used for grandmothers in these between-group analyses. Posthoc analyses (not shown) revealed that results did not noticeably differ if controls were compared with grandmothers on caregiving and non-caregiving days, respectively, rather than the average of grandmothers' hormone levels.

Figure 1

Table 1. Univariate analyses of hormones and potential confounding variables.

	Age	BMI	Medications	Time of Day	Location
Log Cortisol	r=-.084, p=.492	r=.085, p=.482	t=.1.772, p=.081	r=-.133, p=.270	t=-1.34, p=.893
Prolactin	r=-.217, p=.076	r=.289, p=.018	t=1.331, p=.188	r=.064, p=.603	t=.723, p=.472
Log Oxytocin	r=.303, p=.018	r=-.201, p=.123	t=-1.006, p=.318	r=-.024, p=849	t=-1.882, p=.065
Log Vasopressin	r=-.027, p=.829	r=-.109, p=.382	t=-.603, p=.549	r=.011, p=.930	t=-2.025, p=.047

BMI = body mass index; Medications = takes daily Type 2 diabetes and/or hypertension medications; Location = participated at a church or at home. Results are reported for either t tests or Pearson's correlations. A positive t statistic for Medications indicates higher hormone levels among women reporting taking daily medications. A positive t statistic for Location means higher hormone levels at home.

RESULTS

SOCIODEMOGRAPHIC DATA

We recruited 45 women aged 50-67 to participate. The group of 25 grandmothers did not differ significantly from the 20 "control" women in age, BMI, education, household material items, or employment status (see Table 2). The completed fertility was not significantly different between the two groups of women either. Each woman in the sample had born at least one child. Commonly, women had children fathered by different men. In one of the more extreme examples, a grandmother reported having 8 children fathered by 5 men; more typical was a woman having 3 children by 2 men. The only significant difference between the groups of women was that grandmothers were less likely to be involved in a current relationship with a man than were control women ($t=3.259$, $df=34.25$, $p=0.003$). Formal marriage was relatively rare, with partnerships more equivalent to live-in common-law unions.

Figure 2

Table 2. Sociodemographic data (Mean ± SD) of participants.

	Grandmothers (25)	Controls (20)	All women (45)
Age	57.3 (5.5)	59.3 (4.9)	57.9 (5.3)
BMI	29.2 (6.4)	27.1 (6.6)	28.6 (6.5)
Education	2.6 (0.8)	3.0 (0.9)	2.7 (0.9)
Household Items	5.1 (2.8)	6.0 (2.8)	5.5 (2.8)
Employed?	8/25 yes (32%)	8/20 yes (40%)	16/45 yes (35.6%)
Number Kids Born	4.4 (2.4)	3.7 (2.6)	4.1 (2.5)
In Relationship?*	4/25 yes (16%)	12/20 yes (60%)	16/45 (35.6%)
On T2D and/or HP medications?	10/25 yes (40%)	9/20 yes (45%)	19/45(42.2%)

BMI = body mass index; T2D = Type 2 Diabetes; HP = Hypertension
*p<0.05

Most (N=16) grandmothers served supplemental roles to a parent or parents rather than as primary caregivers (N=9). In a few cases, grandmothers lived with their son and grandchildren, but in the vast majority of cases grandmothers lived with a daughter, sometimes the daughter's partner, and the daughter's children (hence emphasizing maternal grandmothering). Grandmothers reported frequent patterns of caregiving that emphasized their roles spending time with grandchildren (especially while the children's parents worked); helping defray costs of material items such as school, food and medications; helping protect their grandchildren from danger (e.g., keeping them off rough urban roads); and acting as indulgent caregivers compared to the children's parents (e.g., holding a crying grandchild).

There were no differences between grandmothers and controls in the proportion of women reporting a diagnosis of Type 2 diabetes and/or hypertension in the study. The average blood pressures (Table 3) were quite high, but also consistent with broader Caribbean data. Interestingly, no women indicated taking hormone therapy.

Figure 3

Table 3. Blood pressure and hormone data (Mean ± SD) of participants.

Variable	Grandmothers (Care Day)	Grandmothers (Non-care Day)	Grandmothers (Average of Two Days)	Control Women	Overall Average
Systolic Blood Pressure	144.0 (26.6)	140.3 (26.9)	142.2 (26.6)	143.2 (24.0)	142.2 (25.6)
Diastolic Blood Pressure	89.8 (12.2)	88.7 (11.9)	89.2 (12.0)	88.9 (13.1)	89.0 (12.1)
Prolactin Levels (ng/mL)	5.8 (2.3)	6.1 (2.6)	6.0 (2.3)	6.0 (3.0)	6.0 (2.6)
Oxytocin Levels (pg/mg creatinine)	14.0 (13.0)	18.2 (23.1)	18.0 (19.2)	13.5 (9.4)	16.0 (15.6)
Cortisol Levels (ug/dL)	0.08 (0.11)	0.07 (0.07)	0.11 (0.19)	0.06 (0.06)	0.09 (0.15)
Vasopressin Levels (pg/mg creatinine)	23.6 (17.5)	25.8 (22.0)	27.8 (22.4)	14.9 (7.4)	22.2 (18.6)

HORMONE DATA

Hormone concentrations are reported in Table 3. In multivariate models testing for within-subject effects of caregiving on cortisol, the overall model (F=3.701, df=23, p=0.032) was significant, but caregiving day (F=.594, p=0.449) was not related to cortisol levels, though use of medications was (F=5.472, p=0.028). In testing between-subject effects (controls vs. grandmothers), the overall model was not significant (F=.704, df=42, p=0.500). Use of daily medications (F=.877, p=0.565) and caregiving (F=.337, p=0.565) were not associated with cortisol levels.

In multivariate models testing for within-subjects effects of caregiving on prolactin, the overall model was not significant (F=.955, df=21, p=0.423), and BMI (F=1.347, p=0.259), age (F=.175, p=0.680), and caregiving day (F=1.143, p=0.297) were also not significant predictors of prolactin. In testing between-subject effects, the overall model (F=3.235, df=40, p=0.034) was significant. BMI (F=5.760, p=0.022) was significantly associated with prolactin, age exhibited a tendency (F=2.969, p=0.094) toward an association with prolactin, and caregiving (grandmothers vs. controls) was not associated (F=.368, p=0.548) with prolactin levels.

In multivariate models testing for within-subject effects of caregiving on oxytocin, the overall model was not significant (F=1.785, df=16, p=0.166), nor were age (F=.997, p=0.333), location (F=.604, p=0.449) or caregiving day (F=.125, p=0.728). In testing between-subject effects (grandmothers vs. controls), the overall model neared significance (F=2.853, df=38, p=0.053). Location (F=.632, p=0.432) and caregiving (F=.055, p=0.816) were not significantly, though age (F=5.944, p=0.021) was significantly associated with oxytocin levels.

In multivariate models testing for within-subjects effects of caregiving on vasopressin, the overall model was not significant (F=.479, df=21, p=0.622), nor were location (F=..365, p=0.552) or caregiving day (F=.010, p=0.920). In testing between-subject effects, the overall model was significant (F=5.653, df=41, p=0.007). Location was not significantly associated with vasopressin (F=2.166, p=0.149), but caregiving was (F=6.080, p=0.018).

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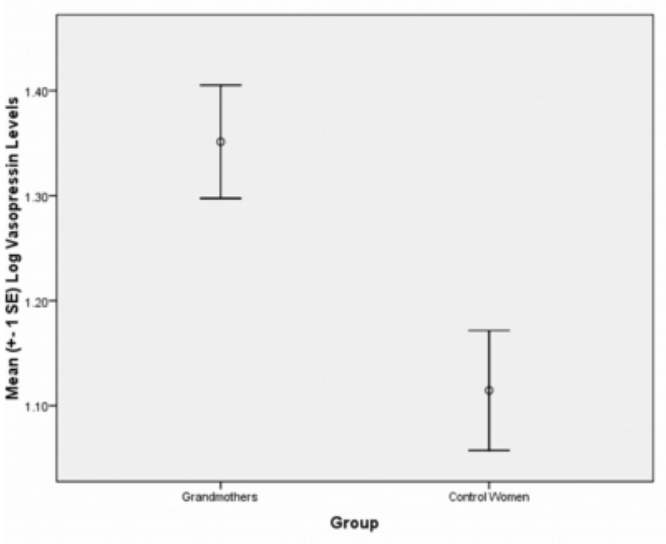
Figure 4

Figure 1. Vasopressin levels according to grandmothering status



DISCUSSION

In this study of hormonal associations with Jamaican grandmaternal care, we found that our grandmothers did not differ from control women in age, BMI, socioeconomic status, health status, or fertility. Grandmothers were less likely to be involved in a current partnership with a man than were controls. Hormone data revealed that grandmothers had higher vasopressin, but not oxytocin, prolactin, or cortisol levels compared with control women. In within-subject analyses, prolactin, oxytocin, vasopressin, and cortisol levels did not differ on days when grandmothers had spent the previous four hours caring for their youngest grandchild compared with days when these same grandmothers had not provided such care.

The failure to support most between-subject and within-subject expectations, particularly for oxytocin and prolactin, raises several questions. Are these hormones truly uninvolved in postmenopausal caregiving? Or are these hormones actually involved, but not detected in the study design, perhaps due to methods of assessing behavior and measuring hormone levels? Previous work implicating these hormones in maternal and other forms of childcare, both in nonhuman animals and humans, suggests the present pilot study may fail to have detected the predicted hormonal associations. Recent reports observed elevations in oxytocin, prolactin, and cortisol during brief interactions between humans and dogs[26-28], further supporting an expected role in human grandmaternal care. Even post-hoc analyses testing for possible effects of a woman' partnership status (single or partnered) or status as a primary caregiver (vs. secondary caregiver) were not associated with hormone differences (all $p>0.05$) across all women or within grandmothers and controls respectively. We thus suggest that our main reasons for failing to observe support for roles of oxytocin, prolactin, and cortisol may be more due to issues of study design.

Our naturalistic study was designed to capture women on days they engaged in regular kinds of behavior, such as caring for a grandchild, in the familiar environments of their homes or churches. This study thus avoided use of a novel environment such as a Psychology or Hospital testing lab, or use of experimental social stimuli (e.g., having grandmothers hold a baby doll or watch a video containing images and sounds of babies crying). Effects of offspring stimuli may be transient, meaning they may be more difficult to capture in samples obtained only once or twice. The potency of offspring stimuli may not be adequate in most naturalistic settings to elicit changes in these hormone levels. We suggest that these kinds of possibilities do indeed help account for our failed hypotheses.

Another reason we suggest that research design accounts for null findings is that qualitative data from interviews suggest that grandmothers overwhelmingly viewed their caregiving roles as emotionally positive and important, meaning that this was a good study population in which to test for possible hormonal association of normative grandmaternal care. When asked open-ended questions about benefits, disadvantages, and potential burdens of their roles, grandmothers almost universally expressed positive sentiments to their caregiving roles. As one woman said, "Feel good, love them, and like them around me." Another completed an interview by exclaiming, "I love to be a grandmother. I love kids." These types of response were common, and positive sentiments were expressed almost without hesitation, frequently with smiles, sometimes woven into religious innuendo, and usually counterbalanced by a sense that asking about disadvantages or burdens of grandmothering seemed silly. Several exceptions to these generalizations may be revealing. One woman described a son's former partner as a "[W]icked woman. She doesn't even call." This grandmother was left to care for the grandchild after the child's mother disappeared, perhaps to Miami. Another grandmother, who lived with her children and 13 grandchildren, expressed resentment, suicidal thoughts, and a desire to sometimes run away over the obligations of helping provide care. Her sentiments appeared to stem, in part, from some grandchildren having gone "bad"

and tensions with her own children, though this grandmother also professed to enjoying her grandchildren generally.

Why did grandmothers have higher vasopressin levels than control women? This finding was less expected than predicted effects on oxytocin and prolactin. Most research on vertebrates implicates vasopressin more in male social behavior than in females. However, among postmenopausal women, the declines in estrogen and alterations in the estrogen/androgen ratio may result in a greater role for vasopressin in these ages than at others in females. The fact that vasopressin levels did not differ in grandmothers between days on which they had or had not cared for their youngest grandchild the previous four hours appears to lessen an interpretation based on acute social behavioral effects of caregiving on vasopressin. Perhaps this difference represents more chronic effects of social orientations of women, with grandmothers oriented toward a young grandchild requiring care. Other typical mood, cognitive, and behavioral effects associated with vasopressin include anxiety, focused attention, and aggression[21], the kinds of effects that might in turn suggest that grandmothering pushes postmenopausal women toward an allostatic state in order to successfully respond to needs of their young grandchildren. A recent report causally linked effects of central vasopressin to rat maternal care, perhaps indicating that vasopressin may have a somewhat unexpected role in mammalian female offspring care[29], and areas of the brain rich in vasopressin (and oxytocin) receptors are activated when women look at photos of their young children[30].

Findings of this study are subject to limitations. Oxytocin and vasopressin levels were measured peripherally (in urine) rather than the ideal of centrally (in brain) due to inherent constraints of human research, although the interpretation of the vasopressin association with grandmaternal care is consistent to effects of vasopressin that have been demonstrated through nonhuman invasive research and to a lesser degree human experimental nasal spray studies[20-21]. Furthermore, specifics of the study sample might be duly noted: women in this study were recruited from a nonprobability sample, meaning that findings from this study may not generalize to other samples. Moreover, our emphasis in the research design on group differences comes at some expense to better addressing individual differences within groups: both grandmothers and control women provided variable degrees of grandmaternal care (e.g., controls providing care to young children they do not live with), but we do not have good quantitative measures of that variation to analyze in the present study.

To summarize, results of the present study represent the first attempt to test the hormonal associations of grandmaternal care in humans. The methods entailed a naturalistic study conducted in Jamaica. The results raise methodological questions relevant to the present findings as well as future research in this area. Future research could profit by investigating alternative research designs (e.g., exposing grandmothers to crying babies in a laboratory) as well as different subject populations of grandmothers (e.g., grandmothers who are unhappily forced to care for grandchildren due to a daughter's absence, or among premenopausal grandmothers). These kinds of studies will acknowledge the importance and physiological underpinnings of grandmaternal care in specific sociocultural contexts.

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References

1. Williams, GC: Pleiotropy, natural selection, and the evolution of senescence. Evol; 1957; 11: 398-411.
2. Hawkes K, O'Connell JF, Blurton Jones NG, Alvarez H, Charnov EL: Grandmothering, menopause, and the evolution of human life histories. Proc Natl Acad Sci; 1998; 95: 1336-1339.
3. Sear R, Mace R: Who keeps children alive? A review of the effects of kin on child survival. Evol Hum Behav; 2008; 29: 1-18.
4. Voland E, Chaiotis A, Schiefenhovel W. 2005. Grandmotherhood: The Evolutionary Significance of the Second Half of Female Life. New Brunswick: Rutgers University Press.
5. Horowitz, M. Ed. 1971. Peoples and Cultures of the Caribbean. Garden City, NY: The Natural History Press.
6. Barrow C. 1996. Family in the Caribbean: Themes and Perspectives. Kingston, Jamaica: Ian Randle.
7. Smith RT. 1996. The Matrifocal Family: Power, Pluralism, and Politics. New York: Routledge.
8. Roopnarine JL, Bynoe P, Singh R, Simon R. 2005. Caribbean families in English-speaking countries: a rather complex mosaic. In: Roopnarine JL, Gielen UP, editors. Families in Global Perspective. Boston: Allyn and Bacon, p.

311-329.
9. Quinlan RJ: Gender and risk in a matrifocal Caribbean community: a view from behavioral ecology. Amer Anthropol; 2006; 108: 464-479.
10. Samms-Vaughan ME. 2006. Children Caught in the Crossfire. Grace, Kennedy Foundation.
11. Samms-Vaughan ME. 2005. Profiles: The Jamaican pre-school child: The status of early childhood development in Jamaica. Planning Institute of Jamaica Publication.
12. Roopnarine JL. 2004. African American and African Caribbean fathers: Level, quality, and meaning of involvement. In: Lamb ME, editor. The Role of the Father in Child Development. Hoboken, NJ: John Wiley and Sons, pp. 58-97.
13. Adkins-Regan E. 2005. Hormones and Animal Social Behavior. Princeton: Princeton University Press.
14. Carter CS: The neuroendocrinology of social attachment and love. Psychoneuroendocrinol; 1998; 23: 779-818.
15. Ellison PT, Gray PG, Eds. 2009. Endocrinology of Social Relationships. Cambridge: Harvard University Press.
16. Nelson RJ. 2005. An Introduction to Behavioral Endocrinology, 3rd Edition. Sunderland, MA: Sinauer.
17. Feldman R, Weller A, Zagoory-Sharon O, Levine A: Evidence for a neuronendocrinological foundation of human affiliation: plasma oxytocin levels across pregnancy and the postpartum period predict mother-infant bonding. Psychol Sci; 2007; 18: 965-970.
18. Taylor SE. 2002. The Tending Instinct. New York, Holt.
19. Uvnas-Moberg K. 2003. The Oxytocin Factor: Tapping the Hormone of Calm, Love, and Healing. US: Da Capo Press.
20. Donaldson ZR, Young LJ: Oxytocin, vasopressin, and the neurogenetics of sociality. Science; 2008; 322: 900-904.
21. Sanchez R, Parkin JC, Chen J, Gray PB. 2009. Oxytocin, vasopressin and human social behavior. In: Ellison PT, Gray PB, editors. Endocrinology of Social Relationships. Cambridge: Harvard University Press, p. 319-339.
22. Gray PB, Parkin JC, Samms-Vaughan M: Hormonal correlates of human paternal interactions: A hospital-based investigation in urban Jamaica. Horm Behav; 2007; 52: 499-507.
23. Lucas BK, Ormandy CJ, Binart N, Bridges RS, Kelly PA: Null mutation of the prolactin receptor gene produces a defect in maternal behavior. Endocrinol; 1998; 139: 4102-4107.
24. Soltis J, Wegner FH, Newman JD: Urinary prolactin is correlated with mothering and allo-mothering in squirrel monkeys. Phys Behav; 2005; 84: 295-301.
25. Brizendine L. 2006. The Female Brain. New York: Broadway.
26. Odendaal JSL, Meintjes RA: Neurophysiological correlates of affiliative behaviour between humans and dogs. The Veter J; 2003; 165: 296-301.
27. Miller SC, Kennedy C, DeVoe D, Hickey M, Nelson T, Kogan L: An examination of changes in oxytocin levels in men and women and after interaction with a bonded dog. Anthrozoos; 2009; 22: 31-42.
28. Nagasawa M, Kikusui T, Onaka T, Ohta M : Dog's gaze at its owner increases owner's urinary oxytocin during social interaction. Horm Behav; 2009; 55: 431-441.
29. Bosch OJ, Neumann ID: Brain vasopressin is an important regulator of maternal behavior independent of dams' trait anxiety. Proc Natl Acad Sci; 2008; 105: 17139-17144.
30. Bartels A, Zeki S: The neural correlates of maternal and romantic love. NeuroImage; 2004; 21: 1155-1166.

Author Information

Peter B. Gray
Department of Anthropology, 4505 S. Maryland Parkway Box 455003, University of Nevada, Las Vegas, Las Vegas, NV, 89154-5003, USA

Maureen Samms-Vaughan
Section of Child Health, University of the West Indies, Mona, Jamaica