MATERNAL STRESSORS
IMPACT MATERNAL WELLBEING AND CORTISOL
AND INFANT GROWTH IN RURAL GUATEMALA:
INSIGHTS FROM QUALITATIVE AND QUANTITATIVE APPROACHES

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ABSTRACT

Background: Despite decades of nutrition interventions, Guatemala still has one of the highest rates of child stunting in the world, with the indigenous populations being disproportionately affected. Impaired linear growth may be a consequence of maternal stresses associated not only with malnutrition and infection but also with psychosocial factors, the effects of which may be mediated by maternal cortisol. **Objective:** In 8 historically marginalized rural *Mam*-Mayan communities in the Western Highlands of Guatemala, our objectives were to (1) characterize women's exposure to nutrition, infection and psychosocial stressors vs. resilience factors, (2) describe the maternal diurnal salivary cortisol rhythm in pregnancy and postpartum (PP) and explore its association with psychosocial variables, (3) assess the cumulative impact of maternal-level factors (nutritional, infectious, psychosocial), social factors (autonomy, social support, domestic violence), and household factors (socioeconomic status, food security) on early infant growth, and (4) evaluate whether maternal cortisol may be a mediator in the *vertical transmission of stress*. **Methods:** Grounded in participatory action research and a socio-ecological framework, this mixed-methods, observational study enrolled a longitudinal cohort of 155 women, seen during pregnancy (6-9 mo), early (0-6 wks) and later (4-6 mo) PP, and two cross-sectional cohorts (60 early, 56 later PP). Maternal and infant anthropometry was recorded, maternal fecal, urine and saliva samples were collected, and questionnaires were used to explore household factors (socioeconomic status, food security), social factors (autonomy, paternal/social support, domestic violence), and maternal-level factors (nutrition, infection, emotional distress). Photovoice activities involved giving a camera to 23 women from study communities, who documented sources of stress vs. resilience for local women, and shared photo-elicited narratives through six group sessions. **Results:** Diet diversity (3.4 ± 1.3) was low and only 38% of women were food secure. Urinary and gastrointestinal infections were rare (<5%). Participants reported low maternal autonomy (81%), high paternal support (70%), small social support networks (2.7 ± 1.3 individuals) and common domestic violence (22%). Many women (20-50%) had local idioms of distress (*enojo*, *susto, nervios*). Infant stunting was common (36% early PP, 43% later PP). Waking and evening salivary cortisol concentrations were 13.1 ± 5.2 and 5.0 ± 3.0 nmol/l in pregnancy and 6.1 ± 3.1 and 2.2 ± 2.3 nmol/l PP. Lower household wealth, food insecurity, shorter maternal stature, high maternal autonomy, high paternal support, low/moderate social support and domestic violence were associated with a more "stressed" cortisol rhythm. Domestic

violence increased the likelihood of feeling overwhelmed (OR = 27.3) and of experiencing local idioms of distress (OR = 2.3 to 5.4). Dirt floor, lack of prior day meat consumption, insufficient breast milk, and short maternal stature were associated with lower early PP height-for-age Z score (HAZ) and increased likelihood of stunting. Early PP, infants of mothers with greater paternal support, autonomy and emotional distress were more likely to be stunted. Higher concentrations of early PP evening salivary cortisol increased the likelihood of stunting. Change in HAZ between early and later PP visits (ΔHAZ) was positively associated with maternal height, BMI and female gender, and negatively with maternal autonomy, problems with partner and difficulty breastfeeding. Later PP waking cortisol was positively associated with ΔHAZ. Photovoice narratives highlighted 2 scenarios of particular vulnerability: (1) experiencing domestic violence, low autonomy and socioeconomic dependence, and (2) being a single mother with few employment options and limited rights. Additional sources of stress were poverty, having no social support and the absence of social services. Sources of resilience were family, nature, having livestock, agriculture, traditional knowledge/practices and spirituality.
Implications: This transdisciplinary research highlighted the importance of integrating psychosocial interventions into research and intervention programs targeting early infant growth, and sheds light on important strategies to increase resilience and empower women and communities to break the intergenerational cycle of poor growth and reduced lifetime health and opportunity.

ABREGE

Contexte: Malgré des décennies d'interventions nutritionnelles, le Guatemala a l'un des taux de retard de croissance infantile plus élevés au monde. Les populations autochtones sont disproportionnellement affectées. Le retard de croissance infantile peut être dû au stress maternel lié non seulement à la malnutrition et à l'infection, mais aussi à des facteurs psychosociaux, dont les effets peuvent être transférés de la mère à l'enfant par le biais du cortisol. **Objectif:** Dans 8 communautés maya-*Mam* rurales marginalisées de l'occident montagneuse du Guatemala, nos objectifs étaient de (1) caractériser l'exposition des femmes d'une part aux stress liés à la nutrition, à l'infection et à des facteurs psychosociaux, et d'autre part à des facteurs de résilience, (2) décrire le rythme diurne de cortisol salivaire maternel pendant la grossesse et post-partum, et explorer son association avec les variables psychosociales, (3) évaluer l'impact cumulatif des facteurs maternels (nutritionnels, infectieux, détresse émotionnelle), sociaux (autonomie, soutien social, soutien paternel, violence), et domestiques (statut socio-économique, sécurité alimentaire) sur la croissance des nourrissons, et enfin (4) évaluer si le cortisol maternel pourrait être un médiateur dans la transmission verticale du stress. **Méthodes:** basée sur une approche de recherche-action partici-pative et un cadre socio-écologique, cette étude observationnelle de méthodologies mixtes (quantitatives et qualitatives) avait inscrit une cohorte longitudinale de 155 femmes, vues pendant la grossesse (à 6-9 mois), à 0-6 semaines post-partum, et à 4 -6 mois post-partum, et deux cohortes transversales (60 à 0-6 semaines, 56 à 4 -6 mois). L'anthropométrie maternelle et infantile ont été mesurées, des échantillons maternels d'urine, fécaux et de salive ont été recueillis, et des questionnaires ont été utilisés pour explorer les facteurs domestiques, sociaux, et maternels. De plus, au cours d'une étude de « Photovoice », 23 femmes de la communauté avaient à leur disposition une caméra pour documenter l'expérience de vie quotidienne des femmes de leurs communautés, surtout par rapport à leur vécu de sources de stress et de résilience. Photos et discussions couvrant les thèmes des photos furent partagées par groupe au long de six séances. **Résultats:** la diversité de la diète (3,4 ± 1,3) était basse, et seulement 38% des femmes étaient en sécurité alimentaire. Les infections urinaires et gastro-intestinaux étaient rares (<5%). Les participantes ont signalé une faible autonomie de la mère (81%), un fort soutien paternel (70%), des petits réseaux de soutien social (2,7 ± 1,3 personnes) et un taux de violence domestique élevé (22%). Beaucoup de femmes (20-50%) souffraient d' « idiomes locaux de détresse » (*enojo, susto, nervios*). Le retard de croissance infantile était

fréquent (36% à 0-6 semaines, 43% à 4-6 mois). Concentrations de cortisol salivaire au lever et au coucher étaient de 13,1 ± 5,2 et 5,0 ± 3,0 nmol / litre pendant la grossesse et de 6,1 ± 3,1 et 2,2 ± 2,3 nmol / litre après l'accouchement. La pauvreté du foyer, l'insécurité alimentaire, la petite taille maternelle, l' autonomie maternelle, le fort soutien paternel, le faible soutien social et la violence domestique étaient tous associés à un rythme diurne de cortisol dit « stressé ». La violence domestique augmentait la probabilité que la femme se ressentirait accablée (OR = 27,3) et souffrirait d' « idiomes locaux de détresse » (OR = 2,3 à 5,4). Vivre dans une maison en terre battue, le manque de consommation de viande durant la journée précédente, la perception de manquer de lait maternel, et une petite taille maternelle étaient associés à une basse taille-pour-âge (HAZ) de l'enfant et à une probabilité accrue de retard de croissance. A 0-6 semaines d'âge, les nourrissons de mères avec un plus fort soutien paternel, une plus grande autonomie et qui souffraient de détresse émotionnelle étaient plus susceptibles d'avoir un retard de croissance. Une concentration plus élevée au coucher de cortisol maternel, à 0-6 semaines, augmentait la probabilité d'un retard de croissance chez l'enfant. Changement de HAZ entre la première et la seconde visite post-partum (ΔHAZ) était positivement associé à la taille et à l'indice de masse corporelle de la mère et au sexe féminin de l'enfant, et négativement avec l'autonomie de la mère, la présence de problèmes conjugaux et l'expérience de difficultés avec l'allaitement. A la seconde visite post-partum, la concentration de cortisol au lever était positivement associée au ΔHAZ. Les récits de « Photovoice » ont mi en évidence 2 scénarios de vulnérabilité particulière pour la femme: (1) être victime de violence domestique, avoir une faible autonomie et être économiquement-dépendant, et (2) être une mère seule au foyer avec peu de possibilités d'emploi et des droits limités. Les autres sources de stress identifiées furent la pauvreté, le manque de soutien social et l'absence de services sociaux dans la région. Les sources identifiées de résilience pour la femme furent la famille, la nature, avoir des animaux d'élevage, l'agriculture, les connaissances et pratiques traditionnelles, et la spiritualité. **Implications:** Cette recherche transdisciplinaire met en évidence l'importance d'intégrer des interventions psychosociales dans les programmes de recherche et d'intervention ciblant la croissance adéquate des enfants dès la naissance, et souligne des stratégies importantes pour augmenter la résilience et la capacité des femmes et des communautés qui leur permettraient de rompre le cycle intergénérationnel de la faible croissance infantile, qui nuit a la santé et aux opportunités de vie.

RESUMEN

Antecedentes: A pesar de décadas de intervenciones en nutrición, Guatemala todavía tiene una de las mayores tasas de retraso del crecimiento infantil en el mundo, siendo las poblaciones indígenas las más afectadas desproporcionalmente. Las alteraciones en el crecimiento normal pueden ser una consecuencia de las tensiones maternas asociadas no sólo con la desnutrición y la infección, sino también con factores psicosociales, cuyos efectos pueden ser mediados por el cortisol materno. **Objetivo:** Los objetivos en 8 de las comunidades del área rural Maya-Mam en las montañas del Occidente de Guatemala fueron: (1) Caracterizar la exposición de las mujeres a la nutrición, las infecciones y los estresores psicosociales *versus* los factores de resiliencia, (2) Describir el ritmo diurno del cortisol materno durante el embarazo y el post parto (PP) y explorar su asociación con las variables psicológicas. (3) Valorar el impacto acumulativo de los factores a nivel materno (nutricionales, infecciosos, psicosociales), factores sociales (autonomía, apoyo social, violencia doméstica) y factores del hogar (nivel socioeconómico, la seguridad alimentaria) en el crecimiento infantil temprano y (4) Evaluar si el cortisol materno tpuede ser un mediador en la transmisión vertical del estrés. **Métodos:** Se basaron en la investigación-acción participativa y un marco socio-ecológico; estos métodos mixtos incluyeron el estudio observacional de una cohorte longitudinal de 155 mujeres, vistas durante el embarazo (6-9 meses), el PP temprano (0-6 semanas) y tardío (4 -6 meses) y dos cohortes transversales (60 PP temprano, 56 PP tardío). Se registraron los datos antropométricos maternos e infantiles, se recogieron muestras de orina, saliva y heces a las madres, y se aplicaron cuestionarios para explorar los factores domésticos (nivel socioeconómico, la seguridad alimentaria), factores sociales (autonomía, apoyo paterno /apoyo social, violencia doméstica) y factores a nivel materno (nutrición, infecciones, estrés emocional). Las actividades de Foto Voz incluyeron darle una cámara a cada una de las 23 mujeres de las comunidades de estudio, quienes documentaron fuentes de estrés así como la resiliencia de las mujeres locales, y las narrativas inspiradas por las fotos compartidas a través de seis sesiones de grupo. **Resultados:** La diversidad de la dieta (3.4± 1.3) fue baja y sólo 38% de las mujeres contaban con seguridad alimentaria. Las infecciones urinarias y gastrointestinales fueron escazas (<5%). Las participantes reportaron baja autonomía materna (81%), un alto apoyo paterno (70%), pequeñas redes de apoyo social (2.7 ± 1.3 personas) violencia doméstica común (22%). Muchas mujeres

(20-50%) tuvieron expresiones locales de angustia (enojo, susto, nervios). El retraso en el crecimiento infantil fue común (36% durante el PP temprano y 43% en el PP tardío). Las concentraciones de cortisol matutino y vespertino fueron 13.11 ± 5.2 y 5.0 ± 3.0 nmol/l en el embarazo y 6.1 ± 3.1 y 2.2 ± 2.3 nmol/l en el PP. Los hogares con mas bajos recursos, la inseguridad alimentaria, la estatura materna más baja, la autonomía materna alta, el apoyo paterno alto, el apoyo social bajo / moderado y la violencia doméstica se asociaron con un ritmo de cortisol de mayor estrés. La violencia doméstica aumenta la probabilidad de sentirse abrumado (OR = 27,3) y de experimentar las expresiones locales de angustia (OR = 2,3 a 5,4). El Piso de tierra, la falta de consumo de carne el día anterior, la leche materna insuficiente y la baja estatura materna se asociaron con una menor talla para la edad (HAZ) y aumentó la probabilidad de retraso en el crecimiento durante el PP temprano. Los bebés de madres con mayor apoyo paterno, mayor autonomía y angustia mostraron mayor retraso en el crecimiento durante el PP temprano.. Concentraciones elevadas de cortisol en la saliva durante la noche mostraron un aumento en la probabilidad de retraso en el crecimiento durante el PP temprano. Se encontró una relación directamente proporcional entre los cambios de talla para la edad entre las visitas durante el PP temprano y tardío (ΔHAZ) y la talla materna, el indice de masa corporal y el sexo femenino, y se encontró una relación inversamente proporcional entre la autonomía materna, problemas con la pareja y dificultad para la lactancia materna. Se encontró una relación directamente proporcional entre los niveles de cortisol matutino y el cambio de talla para la edad (ΔHAZ) durante el PP tardío. Las narrativas de las Foto-voz destacaron 2 escenarios de especial vulnerabilidad: (1) violencia doméstica, baja autonomía y dependencia socioeconómica, y (2) siendo una madre soltera se tiene acceso a pocas opciones de empleo y sus derechos se ven reducidos. Otras fuentes de estrés identificadas fueron la pobreza, la ausencia de apoyo social y la ausencia de servicios sociales. Las fuentes de resiliencia fueron la familia, la naturaleza, la tenencia de animales de corral, la agricultura y conocimientos, prácticas y espiritualidad tradicionales. **Implicaciones:** Esta investigación trans-disciplinaria ha destacado la importancia de integrar las intervenciones psicosociales en los programas de investigación e intervención dirigidos al crecimiento temprano infantil, y destaca la prioridad que se le debe dar para aumentar la resiliencia y la autonomía de la mujer y sus comunidades para romper el ciclo intergeneracional del retraso en el crecimiento y la reducción de la salud de por vida y las oportunidades.

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I first wish to thank the women and the communities who opened their doors and homes to me during my two years of fieldwork. Their trust, time, engagement, generous participation, and willingness to share, learn and teach made the experience more valuable than I have words to say. The lives and stories they shared with me over the years have transformed me deeply. I would especially like to thank the women who acted as fieldworkers, guides, educators, and ultimately as colleagues and friends. Their commitment to the project as well as the stories and observations they shared with me opened my eyes to the reality of their lives, and to new ways of seeing and understanding.

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I will forever be grateful to Dr. Noel Solomons, whose mentorship during my time in Guatemala not only provided invaluable scientific and logistical guidance but also sound cultural advise. His dedication not only to teaching but also to allowing his mentees to learn and grow is an inspiration. I wouldn't have headed to Guatemala if it hadn't been for his warm invitation in 2009 and the trust he bestowed on me to develop a project on maternal health in the Western Highlands of Guatemala. Noel also sowed the first seed in my head of pursuing a PhD, and put me in touch with the professors who would later become my PhD supervisors. In turn I wouldn't have met Noel – and would not have gone to Guatemala – if it weren't for Prof. Odilia Bermudez, whom I met as a student in Public Health at Tufts

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As a PhD student, I have been lucky to have the opportunity to work with two supervisors and incredible mentors, Professors Marilyn Scott and Kristine Koski, who challenged me to grow as a researcher and gave me both the support and freedom to explore and develop this project. I have learned greatly from their engaged mentorship, dedication, thoughtfulness, curiosity, enthusiasm, and ability to work across disciplines. Prof. Scott also gave me the opportunity to be part of the McGill School of Environment Graduate Option, where I had the opportunity to interact with faculty and students from diverse fields and perspectives and explore the relevance of my own work. I also wish to thank my thesis committee. Dr. Berrang-Ford gave me useful guidance in data analyses, and Dr. Pedersen guided me to the transcultural psychiatry literature, especially relating to local idioms of distress and cross-cultural validation of research instruments, as well as to the literature on social capital. Dr. Pedersen also enabled me to participate as a fellow in the Global Health Research Capacity Strengthening Program (GHR-CAPS, 2012-14) and the 2014 Summer Program in Social and Transcultural Psychiatry, from which I learned greatly. Dr. Pedersen encouraged me to continue my work in the *Mam* communities after completion of my doctoral fieldwork, which enabled me to strengthen the "action" component of my commitment to Participatory Action Research (PAR). Finally, Prof. Ann Macaulay in the McGill Department of PAR, provided me with a strong foundation in PAR through a course I took with her in early 2011.

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CONTRIBUTION OF AUTHORS

I designed the conceptual framework for this research. I was responsible for all the fieldwork, statistical analysis of the data and data interpretation. In the field, I identified, trained and oversaw local field workers, CeSSIAM nutritionists, laboratory personnel and other students, was responsible for medical evaluation of all mothers and their infants, and actively participated in data collection and home follow-up visits. I organized monthly workshops with all field staff to promote ongoing knowledge exchange, reflection and team building. I did all statistical analyses of the data, interpreted the findings, drafted all the manuscripts and wrote the thesis.

In the field, local field workers (20 *Mam* women from study communities, including two traditional midwives and 12 community health workers), participated in all aspects of the study: design, pre-testing and semantic validation of study instruments, participant recruitment, administration of questionnaires, collection of biological samples, house visits and follow-up, and ongoing knowledge exchange. A *Mam*-Mayan social worker assisted me in all aspects of fieldwork and data management, and helped me understand the historical and sociocultural context of the *Mam*-Mayans. The two CeSSIAM nutritionists performed anthropometric and nutritional assessments (previous-day dietary recall, previous-day physical activity recall), collected breast milk samples, calculated z-scores, entered nutrition data, helped follow-up malnourished infants, helped develop materials for the study women, and helped develop and lead monthly participatory workshops with local field workers. Laboratory personnel conducted urine and fecal analyses. I saw study participants at each perinatal visit, and was responsible for performing the physical exam of infants and newborns, inquiring about personal safety and experience of domestic violence, reviewing the questionnaires, coordinating the logistics of data collection, reviewing lab work for quality, preparing laboratory results, distributing warranted treatments to study women, and referring those women who needed to be seen by a physician or nutritionist. A number of students helped in various stages of data collection, and I was responsible for their local mentorship and fieldwork experience. Students included: Caitlin Crowley, Amanda deLoureiro, Mariah Kincaid, Lucy Manchester, Eleanor Platt, Olivia Russell, Cindy Stoffel and Christine Whang.

The thesis consists of four manuscripts, all of which were co-authored with my supervisors, Dr. Marilyn E. Scott and Dr. Kristine G. Koski as the research was developed in collaboration with them. In addition, Dr. Noel W. Solomons co-authored the first (Chapter 3), second (Chapter 4) and third (Chapter 5) manuscripts as he contributed to the development of the research and data interpretation. Financial resources for the fieldwork were obtained through two research grants that I wrote under the guidance of Profs. Scott and Koski, one research grant that I wrote under the guidance of Dr. Duncan Pedersen, a member of my thesis committee, and a $500 donation from the student Lucy Manchester. Profs. Scott and Koski also provided financial resources during both fieldwork and data analyses, they were involved in the study design, critiqued data presentation and analyses and pre-edited all written manuscripts and the thesis. Dr. Noel Solomons also provided financial resources during the fieldwork, was involved in the study design, critiqued data presentation and analyses and pre-edited all written manuscripts.

The first manuscript (Chapter 3) was also co-authored with Hilary Wren, a PhD student in the School of Dietetics and Human Nutrition at McGill University studying breastfeeding and subclinical mastitis in the same study population. She helped with data collection, laboratory logistics and physical activity questionnaire analyses. Marieke Vossenaar, a CeSSIAM nutritionist, provided critical feedback on the study questionnaires and helped with dietary diversity analyses, which were also central to the first manuscript. The first manuscript is published in the *Food and Nutrition Bulletin*.

The second manuscript (Chapter 4) was also co-authored with María García Maldonado, who helped validate the study's psychosocial questionnaires, assisted in data collection and entry and provided valuable insights into the *Mam* socio-cultural context. The second manuscript has been submitted to *Social Science and Medicine.*

The third manuscript (Chapter 5) was also co-authored with Marta Lucía Escobar and Alejandra Maldonado, two CeSSIAM nutritionists who performed anthropometric and nutritional assessments, calculated z-scores, entered data and helped with follow-up of all infants diagnosed with wasting or severe stunting. The third manuscript will be submitted in the near future to *Early Human Development.*

The fourth manuscript (Chapter 6) was also co-authored with Paola Letona, a Guatemalan psychologist who performed an independent analysis of the data, and both María García Maldonado and Eleanor Platt, a midwifery student, who both participated in Photovoice activities, assisted with logistics, and verified that the results presented in the manuscript accurately represent the women's narratives. The fourth manuscript will be submitted in the near future to *Social Science and Medicine*.

STATEMENT OF ORIGINALITY

This doctoral research study has provided a comprehensive, transdisciplinary analysis of the multi-level factors associated with the maternal cortisol stress response and with early infant linear growth, and of the sources of vulnerability versus resilience in the lives of the *Mam*-Mayan women living in the Western Highlands of Guatemala who were the subject of our study. To the best of my knowledge, this is the first such study that has integrated such a broad range of variables from parasitology, nutrition, trans-cultural psychiatry and psychosocial stress research, as well as to incorporate a mixed-methods, participatory action research approach. Although a few prior studies had evaluated the maternal cortisol stress response in resource-poor contexts, this is the first to do so in an indigenous population.

Major original findings are listed below:

1. This is the first time that the maternal cortisol stress response has been assessed in an indigenous population. *Mam*-Mayan mothers had lower salivary cortisol concentrations both in pregnancy and postpartum compared to most other reports in the literature, suggesting potential population-level exposure to chronic stress.
2. Social factors and gender relations (inequality in decision-making, violence) consistently emerged as determinants of both maternal stress (as assessed via the diurnal salivary cortisol rhythm) and infant stunting in the first six months of life.
3. Women with high levels of involvement in household decision-making and high paternal involvement were not the advantaged women in the community. Instead, they experienced more chronic stress as assessed through salivary cortisol, and had infants with compromised linear growth.
4. Although childhood stunting has been previously found to be associated with children's diurnal cortisol rhythm, this is the first time that adult stunting is associated with cortisol, namely with lower waking and higher evening cortisol concentrations, which could result from early programming of the cortisol stress response and be a biological mediator for the intergenerational transfer of stunting.
5. To the best of my knowledge, this is the first report of the postpartum – rather than prenatal – maternal diurnal cortisol rhythm being associated with infant growth. Higher

maternal salivary evening cortisol concentrations, measured in the first six weeks postpartum, were associated with early infant stunting. Higher maternal salivary waking cortisol concentrations, measured four to six months postpartum, were associated with greater infant catch up growth between early and later postpartum visits.

6. Hence this study uncovered significant evidence that the maternal cortisol rhythm is an indicator of stress originating from various stressors (maternal autonomy, social support, paternal support, experience of violence, lower household wealth, food insecurity, maternal stunting – and potentially, population-level stressors resulting in low basal levels overall in the population), and hence is an indicator of cumulative stress.
7. Maternal emotional distress, measured using local idioms of distress (*susto, enojo, nervios*), was associated with mothers' report of domestic violence, problems with partner and having low/moderate paternal support, as well as with early infant stunting.
8. Through qualitative, participatory methodologies, we found that communities had a strong sense of priority health concerns. Women identified the same contexts of increased vulnerability as those that emerged in quantitative analyses.
9. Photovoice activities and photo-elicited narratives recognized the same sources of stress and vulnerability as quantitative analyses, yet represented women as being particularly resilient, with the strongest sources of resilience being one's own children, family support, a sense of belonging to the land and environment, spirituality and individual agency.

Other novel findings included:

1. Study women had a very low prevalence of helminth (only *Ascaris lumbricoides* recovered) and other intestinal parasitic (*Giardia spp., E. histolytica/dispar*) infections, suggesting a distinct micro-ecology of study area.
2. Our population did not exhibit the double burden of malnutrition characteristic of most other areas in Guatemala.
3. This is the first time that the Panama food insecurity questionnaire was administered in Guatemala. Our finding that environmental causes – a dimension not assessed in most food security questionnaires – emerged as a latent component of food insecurity is novel and worthy of particular consideration, especially in a context of subsistence farming.

4. Women appeared to make an effort to increase the diversity of their diets during pregnancy and early postpartum, as illustrated by significantly higher dietary diversity scores in these perinatal stages relative to later postpartum. However, close to 80% of women did not meet adequate diet diversity and therefore were at risk of inadequate micronutrient intake.
5. Study findings uncovered an unusually high rate of preterm birth and neonatal mortality, and a high rate of microcephaly in infants within the first six months postpartum.

Finally, through the use of participatory action research, novel approaches to collaboration with the local indigenous communities were successfully explored, with implications for continued collaborations:

1. This was the first time participatory action research was conducted in this region of Guatemala.
2. The involvement in the research of indigenous women from the study communities, including traditional midwives, was novel for health research in Guatemala, especially with regard to the inclusion of local women's health perspectives to inform the design of a health investigation, and the training of local women to administer questionnaires and collect samples
3. The inclusion of participatory activities, including Photovoice, promoted self-representation by local women, were key in establishing horizontal exchanges and equal community partners in this historically marginalized and poorly autonomous community, and fostered a space of critical consciousness.
4. As a result, considerable local capacity building and empowerment occurred, and women became better able to take a proactive stance on maternal and child health and wellbeing within their communities, and to become agents of change in their own lives and communities.

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LIST OF ABBREVIATIONS

A. lumbricoides	*Ascaris lumbricoides*
ACTH	Adrenocorticotrophin-releasing hormone
AMC	Anne Marie Chomat
ANC	Antenatal care
ANOVA	Analysis of Variance
APA	American Psychiatric Association
B	Unstandardized coefficient
B. hominis	*Blastocystis hominis*
BCIE	Banco Centroamericano de Integración Económica
BMI	Body mass index
CAR	Cortisol awakening response
CDC	United States Centers for Disease Control and Prevention
CEH	Commission for Historical Clarification
CeSSIAM	Center for Studies of Sensory Impairment, Aging and Metabolism
Cfu	Colony forming units
CHW	Community health workers
CI	Confidence interval
CIHR	Canadian Institutes of Health Research
CRH	Corticotrophin-releasing hormone
CSDH	Commission on Social Determinants of Health
CV	Coefficients of variation
DHS	Demographic Health Survey
E. coli	*Entamoeba coli*
E. histolytica/dispar	*Entamoeba histolytica/dispar*
E. nana	*Endolimax nana*
ENSMI	Encuesta Nacional de Salud Materno Infantil
EP	Eleanor Platt
G. lamblia	*Giardia lamblia*
GHR-CAPS	Global Health Research Capacity Strengthening Program
HAZ	Height-for-age Z score

HCZ	Head circumference for age Z score
HPA axis	Hypothalamic-pituitary-adrenal axis
Hpf	High-power field
HWI	Household Wealth Index
I. butschlii	*Iodamoeba butschlii*
IgA	Immunoglobulin A
IGF-1	Insulin-like growth factor-1
IL	Interleukin
INCAP	Institute of Nutrition of Central America and Panama
INE	Instituto Nacional de Estadística
IQR	Interquartile distance
IUGR	Intrauterine growth restriction
IWGIA	Grupo Internacional de Trabajo sobre Asuntos Indígenas
LBW	Low birth weight
LMP	Last menstrual period
MDG	Millennium Development Goal
MGM	Maria Garcia Maldonado
MINSA	Ministerio de Salud de la Republica de Panamá
MSPAS	Ministerio de Salud Pública y Asistencia Social
N	Number
NGO	Non-governmental organization
Nmol/l	Nanomol per liter
OR	Odds ratio
P	P-value
PAR	Participatory action research
PBEEE	Programme de Bourses d'Excellence pour Etudiants Etrangers
PCA	Principal component analysis
PL	Paola Letona
PP	Postpartum
PSQ	Paternal support score
REMHI	Recovery of Historical Memory Project

SD	Standard deviation
SE	Standard error
SES	Socioeconomic status
SGA	Small for gestational age
STH	Soil-transmitted helminths
UN	United Nations
UNFPA	United Nations Population Fund
UNICEF	United Nations International Children's Fund
US	United States
US DHHS	United States Department of Health and Human Services
WAZ	Weight for age Z score
WHO	World Health Organization
WHZ	Height for weight Z score
ΔHAZ	Change in height-for-age between early and later postpartum visits, per mo

CHAPTER 1

INTRODUCTION

The first 1,000 days following conception is a critical window of time when many crucial development processes occur (Victora et al. 2008). Accumulating evidence suggests that the environmental conditions present throughout the foetal period and early infancy directly impact infant growth, with potential repercussions throughout the life course. Linear growth failure, or stunting, is associated in the short-term with increased infant morbidity and mortality, and in the long-term with decreased adult cognition, work capacity and overall health (Dewey & Begum 2011). Implications are particularly dire in the developing world, where an estimated 26% of children under the age of 5 are stunted (UNICEF 2012).

Not without reason, the bulk of ongoing research as to the causes of stunting has mainly focused on the nutrition-infection environment (Bhutta et al. 2008, Bhutta et al. 2013). The vicious cycle of poor health and growth failure caused by infection-malnutrition interactions has been well documented, and most interventions have therefore focused on alleviating their impact (Bhutta et al. 2013). However, early infant stunting is also associated with psychosocial (maternal anxiety, depression, poor social support, low autonomy, domestic violence) (Broekman et al. 2014, Carlson et al. 2015, Feldman et al. 2000, Rico et al. 2011, Surkan et al. 2011), and sociodemographic (ethnic marginalization, low socioeconomic status, low schooling, food insecurity, poor sanitation) (Black et al. 2013, UNICEF 2013) factors. Individual susceptibility in turn is largely determined by underlying socioeconomic, cultural and political factors, and by individual or societal coping strategies that might serve as buffers to stress (Black et al. 2013, Gillespie et al. 2013, Kirmayer et al. 2011, Ruel et al. 2013, Smith et al. 2003).

Guatemala holds the worst rates of stunting in Latin America and one of the worst worldwide, at 47% (MSPAS 2015), but reaches 80% in some indigenous communities in the country'sWestern Highlands (Saenz de Tejada 2009). As elsewhere, postnatal deterioration in growth has been broadly attributed to two major determinants: undernutrition and infections (Marini & Gragnolati 2003, Martorell et al. 1975). However, potential contributions of psychosocial and cultural factors to illness and malnutrition have not been systematically explored in this setting, to identify potential beneficial interventions.

Recent calls for greater consideration of social and cultural factors in global health (Gillespie et al. 2013, Napier et al. 2014, Ruel et al. 2013, CSDH 2008) and the failure of global health interventions to reach many of the world's poorest and most marginalized – yet most in need – populations (Farmer 2006, Mumtaz et al. 2014, MSPAS 2010, Napier et al. 2014) require researchers to think beyond conventional frameworks. Overcoming high rates of early infant stunting will require strongly contextualized research that assesses multiple behavioural and psychosocial pathways to health and wellbeing – a task that requires an integration of biological and social science and consideration of both proximal and more distal factors. This is possible using a transdisciplinary approach to health, which combines a socio-ecological framework and a mixed-methods, community-based participatory research methodology that allows research to be contextualized, local narratives, knowledge and priorities to be voiced, and findings to be readily translatable to much needed action.

Rationale and objectives

Few studies have investigated the combined impacts of nutrition, infection and psychosocial stressors on early infant stunting. In addition, few studies investigating the effect of psychosocial stress on maternal health, and ultimately on early infant growth, have occurred in disadvantaged, resource-poor settings (O'Connor et al. 2014, Suglia et al. 2010, Valladares et al. 2009), let alone in indigenous contexts (Nyberg 2012), which are consistently characterized by greater disadvantage and worse health statistics (Montenegro & Stephens 2006). Especially in indigenous populations, narratives and terminology relating to emotional distress and to what constitute a stressful situation, and available coping strategies, may differ significantly from those characteristic of Western and resource-rich populations (Hatala et al. 2015, Pedersen et al. 2010), which may hinder studies of psychosocial factors in such populations.

Concerned with bridging these gaps, I constructed a socio-ecological (Berkman 2000, Bronfenbrenner 1979) conceptual framework integrating all factors known to affect the vertical transmission of stress between mother and infant within the first 1,000 days of life (Fig. 1.1). At an individual-level, three broad categories of stressors (nutritional, infectious, psychosocial) may each affect a mother and ultimately impact her infant's growth and development. The quality of these stressors, and how a mother experiences them, are in turn directly influenced by relationship, community and societal factors within which they are embedded, and which operate within each of the following spheres: prior experiences (i.e. obstetric), social factors (i.e. social support, maternal autonomy, difficult life experiences), household factors (living conditions, socioeconomic status, food security) and cultural factors (cultural norms, social policies), which may either promote resilience or increase vulnerability. There are myriad potential pathways linking these factors with infant growth, including biological and behavioural. In particular, the maternal diurnal cortisol rhythm may be an important biological mediator between the maternal experience of stress (nutritional, infectious, psychosocial) and early infant growth.

Within this conceptual framework, we developed the following objectives, to be implemented in a marginalized, *Mam*-Mayan indigenous, rural area of Guatemala where we have previously documented that 36% of infants are already stunted at birth (Solomons et al. 2015) – evidence that the perinatal period has a determining impact on early infant growth in this setting:

1. To develop quantitative methodologies with cross-cultural equivalence validated to the local context to measure psychosocial factors (emotional distress, social support, partner support, maternal autonomy) relevant to early infant growth.

2. To characterize women's exposure to nutrition, infection and psychosocial stressors vs. resilience factors in our study population.

3. To describe the maternal diurnal salivary cortisol rhythm in pregnancy and postpartum, and explore psychosocial determinants of a "stressed" rhythm.

4. To qualitatively explore personal narratives with regard to sources of vulnerability vs. resilience experienced by women in study communities.

5. To assess the cumulative impact of maternal-level factors (nutritional, infectious, psychosocial), social factors (autonomy, social support, domestic violence), and household factors (socioeconomic status, food security) on early infant growth, from pregnancy up to six months postpartum, and whether maternal cortisol may be a mediator in the vertical transmission of stress.

Study setting: rural *Mam*-Mayan populations in Guatemala

Our population of interest was rural, *Mam*-Mayan communities in the Western Highlands of Guatemala, characterized by extreme poverty, food insecurity and high rates of early infant stunting (Solomons et al. 2015). The *Mam*, who constitute the fourth largest Mayan population in Guatemala (INE 2003), live in south-western Guatemala in the departments of Huehuetenango, San Marcos and Quetzaltenango where rates of stunting are the highest in the country, reaching up to 80% of children under five in some communities (Saenz de Tejada 2009). The *Mam* have lived a long history of marginalization beginning prior to the 1524 Spanish Conquest, when they vied for control of their lands with the more powerful *K'iche'*, and had to relocate to more rugged terrain. They were later forced to reorganize their social, economic and political lives under Spanish rule (Watanabe 2010). In the 1980s, political violence between leftist insurgents and the Guatemalan government subjected the *Mam* to brutal counterinsurgency warfare, leaving many communities deeply scarred and their social fabric weakened. Most recently, economic forces tied to rapid globalization and open trade agreements have increased the vulnerability of *Mam* communities, leading to increasing inequality and large-scale work migration mostly by men to the United States (Foxen 2007), and pressure on communities for extraction of natural resource on their land, both of which disrupt local economies, negatively impact socio-cultural structures, and lead to increased economic inequity, decreased social cohesion and social unrest (Caxaj et al. 2014). Despite signing of the Peace accords in 1996, a state of instability has characterized the past 15 years, characterized by heightened levels of fear, distrust, and domestic and social (including gang) violence (Burrell 2009, Foxen 2010).

Today the *Mam* remain marginalized from most political, economic and social programs, and engaged primarily as subsistence farmers and rural wage labourers in the cultivation of the Mesoamerican crops of maize, beans and squashes (Hostnig et al.1998, Watanabe 2010). Data on the *Mam* populations of Guatemala, especially pertaining to maternal-infant health, is scarce. A previous study by our group (Chomat et al. 2014) within rural *Mam* communities of Quetzaltenango revealed a context of food insecurity and extreme poverty within which most women did not access formal health services at the time of delivery, rather relying on traditional birth attendants, or *comadronas*. A number of studies investigated stunting, breastfeeding and infant feeding practices in metropolitan Quetzaltenango have revealed a 45% prevalence of stunting among children under 2 years of age, associated with short maternal stature, Mayan ethnicity, lower maternal education, home birth and early introduction of ritual fluids (Reurings et al. 2013, Van Beusekom et al. 2013, Doak et al. 2013); however this population is socially and culturally distinct from that living in the nearby rural *Mam* communities of Quetzaltenango (Hostnig et al.1998, Watanabe 2010).

Chapters

Chapter 2 consists of a review of the relevant literature from the fields of nutrition, parasitology, transcultural psychiatry, stress biology, and social capital to contextualize my thesis. It also reviews the main methodological theories used, including mixed-methods research and participatory action research. In Chapter 3, I present the study's quantitative methodologies, including an assessment of internal consistency and construct validity of questionnaires, and descriptive findings. In addition, I identify which nutritional, infection/illness and psychosocial measures have sufficient variability to warrant further investigation, and determine whether ongoing engagement with the study population affected variable measures through comparison between paired longitudinal and cross-sectional cohorts. This manuscript has been published in the *Food and Nutrition Bulletin*. In Chapter 4, I explore women's psychosocial environment by exploring interrelationships among household factors, social factors and emotional distress, describe the maternal salivary cortisol rhythm in pregnancy and postpartum, and investigate psychosocial determinants of a "stressed" maternal salivary cortisol rhythm. In Chapter 5, I investigate the impact of maternal-level factors (nutritional, infectious, psychosocial), social factors (maternal autonomy, social/paternal support, support, domestic violence) and household factors (socioeconomic status, food security) on early infant growth, and evaluate whether the maternal diurnal cortisol rhythm may be a biological mediator in the vertical transmission of stress. In Chapter 6, I present personal narratives on sources of vulnerability vs. resilience experienced by women in study communities, using Photovoice, and use them to assess the validity of quantitative findings. In Chapter 7, I expand on overarching themes that emerged from this research in a general discussion.

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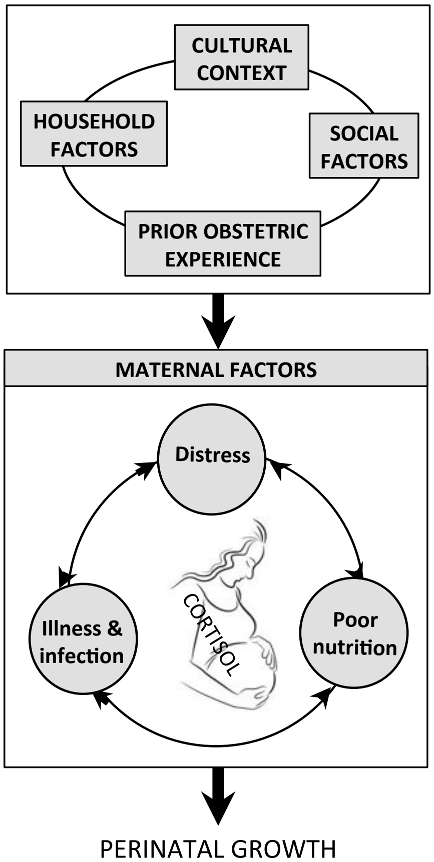

HOUSEHOLD FACTORS		
	Socio-demographic factors	Ethnicity Language proficiency Marital status Schooling
	Household characteristics	House materials Water, sanitation Ownership of durable assets Household wealth index (HWI)
	Food insecurity	Adult food insecurity
SOCIAL FACTORS		
	Structural social capital	Household autonomy Social support, general Social support, Infant's father
	Cognitive social capital	Trust, perceived harmony
	Difficult life experiences	Domestic violence Problems with partner, family Alcohol problem in household
MATERNAL FACTORS		
	Prior obstetric experience	Age Prior family planning, age of 1st pregnancy Prior loss of a child Delivery care (formal/informal)
	Nutrition	Maternal stunting BMI Dietary diversity Physical activity
	Infection	Periodontal Respiratory Gastrointestinal Urinary
	Distress	Experience of local idioms of distress *(susto, enojo, nervios)*[1]

Figure 1.1. Conceptual socio-ecological framework that distinguishes three broad categories of stressors affecting the mother (nutrition, infection, psychosocial distress) that may cumulatively impact the health of the maternal-infant dyad, through the vertical transmission of stress. *Susto*, *enojo* and *nervios* are local idioms of distress. *Susto* is believed to result from a frightening or startling experience, which manifests as an array of symptoms and pathologies. *Enojo* is a form of anger that leads to headaches, stomach pains, weakness or fatigue and chronic illness. *Nervios* is an illness due to experiencing strong emotions, particularly anger, grief and sorrow.

CHAPTER 2

LITERATURE REVIEW

Stunting

Definition of stunting

Stunting, or low height-for-age Z score (HAZ), is defined as HAZ below two negative standard deviations of the World Health Organization (WHO) Child Growth Standards (WHO 2006). These standards are based on the finding that all children worldwide have the potential to develop to within the same range of height and weight, if they are raised in healthy environments and if their caregivers follow recommended health, nutrition and care practices (WHO 2006). Indeed, although individual differences in child growth exist, nutrition, feeding practices and health have been found to be stronger determinants of growth than either genetics or ethnicity (WHO 2006). This is well illustrated by studies where substantial improvements in linear growth have occurred with improvement in living conditions (Addo et al. 2013, Bredenkamp et al. 2014) or migration (Bogin et al. 2002, Martorell & Zongrone 2012). For instance, Bogin et al. (2002) found that Mayan children born in the US to women who had immigrated from Guatemala as refugees, were 11.5 cm taller than were Mayan children still living in Guatemala.

Timing of growth faltering

The first 1,000 days of life, from the time of conception to two years of age, is when infants are most susceptible to poor growth (Bhutta et al. 2008, Martorell et al. 2010). This "window of opportunity" has become a guiding principle for research and programmatic action to prevent permanent deficits in growth and development (UNICEF 2013). The insights for delineating this period came from observations derived from a longitudinal study in eastern Guatemala, starting in the 1960s (Ramirez-Zea et al. 2010), where only interventions reaching the mother-infant dyad prior to 24 months had measureable impacts on growth and development. The recent recognition that stunting begins *in utero* (Dewey & Begum 2011, Solomons et al. 2015, Victora et al. 2015) further highlights the importance of the maternal environment prior to delivery. In particular, a recent meta-analysis of 19 birth cohort studies (Christian et al. 2013) estimated that one-fifth of childhood stunting could originate in the foetal period – although it could be more prevalent in some contexts, as illustrated by our prior work in the Western Highlands of Guatemala (Solomons et al. 2015) where we found that 36% of infants were already stunted in the first six weeks postpartum.

Consequences of early infant stunting

Undernutrition, including foetal growth restriction, suboptimal breastfeeding, stunting, wasting, and deficiencies of vitamin A and zinc, are estimated to cause 45% of child deaths worldwide and result in 3.2 million deaths annually. Considered alone, stunting is the leading cause of child mortality, causing 15% (1.0 million) of child deaths annually (Black et al. 2013). In addition to increasing the risk of childhood morbidity and mortality, the ‘developmental origins of health and disease’ hypothesis posits that the intrauterine and early postnatal environments can modify expression of the foetal genome and lead to lifelong alterations in metabolic, endocrine and cardiovascular function (Gluckman et al. 2010), as manifest by the association between stunting and increased risk of developing metabolic disorders and chronic diseases in adulthood, such as diabetes, high blood pressure and dyslipidemia (Victora 2008, Martorell 2010).

Stunted children show behavioural changes in early childhood that include apathy, more negative affect, and reduced activity, play and exploration (Aburto et al. 2009, Gardner et al. 1999). Stunting also negatively impacts educational performance and economic productivity (Dewey & Begum 2011, Martorell et al. 2010). In a review (Victora et al. 2008) that involved long-term follow-up of children into late adolescence and adulthood from five low-income and middle-income countries (Brazil, Guatemala, India, Philippines and South Africa), childhood stunting was associated with adult stunting, reduced lean body mass, diminished intellectual functioning, less schooling, and reduced earnings.

Stunted girls are also more likely to experience early menarche and younger age at first pregnancy (Pollet & Nettle 2008). Maternal stunting can reduce uterine blood flow, increasing the risk of intrauterine growth restriction (IUGR) and adverse foetal and neonatal outcomes such as stillbirth and neonatal mortality (Ozaltin et al. 2010, Pollet & Nettle 2008, Victora et al. 2008). A narrower pelvis in short women may also lead to obstructed labour, increasing the risk of maternal and neonatal mortality (Khan et al. 2006) and birth asphyxia (Dewey & Begum

2011). Finally, decreased maternal stature is associated with an increased risk of underweight and stunting among offspring (Ozaltin et al. 2010).

The most convincing evidence on the long-term consequences of stunting comes from the Institute of Nutrition of Central America and Panama (INCAP) Oriente Longitudinal Study, a randomized supplementary feeding trial conducted in four rural Guatemalan villages starting in 1969 (Martorell 1992). Children who had received a high-protein, high-energy supplement (*atole*) within the first two years of life grew to be taller, developed greater lean body mass, and exhibited improved intellectual functioning (scored higher on tests of knowledge, numeracy, reading and vocabulary, increased years of schooling, improved reading comprehension), and increased economic productivity (Hoddinott et al. 2008, Maluccio et al. 2009, Martorell et al. 2010, Pollitt et al. 1995, Rivera et al. 1995), compared to children who had received a no-protein, low-energy supplement (*fresco*), when evaluated in adolescence and again in adulthood. In addition, women who had received *atole* as children had infants with greater birthweight, height, head circumference and both height- and weight-for-age z-scores (Behrman et al. 2009).

The profound adverse consequences of stunting for the physical, cognitive, and economic development of affected children, their families and their communities leave no doubt as to why investing in women and children in the first 1,000 days is key to the wellbeing of populations – perhaps especially in societies where manpower is essential for subsistence. Indeed, at a population level, a high prevalence of stunting is predictive of poor population health and socioeconomic conditions (Victora et al. 2008) and significantly impairs a nation's economic advancement (Bhutta et al. 2013). The trans-generational impact of stunting calls for a concerted focus on early child development so as to break the vicious cycle of poor health and decreased opportunity not only within an individual's lifespan but across future generations as well.

Global distribution of stunting

In developing countries, stunting is more prevalent (32%) than either underweight (low weight-for-age, 20%) or wasting (low weight-for-height, 10%), possibly because height gain is a more sensitive indicator of poor dietary quality over time than is weight gain (Dewey & Begum 2011). However, stunting often goes unrecognized in areas where short stature is so common that it seems normal. Even among health workers, stunting generally does not receive the same attention as either underweight or wasting, and many families, health workers and policy makers are unaware of its consequences (Dewey & Begum 2011, Victora et al. 2015).

Stunting affects 26% of children under five worldwide, or 165 million children under the age of five – a 35% decline from an estimated 253 million (40%) of children in 1990 (UNICEF 2012). Worldwide, 34 countries account for 90% of all children with stunted growth; only the Central American Republic of Guatemala is located outside of Africa and South/Central Asia (Bhutta et al. 2013). Regional prevalence of stunting are of 37% in Africa, 36% in Oceania, 27% in Asia, and 13% in Latin America and the Caribbean (Black et al. 2013). However, national and regional statistics hide significant differences in stunting that exist within populations. Indeed, in a large meta-analysis of ~80 countries, Black et al. (2013) found that stunting prevalence of children under five was 2.5 times higher in the poorest vs. richest household wealth quintile, 1.5 times higher in rural vs. urban areas, and 1.1 times higher in boys than in girls.

Stunting in Guatemala

At 47% (MSPAS 2015), Guatemala has one of the highest rates of child stunting in the world and the highest rate in Latin America (UNICEF 2013). The indigenous populations are disproportionately affected, with stunting affecting 58% of indigenous children overall (MSPAS 2010), and up to 80% in the historically marginalized communities in the Western Highlands of the country (Saenz de Tejada 2009), compared to 34% among their non-indigenous counterparts (MSPAS 2015). Despite decades of intensive nutrition research and interventions in Guatemala, these metrics have improved only minimally over the last 30 years (MSPAS 2010). This is likely due not only to a history of wealth disparity, and more recent civil war and military violence affecting many rural indigenous populations, but also to low public health expenditures and the difficulty of implementing programs in the complex multiethnic, multi-linguistic context that modern post-civil war Guatemala represents (Anckermann et al. 2005). Any progress achieved in reducing stunting prevalence over the last few decades has disproportionately benefitted urban and non-indigenous populations (MSPAS 2010).

Causes of infant stunting within the first 1,000 days of life, from proximal to more distal: stressors[1] and sources of resilience

The large majority of studies evaluating the impact of maternal factors on pregnancy outcome and IUGR have focused on preterm birth and birth weight, and only a few on linear growth or stunting. When no data is available on linear growth, I have referred to the former outcome variables.

Nutrition

Maternal nutrition

Maternal stunting (height < 145cm) and low maternal BMI in early pregnancy (<25 kg/m^2) both increase the risk of small-for-gestational age (SGA) (Deierlein et al. 2010, Heslehurst et al. 2008, Ozaltin et al. 2010). Although nutritional requirements to support rapid growth and development are high in the first 1,000 days (Dewey & Begum 2011), it is unclear what degree of maternal undernutrition is needed to influence pregnancy outcome (Hobel & Culhane 2003). Data suggests that among women subsisting on a low dietary intake, maternal nutritional status does not deteriorate during pregnancy provided mothers are not themselves still growing (Bhutta et al. 2013), that there is no further reduction in dietary intake, that the inter-pregnancy interval is about 3 years (Dewey & Cohen 2007), that heavy manual labour is avoided (Ramachandran 1989, Prentice 1980) and that continued lactation during pregnancy does not occur (Marquis et al. 2002, Merchant et al. 1990). Balanced energy protein supplementation (25% of total energy supplemented as protein), is an important intervention for the prevention of SGA in malnourished women (Imdad & Bhutta 2012a, Kramer & Kakuma 2003).

Maternal deficiencies in iron (Allen 2001, Christian 2010), folate (Bhutta et al. 2013, Sram et al. 2005), vitamin A (Tielsh et al. 2008), vitamin D (De-Regil et al. 2012, Dror 2011), and zinc (Simmer & Thompson 1985) have been associated with foetal growth retardation. Improved foetal growth has been associated with prenatal iron and folic acid supplementation

[1] The terms *stressor* refers to objective events, either acute or chronic, that occur to individuals and may tax or exceed the adaptive capacity of an organism; *stress*, to the psychological or biological changes occurring as a result of experiencing a *stressor*; and *distress* or *emotional distress*, to the emotional state that may result from the perception of stress (Hoffman & Hatch 1996).

(Black et al. 2013, Imdad & Bhutta 2012b), calcium supplementation in populations with low calcium intake (Imdad & Bhutta 2012c), vitamin D (De-Regil et al. 2012) and multiple micronutrient supplements (Bhutta et al. 2013) – but neither with vitamin A (Black et al. 2013) or zinc (Mori et al. 2012) supplementation.

There has been relatively little research on the extent to which the nutrient content of human breast milk is affected by maternal status and intake and how low milk concentrations affect infant nutritional status (Allen 2012). It is generally assumed that undernutrition has little effect on the volume or composition of breast milk unless malnutrition is severe (Allen 2012). The concentration of some micronutrients (thiamine, riboflavin, choline, selenium, iodine, and vitamins A, B_6, B_{12}, and D) in breast milk is dependent on maternal status and intake, so the risk of infant depletion is increased by maternal deficiency (Allen 2012). This is most evident with vitamin A, where breast milk content is the main determinant of infant status because stores are low at birth (Black et al. 2008). Maternal supplementation with these micronutrients increases the amount secreted in breast milk, which can improve infant status (Black et al. 2008). Based on the growth retardation that can accompany inadequate intakes of thiamine and vitamins B_6, B_{12} and D in breast milk, low milk concentrations of these nutrients could contribute to infant stunting in the first year of life (Allen 2012, Thiele et al. 2013).

Infant nutrition

Strong evidence links appropriate complementary feeding practices – the timely introduction of safe and nutritionally rich foods in addition to breast-feeding at about 6 months of age, and typically provided to 2 years of age (WHO 2002) – and reduced incidence of stunting (Bhutta et al. 2013). In two separate studies of low-income country Demographic Health Survey (DHS) datasets (Arimond & Ruel 2004, Marriott et al. 2012), increased dietary diversity improved linear growth. In a study in Guatemala (Stein et al. 2008), stunting was associated with an energy-deficient diet. A meta-analysis of zinc supplementation trials (Imdad & Bhutta 2011) showed a significant protective effect against stunting. Additionally, zinc supplementation has reduced the risk of childhood diarrhoea and acute lower respiratory infections in populations at risk of zinc deficiency (Imdad & Bhutta 2011, Brown et al. 2009), which could indirectly reduce the risk of stunting. Vitamin A supplementation has been shown to reduce both all-cause and diarrhoea-related mortality in children aged 6-59 months (Imdad et al. 2010), and likely also has an indirect effect on reducing the risk of stunting in populations at risk of deficiency.

Infection

Maternal infection

Parasitic infections affect millions of pregnant women worldwide (Dotters-Katz et al. 2011). Although all parasites have different pathophysiologic mechanisms, almost all cause maternal anemia and malnutrition, either directly or indirectly, which in turn are associated with an increased incidence of adverse pregnancy outcomes (Dotters-Katz et al. 2011). As is true for most viral and bacterial infections, parasitic infection occurring in the first trimester of pregnancy is associated with more severe consequences than that occurring later (Dotters-Katz et al. 2011). Moreover, the natural immune response in pregnancy causes pregnant women to be more susceptible to parasitic infection than non-pregnant women (Dotters-Katz et al. 2011). Poverty, lack of adequate water-sanitation systems and tropical climate are some of the common conditions that favour intestinal parasitism in humans (Bethony et al. 2006, WHO 2015).

The most common parasitic infections in humans are the soil-transmitted helminths (STH), which include *Ascaris lumbricoides,* hookworm (*Ancylostoma duodenale, Necator americanus*) and *Trichuris trichiura*, and inflict a substantial burden of morbidity on poor populations living in tropical and subtropical regions (Imhoff-Kunsch & Briggs 2012). Between one and two billion people worldwide are infected with at least on STH, and at least 44 million pregnant women are infected with hookworm alone (WHO 2015). STHs are transmitted by eggs present in human faeces, which contaminate the soil in areas with poor hygiene and sanitation (Bethony et al. 2006, WHO 2015). Chronic STH infections can cause malnutrition and lead to protein and nutrient loss or malabsorption, causing or aggravating nutritional deficiencies (Stephenson et al. 2000). Hookworm infection in particular can induce anemia in pregnancy through micro-bleeding at the sites where the nematodes attach to the intestinal wall (Brooker et al. 2008, Imhoff-Kunsch & Briggs 2012). *Ascaris* and *Trichuris* can also cause blood loss, although in pregnancy, only a high burden of *Trichuris* infection has been associated with anemia (Gyorkos et al. 2011, Gyorkos & Gilbert 2014). Anemia in pregnancy in turn is an important cause of maternal morbidity and mortality, preterm birth, IUGR, low birth weight (LBW), and poor iron status in the infant (Benoist et al. 2008).

Maternal hookworm infection has most consistently been associated with foetal growth restriction and LBW (Beach et al. 1999, Torlesse and Hodges 2001). However, despite a number of observational studies in humans suggesting that certain maternal helminth infections adversely affect birthweight, antihelminthics trials during pregnancy have failed to confirm that these associations are causal by showing a benefit of treatment (Imhoff-Kunsch & Briggs 2012, Salam et al. 2015). Several animal studies have shown an association between maternal helminth infection and offspring growth. In mice models (Odiere et al. 2010a, Odiere et al. 2010b, Starr et al. 2015), maternal helminths infection has been found to reduce foetal crown-rump length, an effect that increased with infection burden and was possibly mediated by a decrease in leptin and insulin-like growth factor-1 (IGF-1) (Odiere et al. 2010a) or in f-prolactin (Starr et al. 2015). One study in mice (Starr et al. 2016) found evidence that expression of placental genes involved in foetal growth was influenced by the interaction between maternal protein deficiency and nematode infection. Antihelminthic treatment of sheep and goat flocks in Kenya was found to significantly improve offspring birth weight and growth rates (Gatongi et al. 1997).

Blastocystis hominis is a common protozoan parasite found in the human large intestine, with a high prevalence in developing countries worldwide, and transmitted as a cyst by the fecal-oral route (Deeb et al. 2012). The pathogenicity of *B. hominis* is still under debate, because the parasite is very common in many asymptomatic, healthy people (Tan et al. 2010). Symptomatic *B. hominis* infection is characterized by diarrhoea, abdominal pain (Tan et al. 2010) and iron deficiency anemia (Yavasoglu et al. 2008), including in pregnant women (Deeb et al. 2012). No association to date exists in the literature between *B. hominis* infection and infant growth.

Giardia lamblia, also called *Giardia duodenalis* or *Giardia intestinalis*, is a common protozoan parasite of the intestine transmitted by the ingestion of its cyst in contaminated water or food or by direct fecal-oral contact, and that causes extensive morbidity worldwide (Gardner & Hill 2001). Although the majority of infections are asymptomatic, symptomatic infection is characterized by diarrhoea, anorexia and weight loss, and chronic infection can result in malabsorption of fat, lactose and vitamins A and B_{12} (Gardner & Hill 2001). There is no information in the medical literature of the effect of giardiasis on pregnancy outcomes.

Other maternal infections during pregnancy that have been associated with IUGR or LBW include periodontal disease (Srinivas et al. 2008), chronic low-grade intrauterine infections (Vrachnis et al. 2010, Johnson et al. 2011), and urinary tract infections (Sheiner et al. 2009, Pisake et al. 2010).

Any influence of maternal infection postpartum, during continued breastfeeding, on infant growth has been less well documented. Subclinical mastitis in developing countries has been associated with lactation failure (Aryeetey et al. 2008, Aryeetey et al. 2009) and growth faltering (Gomo et al. 2003) during the early postpartum period. Animal studies support these findings (Newman et al. 1991). Furthermore, while no human studies have been published on this topic, gastrointestinal parasite infection in animal models has been associated with compromised lactation (Perri et al. 2011).

Infant infection

Severe infectious diseases in early childhood, such as measles, diarrhoea, pneumonia, meningitis, and malaria, can have long-term effects on linear growth (Rivera & Martorell 1988, Moore et al. 2001, Guerrant et al. 2008). However, studies have consistently shown that diarrhoea is the most important infectious disease determinant of linear growth faltering, perhaps because of its association with malabsorption of nutrients, as well as anorexia and catabolism (Black et al. 2008, Mata 1992). In a pooled analysis (Checkley et al. 2008) of nine community-based studies in low-income countries, the odds of stunting at 24 months of age increased multiplicatively with each diarrhoea episode or day of diarrhoea before that age. The proportion of stunting attributed to five previous episodes of diarrhoea was 25%.

The STH represent the most common parasitic infection of children (Bethony et al. 2006). The intensity of each of the major helminth infections primarily peaks in school-age children or adolescents, which results in increased vulnerability to the effects of infection (Weatherhead & Hotez 2015). The STH have been strongly implicated in child stunting (Hall et al. 2008, Moore et al. 2001, Stephenson et al. 2000). In addition, hookworm infection causes both iron deficiency anemia and protein malnutrition, trichuriasis can cause mild anemia and chronic inflammation, and ascariasis can cause vitamin A malabsorption (Weatherhead & Hotez 2015). *Giardia lamblia* has also been implicated in persistent – but not often acute – diarrhea in young children in developing countries (Muhsen & Levine 2012), and has been associated with decreased weight-for-age (Duffy et al. 2013) and linear growth (Farthing et al. 1986).

Environmental enteropathy is an acquired disorder characterized by reduced intestinal absorptive capacity, altered barrier integrity and mucosal inflammation, occurring in young children living in unsanitary settings (Keusch et al. 2014). These children also have high rates of infection with enteric pathogens, but their exact association with enteropathy is unclear. Some researchers (Humphrey 2009, Keusch et al. 2014) have suggested that environmental enteropathy has significant adverse effects on growth, possibly due to diversion of metabolism into a catabolic, no-growth mode. Alternatively, these changes might be due to early nutritional deficits, including *in utero*, leading to intestinal microbial colonization (Keusch et al. 2014).

There is very limited data in the literature regarding infection prior to six months of age, which is generally believed to be the age at which infants begin to be exposed to environmental pathogens (Bethony et al. 2006), often through complementary feeding (Victora et al. 2008). Infants who are exclusively breastfed for 6 months generally have fewer, and less severe, infectious episodes than their partially breastfed or non-breastfed peers (Dujits et al. 2010, Ladomenou et al. 2010). Breastfeeding enhances the infant's immune system, and reduces exposure to water and foodborne pathogens – an effect that is most marked in settings in which poverty, malnutrition and poor hygiene are prevalent (Chirico et al. 2008, Victora et al. 2008). Breastfeeding has also been associated with protection against specific pathogens, such as *Giardia*, which has found to be correlated with levels of specific anti-*G. lamblia* IgA in breast milk (Mahmud et al. 2001, Walterspiel et al. 1994). However, even when breastfeeding is adequate, stunting and pathologic changes in the intestinal mucosa consistent with environmental enteropathy have been found in infants as young as three months (Korpe & Petri 2012), suggesting early life exposure to infection and inflammation. Such inflammation can be detected in the stool through fecal leukocytosis (Korpe & Petri 2012).

Psychosocial factors

Maternal mental health and emotional distress

Although evidence from the developed world has been mixed with regard to an association between maternal emotional distress and infant stunting, with some negative reports (Andersson et al. 2004) and some evidence that the association may only be apparent under circumstances of socio-economic adversity (Orr et al. 2002), research in developing countries (Rahman et al. 2008, Surkan et al. 2011) has been more consistent and suggests that poor maternal mental health may be a risk factor for poor infant growth. In particular, a recent systematic review and meta-analysis of 17 studies of maternal depression and child growth in 11 developing countries (Surkan et al. 2011) found that children of mothers with depression or depressive symptoms were 1.4 to 2.0 times more likely to be stunted. The estimated population attributable risk indicated that if the population were unexposed to maternal depressive symptoms, 27% fewer children would be stunted (Surkan et al. 2011). Several systematic reviews (Grote et al. 2010, Dunkel-Schetter & Lobel 2010, Stewart 2007) found a significantly larger risk of depression-associated LBW in developing countries compared with the US or Europe, and in the US among low-income or low-social-status women, suggesting a context-dependent impact of psychosocial stress on women and their offspring.

On the other hand, maternal anxiety symptoms have most consistently been associated with preterm birth (Dunkel-Schetter 2011, Dunkel-Schetter & Glynn 2011), although several studies found an association with LBW, including a study of pregnant teenagers from a socioeconomically disadvantaged community in Sao Paulo, Brazil (Ferri et al. 2007) and a study in the US (Hosseini et al. 2009).

More than 60 years ago, the *Lancet* reported a natural experiment, carried out in two post-war German orphanages, showing that a loving caretaker was a stronger predictor of children's weight gain than additional food rations (Widdowson 1951). The authors concluded that "harsh and unsympathetic handling may seriously curtail growth rates in children" and warned nutritionists to be attentive to psychological factors that could "ruin even the most perfectly planned nutritional investigation." More recently, interventions that focus on strengthening mother-child interactions have been shown to be more effective than nutrition interventions alone in improving child growth and development in Bangladesh, China, Jamaica and South Africa (Engle et al. 2007). However, the role of maternal mental health in developing countries has been almost entirely neglected (Rahman et al. 2008).

The variability of expressions of distress across cultures suggests that cross-cultural comparisons in symptoms of distress is difficult. Similar complaints may appear in different cultural groups, but have different meanings and attributions of causality and distinct symbolic values (Pedersen et al. 2010). Like many other Indigenous groups throughout the world, the Maya of Guatemala have maintained distinct concepts of mental health and illness, as compared to Western psychiatric nosology (Hatala et al. 2015). Tensions exist regarding how indigenous concepts of mental illness relate to biomedical categories, affecting clinicians' and researchers' ability to organize them into distinct, quantifiable categories (Hatala et al. 2015). The most common local idioms of distress described by indigenous populations living in the Western Highlands of Guatemala include *susto*, *nervios*, and *enojo* in adult women, and *susto, mollera caída, empujo* and *mal de ojo* in children. *Susto* is believed to result from a frightening or startling experience, ranging from an accidental fall or physical trauma to witnessing an accident or human suffering, which, sometimes only after a significant time lapse, affects the normal equilibrium of the human body and manifests as a diverse array of symptoms and pathologies (Pies de Occidente, 2006). *Susto* in newborns is usually transferred from the mother during pregnancy or via breastfeeding, and manifests as poor appetite, discoloration, irritability and fatigue (Pies de Occidente, 2006, Saravia & Kolstrup 2006). *Enojo* is a form of anger that leads to headaches, weakness, fatigue and chronic illness. *Nervios* (being nervous or having nerves) is most often characterized by symptoms of anxiety, tension and fear. *Mollera caída* presents in newborns as a sunken fontanel and is attributed to sudden movement or cold air, especially if the infant's head is uncovered (Saravia & Kolstrup 2006). *Empujo* is an illness of newborns that manifests as straining, irritability and distended stomach. *Mal de ojo* in vulnerable infants is most often related to a loss of the body's normal hot-cold equilibrium due to experiencing a "hot" condition, such as a penetrating gaze or contact with pregnant or menstruating women, drunken individuals or persons who have been out in the sun; it results in fever, crying, irritability, poor sleep and appetite, stomach pains, diarrhea, and cold extremities (Pies de Occidente, 2006, Saravia & Kolstrup 2006). No research has investigated the association between local idioms of distress and infant nutritional outcomes.

Maternal social support

A number of prospective studies have examined the influence of social support during pregnancy on birth outcomes. Most (Campos et al. 2008, Dejin-Karlsson et al. 2000, Feldman et al. 2000, Pryor et al. 2003) have reported that greater social support during pregnancy predicts more optimal foetal growth and higher birth weight. Importantly, Feldman et al. (2000) found that several types of social support (family support, baby's father support, general functional support) together predicted infant birth weight independently but to the same extent as other well-known medical determinants of birth weight (i.e. obstetric risk). However, several recent studies of determinants of worse pregnancy outcomes among minority populations in the US have found that maternal ethnicity and cultural values are important moderators of effect. For instance, Campos et al. (2008) found that prenatal social support predicted higher birth weight among foreign-born – but not US-born – Latinas. Dyer et al. (2011) found that among women born in Mexico who delivered in the US, social network size was positively associated with birth weight. Buka et al. (2003) found that perceived neighbourhood social support was positively associated with birth weight in Caucasian but not African American mothers. Almeida et al. (2014) found that lower social support decreased the odds of LBW among immigrant mothers in New York City (Almeida et al. 2014). Hence, it appears that social support generally has beneficial effects on the mother-infant dyad, although evidence suggests that benefits may not accrue under all circumstances or among all social groups. Identifying the types of social involvement and support that may be beneficial to mothers in different contexts is important.

Particular members of a woman's social network may be especially important in providing support. A British study (Mutale et al. 1991) found that the lack of a close, confiding relationship with a husband or partner was related to greater risk of having a SGA infant. Similarly, a study conducted in the US found that being married and cohabiting with a partner (vs. an extended family) were both associated with higher infant birth weight (Ramsey et al. 1986). In one study in Malaysia (Mohd Zain et al. 2015), risk of LBW was reduced in married women. In a study of low-income women in the US, partner support predicted greater gestational age and fewer gestational complications among African American but not European American or Latina women (Norbeck & Anderson 1989). Several studies of teenage pregnancies (Alio et al. 2011, Shah et al. 2014, Turner et al. 1990) also found an association between higher partner support and greater birth weight, which may be moderated by ethnicity and race (Alio et al. 2011). On the other hand, a study of African American families in Detroit (Straughen et al. 2013) and a study in a low socioeconomic area of South Africa (Koen et al. 2014) found no association between partner support and birth outcomes.

In addition, during pregnancy and postpartum, both social support (Beck 2001, Robertson et al. 2004) and partner support (Dennis & Ross 2006, Stapleton et al. 2012) have been associated with lower maternal depression and anxiety, which could indirectly affect infant nutritional status. Conversely, lack of prenatal social support has been associated with increased stress and anxiety (Hoffman & Hatch 1996). Both social support and paternal support have also been found to act as effect modifiers of maternal emotional distress on pregnancy outcome, measured as preterm birth (Ghosh et al. 2010, McDonald et al. 2014) or LBW (Nylen et al. 2013, Wado et al. 2014), including in Los Angeles among Latina women (Ghosh et al. 2010) and in Ethiopia (Wado et al. 2014).

The variation in findings between studies with regard to the impact of social support and partner support on health outcome may be due to the heterogeneity in methods used to quantify these measures, and to differences in relevance of the various constructs across social groups and cultures. Indeed, both social support and partner support are difficult to define and quantify, and tools used to measure these constructs have varied widely across studies of pregnancy outcome. Dimensions that have been measured have included affection and positive social interactions (Campos et al. 2008, Mutale et al. 1991), criticism (Ghosh et al. 2010), maternal involvement in social groups (Pryor et al. 2003), social resources such as stability, participation and support (Dejin-Karlosson et al. 2000), and willingness to offer financial support or talk about feelings, and reliability in childcare (Ghosh et al. 2010, Turner et al. 1990). Paternal support has also been measured as paternal attitudes and behaviours during pregnancy and substance abuse as indicators of father involvement (Misra et al. 2010), marital status (Mohd Zain et al. 2015), support effectiveness and pregnancy-specific support received (Stapleton et al. 2012), and whether the father would be there if he was needed, provide financial assistance if needed, and provide help when the baby comes (Feldman et al. 2000). Importantly, very few of these studies (Koen et al. 2014, Mohd Zain et al. 2015, Wado et al. 2014) have been carried out in low- or middle-income countries, limiting the generalizability of findings to resource poor contexts.

Maternal autonomy

In many parts of the world, women experience very low levels of autonomy. According to an analysis using data from 2004 to 2009 in 18 developing countries, more than half of the women reported having no say in everyday household decisions such as making purchases for daily needs, visits to family and relatives and their own health care (UN Women 2011). Women's autonomy broadly refers to a woman's ability to have control or influence over choices that affect herself and her family within her own particular context (Carlson et al. 2015). A mother's degree of autonomy at the household level may impact her ability to make decisions in the best interest of her children or may limit her ability to divert household resources to her children. Women with greater autonomy also tend to be more likely to use contraception, have longer birth intervals, and to seek health care and use prenatal care (Malhotra et al. 2002). Studies have suggested that maternal autonomy may be especially important in situations of resource scarcity (Brunson et al. 2009).

Recently, interest has grown regarding how women's autonomy may be implicated in child malnutrition. A recent systematic review (Carlson et al. 2015) of 22 studies from developing countries (10 from South Asia, 8 Africa, 1 Latin America) found that higher autonomy was positively associated with child nutritional status. The dimension of maternal autonomy most consistently associated with improved child nutritional status – including higher HAZ – is women's autonomy over health care, either for herself (Dancer & Rammohan 2009, Ross-Suits 2010) or for her children (Mashal et al. 2008, Merchant & Udipi 1997, Shroff et al. 2011). Women's autonomy over her mobility (ability to travel independently, attend social events, or visit friends and family) (Merchant & Udipi 1997, Sethuraman et al. 2006, Shroff et al. 2009), financial resources (Shroff et al. 2009) and child feeding decisions (Bégin et al. 1999) have also been associated with improved child nutritional status, but not consistently across the literature.

Conversely, several studies (Heaton & Forste 2008, Patel et al. 2007, Smith et al. 2003) found significant negative associations between women's autonomy and child's nutritional status, suggesting that increasing the bargaining power of mothers does not always improve child nutritional status. In the literature pertaining to the impact of maternal autonomy on child nutritional status, the least consistent are those reported for Latin America/Caribbean. Smith et al. (2003) measured women's status in nine Latin America/Caribbean countries and found a significant positive association with child weight-for-age in Peru, a marginally positive association in the Dominican Republic, a marginally negative association in Brazil, and no association in Paraguay, Bolivia, Guatemala, Haiti, Colombia or Nicaragua. Desai & Johnson (2005) found a marginal negative association of women's autonomy with child HAZ in Haiti, but no association in Colombia, Nicaragua or Peru. Heaton & Forste (2008) found a negative association of women's decision-making with child HAZ in Haiti but no association in Colombia, Peru, Nicaragua or Bolivia. On the other hand, joint decision-making was negatively associated with child HAZ in Bolivia and positively so in Nicaragua (Heaton & Forste 2008). In Bolivia, Patel et al. (2007) also found that joint decision-making was associated with higher child body mass index (BMI), and higher mother decision-making with lower BMI.

The negative relationship between maternal autonomy and child nutritional status found in some studies could be explained in several ways. First, it may be that increasing maternal autonomy when autonomy is already high does not improve child nutrition, or could have a negative effect. Women with high autonomy may be less likely to breastfeed (Smith et al. 2003) or spend time with children, as may occur if a woman seeks employment. Smith et al. (2003) found that child wasting decreased with increasing maternal autonomy when maternal autonomy was low, but increased with increases in maternal autonomy when mothers already had high autonomy. Secondly, higher autonomy could result in more domestic violence and have a negative effect on child nutrition (Koenig et al. 2003, D'Oliveira et al. 2009). Thirdly, no Latin American study appears to have used a questionnaire based on qualitative research, and it is possible that many of the standard questions used to measure women's autonomy have different meanings or effects in this context. Finally, it is debatable whether increased maternal household decision-making is a true reflection of women's autonomy. Indeed, although greater maternal control over household decisions may result in certain benefits, female-headed households also tend to be more impoverished (Kennedy & Peters 1992, Haidar & Kogi-Makau 2009) and it is likely that many women do not freely choose to lack the support of a male partner. Hence increased maternal responsibility for household decisions is perhaps mislabelled as "autonomy."

A significant limitation in these studies is that no standard definition of autonomy has been accepted, and that studies henceforth define autonomy in distinct ways (Carlson et al. 2015). One of the most often used methods of measuring autonomy has been to directly measure a women's ability to make household decisions (Agarwala & Lynch 2006). For instance, Demographic and Health Surveys typically inquire who in the household makes decisions on a number of dimensions of autonomy such as what to cook, daily household purchases, large household purchases, etc. (Carlson et al. 2015). Mothers report who has the final say on each decision – themselves, partner, both jointly, or someone else – and women are typically rated as having high (woman has the final say), intermediate (decision is made jointly) or low (woman has no say) autonomy. Varying dimensions of autonomy have been included in different studies, including mobility (Chakraborty & Anderson 2011, Shroff et al. 2011), finances (Chakraborty & Anderson 2011, Shroff et al. 2011), health care for self or child (Chakraborty & Anderson 2011, Radebe et al. 1996), family planning (Radebe et al. 1996), having to obtain permission from a male relative on what to grow or sell (Radebe et al. 1996), and acceptance of or experience with domestic violence (Shroff et al. 2011). However, little research has been done to determine whether typical autonomy measurements are valid across different cultural contexts, and studies that do compare contexts suggest that in fact, autonomy measurements do not appear to be valid across different communities, as illustrated by studies in Latin America (Carlson et al. 2015).

Domestic violence

A growing body of literature recognizes the negative impact of domestic violence on child nutritional status. A recent systematic review and meta-analysis of studies conducted in high-income countries (US, Norway, Australia) (Murphy et al. 2004), found that women exposed to physical, sexual or emotional abuse during pregnancy were 1.4 times more likely to give birth to a LBW newborn than women who were not. Intimate partner violence during pregnancy has been associated with increased likelihood of SGA and LBW in low-income women in the US (Alhusen et al. 2014). Developing country studies are less numerous, but show similar findings. In a survey of women delivering in a public hospital in Mexico (Valdez-Santiago & Sanin-Aguirre 1996), women who experienced intimate partner violence during pregnancy were four times more likely to deliver LBW infants than women who had not. Similar findings were found among teenagers from a socioeconomically disadvantaged community in Sao Paulo, Brazil (Ferri et al. 2007), women attending primary health care clinics in a low socioeconomic area of South Africa (Koen et al. 2014) and women in Uganda (Kaye et al. 2006). Heaton & Forste (2008) found that women's experience of domestic violence had a significant negative association with child HAZ in Bolivia and Haiti, but not in Colombia, Peru or Nicaragua.

Sociodemographic factors

Socio-demographic factors implicated in poor infant growth include young maternal age, low maternal schooling and health-related knowledge and low socioeconomic status (Black et al. 2013), unsafe or segregated neighbourhoods (David & Collins 1991, Dunkel-Schetter 2011, Krieger et al. 1993) and higher household density (Halpenny 2012). Intense or prolonged physical labour (Hobel & Culhane 2003, Rao et al. 2009) and food insecurity (Baig-Ansari et al. 2006, Hackett et al. 2009, Addo et al. 2011) have also been shown to negatively affect infant growth.

There is also a growing consensus that endemic violence and social disruption have a negative impact on height. In an analysis of adult height in Latin America over an 8,250 year period, Bogin & Keep (1999) showed how economic, social and political changes prior to the European conquest of the Americas resulted in positive and negative trends in mean stature. Declines in mean adult stature continued following the European conquest until about 1939, after which there was an overall trend for increasing mean stature paralleling improved economic conditions in most Latin American countries. However, economic decline and political unrest in Guatemala was associated with a significant decline in the mean stature of 10- and 11-year-old children from 1974 to 1984, from families from very high, moderate, and very low socioeconomic status, with the latter being the most affected (Bogin & Keep 1999).

Resilience

The concept of resilience recognizes that many individuals and communities do well despite enduring hardships, trauma and deprivation (Luthar et al. 2006). A focus on resilience shifts attention from vulnerability and pathology toward the analysis of resources, strengths and positive outcomes. It infers not simply looking at the opposite of risk factors, but rather to consider unique dimensions of development and adaptation that may contribute to human flourishing (Keyes 2007, Kirmayer et al. 2011). Resilience resources include ego-related resources such as mastery or self efficacy, perceived control, and self-esteem; social constructs such as social integration, connectedness, and perceived and enacted support; personality factors such as dispositional optimism and conscientiousness; beliefs and values including world views, spirituality, and cultural values; and endowed or constitutional resources such as cognitive ability and absence of disease risks (excellent physical health) (Dunkel-Schetter 2011). However, cross-cultural research has provided evidence that facilitative aspects of resilience may vary across contexts and be influenced by culturally shaped values (Ungar et al. 2007). For indigenous populations, notions of resilience are often grounded in cultural values that have persisted despite historical adversity and colonialism, or that have emerged out of the renewal of indigenous identities. These include culturally distinctive concepts of the person (for instance, rooted in the land and environment and connected to a larger spiritual world), the importance of collective history, the richness of indigenous languages and traditions, and the importance of individual and collective agency (Kirmayer et al. 2011).

Pregnant women at risk of adverse birth outcomes due to high chronic stress are likely to fare better in coping if they possess resilience resources. High self-esteem may enable a person to confront authorities when necessary to defend one's rights and obtain needed services. Emotional stability may enable a woman to manage a difficult child or an unreliable partner on a day-to-day basis. Being physically strong and in good health in the face of chronic stress is clearly useful in coping, as is being intelligent and able to problem-solve effectively. Being connected to others and perceiving that support is there if needed is also an important coping resource (Dunkel-Schetter 2011). Conversely, low levels of mastery, self-esteem, and self-efficacy have been associated with LBW (Copper et al. 1996, Jesse et al. 2003). A latent personal resources factor (composed of mastery, self-esteem, and optimism) assessed in pregnancy predicted birth weight after controlling for prenatal anxiety and gestational age at birth (Rini et al. 1999). Finally, greater optimism in pregnant women has also been associated with higher birth weight after controlling for stress and medical risk in one study (Lobel et al. 2000).

Potential pathways for the vertical transmission of stress

Nutrition-infection pathways

Foetal and early infant growth is primarily determined by the availability and delivery of nutrients from the mother, first via the placenta and postpartum via breastfeeding and infant feeding practices – and hence directly depends on maternal diet and nutrient stores.

Infection may affect infant growth in a number of ways. In the developing world, women, infants and children frequently experience a vicious cycle between undernutrition and repeated infection. Reviews of malnutrition and helminth infections (Stephenson et al. 2000) and malnutrition, infection and immunity (Scrimshaw & San Giovanni 1997) suggest a strong link between protein-energy malnutrition, micronutrient deficiency, and infection. More specifically, poor nutritional status and specific deficiencies in iron (Beisel 1982, Scrimshaw 1990), zinc (Uriu-Adams & Keen 2010) and vitamins A, B_{12} and D (Black et al. 2013, Walker & Modlin 2009) impair host immune responses and increase the incidence, duration and severity of diarrheal and other infections (Solomons & Scott 1994, Scrimshaw & San Giovanni 1997, Katona & Katona-Apte 2008). Infections in turn impair nutrient intake and absorption, and aggravate undernutrition (Mata 1992, Scrimshaw 1994). Although these interactions are not specific to pregnancy, the increased demands on micronutrients during pregnancy likely exacerbate any deficiency and its consequences.

In addition, certain pathogens and nutrition deficiencies (i.e. vitamins A and D) may induce a pro-inflammatory environment through activation of a type-1 immune response and the release of cytokines (Odiere et al. 2010a, Odiere et al. 2010b, Irwin-Kristmanson et al. 2011). Pro-inflammatory cytokines (IL-1β, IL-6) in turn inhibit insulin growth factor-1 (IGF-1), which plays an important role in regulating placental development and growth through the growth plate chrondrocyte (MacRae et al. 2006, MacRae et al. 2007), ultimately contributing to growth retardation. Pro-inflammatory cytokines may further activate the secretion of cortisol (Kwan et al. 2004), with high cortisol levels inhibiting somatomedin-activation of epiphyseal cartilage by growth hormone, and also reducing skeletal growth (Smith et al. 1981).

Existing strategies to impact maternal and infant nutrition and health, such as promoting optimal nutrition, breastfeeding and early infant feeding counselling, hygiene promotion, immunization, health education and health seeking behaviours are all directed towards the mother. However, the effect of these programs is related to mothers' receptivity to the message and their ability to take up the intervention offered, all of which will be influenced by their mental health and psychosocial wellbeing, autonomy and self-efficacy, partner relations, support networks, access to enabling resources (i.e. food security, socioeconomic status) and societal norms and expectations.

Psychosocial and sociodemographic pathways

There are myriad potential pathways linking psychosocial factors with infant growth, which may vary between countries and regions. Previous research suggests that maternal depression is associated with compromised parenting behaviour (Lovejoy et al. 2000, McLearn et al. 2006a), nonresponsive caregiving practices (Lovejoy et al. 2000) and a shorter duration of breastfeeding (McLearn et al. 2006b, Papinczak & Turner 2000). Yet depression in women, most especially in resource poor contexts, involves factors as diverse as poverty, marital conflict, domestic violence and lack of control over economic resources (Wachs et al. 2009) – all of which could also contribute to worse pregnancy outcome.

The provision of emotional, informational, and material resources – for instance through effective social support and paternal support, but also through improved maternal agency and self-efficacy – may mitigate physical and psychological stressors and improve a woman's access to resources, including nutritional and financial (Dunkel-Schetter 2011, Feldman et al. 2000). Support may also motivate a mother to engage in positive health behaviour and make lifestyle changes that may improve her health and wellbeing (Feldman et al. 2000). Conversely, lack of support, or support that is either ineffective or abusive, as with domestic violence, may increase maternal stress, have a negative impact on a mother's self-esteem and mental health (Bonomi et al. 2006, Campbell 2002, Ferri et al. 2007), reduce a mother's self-efficacy, agency and household decision-making power (Kaye et al. 2006, Smith et al. 2003), limit access to food and antenatal care (Campbell 2002), compromise maternal physical health and nutrition, and contribute to poverty – all of which could negatively impact a mother's ability to breastfeed and care for her child (Yount et al. 2011).

There may also be more direct biological pathways linking psychosocial factors to infant growth. Indeed, growing evidence suggests that psychosocial stress-induced alterations in neuroendocrine function during pregnancy, as mediated by the maternal hypothalamic-pituitary-adrenal (HPA) axis and an altered diurnal cortisol rhythm, may contribute to IUGR. Maternal prenatal cortisol concentrations and diurnal cortisol rhythm have been correlated with anxiety and depression (Kivlighan et al. 2008, O'Keane et al. 2011, O'Connor et al. 2014, Pluess et al. 2010), stressful life events (Obel et al., 2005, Suglia et al. 2010), gender violence and social support (Valladares et al., 2009) and discrimination and lower socioeconomic status (Thayer & Kuzawa 2014). In turn, high levels of cortisol may inhibit intra-uterine growth (Bolten et al. 2011, d'Anna-Hernandez et al. 2012, Hompes et al. 2012, Kivlighan et al. 2008, Valladares et al. 2009) and accelerate the onset of parturition (Sandman et al. 1997).

Cortisol, a biomarker of stress

Biomarker assessments have become increasingly popular among behavioural and social science researchers as a way to connect behavioural, environmental, and social factors to an individual's health and wellbeing (Smyth et al. 2013). Cortisol is the body's main stress response hormone, and disturbances in its secretion are thought to be a prime mediator of associations between psychosocial stress and health (Adam & Kumari 2009). Salivary cortisol is increasingly being incorporated into psychosocial studies that aim to investigate the role of social factors in the cortisol stress response (Smyth et al. 2013). Including a stress biomarker adds value to psychosocial research by providing additional and potentially corroborative assessment to questionnaire-based measures of the psychosocial environment (Smyth et al. 2013), and may be useful for conceptual validation of instruments.

Cortisol physiology

The hypothalamic-pituitary-adrenal (HPA) axis is an integrated neural and endocrine system that is one of the primary stress systems in mammals and plays a key role in regulating the release of cortisol (Johnson et al. 1992). Cortisol is the end product of a cascade that begins with the stimulation of cells in the hypothalamus in response to a stressor – any physical or psychological stimulus causing stress – which then release corticotrophin-releasing hormone (CRH), which, in turn, stimulates the release of adrenocorticotrophin-releasing hormone (ACTH) from the anterior pituitary into the bloodstream. ACTH is picked up by receptors on the cortex of the adrenal gland, stimulating the synthesis and secretion of cortisol (Johnson et al. 1992).

Cortisol plays a central role in supporting important processes including immunity, growth, reproductive function, and cognitive and affective processes (Sapolsky et al. 2000). During pregnancy, cortisol is necessary for normal foetal organ maturation, growth and development, for protecting the foetus from adverse exposures, and for preparing it for extra uterine life (Challis et al. 2001). Cortisol also plays a vital role in regulating the stress response and preparing the body for survival by mobilizing energy stores, suppressing nonessential physiological systems, and orchestrating behavioral responses (Johnson et al. 1992). To be effective, the cortisol response should be rapid in onset and quickly terminated when the threat has passed. If stressors become chronic, however, the HPA axis may be abnormally reset and persistent alternations in cortisol excretion can ensue (Edwards et al. 2011).

In addition to its release during the body's stress response, cortisol also exhibits a basal secretory pattern that follows a circadian rhythm (Adam & Kumari 2009). The diurnal cortisol rhythm is characterized by high waking cortisol levels, a substantial (50-60%) increase in levels in the 30-45 min after waking (cortisol awakening response, or CAR), and a subsequent decline over the remainder of the day, reaching a low point or nadir around midnight (Adam & Kumari 2009, Kirschbaum & Hellhammer 1989). This pattern is an important indicator of a healthy HPA axis response, and any deviation can provide valuable information on individuals' exposure to chronic stress and or illness (Adam & Kumari, 2009).

Assessing the diurnal cortisol rhythm in pregnancy is complicated by the fact that, although the diurnal cortisol rhythm and its response to stressors are largely maintained, basal cortisol levels start to rise steadily at around 25 weeks of gestation, reaching in late pregnancy levels that are more than 2-fold that of the non-pregnant state (Allolio et al. 1990, Obel et al. 2005, de Weerth & Buitelaar 2005). In addition, cortisol-binding proteins increase markedly in plasma during pregnancy, affecting cortisol measurement in plasma. Hence, because, salivary cortisol is 100% unbound and biologically active and strongly correlates with serum cortisol levels (Gatti et al. 2009), it gives a more accurate measure of the biologically active hormone. For these reasons, and due to several advantages over blood analyses (stress-free sampling, lower costs) saliva cortisol assessment is the method of choice in basic research and clinical environments during pregnancy (Kirschbaum & Hellhammer 1989, Obel et al. 2005).

The HPA axis during the postpartum period gradually recovers from its activated state during pregnancy, and salivary cortisol levels typically return to normal within a week following delivery (Allolio et al. 1990, Mastorakos & Ilias 2003). However, the adrenal glands (where cortisol is produced) remain mildly suppressed up to 12 weeks postpartum (Mastorakos & Ilias 2003). Furthermore, breastfeeding likely affects the cortisol rhythm as suckling provides a neural stimulus that dampens the HPA axis and reduces stress responses, possibly through reduced noradrenergic input activity and the activity of prolactin (Tu et al. 2006).

Cortisol physiology in stress

Short-term activation of the HPA axis is adaptive and essential for supporting normal daily functioning in everyday life (Adam & Kumari 2006). However, both high and low levels of cortisol as well as disrupted circadian rhythms are implicated in physical and psychological disorders (McEwen 2012, McEwen 2013). Dysregulation of the HPA axis, other than that attributed to severe endocrine pathology, is attributed to the cumulative effect of chronic stress, characterized by hyper- or hypo-secretory patterns depending upon the timing, nature and duration of stress exposure (Smyth et al. 2013). In particular, growing evidence suggests that long-term chronic activation of the HPA axis might ultimately lead to a form of HPA dysregulation termed hypocortisolism, characterized by lower waking cortisol concentration, higher evening concentrations, and/or a flatter diurnal slope (Edwards et al. 2011, Fries et al. 2005).

HPA activation and alterations in cortisol secretion can result from a number of stressors, including nutritional and infectious. Glucocorticoids are the most potent inhibitors of proinflammatory cytokines, and during periods of acute illness, including infectious, levels of cortisol increase in order to suppress immune over-reactivity, thereby preventing tissue destruction (McEwen 2008). In response to recurrent or ongoing infectious assaults, hypocortisolism may occur as an adaptive survival mechanism to promote a more vigorous immune response (Edwards et al. 2011). Mice models suggest that maternal infection with helminths may increase glucocorticoids (corticosterone in mice) in her breast milk (Odiere et al. 2010a), highlighting a potential mechanism for the vertical transmission of stress postpartum. Certain nutrient deficiencies may also activate the secretion of cortisol. Mice models (Odiere et al. 2010a, Starr et al. 2015) have shown that protein deficient diets are associated with elevated corticosterone in maternal serum. Deficiencies in vitamins A and D may also activate secretion of cortisol through activation of a type1, proinflammatory immune response (Irwin-Kristmanson 2011, Odiere et al. 2010a, Odiere et al. 2010b).

HPA activation and alterations in cortisol secretion have also been observed in relation to chronic psychosocial stress. In a review of the literature on socioeconomic status (SES) and cortisol, Dowd et al. (2009) found that lower SES was associated with a blunted pattern of diurnal cortisol secretion. Specifically, Cohen et al. (2006) found that lower income and education were associated with flatter slopes and higher evening cortisol levels in middle-aged adults in the US. In a meta-analysis evaluating the effect of chronic stress on the HPA axis, Miller et al. (2007) found that stressors that threaten physical integrity (i.e. combat) or the social self (i.e. divorce), involve trauma (i.e. domestic violence) and are uncontrollable elicit a high, flat diurnal profile of cortisol secretion with lower waking but high evening cortisol levels. DeSantis et al. (2007) found that African-American and Hispanic adolescents in the US had flatter cortisol slopes across the waking day than did their Caucasian counterparts, due to higher bedtime cortisol levels in both Hispanics and African-Americans and to lower morning levels in African-Americans. The authors argue that evening cortisol levels may be more strongly influenced by social factors than are either waking levels or the CAR, as high evening levels may suggest either continued stress exposure throughout the day or a failure to turn off the stress response system in the evening. Moreover, the higher evening levels may be responsible for low morning levels via negative feedback overnight (DeSantis et al. 2007). Several studies of non-pregnant women echo these findings with cortisol response to stress, anxiety and lower SES most frequently being related to flatter cortisol diurnal profiles and higher evening cortisol levels (Grossi et al. 2001, Powell et al. 2002, Ranjit et al. 2005).

A similar pattern has also been noted in pregnant women facing chronic stressors. In pregnancy, lower waking concentrations of salivary cortisol have been associated with stressful life events (Suglia et al. 2010), depression, anxiety and minority status (O'Connor et al. 2014, Pluess et al. 2010), and higher evening concentrations and/or a flattened slope with lower SES, discrimination (Thayer & Kuzawa 2014), stressful life events (Obel et al. 2005), gender violence (Valladares et al. 2009) and anxiety and depression (O'Keane et al. 2011, Kivlighan et al. 2008). One study that measured both waking and evening cortisol during the third trimester observed 27% higher evening cortisol levels among women who experienced a stressful life event or were concerned about pregnancy complications during the second trimester, while morning levels were unaffected, suggesting a shallower decline in cortisol across the day in stressed women (Obel et al. 2005). Thus, in pregnant women as well, evening cortisol measures may be more sensitive to the influence of chronic stress, and stress effects may best be detected as a less rapid decline from the morning peak level, and an elevated evening level (Obel et al. 2005, Suglia et al. 2010).

The relationship between psychosocial stress and maternal salivary cortisol postpartum has been less clearly established, possibly because it has been the focus of less research (Gonzalez et al. 2009; Taylor et al. 2009), and also because it may be confounded by infant feeding choice (Tu et al. 2006), the inhibitory effect of oxytocin on cortisol excretion during breastfeeding (Heinrichs et al. 2002), sleep deprivation-induced changes in the HPA-axis (Minkel et al. 2014), and adrenal suppression up to 12 weeks postpartum (Mastorakos & Ilias 2003). However, higher waking cortisol levels were found in postpartum women who were depressed (Taylor et al. 2009, 6-8 wks PP) and in women who had experienced early life adversity (Gonzalez et al. 2008, 2-6 mo PP).

In summary, the cortisol stress response integrates stress from a broad range of stressors, including nutritional, infectious and psychosocial, as well as from contextual factors such as lower social status and lower SES, and may be an important mediator in the vertical transmission of stress from a mother to her foetus. No prior study has investigated the cumulative effect of various nutritional, infectious and psychosocial stressors on maternal cortisol during pregnancy or postpartum or on the vertical transmission of stress from mother to infant. Although breast milk has emerged as a potential transmitter of elevated maternal cortisol in mice models (Odiere et al. 2010a), no such association has been documented in humans. In fact, postpartum stress research has been rare in humans (Gonzalez et al. 2008, Taylor et al. 2009), and findings have been inconsistent. In addition, to the best of our knowledge, there have been no human studies on the impact, postpartum, of maternal experience of stress on infant growth. Finally, few studies investigating the effect of psychosocial stress on the maternal cortisol rhythm have occurred in disadvantaged, resource-poor settings (O'Connor et al. 2014, Suglia et al. 2010, Valladares et al. 2009), and none in indigenous contexts, which are consistently characterized by greater disadvantage and worse health statistics (Montenegro & Stephens 2006).

Towards an integrated approach to maternal and child nutrition

Historical perspectives in global health

In 1978, the WHO-backed Alma-Ata conference emphasized the need for an interdisciplinary, multi-level approach to health and the goal of "Health for All in the Year 2000" (Alma-Ata 1978). However, during the 1980s and 1990s, a shift of actors and paradigms in the field of international health advocated instead for an orientation that precluded social approaches and broader targets of health and wellbeing for all (Brown et al. 2006). The new focus involved reduced public- and greater private-sector involvement in health care provision, and promoted standardized, technical and evidence-based interventions that narrowly targeted individual diseases in order to reach concrete and easily measurable goals (Birn 2009). Within this context, the Millennium Development Goals (MDGs) established in 2000 largely focused global health efforts into eight sectoral goals, with the overarching goal being poverty reduction by 2015 (UN 2000). Despite successes, overall failure to reach the MDGs has been attributed to the lack of interdisciplinary and participatory approaches and fragmentation of complex health problems into silos (Waage et al. 2010). Moreover, the use of a results-based framework did not allow to measure complexity or the qualitative nature of development, and may have promoted a focus on those targets that were easier to implement or monitor, or on populations where results could most rapidly be achieved (Waage et al. 2010).

These trends in global health have also characterized the field of maternal and child nutrition, which in many contexts worldwide has mostly focused on proximal, individual-level factors of nutrition and infection, and on those nutrition-specific interventions for which the strongest evidence of impact exists (Bhutta et al. 2008, Bhutta et al. 2013). These include periconceptional folic acid supplementation, maternal balanced energy protein supplementation, maternal calcium supplementation, multiple micronutrient supplementation in pregnancy, promotion of breast feeding, appropriate complementary feeding, vitamin A and preventive zinc supplementation in children 6–59 months of age, and management of acute malnutrition (Bhutta et al. 2013). However, the last ten years have witnessed a gradual shift to more fully embrace the complexity of early infant growth, first calling attention on the 1,000 first days of life and the intergenerational transmission of stunting (Bhutta et al. 2008, Victora et al. 2008), and more recently, advocating for strategies that tackle both proximal and distal determinants of early infant growth and development (Ruel et al. 2013, Gillespie et al. 2013). Indeed, the 2013 Lancet Series on maternal and child nutrition, in addition to highlighting "nutrition-specific strategies" (Bhutta et al. 2013) to improve early infant growth and development, additionally emphasized the need for "nutrition-sensitive strategies" in the areas of agriculture, food security, social security, early child development and formal schooling, drawing on the experience of countries that made progress by focusing on gender and social equality as the cornerstones of nutritional success (Ruel et al. 2013). Furthermore, Gillespie et al. (2013) discussed the political context necessary for effective action, prioritized the realization of human rights and a commitment to equity and gender equality, and proposed ways in which business and civil society could be engaged.

Gaps in the field of maternal and child nutrition to address infant stunting

Despite these encouraging trends, the 2013 Lancet Series still represents a bias towards the discipline of nutrition, which is where the strongest evidence has accumulated (Bhutta et al. 2013). While nutrition-sensitive interventions mainly focus on improving food systems and providing social safety nets that will increase economic security of women and households, only cursory mention is made of the potential role of psychosocial interventions, and only with regard to reducing maternal depression and of linking basic health services with a wide range of social support for women (Ruel et al. 2013). The overall silence on psychosocial factors reflects important gaps that still exist within the fields of maternal-child research and program implementation. It also reflects the challenges of scaling-up interventions that are both psychosocial and context-specific, and of generating the necessary evidence to prove their efficacy in improving early infant growth.

Moreover, despite a continued stated commitment of global health to social justice and equity, concerns have arisen that this focus has often been diluted in efforts to translate the MDGs into actions with measurable impacts (Kabeer 2010) – resulting in interventions targeting populations where results could most rapidly be achieved (Waage et al. 2010). As a result, interventions have generally failed to reach the world's poorest and most marginalized populations (Mumtaz et al. 2014). Tight project timelines and a focus on aggregate outcome indicators militate against efforts to understand and address the needs of the most marginalized.

The complex interplay of social, political, cultural, and economic marginalization, and the need for improved understanding of the experiences and relationships lived by poor people on a daily basis, has been well documented in social development literature (Chambers 1995, Hulme et al. 2001). Furthermore, the work of the WHO commission on social determinants of health has identified three causes of health inequities: differential power and influence associated with income inequality and social status, differential exposures to stress and other adverse conditions, and differential results associated with discrimination and unequal access to services (CSDH 2008). So far, however, the global community has paid very little attention to these realities (Mumtaz et al. 2014).

A transdisciplinary approach to early infant nutrition is needed

Recent calls for greater consideration of social, cultural and other context-specific factors in global health (CSDH 2008, Napier et al. 2014), and the failure of global health interventions to reach many of the world's poorest and most marginalized populations (Farmer 2006, Mumtaz et al. 2014, Napier et al. 2014) require researchers to further bridge disciplines and think beyond conventional frameworks. Determinants of early infant growth occur at multiple levels, from individual to societal, and across generations and disciplines. Addressing early infant stunting hence requires a transdisciplinary approach able to bridge across these various levels. Indeed, transdisciplinary research offers a holistic approach to health research by combining concepts, theories, methods, and measures from various disciplines into a new, shared conceptual framework able to holistically address a common problem (Rosenfield 1992). This approach transcends traditional disciplinary perspectives and moves beyond the limitations of any single one, allowing for the creation of new ways of conducting research and evaluation, and an increased understanding of the complex, cross-cutting processes characteristic of many public health issues (Abrams 2006, Fuqua et al. 2004, Stokols 2006).

Tools for a transdisciplinary approach to early infant stunting in a marginalized, indigenous context

A context-relevant, transdisciplinary, translational and transformational approach (Dankwa-Mullan et al. 2010) to addressing complex health problems such as early infant stunting, seems particularly relevant.

Community-based Participatory Action Research

The need for an improved understanding of the experiences lived by marginalized populations – that face intersecting social, political, cultural and economic inequalities and often experience the worst health conditions and most reduced life opportunity (Farmer 2006) – has been well documented in social development literature (Chambers 1995, Hulme et al. 2013, CSDH 2008, Napier et al. 2014) and is critical in informing interventions for improving health and reducing inequity. Marginalized populations have often been the subject of health research and interventions by "outsiders", and the evolution of western science has largely diverged from other ways of "knowing" such as exist in indigenous populations, which have developed ways of learning and sharing traditionally important to their health and survival (CIHR 2007).

Growing interest among health professionals and academics in finding new ways to study and address complex health and social problems has intersected in recent years with increasing community demands for research that is *community-based*, rather than merely *community-placed* (CIHR 2007, Minkler & Wallerstein 2008). The new focus on translational research to improve intervention outcomes within diverse cultures and contexts has also highlighted the potential of action-oriented and community-partnered approaches to health and health disparities research (CIHR 2007). Such Participatory Action Research (PAR) approaches decolonize the more traditional applied research paradigm in which "outsiders" largely determine the questions asked, the tools used, the interventions developed, and the kind of results and outcomes documented and valued, which may inadvertently only reinforce a sense of impotence, inferiority and resentment among disempowered populations (Gaventa 1993, Wang & Burris 1997), and neglect what the community thinks is important (Gaventa 1993).

PAR is defined as a collaborative approach to research that begins with a research topic of importance to the community and combines community and academic knowledge toward a goal of promoting social change to improve community health and reduce disparities (US DHHS 2007). PAR is not so much a research method as an orientation to research that emphasizes equitable engagement of all partners throughout the research process, from problem definition through data collection and analysis, to the dissemination and use of findings to help effect change (Minkler 2010). The community and participating experts interact in an open dialogue, accepting each perspective, and relating different perspectives to each other. A PAR approach hence aims to address health issues within an environment of mutual trust and collaboration between researchers and members of the community (Macaulay et al. 1999, Cargo & Mercer 2008). Collaboration with, and engagement of, community members in all steps of the research process helps ensure that research proceeds in a manner that is culturally sensitive, relevant, respectful, responsive, equitable and reciprocal, with regards to methods used, interpretation of key findings, and research benefits (CIHR 2007). Moreover, PAR helps increase the local relevance of the research, contextualize methods and findings, and facilitate translation of research findings into meaningful and locally relevant action (Weijer & Emanuel 2000, Minkler 2004, Glass & Kaufert 2007).

Mixed methods research

Definitions of quantitative, qualitative and mixed-methods research

Historically, the approach in health care research was nearly exclusively of the quantitative or positivist tradition, which was predicated on the necessity for the researcher to be objective and unbiased (Doyle et al. 2009). Positivism contends that there is a single reality and therefore seeks to identify causal relationships through objective measurement and quantitative analysis (Firestone 1987). Quantitative data includes closed-ended information, usually involving a closed-ended checklist of multiple-choice questions. Analysis consists of statistically analyzing variable measures to answer research questions or test hypothesis. The strengths of quantitative approaches include accurate measurement of specific constructs, and the capacity to conduct group comparisons, examine the strength of association between variables of interest, and test research hypotheses (Moghaddam et al. 2003). However, one major limitation is that quantitative measurement typically detaches information from its original context, a phenomenon referred to as decontextualization (Viruell-Fuentes 2007).

Qualitative research, also described as constructivist or interpretative (Creswell 1994), emerged as an alternative to the positivist form of inquiry as researchers sought to examine the context of human experience (Schwandt 2000). Constructivism proposes that there are multiple realities and that different interpretations may result from any research endeavour (Appleton & King 2002). The qualitative approach examines the "whole person" using a fully contextualized approach (Gelo et al. 2008). Qualitative data consists of open-ended information gathered from participants through a range of methods that allow participants to create their own narratives (Bryman 2006). This approach affords in-depth accounts of human experiences, emotions, beliefs and behaviours in a manner that may not be fully captured with measurement scales and multivariate models (Bryman 2006). However, purely qualitative studies have been challenged for their small or unrepresentative samples and their limited capacity to produce generalizable findings, although generalizability, replication, reliability and validity may arguably not be relevant for qualitative research (Gelo et al. 2008).

Mixed methods research focuses on collecting, analyzing, and mixing both quantitative and qualitative methods in a single study under the assumption that the use of both approaches provides a better understanding of research problems than either approach alone (Johnson & Onwuegbuzie 2004, Tashakkori & Creswell 2007). Advantages of such an approach are multiple (Bryman 2006). First, triangulation allows for greater validity by seeking corroboration between quantitative and qualitative data. Second, using a combination of research approaches allows for a greater repertoire of tools to meet the particular aims and objectives of a study, provides a more complete and comprehensive picture of the study phenomenon, and offsets weaknesses inherent in either quantitative or qualitative approaches. Third, mixed methods studies can use one research approach to explain the data generated using the other approach, which is particularly useful when unanticipated or unusual findings emerge. Finally, an initial qualitative phase of a study may help develop hypotheses to be tested in a follow-up quantitative phase, or to generate items for inclusion in a questionnaire (Bryman 2006).

Quantitative methods used in my doctoral thesis

The following types of quantitative data were collected: (1) Structured questionnaire, administered in Spanish or *Mam* to inquire about household and psychosocial factors, obstetric and past medical history, and current symptoms; (3) Previous-day dietary recall for mother and infant; (4) Food security questionnaire; (5) Previous-day physical activity recall; (6) Targeted physical exam of mother and infant; (7) Maternal and infant anthropometry (height, weight and head circumference); and (8) Biological sample collection of stool, urine and saliva from mothers, and stool from infants. In addition, breast milk was collected from postpartum mothers, for the doctoral thesis of another PhD student (Hilary Wren).

Among the types of variables collected, the quantitative measurement of psychosocial factors presents a particular challenge. Psychosocial factors have multidimensional constructs, making them hard to define or quantify, as previously illustrated by the heterogeneity in questionnaires used to measure dimensions of social support, paternal support or maternal autonomy. Moreover, perceptions of psychosocial wellbeing differ across and between societies, making it difficult to develop cross-cultural questionnaires (Flaherty et al. 1988). There is a surprising dearth of research that qualitatively examines psychosocial factors in various cultural contexts, particularly in developing countries (Carlson et al. 2015, Napier et al. 2014), limiting contextualization and validation of existing measures. Nevertheless, their adequate quantification is necessary so as to allow for testing of associations between psychosocial factors and health outcome measures. Moreover, if the role of psychosocial and cultural systems is ignored, biological wellness will be the sole measure of wellbeing, and the potential for psychosocial and cultural factors to become key components in health maintenance and promotion will not even be considered (Napier et al. 2014).

Flaherty et al. (1988) has described a step-wise method for developing instruments for use in cross-cultural psychosocial research. Preference in instrument selection is usually given to instruments that purport to measure the constructs to be studied, and that have already proven to be cross-culturally relevant, which is rare, or, alternatively, that have been extensively tested and found to be psychometrically sound at least in one context (Flaherty et al. 1988). If new to a given context, the instrument will then require evaluation for cross-cultural equivalence (Flaherty et al. 1988). First, *content validity* is established by showing that the instrument items indeed represent all dimensions of the concept of interest, and that each item describes a phenomenon that is relevant to the culture under investigation – with items deleted or added as needed. The new instrument must then be examined with respect to *internal consistency and reliability* – a measure based on the correlations between different items of the same scale, meant to determine whether several items that propose to measure the same general construct produce similar scores (George & Mallery 2003). Standardized Cronbach's alpha-coefficients are calculated after preliminary data have been collected; alpha-coefficients are generally classified as excellent ($\alpha \geq 0.9$), good ($0.9 > \alpha \geq 0.8$), acceptable ($0.8 > \alpha \geq 0.7$), questionable ($0.7 > \alpha \geq 0.6$) or poor (< 0.6) (George & Mallery 2003). Second, *construct validity* can be assessed, for example using principal components analysis (PCA), to determine whether questionnaire items measure multiple dimensions and if so, whether items could be grouped into dimension-specific variables. Third, *semantic equivalence* requires assuring both equivalence in meaning with the original questionnaire and culturally relevant and appropriate translation. Fourth, *technical equivalence* refers to ensuring that the data collection method will not affect results. For instance, private interviews of women by male interviewers in certain contexts may not be appropriate and may significantly bias data collection (Flaherty et al. 1988). Finally, *conceptual equivalence* refers to the fact that instruments measure the same basic construct in two cultures (Flaherty et al. 1988). An example of assessing conceptual equivalence could apply to the measurement of social support; if social support is found to correlate with the biological stress response in a way that would be expected based on the literature, and if a cross-culturally valid way of measuring the biological response exists (i.e. using the diurnal cortisol rhythm), then the finding of a significant correlation between the two variables (social support and cortisol) would suggest conceptual equivalence of the social support instrument.

Qualitative methods used in my doctoral thesis

Local narratives and beliefs relating to health and illness, dietary practices and local sources of maternal vulnerability versus resilience were explored using focus groups, key-informant interviews as well as Photovoice. Taken together, these methods helped in study and questionnaire design, in ongoing contextualization of data collection and research findings, and in understanding of the diversity of local perspectives and experience.

Photovoice in particular emerged as a powerful tool of inquiry in this study. Photovoice was first developed by Wang & Burris (1994) for use by Chinese village women to explore the topic of reproductive health (Wang & Burris 1994), and its use has since expanded significantly (Martin et al. 2010). Most relevant to our own work, it has been used to explore health-related experiences and stories of day life and survival among various indigenous communities (Badry & Felske 2013, Berrang-Ford et al. 2012, Genuis et al. 2015), including in Guatemala (Cooper & Yarbrough 2010, Lykes et al. 2001). The theoretical underpinnings of Photovoice include Paulo Freire's education for critical consciousness, feminist theory, and a community-based approach to documentary photography. Freire's work highlights the importance of people's sharing and speaking from their own experience, seeing connections among their individual situations, creating an analytical perspective from which to relate their situations to root causes, and developing solutions and strategies for change (Freire 1970). Feminist theory holds that power accrues to those who have a voice and participate in decisions (Hesse-Biber & Yaiser 2004, Smith 1999). Participatory approaches to documentary photography (Wang & Burris 1997) promote a grassroots approach to representation, and demonstrate ways in which photography can be used as personal voice.

By giving cameras to individuals who might otherwise not have access to such a tool, Photovoice enables individuals to document reality through their own eyes and lived experiences, share expertise and knowledge, and catalyze change in their communities, rather than stand as passive subjects of other people's intentions, images and interpretations (Wang & Burris 1997). Photovoice can be a powerful tool in the hands of individuals who do not typically have a voice, who may be disempowered or stigmatized, or may not feel comfortable communicating in the dominant language, and can affirm the perspective of society's most vulnerable populations.

Use of Photovoice in this study was driven by the considerable gaps that remain in our understanding of how marginalized populations, including indigenous *Mam*-Mayan women in Guatemala, perceive and experience their lived environments. Furthermore, the large amount of literature on psychosocial stress and maternal health is not representative of the lives of our study population, yet such an understanding is critical in informing interventions for improving health and reducing inequity. Finally, the concerns expressed by some individuals at the beginning of the study, that their communities have often been the subject of research but have rarely benefited from them, made it clear that it was important to engage our community collaborators in new ways that would be important to them, give them tools for self-representation, and create a space for empowerment.

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CHAPTER 3

QUANTITATIVE METHODOLOGIES REVEAL A DIVERSITY OF NUTRITION, INFECTION/ILLNESS AND PSYCHOSOCIAL STRESSORS DURING PREGNANCY AND LACTATION IN RURAL MAM-MAYAN MOTHER-INFANT DYADS FROM THE WESTERN HIGHLANDS OF GUATEMALA

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Abstract

Background: The nature and severity of three categories of maternal stressors (nutritional, infectious, psychosocial) that may impact maternal health and early infant growth is not often considered together. **Objectives**: To describe quantitative methodologies; assess construct validity of questionnaires; report variability in socio-demographic, obstetric, nutritional, infectious and psychosocial characteristics; and compare characteristics between pregnancy and lactation and between study cohorts of *Mam*-Mayan mother-infant dyads. **Methods:** Grounded in Participatory Action Research and a socio-ecological framework, this observational study enrolled a longitudinal cohort of 155 women, followed during pregnancy (6-9 mo), early (0-6 wks) and later (4-6 mo) postpartum, and two cross-sectional cohorts (60 early and 56 later postpartum). Household and social factors, obstetric history, nutritional, infectious and psychosocial stressors, and infant characteristics were explored. **Results:** Diet diversity (3.4±1.3) and adult food security (38%) were low. Urinary and gastrointestinal infections were rare (<5%) whereas experience of local idioms of distress was frequent (20-50%). Participants reported low maternal autonomy (81%), high paternal support (70%), small social support networks (2.7±1.3 individuals), high trust in family (88%) and community-based institutions (61-65%) but low trust in government services (6%). Domestic violence was commonly reported (22%). Infant stunting was common (36% early postpartum, 43% later postpartum) despite frequent antenatal care visits (7.5±3.8). Participant engagement with the research team did not influence study outcomes based on comparisons between longitudinal and cross-sectional cohorts. **Conclusions:** The variability in socio-demographic, nutritional and psychosocial variables will allow exploration of factors that promote resilience or increase vulnerability of the mother-infant dyad.

Background

Within the context of health of mother-infant dyads in impoverished developing country populations, maternal nutritional status and diet diversity[1,2] and child nutritional status[3,4] have received the most attention. However, there is evidence that a much wider range of maternal factors is involved. Maternal hookworm infection[5], urinary tract infection[6] and periodontal disease[7] have each been associated with intra-uterine growth retardation and low birth weight (LBW). In addition, rural place of residence, low socioeconomic status and marginalized ethnicity[1,8]; poor social support[9]; poor maternal autonomy and self-efficacy[10]; and maternal experience of violence[11] have been associated with stunting. Finally, maternal anxiety and depression have been associated with impaired infant growth in both developed and developing countries.[12,13] In indigenous cultures, these conditions are described through local idioms of distress[14,15] and remain largely unexplored in their impact on maternal-child health.

Despite the diversity of factors known to influence the health of the mother-infant dyad, there remains a large gap in our understanding and in our ability to implement effective measures to promote health.[4] Recent calls for greater consideration of social, cultural and other context-specific factors in global health[16,17] require researchers to bridge disciplines and think beyond conventional frameworks. In response to such a request, we propose a socio-ecological conceptual framework (Figure 3.1) that recognizes three broad categories of stressors (nutritional, infectious and psychosocial) that may cumulatively affect the mother and ultimately impact her infant. The nature and severity of these stressors, and how a mother experiences them, are in turn directly influenced by social (social capital, gender relations, cultural norms)[9-11] and socio-demographic (living conditions, food security)[1,8] factors, which may either promote resilience or increase vulnerability.

Using a Participatory Action Research (PAR) approach[18], we conducted a mixed-methods study in indigenous *Mam* women in the Western Highlands of Guatemala to assess the diversity of household, social and individual-level factors related to maternal nutrition, infection and psychosocial distress that may influence the health of the mother-infant dyad from the sixth month of pregnancy to six months postpartum (PP). While Guatemala has the highest percentage of stunting in Latin America and among the ten worst worldwide[8,19], stunting rates reach over

80% of children under five years of age in some Western Highland indigenous communities[19], where prior work by our group has shown that up to 38% of infants are already stunted at birth[20] implying that maternal influences during pregnancy require further attention.

As the first in a series, this paper presents the quantitative methodologies, including an assessment of internal consistency and construct validity of questionnaires, and the descriptive results emerging from the quantitative component of the study. Secondary objectives include (1) identifying which nutritional, infection/illness and psychosocial measures had sufficient variability to warrant further exploration, (2) determining whether ongoing engagement with the longitudinal cohort affected measures through comparison with paired cross-sectional cohorts, and (3) comparing these measures across pregnancy, early and later PP. The qualitative components of the larger mixed-methods study and the analyses that make attributions of causality with regard to fetal and early infant growth will form the basis of subsequent publications.

Methods

Study setting

The *Mam* constitute the fourth largest Mayan population in Guatemala[21] and live in the Western Highland departments of Huehuetenango, San Marcos and Quetzaltenango.[22] The study was conducted in eight rural *Mam* communities located at 2,500-2,900 m elevation and within ~15 km of San Juan Ostuncalco (~30 min drive on mix of dirt and paved road) and ~25 km of the city of Quetzaltenango (~60 min on paved road). Community populations of 1,000 to 4,000 have been characterized by dispersed houses and high rates of poverty (68% extreme poverty, 19% poverty).[23,24] Communities were engaged in subsistence agriculture with similar socioeconomic and infrastructural conditions. All were involved in the nationwide rural health *Programa de Extensión de Cobertura*. Full time community health workers (CHWs), a nurse who visited the community health post every seven to fourteen days, and traditional midwives (*comadronas*) all provided maternal health care.

Participatory Action Research

PAR was adopted in an effort to ensure that the research was culturally sensitive, relevant and respectful of local values.[18] An initial needs assessment allowed community women to identify their most pressing concerns regarding maternal and child health which guided the study's lines of inquiry. In addition, 21 *Mam* women, including the research coordinator, two traditional midwives and 12 CHWs, participated in all aspects of the study: design, pre-testing and semantic validation of study instruments, participant recruitment, administration of questionnaires, collection of biological samples, house visits and follow-up, and ongoing knowledge exchange.

Study design

This integrated mixed-methods research involved one longitudinal cohort, as well as two cross-sectional cohorts, which were included to determine whether ongoing involvement with the longitudinal cohort altered outcomes. The longitudinal cohort was recruited during pregnancy and seen three times: 6-9 mo of pregnancy (June 2012 – January 2013), 0-6 wk PP (early PP) (July 2012 – May 2013) and 4-6 mo PP (later PP) (November 2012 – October 2013) (Figure 3.2). One of the two cross-sectional cohorts of mother-infant dyads was recruited early PP (June 2012 - March 2013) and the second, later PP (June - September 2012). Data collection included both quantitative and qualitative methodologies. The present paper describes the quantitative aspects of the research; a description of the qualitative components will be presented separately.

Inclusion and exclusion criteria

For the longitudinal cohort, inclusion criteria were (1) consenting women from the study communities, and (2) pregnancy confirmed by measurement of suprapubic fundal height ≥ 5 cm above the umbilicus suggesting a gestational age ≥ 6 mo.[25] There were no exclusion criteria, however the participation of six was discontinued following notification that their infant had died. For the cross-sectional cohorts, the inclusion criteria were (1) consenting women from the study communities with (2) infants aged either 0-6 wks (early PP cross-sectional cohort) or 4-6 mo (later PP cross-sectional cohort) based on infant date of birth. The only exclusion criterion for the cross-sectional cohorts was a non-singleton birth.

Recruitment and ethics

Women were recruited with the assistance of the 20 community staff (CHWs and *comadronas*) from June 2012 - March 2013 (Figure 3.2) in an effort to include all women until the pre-determined samples sizes were achieved. Recruitment methods included home visits, loudspeaker announcements, and word-of-mouth invitations to attend meetings at the community health post where the study was explained, questions were answered and women were invited to provide fully informed written consent (thumbprint if unable to sign) if they wished to participate. Women who had delivered within the previous 40 days were observing a period of *cuarentena*; therefore all procedures were carried out during a home visit.

The Institutional Review Boards of both McGill University and the Center for Studies of Sensory Impairment, Aging and Metabolism in Guatemala approved the study and permission was obtained from community leaders and the local authorities of the Ministry of Health. Participants were referred to the public health system whenever medically indicated. Laboratory results were communicated to participants directly and treatment was provided free of charge for any diagnosed infection.

Sample size and loss to follow-up

Power estimations for the longitudinal cohort determined that 118 participants would be necessary to detect an effect size of 0.15 for infant length-for-age Z score, assuming inclusion of ten independent variables within a multiple regression analysis with $\alpha=0.05$ and $\beta=0.2$.[26] Assuming 12% loss to follow-up, we enrolled 155 participants (Figure 3.2), 59 in their second, and 96 in their third trimester. One mother lost her infant in pregnancy (stillbirth), four in the neonatal period prior to the early PP visit and one at three months PP. In addition, 18 women (11.6%) were lost to follow-up due to participant decision or relocation. Loss to follow-up was higher in the community (32%) where families more often migrated to the coast for work compared with the other communities (10%; $p = 0.001$) where migration was less frequent. The final samples sizes for the longitudinal cohort were 155 during pregnancy, 144 early PP and 131 later PP.

Power estimations for each cross-sectional cohort determined that 46 participants would be necessary to detect a difference in infant length-for-age Z score of 0.5 units between the cross-sectional and longitudinal cohorts, with $\alpha=0.05$ and $\beta=0.2$.[26] Assuming 12% loss to follow-up, we enrolled 60 and 56 mother-infant dyads in the early and later PP cohorts, respectively.

The combined sample sizes per perinatal stage were therefore 155 women in pregnancy (all longitudinal), 204 early PP (144 longitudinal, 60 cross-sectional) and 187 later PP (131 longitudinal, 56 cross-sectional) (Figure 3.2). Later comparison with an independent census made available to us after completion of the study revealed that of all infants born in study communities during the 10-month recruitment period, 49% had been enrolled.

Qualitative methodologies

This component of our mixed-methods research will be explored in a separate publication. Briefly, local narratives and beliefs relating to health and illness, dietary practices and local sources of maternal stress versus resilience were explored using focus groups, key-informant interviews as well as Photovoice methodologies developed for use in marginalized populations.[27] Photovoice derives ethnographic data from participant narratives based on photographs that they take of their lives, daily activities, and beliefs, and provides insights that might not emerge during traditional interviews or focus group discussions.[27]

Quantitative methodologies

At each sampling period, community staff administered a structured questionnaire in Spanish or *Mam* about household and social factors, obstetric and past medical history, and current symptoms (20-45 min); staff nutritionists measured anthropometry of mothers and infants (15 min) and conducted a previous-day dietary recall (15 min); a physician reviewed all questionnaire information, inquired about particularly sensitive information such as safety and exposure to violence within the home environment, and performed a physical exam (< 30 min); breast milk was collected from lactating women and the women were given instructions for collecting stool, urine and saliva samples (< 15 min) that were subsequently delivered by staff to a laboratory in Quetzaltenango. A follow-up home visit was performed by community staff, nutritionists and the physician, to administer a food security questionnaire (5 min), a previous-day physical activity recall (15 min), and a second previous-day dietary recall (15 min), and to pick up any remaining samples and deliver lab results and any warranted treatment (<5 min).

Household factors

Socio-demographic factors. Women were asked about language proficiency (*Mam*, Spanish), marital status (married, informal union, single, separated, or widowed), occupation, schooling (none, primary, or ≥ secondary) and religion (evangelical or Roman Catholic). As no universal definition exists to define indigenous ethnicity due to its complex socio-political nature[28], women were categorized as being *Mam* if they wore indigenous clothing and/or if they spoke *Mam* (99% concordance). Women were asked whether their family owned land, and if so, whether they planted maize, potato, broad or black beans, greens, and/or fruits.

House construction materials were defined by floor type (cement, ceramic tiles, or dirt), wall material (wood, cement block, *adobe* [earthen brick], or *lamina* [corrugated sheet metal]), water source (household faucet, public faucet, well, river or stream, other), and sanitation facilities (toilet, pit latrine, or neither). Women were also asked whether their family had electricity or owned any of the following durable assets: radio, television, mobile phone, sewing machine, oven, refrigerator, bicycle, car, or truck.

Measuring household income is difficult in a region such as the study area where sources of income vary daily, weekly, and seasonally, most families engage in home production and informal work, and women have little knowledge about the income of other family members.[23] Therefore, a Household Wealth Index (HWI) was constructed as a proxy for long-term wealth, according to Demographic Health Survey methods.[29] Thirteen items (dirt floor, ceramic/cement floor, *adobe/lamina* walls, cement block walls, electricity, and ownership of a radio, television, mobile phone, sewing machine, oven, refrigerator, bicycle and car/truck) underwent principal components analysis (PCA). The HWI was calculated as the sum of the relative weightings of each asset and housing construction material. It was used as a continuous variable and each household was also categorized as being in the lowest (lowest 40%), middle (middle 40%) or highest (top 20%) asset category.

Adult food insecurity. A nine-item household Adult Food Insecurity Score was adapted from the 14-item experience-based Food Security Questionnaire used by the Panama Ministry of Health.[30] The five items pertaining to children were excluded given that 40% of study participants were primiparous. This questionnaire was chosen over the Latino-American and

Caribbean Food Security Scale based on pilot testing results that revealed poor local understanding of the subtle differences between its questions. The questionnaire asked questions about lacking money to purchase food, decreasing amount of food or frequency of meals because of lack of money, experiencing hunger, and effects of agricultural production and the environment on food production. Individual items were scored on a 4-point Likert scale (never, sometimes, almost always, always). The cumulative Adult Food Insecurity Score ranging from 0 to 27 was categorized into food secure (0) vs. mildly (1 - 9), moderately (10 - 18) and severely (19 - 27) food insecure.

Social factors

Structural social capital, which pertains to participation and connectedness, was assessed through the measurement of maternal autonomy, social support (general and specific to the study infant's father) and group membership.[31] With regard to social support, three dimensions were assessed: emotional support (enabling people to "feel" things); instrumental support (enabling people to "do things"); and informational support (enabling people to "know" things).[31] Cognitive social capital, which pertains to reciprocity, trust and norms, was assessed through the measurement of social trust and perception of harmony.[31]

Maternal autonomy. A Maternal Autonomy Score was calculated using a 5-item questionnaire that assessed women's involvement in household decision-making about food and medicine purchases, health visits for herself or infant, and household finances.32 For each item, two points were assigned if the respondent made the decision on her own and one if decision-making was shared. The cumulative score ranging from 0 to 10 was used both as a continuous variable and as a categorical variable based on no (0), low (1-5) and moderate/high levels (6-10) of autonomy.

Social support and group membership. A Paternal Support Score was calculated using a 5-item questionnaire[33], which inquired about support received from the baby's father (providing financial support, spending time with her, helping her make difficult decisions, providing affection, showing interest in caring for the newborn). Each item rated paternal support on a three-point Likert scale from 0 to 2 (never, sometimes, always). The resulting cumulative score ranging from 0 to 10 was used both as a continuous variable and as a categorical variable of no (<1), low (1-5), moderate (6-8) and high (9-10) levels of paternal support.

A Social Support Score was calculated using an 8-item questionnaire adapted from the Social Provisions Scale[34] and the Social Network Questionnaire.[35] Items inquired about how many people overall could the respondent count on to deliver emotional, instrumental and informational support when needed (to provide a listening ear, help make difficult decisions, give useful advice about pregnancy and newborn care, look after family safety, ensure that mother and child received medical care, provide enough money to buy basic necessities, help with child care). The score (the sum of total number of people for each item divided by the number of items) was used as a continuous variable and to define categories of social support as lowest (for scores <1), average (1 to 2) and highest (>2). The number of individuals in network was obtained by summing the number of different individuals identified throughout the eight items, and was used as a continuous variable.

Group membership was defined as active membership in a cooperative or union, community association, women's association, religious group, health organization, or political group. A binary variable was created for active group membership that differentiated women who did versus did not participate in any group.

Social harmony and trust. Social harmony was scored according to whether women felt that most people got along well in their community (yes, no, or more or less). A binary variable was created that differentiated "yes" from other responses.

Trust was evaluated using a 13-item questionnaire adapted from Pennock's Wellbeing Survey[36] that inquired about a participant's level of trust (never, sometimes, always) in various institutions which were later grouped according to initial PCA loading into family, neighborhood (neighbors, church), public services (community health center, hospital, police, school), government institutions (government, mayor), non-government institutions (NGO, women's group) and media (television, newspapers).

Experience of difficult life events. An adapted Life Experience Survey37 inquired about experience of various stressful life events (yes/no), including experience during pregnancy or PP of various potentially stressful life events (loss, difficulties with partner or other family members, household alcohol abuse). In addition, an open-ended discussion in a space that ensured confidentiality and safety was used to explore particularly sensitive topics such as experience of domestic violence including verbal, physical or sexual. Any indication of a stressful life event was used to build dichotomous variables reflecting exposure to each life event.

Maternal factors

Obstetric experience. Maternal age was determined based on the mother's date of birth, or self-reported age when the date was unknown (n=7). Age at delivery was categorized as < 20, 20 to 34 and ≥ 35 years, reflecting the greater obstetric risks associated with either extreme of age.[38] Parity, defined as number of live births, was categorized as one, two to four, and ≥ five, reflecting the greater obstetric risks associated with primiparity and grand-multiparity.[38] Loss of a previous child under five years was recorded, and classified as stillbirth, death within the first 28 d PP, or ≥ 28 d PP. Mean birth spacing interval during the woman's reproductive years was classified as < 3 or ≥ 3 years.[38] Prenatal and delivery services were identified as either informal (if delivered by a *comadrona*) or formal (in public or private facility). Frequency of ANC was categorized as never, one to three, or ≥ four times.[39] Women were also asked whether they had taken prenatal vitamins, iron or folic acid supplements.

Maternal nutrition. Maternal height was measured in duplicate to the nearest 0.5 cm using a wall stadiometer, shoeless and with the gaze in the Frankfort plane. Heights <145 cm were classified as stunted.[1] Weight was measured in duplicate to the nearest 100 g using a digital scale (SECA803, Hamburg, Germany). Body Mass Index (BMI) was calculated in PP women as weight (kg) divided by height squared (m^2), and classified as underweight (BMI <18.5 kg/m^2), normal (BMI 18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2) or obese (BMI ≥30.0 kg/m^2).[40]

A maternal Dietary Diversity Score was derived from a single previous-day dietary recall at each sampling period. All foods and beverages reported, with a minimum portion size of 15g, were classified into the following ten food groups: starchy staples; legumes (beans/peas); nuts/seeds; dairy; flesh foods; eggs; vitamin A-rich dark green leafy vegetables; other vitamin A-rich vegetables/fruits; other vegetables; and other fruits.[41] The score was calculated as the sum of all food groups consumed; a dichotomous variable of probable micronutrient adequacy (yes/no) was created based on a cut-off score of ≥ five food groups.[41]

Physical activity was assessed through a previous-day activity recall inquiring about type of activity, frequency, intensity (0 to 5) and duration.[42] Physical activities were grouped by: indoor domestic chores (cooking, cleaning, weaving/sewing); outdoor domestic chores (washing clothes, tending to animals, running errands, performing heavy manual labor such as agricultural work); non-domestic work activities (store-keeping); social activities (church attendance, visiting friends/family, health visits); exercise (walking); sedentary (rest, watching television, eating); and childcare. Means (hours/day) for each activity was calculated. Because *Mam* women commonly practice *cuarentena,* a recovery period of ~40 d PP when a mother is expected to dedicate herself to breastfeeding and taking care of her newborn[43], early PP estimates were only calculated for those women ≤ 40 d PP. Activities that involved leaving the community were noted. A subjective Physical Activity Intensity Score was calculated from all activities except sedentary activities and childcare as the sum of individual activity scores, each calculated as duration multiplied by participant-perceived intensity. Women were also asked about their utilization of a *temascal*, a sauna typically used in the Highlands for bathing, relaxation and healing purposes and strongly tied to PP care within local cultural practices.[44]

Maternal illness and infection. Women were asked about their experience within the last week (yes/no) of symptoms suggestive of infection (fever, headache, cough, flu-like symptoms, skin changes, vomiting, abdominal pain, diarrhea, dysuria and vaginal discharge), and of specific nutrient deficiencies.[25] Periodontal disease was diagnosed through detection of dental cavities (caries) or inflammation of the gum (gingivitis). Reported symptoms of upper (cough, nasal congestion, sore throat) or lower (productive cough, difficulty breathing) respiratory tracts were complemented by exam of the sinuses, oral cavity and cervical lymph nodes and lung auscultation (decreased breath sounds, rales, crepitus). Reported gastrointestinal symptoms were evaluated by physical exam for abdominal distension or tenderness, hepatosplenomegaly and quality of bowel sounds. Skin lesions typical of scabies (small papulo-vesicular lesions), cellulitis (warmth, erythema, swelling) and abscesses were recorded. Clinical findings associated with specific nutrient deficits were assessed, including nail spooning and nail/conjunctival pallor (iron deficiency anemia); and goiter (iodine deficiency).

Urine samples were collected from all women at all sampling periods, except later PP for asymptomatic, longitudinal women. An experienced laboratory technician analyzed the samples using dipstick analysis and urine microscopy to yield pyuria, defined as > 5 neutrophils per high-power field (hpf) of unspun urine.[45] A culture was performed if infection was suspected on initial testing (positive leukocyte esterase and nitrites by dipstick, pyuria).[45] In pregnant women, asymptomatic bacteriuria $\geq 10^5$ colony forming units (cfu)/ml was considered pathological, whereas only symptomatic bacteriuria was considered pathological in non-pregnant women.[45]

Stool samples were analyzed for leukocytes, nematodes and protozoa using a direct smear by an experienced laboratory technician trained in parasitology. The direct smear methodology was validated for detection of nematodes via Kato-Katz on 30 specimens, with a finding of 100% concordance (data not shown). Both pathogenic (*Giardia spp., Entamoeba histolytica/dispar*) and non-pathogenic (*Blastocystis hominis, Entamoeba coli, Endolimax nana, Iodamoeba butschlii*) protozoa were recorded, with the latter being used as a measure of exposure to potentially contaminated food and water sources. Of note, *B. hominis* is generally considered non-pathogenic but there is growing evidence that it may be an emerging pathogen.[46] Fecal leukocyte counts > 10/hpf were considered indicative of an inflammatory process.[47]

Saliva samples were collected from mothers at each perinatal stage to assess diurnal cortisol as an indicator of stress. Breast milk samples were also collected at both early and later PP sampling periods to measure cortisol and to detect subclinical mastitis. Details regarding collection and analyses will be reported separately.

Local idioms of distress. The lack of culturally appropriate mental health assessment tools is a barrier to screening and evaluating of emotional distress in diverse populations. Women were asked about current experience of local idioms of distress that have been previously described in this population and that were mentioned during the pilot study.[15,48,49] *Susto* is believed to result from a frightening or startling experience, ranging from an accidental fall or physical trauma to witnessing an accident or human suffering, which, sometimes only after a significant time lapse, affects the normal equilibrium of the human body and manifests as a diverse array of symptoms and pathologies.[48] *Enojo* is described as an anger that upsets the body's equilibrium and leads to headaches, stomach pains, weakness or fatigue and chronic illness.[48] *Nervios* is an illness due to experiencing strong emotions, particularly anxiety, grief and sorrow (*pena*).[48]

Infant factors

Infant characteristics. Infant age and sex were recorded. For women in the longitudinal cohort that recalled the date of their last menstrual period (LMP) (n=82; 56%), gestational age was calculated, in weeks, as the difference between the LMP and birth; infants were classified as premature if born < 37 weeks.50 Mother-reported infant birth weight was classified as LBW if < 2.5 kg.[51]

Infant anthropometry and feeding practices. Recumbent supine length (cm) was measured thrice according to standardized procedures using an infantometer (SECA210, Hamburg, Germany) and recorded to the nearest 0.5 cm; the final value was the mean. Weight (kg) was measured to the nearest 100 g using a digital infant scale (SECA354). Head circumference (cm) was measured thrice using a Head Circumference baby band (SECA212). Length-for-age Z score (HAZ), weight-for-age Z score (WAZ), height-for-weight Z score (WHZ) and head-circumference-for-age Z score (HCZ) z-scores were calculated as indicators of infant nutritional status using WHO Anthro software (3.1).[52] Stunting, underweight, wasting and microcephaly were defined as z-scores < -2.0 SD below the respective WHO reference median. Scores < -3.0 SD were considered severe.

Infant feeding practices were classified as exclusive breastfeeding (breast milk, certain medications), predominant breastfeeding (breast milk plus certain liquids and medications) and mixed feeding (breast milk and any solid or semi-solid foods) based on reported feeding practices since birth.[53] Timing of initiation of breastfeeding was also determined.

Infant mortality and morbidity. Neonatal mortality was calculated as the number of deaths of longitudinal infants during the first 28 days PP, divided by the number of live births for which the birth outcome was known (n=149), multiplied by 1,000.

Mothers were asked whether their infant had experienced any of the local idioms of distress during the last week or at any time since birth. According to local beliefs, *susto* in newborns is usually transferred from the mother during pregnancy or via breastfeeding, and manifests as poor appetite, discoloration, irritability and fatigue.[14,48] *Mollera caída* presents as a sunken fontanel and is attributed to sudden movement or cold air, especially if the infant's head is uncovered.[14,48] *Empujo* is an illness of newborns that manifests as straining, irritability and distended stomach. *Mal de ojo* in vulnerable infants is most often related to a loss of the body's normal hot-cold equilibrium due to experiencing a "hot" condition, such as a penetrating gaze or contact with pregnant or menstruating women, drunken individuals or persons who have been out in the sun; it results in fever, crying, irritability, poor sleep and appetite, stomach pains, diarrhea, and cold extremities.[14,48] These local idioms of distress are considered general indicators of poor infant health.

Mothers were asked whether their infant had experienced (yes/no) symptoms of infection or compromised feeding, including fever, cough, flu-like illness, vomiting, diarrhea, stomach discomfort or gas within the last week. A physical exam conducted by a physician assessed for any congenital abnormalities or complications of delivery and diagnosed infection and poor feeding.[25] Dehydration was assessed (skin turgor, sunken fontanelle). Cough and reported symptoms of upper (nasal congestion) or lower (difficulty breathing) respiratory tracts were complemented by observation (use of accessory muscles of breathing), exam of the sinuses, oral cavity and cervical lymph nodes, and lung auscultation. Report of gastrointestinal symptoms was followed by evaluation for abdominal distension or tenderness and quality of bowel sounds. Among skin infections, lesions typical of scabies, cellulitis and diaper dermatitis (erythema of genital area) were recorded. The umbilical area was assessed for adequate healing and for any signs of infection (erythema, swelling, drainage).

Stool samples collected later PP were analyzed for leukocytes, nematodes and protozoa using a direct smear by an experienced laboratory technician. Protozoa were recorded as described above.

Statistical analyses

All statistical analyses were carried out using IBM SPSS Statistics Program version 22.0 (SPSS Inc./IBM Chicago, IL, USA). Descriptive statistics (mean ± SD, percentages ± 95% binomial CI) were computed and coefficients of variation (CV) were computed for continuous variables.

Internal consistency of questionnaire items was assessed using Cronbach's alpha test for adult food insecurity, maternal autonomy, paternal support and social support and classified as excellent ($\alpha \geq 0.9$), good ($0.9 > \alpha \geq 0.8$), acceptable ($0.8 > \alpha \geq 0.7$), questionable ($0.7 > \alpha \geq 0.6$) or poor ($0.6 > \alpha \geq 0.5$).[54] If $\alpha \geq 0.8$, principal components analysis (PCA) was then used to assess whether questionnaire items measured multiple dimensions (construct validity) and whether the items could be grouped into dimension-specific variables.

Longitudinal and cross-sectional cohorts were compared using x^2 or Fisher's exact tests for categorical variables, Student's t-tests or ANOVA for normally distributed continuous variables, and Wilcoxon Mann-Whitney U test or Kruskal Wallis test for non-normally distributed continuous variables. Within the longitudinal cohort, comparisons across sampling periods were done by repeated measures ANOVA or Related Samples Friedman's Two-Way Analysis of Variance by Ranks for continuous variables and Related Samples Cochran's Q test for categorical variables. The level of significance was set at $p < 0.05$. In order to assess which factors had sufficient variability to warrant future exploration of their associations with the health of the mother-infant dyad, we considered that continuous variables with a CV >15% are likely to have sufficient variability to be informative in future analyses.

Results and discussion

Household factors

Socio-demographic factors

Based on study inclusion criteria, all participants lived in rural communities and the majority (96%) was *Mam* indigenous (Table 3.1). Most women (94%) self-identified as housewives, and only 7 reported employment outside of the home (Table 3.1). Fewer (6%) participants were single compared to women of reproductive age nationally (31%), and only one-third of women in a relationship were married, compared to two-thirds nationally.[19] Marital status is highly relevant to gender relations, and without legal protection in the case of separation, consensual unions in rural Latin America are typified by lower bargaining power of women and as advantageous to men.[55] Although the percentage of study participants who attended school was similar to the national percentage, both at ~20% (Table 3.1), the percentage of secondary schooling among study participants (17%) was half the national level (34%).[19]

Almost all women (99%) lived in households that practiced subsistence agriculture and cultivated maize, and the majority also cultivated potatoes and legumes (black and broad beans; Table 3.1), as is characteristic in this area of Guatemala.[22,23] The first principal component of the HWI explained 29% of variance. All women in the highest HWI category (top 20%) lived in houses made of blocks with cement or ceramic floors, whereas 47% of those in the lowest HWI category (lowest 40%) lived in *adobe* houses and 54% had dirt floors. Although electricity was available to 73% of the poorest households (compared to 96% in the highest HWI category), few of the poorer households had radios (39%), televisions (13%), stoves (3%), refrigerators (2%), or cars or trucks (4%), compared to the households in the highest asset category (96, 29, 95, 18, and 61% respectively). Compared to other rural populations in Guatemala, access to piped water, sanitation, electricity, housing material and ownership of a motor vehicle was overall better, and conversely, ownership of other household assets (radio, television, mobile phone, and refrigerator) was lower.[19]

Adult food insecurity

Internal consistency between items in the Adult Food Insecurity Questionnaire was good both during pregnancy and early PP (Cronbach's α=0.85) and later PP (α=0.89), consistent with prior use of this questionnaire in Panama (Krause RJ [PhD], 2012, personal communication). The 1st, 2nd and 3rd principal components measured reduced food access, experience of hunger, and environmental causes, respectively. The two former components are common dimensions assessed in food security questionnaires.[56] However, that environmental causes emerged as a latent component – a finding highly relevant to subsistence farming contexts, where difficulty in growing food due to inclement weather and lack of primary resources such as seeds and land both have a significant impact on a household's economy and access to food – is novel and worthy of particular attention, as most food security questionnaires do not assess this dimension.[57,58] Considerable variability in the Adult Food Insecurity Score existed between households (CV > 100%). Approximately two-thirds (62%) experienced some degree of food insecurity in the previous month (Table 3.2), which closely paralleled findings from the National

Maternal-Infant Health Survey 2008-2009 pertaining to the Western Highlands[57] where 64% of all households had experienced adult food insecurity, compared to 57% nationally, with most affected households being poor, rural and indigenous.[57] However, rates of severe adult food insecurity were lower (< 5%) compared to 18% reported for this area of Guatemala,[57] perhaps because of differences in the questionnaires utilized. Previous findings in this area of Guatemala[57] suggested that severity of household food security increases with inclusion of child food security questions, a dimension we were not able to measure given the high rate of primiparity in our study population.

Social factors

Social capital

Maternal autonomy. Internal consistency between items in the Maternal Autonomy Score was excellent (Cronbach's $\alpha > 0.90$), and there was considerable variability among households (CV > 65%). Most women reported no (24%) or low (58%) autonomy whereas only 19% reported moderate to high autonomy (Table 3.2). Women reported the lowest autonomy in management of household money, and the highest autonomy in decisions relating to food purchases. These findings are consistent with prior research in Guatemala, including indigenous populations where 38% of women of reproductive age have no say in household decision-making, 73% need their partner's authorization to visit a doctor, and 69% to make any household expenditures.[19] Greater female involvement in decision-making has been associated in indigenous areas of Guatemala with higher maternal schooling and earnings, Spanish proficiency and women's ability to make strategic life choices[59,60], and nationally with reduced frequency of domestic violence.[19]

Social support and group membership. Internal consistency between items of the Paternal Support Score was excellent (Cronbach's $\alpha=0.93$ in pregnancy and early PP and 0.96 later PP). The score had moderate variability (CV > 30%). Most women (70%) reported high levels of support from the infant's father, but 14% reported no or low paternal support (Table 3.2). Among the types of paternal support, emotional support (affection) was most commonly reported (84%) whereas helping to care for the infant was least commonly reported (76%). These findings are consistent with prior reports in Guatemala[19,55,59] where men are typically highly involved in household decision-making including decisions related to maternal and child health.

Internal consistency between items of the Social Support Score was good (Cronbach's α=0.84 in pregnancy, 0.91 early PP, 0.85 later PP). The resulting score had moderate variability (CV > 35%). Most women (74%) reported moderate levels of social support, whereas 16% reported low levels (Table 3.2). Emotional and informational forms of support (both 96%) and support at home to have time to rest (84%) or to secure the family's safety (89%) were most common. Women relied on a small social network (2.7 individuals) (Table 3.2) that most often included the mother and partner/spouse, followed by father, father-in-law, children, stepsiblings and health care providers. It has been suggested that the small size of such networks may increase women's vulnerability to potential shocks such as illness or death of a main support person, especially in areas, such as our study area, that face extreme poverty and have little access to social safety nets.[61]

Active group membership was reported by 48% of women, most commonly in religious (36%) and health (28%) groups (Table 3.2). These likely are an important source of knowledge exchange and social support for women.

Social harmony and trust. Because internal consistency of the Trust questionnaire was poor to questionable (Cronbach's α=0.50-0.67), no composite Trust Score was developed. Instead, we present responses to individual questions. Early PP, more women (90%) reported social harmony in their communities compared to later PP (75%). Most (88%) women reported a high level of trust in their families but only 65% in their neighborhoods, 61% in public institutions, 9% in NGOs and 6% in government services or the media (Table 3.2). That few women trusted institutions outside of their community likely reflects local norms and beliefs, as well as experience with racism and discrimination.[62] Low levels of trust in turn likely translate into reluctance in seeking help[63,64], further increasing the vulnerability of the population.

Experience of difficult life events

Domestic violence, household alcohol abuse, and problems with the newborn's father were the most commonly reported difficult life events, affecting 22%, 32%, and 18% of longitudinal women, respectively. These values were comparable to national statistics of intimate-partner violence within the last 12 months among indigenous women (20%) and in the overall population (23%).[19] Although our study did not explore contributing factors, national statistics[19] suggest that regardless of location of residence or ethnicity, domestic violence is most likely to occur when the perpetrator is drunk (30%) or jealous (25%) or when the victim disobeys him (16%), complains (16%) or refuses to engage in sexual activity (14%), and most often results in depression and sadness (78%), fear (67%), headache and body pains (63%), anxiety (51%), and loss of interest in living (51%). All could have consequences for maternal and child health.[65]

Maternal factors

Obstetric experience

The majority of pregnancies were high-risk based on maternal age (<20 and ≥ 35 yr), parity (primiparous and grand-multiparous), and/or birth-spacing interval (<3 yr) (Table 3.3). Mean age at delivery for primiparous women was 19.5 yrs. Among the four women ≥ 40 yrs, parity ranged from 8 to 11; nationally, mean parity for women ≥ 40 yrs was 5.2.[19] Prior neonatal and child mortality among non-primiparous participants was 8% and 26%, respectively, and both were higher than the 2% and 5%, respectively, reported nationally for the previous 10 years (2% and 6%, respectively, for indigenous women).[19]

Regarding ANC, women attended a mean of 7.5 ANC visits, only 15% attended less than the WHO-recommended four visits, and some women were seen up to 20 times (Table 3.3). Most women (93%) consulted *comadronas*, compared to only 31% of indigenous women nationwide.[19] On the other hand, a similar percentage of study participants received ANC from the formal sector (78%) compared with indigenous women overall in Guatemala (74%). Of these, 86% used public services, most often the community health post. Most deliveries occurred either in the woman's home or in the *comadrona*'s home, and 79% were attended by a *comadrona*. Only one-fifth (19%) of the women delivered in a hospital compared with 51.2% nationally and 36.0% for indigenous women in Guatemala.[19] The lower percentage of hospital deliveries may be due to the poor access to formal obstetric health services, high social cohesion and trust within communities and in local cultural norms and traditional *Mam* practices and/or low trust in government services by participants. Indeed, previous ethnographic studies have cited various sociocultural factors that explain low utilization of formal health services by indigenous women in Guatemala[66], including lack of confidence in biomedical treatments, perception of poor quality of care, discriminating or condescending treatment by medical personnel, inability of medical staff to speak indigenous languages, embarrassment over being examined and greater confidence in *comadronas*. Moreover, relations between formal and traditional providers are often tense due to social, ethnic and cultural differences and a strong history of devaluation of indigenous knowledge and practices.[67]

Nutrition

Mean maternal height was 146.5 ± 5.2 cm (132.0 to 162.0 cm; CV 4%) (Table 3.4); 33% of women were stunted as compared to 31% overall in Guatemala and 48% in indigenous populations.[19] Based on early and later PP measurements, less than 4% of mothers were underweight, two-thirds had a normal BMI and one-fourth was overweight (20%) or obese (4%). These findings contrast with national statistics[19] where only 2% of women of reproductive age are underweight, 35% are overweight and 15% obese. No difference in BMI was detected between early and later PP visits, consistent with findings in urban Quetzaltenango where maternal BMI did not change between early PP and two years PP.[68]

Dietary Diversity Scores were 3.4, 3.4, and 2.8 in pregnancy, early PP and later PP, respectively (Table 3.4). All women consumed starchy staples (mostly maize), and over half consumed legumes (most commonly black and broad beans) the previous-day (Table 3.4). One-third consumed flesh foods (mostly chicken or beef), dark green leafy vegetables (such as *epazote*, *hierba mora* and *hierba nabo*)[2], other vegetables (such as onions and *güisquil*) and vitamin A-rich vegetables and fruit (mostly tomatoes and carrots). One-fifth consumed eggs. Consumption of other fruits, dairy and nuts/seeds was particularly low. Consumption of flesh foods, vegetables, and fruits was higher during pregnancy and early PP compared to later PP ($p < 0.05$) whereas consumption of nuts/seeds was lower ($p=0.039$). These findings are consistent with prior dietary diversity research in Guatemala.[69] Women appeared to make an effort to increase the diversity of their diets during pregnancy and early PP. However, given that only one-fifth of pregnant and early PP women and one-tenth of later PP women consumed foods

[2] Epazote = wormseed leaves (*Dysphania ambrosioides*); hierba mora = black nightshade leaves (*Solanium nigrum*); hierba nabo = turnip leaves (*Brassica sp.*)

from at least five food groups on the previous-day (Table 3.4), close to 80% of women did not meet adequate diet diversity and therefore were at risk of inadequate micronutrient intake.[41]

With regard to physical activity, other than childcare, the most common activities reported during pregnancy and later PP were domestic chores, social activities and resting (Table 3.4). Early PP, during the *cuarentena,* the most common activities were rest and childcare. Pregnant and later PP women were more likely to leave the community than early PP women (11 vs. 2%), most commonly to run errands or sell produce in nearby San Juan Ostuncalco, and to have a higher Physical Activity Intensity Score ($p < 0.001$). In addition, most women in all sampling periods reported routinely using the *temascal*, which also provided time for rest.

Illness and infection

Maternal experience of biomedical symptoms within the previous week was greatest for headache, cough, abdominal pain, dysuria and vaginal discharge, most of which were more frequent during pregnancy than PP ($p < 0.05$) (Table 3.4). Most women had periodontal disease in the forms of caries (78%) and/or gingivitis (66%). In addition, premature loss of permanent teeth, a useful composite marker of adverse social and economic conditions, malnutrition and lack of health care services[70], affected nearly two thirds (59%) of women, with 22% missing ≥ five teeth. Epigastric tenderness and signs of anemia were uncommon (8% and 5% respectively) and hypertension, pneumonia and clinical mastitis were present in < 1%.

Laboratory-diagnosed urinary or gastrointestinal infection was rare (Table 3.4). Despite a high prevalence (~75%) of non-pathogenic protozoans, a potential indicator of an unsanitary environment, women exhibited a very low prevalence of helminth (*Ascaris lumbricoides*) or other parasitic infection (*Giardia spp., E. histolytica/dispar*) compared to school-aged children in a nearby, similar altitude rural area (Palajunoj Valley) where prevalences were *A. lumbricoides* 18%, *E. histolytica/dispar* 16%, *G. lamblia* 11%, *H. nana* 5% and *B. hominis* 3%.[71] Others have similarly found significant differences in infection prevalence between neighboring rural communities through spatial clustering analyses.[72] However, the low prevalence of helminth infection in study women could be due to the particular ecology of our study area including altitude, soil type, precipitation or temperature, all of which are known to influence transmission dynamics[73], or the lower sensitivity of direct smears compared with Kato-Katz for detecting nematode eggs.[74]

Local idioms of distress

Both *susto* and *enojo* were more commonly reported during pregnancy and later PP compared with early PP ($p < 0.05$) (Table 3.4). Few (< 5%) women reported experiencing *nervios.* This study will allow inquiry as to the impact of maternal experience of local idioms of distress on the maternal-infant dyad, which may be best complemented by our qualitative data.

Infant factors

Infant characteristics

Mean infant ages were 19 d (early PP) and 147 d (later PP) and 47% of infants were female (Table 3.5). Among the 82 longitudinal infants for whom we knew maternal LMP, one-fifth was premature, with mean gestational age of 34.5 wks. This contrasted with the national rate of 8%, 9% in Latin America and 11% worldwide, and with Malawi, which has the highest rate in the world at 18%[50] and begs for skepticism in the accuracy of the self-reported LMP. According to mother-recall of infant birth weight, 9% of all early PP infants had LBW, compared to an overall rate of LBW in Guatemala of 11% and in rural populations of 12%.[19] These findings contrast with observations that in developing countries, the ratio of intrauterine growth retardation to prematurity favors the former.[75]

Nutrition

With regard to infant anthropometry, CVs for all scores exceeded 70%, indicating considerable variation in our study population (Table 3.5). Over one-third (36%) of infants was already stunted early PP. No national data is available for comparison, but studies in urban Quetzaltenango[20] and rural Chimaltenango[76] revealed lower early PP stunting rates, at 25 and 16% respectively. In our study, infant HAZ further declined between early and later PP visits ($p=0.029$) to reach stunting of 43% at the later visit, compared to 56% in rural Chimaltenango[76], and 24% in Guatemalan infants 3 to 5 mo old.[19]

The percentage of underweight and wasted infants were, respectively, 16 and 3% early PP, and 14 and 0% later PP (Table 3.5), compared to national rates of 5 and 1%, respectively in 3-5 mo old infants.[19] Microcephaly affected 19% of infants early PP and 15% later PP. This was unexpected given the paucity of prior national or international data on microcephaly, and the results of a cohort study in rural Chimaltenango[76] in which low infant HCZ was not encountered.

With regard to infant feeding practices, just over half (55%) of study infants initiated breastfeeding within the first hour PP (Table 3.5), which, according to prior work by our group[77], was associated with delivery at the *comadrona*'s home, mother-perceived sufficient breast milk, later exclusive breastfeeding, and higher weight-for-age. Within the first week PP, 26% had received ritual fluids, or *agüitas* (19% prior to initiation of breastfeeding), most frequently as warm water (for perceived insufficient milk) and infusions of anise or orange leaves (for stomach discomfort) and chamomile (for irritability and crying). Rates of exclusive versus mixed feeding were, respectively, 56 and 5% early PP, and 42 and 8% later PP, with exclusive breastfeeding rates being comparable to those overall in Guatemala (56% at 0-3 mo, 43% at 3-5 mo).[19] Of mixed-fed infants, 10% had initiated mixed feeding at 2 mo, 25% at 3 mo and 65% at 4 mo.

Mortality and morbidity

The neonatal mortality rate was high within our study population, at 27 per 1,000 live births, compared to 18 overall in Guatemala and 21 within its indigenous population[19], and 9 in Latin America and the Caribbean.[78]

The majority of mothers reported that their infant was affected by at least one local idiom of distress. At the early PP visit, the most common infant ailments were, by decreasing frequency: *empujo, mal de ojo*, gas and stomach discomfort, and, at the later PP visit, *mal de ojo*, cough, *empujo* and *mollera caída* (Table 3.5). The concurrent influences of local cultural practices and western influences were evident in our observations. Highlighting the poor local uptake of western concepts, women reported local idioms of distress more frequently than they did symptoms representing a biomedical understanding of health and illness. This is consistent with prior findings among rural *Mam* mothers[79] that explanation of illness is most often based on local concepts of health and illness, namely an imbalance of the body's equilibrium due to climate, behavior or emotional states.

Infant physical exams were for the most part normal. Most common findings (all < 10%) included umbilical erythema, perineal rash, and upper respiratory infection, for which most treatments were sought from traditional healers and consisted of herbal preparations. Less than 1% had a congenital abnormality (suspected Hirschsprung's disease), cellulitis or pneumonia. Stool samples were returned for 80% of later PP infants; one third had fecal leukocytosis, indicative of intestinal inflammation and most likely due to bacterial infection and/or environmental enteropathy, which is common in developing countries and can develop as early as 2-12 wks after birth due to chronic exposure to fecal contamination.[80]

Comparison of longitudinal and cross-sectional arms of the study

A methodological challenge of longitudinal studies, and especially of those that actively incorporate PAR, is that the presence of the research team may affect study outcomes either directly (through, for example, treatment of medical conditions) or indirectly (for example through behaviour change in response to exposure to new information and people).[18] The main reason to include both longitudinal and cross-sectional cohorts in our study design was to confirm that ongoing engagement with study participants through frequent follow-up with women had no impact on the measured variables. Analyses revealed only four differences between paired longitudinal and cross-sectional cohorts. First, longitudinal women were significantly more likely to have reported experiencing difficult life events than their cross-sectional counterparts ($p < 0.05$), most likely due to new incidents between the EPP and LPP visits, increased trust by participants of the research team, and repeated opportunity to report violence. Second, at the early PP visit, cross-sectional women spent less time resting than did longitudinal women ($p=0.004$). Third, at the later PP visit, cross-sectional women had a lower Dietary Diversity Score ($p < 0.02$) and consumed legumes, vitamin A-rich leafy green vegetables and other vegetables less frequently than did longitudinal women ($p < 0.05$), which could potentially be due to temporal differences in when the later PP dietary information was collected from the two cohorts. Finally, later PP, moderate microcephaly was more common in the cross-sectional than the longitudinal cohort ($p=0.027$) but analyses revealed no differences between longitudinal and cross-sectional cohorts in linear growth or weight of infants, either early or later PP.

Strengths and limitations

Our study design has several strengths. Continued engagement with communities, close collaboration with CHWs and *comadronas,* and delivery of laboratory results and treatments all engendered confidence between participants and the research team. Furthermore, we chose only to collect biological samples considered by the women to be non-invasive (urine, stool, breast milk, saliva). Together, these elements minimized loss to follow-up. Skilled interviewers and privacy during the interviews enabled disclosure of violence. Finally, we have a diverse database covering household characteristics, social context, experience of difficult life events, obstetric history, maternal nutrition, infection and psychosocial distress, and infant nutrition and infection. This will allow for a comprehensive exploration of determinants of the health of the maternal-infant dyad in this setting.

We however acknowledge six limitations. First, sampling bias may have occurred as only half of potentially eligible women living in study communities presented for enrollment, as assessed by later review of a census. It is likely that our recruitment methods did not reach all women and that some women could not present themselves on the specific clinic days, but we acknowledge the possibility that non-participants might constitute a distinct population (i.e. working mothers, women facing particularly harsh living conditions, women not given permission by a partner or parent to participate, and women who did not have confidence in CHWs or *comadronas*). Second, our loss to follow-up in the longitudinal cohort was higher in one community relative to the other seven. Indeed, in this one community, fewer families owned land (70 vs. 84%, p=0.021) and families often traveled to the coast for work, early PP maternal underweight was more common (11 vs. 2%, p=0.043), women's social support score was lower (1.0 vs. 1.3, p=0.003), and more infants were severely stunted both early (31 vs. 13%, p=0.020) and later (32 vs. 11%, p=0.015) PP. These distinct characteristics of this community may need to be considered if these variables emerge in subsequent analyses of the data. Third, intestinal infections may have been underreported due to limitations in locally available diagnostic methods. Fourth, compliance among women in the longitudinal cohort in providing fecal samples declined over the three visits (94, 86, 80%), perhaps because women were, for the most part, asymptomatic. Fifth, many women did not know the date of their LMP, and birth weight data was dependent on mother recall and had been collected using varying methods, limiting our ability to accurately determine gestational age, prematurity, and birth weight. Finally, as demonstrated by differences between our data and Guatemalan data, study findings may not be generalizable to other communities in Guatemala.

Conclusion

The first 1,000 days of life has been recognized as "the window of opportunity", whereby concerted action and investment in maternal and child health can have a life-changing impact on a child's future and help break the cycle of poverty. Although maternal and child nutrition has received most attention, a wide and multi-sectoral range of factors – including household and psychosocial – has been associated with early infant growth. Our socio-ecological conceptual framework intends to bridge this gap. The diversity of quantitative data and the considerable variability detected in such areas as household wealth, maternal autonomy, social support, diet diversity and infant feeding practices provides a rich database from which we will explore, in subsequent papers, the stressors that may influence the health of the maternal-infant dyad. The qualitative component of the research, also to be described separately, will provide ethnographic insights that will not only guide our interpretation of quantitative data analyses but may also reveal relevant information not captured by quantitative data. Finally, the richness of this database will allow us to identify unique coping strategies that promote resilience within this vulnerable population.

List of abbreviations used

ANC: Antenatal care; ANOVA: Analysis of Variance; BMI: Body mass index; CHW: Community health worker; cfu: Colony-forming units; CI: Confidence interval; CV: Coefficient of variation; HAZ: length for age Z score; HCZ: head circumference for age Z score; hpf: High-powered field; HWI: Household wealth index; LBW: Low birth-weight; LMP: Last menstrual period; NGO: Non-governmental organization; PAR: Participatory action research; PCA: Principal components analysis; PP: Postpartum; SD: Standard deviation; WAZ: weight for age Z score; WHO: World Health Organization; WHZ: height for weight. Z score

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Authors' note

A. M. Chomat contributed to conception and design, contributed to analysis, drafted the manuscript, gave final approval, participated in obtaining funding and supervision, and agrees to be accountable for all aspects of work ensuring integrity and accuracy. N. W. Solomons, K. G. Koski, and M. E. Scott contributed to conception and design, contributed to analysis and interpretation of data, drafted the manuscript, critically revised the manuscript, participated in obtaining funding and supervision, gave final approval, and agree to be accountable for all aspects of work ensuring integrity and accuracy. H. M. Wren contributed to analysis, design of the study, data collection, interpretation of data, critically revised the manuscript, gave final approval, and agrees to be accountable for all aspects of work ensuring integrity and accuracy. M. Vossenaar contributed to analysis, participated in the design of study instruments, interpretation of data, and drafting of the manuscript, critically agrees to be accountable for all aspects of work ensuring integrity and accuracy.

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Table 3.1. Socio-demographic and household characteristics of combined longitudinal and cross-sectional participants [1]

	Percent (95% CI)		Percent (95% CI)
Mam ethnicity	96.3 (93.3-98.2)	House floor material	
Languages spoken		Ceramic tiles	22.1 (17.3-27.6)
Mam	95.2 (91.9-97.4)	Cement	55.7 (49.6-61.7)
Spanish	57.9 (51.8-63.9)	Earth (dirt)	22.1 (17.3-27.6)
Marital status		House wall material	
Married	31.4 (25.9-37.3)	Cement Block	80.4 (73.2-83.3)
Consensual union	62.0 (55.9-67.8)	Wood	2.2 (0.8-4.8)
Single	5.9 (3.4-9.4)	*Adobe* (earthen bricks)	18.5 (14.0-23.6)
Widow	0.7 (0.1-2.6)	*Lamina* (corrugated sheet metal)	0.7 (0.1-2.6)
Works at home	94.1 (90.6-96.6)	Water source	
Maternal schooling		Household faucet	81.5 (76.4-86.0)
None	19.6 (15.0-24.8)	Public faucet	4.4 (2.3-7.6)
Primary	63.5 (57.4-69.2)	Well	6.3 (3.7-9.9)
Secondary or higher	17.0 (12.7-22.0)	River or other source [4]	6.6 (4.0-10.3)
Religion		Sanitation	
Protestant	77.9 (72.4-82.7)	Toilet	15.5 (11.4-20.4)
Roman Catholic	17.7 (13.4-22.8)	Pit latrine	83.8 (78.8-88.0)
None	4.4 (2.3-7.6)	Electricity	83.4 (78.4-87.6)
Land ownership	81.5 (76.4-86.0)	Household assets	
Food production [3]		Radio	62.7 (56.7-68.5)
Maize	99.1 (96.8-99.9)	Television	43.5 (37.6-49.7)
Potato	62.0 (55.2-68.4)	Mobile phone	41.7 (35.8-47.8)
Broad beans	54.3 (47.5-61.0)	Sewing machine	10.3 (7.0-14.6)
Black beans	49.3 (42.6-56.1)	Oven	10.0 (6.7-14.2)
Greens	4.1 (1.9-7.6)	Refrigerator	5.2 (2.9-8.5)
Fruits	2.3 (0.7-5.2)	Household vehicle	
		Bicycle	39.5 (33.6-45.6)
		Car or truck	21.4 (16.7-26.8)

[1] n = 271; all data were collected at the time of recruitment

[2] Food production calculated as percent of those owning land (n=221)

[3] Other not included: cistern (0.7%), rainwater (0.4%)

Table 3.2. Adult food insecurity and social factors, by sampling period [1,2,3]

	Pregnancy (n=155)	Early Postpartum (n=202)	Later Postpartum (n=187)
Food insecurity Score	2.5 ± 3.6 [a]	1.5 ± 2.6 [b]	2.2 ± 3.9 [a]
Null, %	26.0 (19.3-33.7) [a]	45.3 (38.3-52.4) [b]	39.2 (32.2-46.7) [b]
Low-mild, %	69.5 (61.6-76.6) [a]	53.7 (46.6-60.8) [a]	58.1 (50.6-65.2) [ab]
Moderate-severe, %	4.5 (1.9-9.1)	1.0 (0.1-3.6)	2.7 (0.1-6.2)
Maternal autonomy Score	3.6 ± 2.6	3.8 ± 2.7	3.9 ± 2.7
Null, %	23.2 (16.8-30.7)	22.4 (16.7-28.7)	25.0 (14.4-38.4)
Low, %	62.6 (54.5-70.2)	58.0 (51.3-65.3)	53.6 (39.7-67.0)
Moderate-high, %	14.2 (9.1-20.7)	19.5 (14.1-25.4)	21.4 (11.6-34.4)
Paternal support Score	8.4 ± 2.7	8.3 ± 2.9	8.4 ± 3.0
Null-low, %	12.9 (8.1-19.2)	14.0 (9.5-19.6)	14.9 (10.1-20.8)
Moderate, %	17.4 (11.8-24.3)	17.5 (12.5-23.5)	13.8 (9.2-19.6)
High, %	69.7 (61.8-76.8)	68.5 (61.6-74.9)	71.3 (64.2-77.6)
Social support Score	1.3 ± 0.5	1.2 ± 0.5	1.2 ± 0.5
Low, %	16.8 (11.3-23.6)	16.8 (12.0-22.7)	14.3 (9.6-20.1)
Moderate, %	70.3 (62.5-77.4) [a]	72.3 (65.6-78.3) [a]	79.4 (72.9-84.9) [b]
High, %	12.9 (8.1-19.2) [a]	10.9 (7.0-16.0) [ab]	6.3 (3.3-10.8) [b]
Number of supporting persons	2.7 ±1.4 (51.9)	2.6 ±1.4 (53.8)	2.8 ±1.5 (53.6)
Active group membership [4]			
Any membership, %	61.0 (52.5-68.4) [a]	48.3 (35.2-61.6) [ab]	36.4 (23.4-49.6) [b]
Religious group, %	47.4 (39.0-55.3) [a]	40.0 (27.6-53.5) [ab]	23.2 (13.0-36.4) [b]
Health group, %	26.6 (19.7-34.1)	28.3 (17.5-41.4)	27.3 (15.8-40.3)
Political group, %	12.3 (7.5-18.5)	13.3 (5.9-24.6)	8.9 (3.0-19.6)
Association/cooperative, %	10.4 (6.0-16.2)	8.3 (2.8-18.4)	5.4 (1.1-14.9)
Women's group, %	14.3 (9.1-20.7)	15.0 (7.1-26.6)	5.4 (1.1-14.9)
Social harmony perception [5]	86.3 (78.6-90.4) [ab]	90.0 (79.5-96.2) [a]	74.5 (59.7-84.2) [b]
Trust [5]			
Family, %	87.7 (80.8-91.9)	91.7 (81.6-97.2)	85.7 (73.8-93.6)
Neighborhood, %	65.6 (57.5-73.0)	71.7 (17.5-41.4)	57.1 (43.2-70.3)
Public institutions, %	58.4 (50.2-66.3)	60.0 (46.5-72.4)	69.6 (55.9-81.2)
Government bodies, %	5.2 (2.3-10.0)	6.7 (1.9-16.2)	8.9 (3.0-19.6)
NGOs, %	9.1 (5.1-14.8)	13.6 (5.9-24.6)	5.4 (1.1-14.9)
Media, %	5.8 (2.7-10.8)	6.7 (1.9-16.2)	7.1 (2.0-17.3)

[1] Food security, maternal autonomy, paternal support and social support data were collected at each sampling period (thrice for participants in the longitudinal cohort, and once for participants in each cross-sectional cohort). Continuous variables reported as mean ± SD; categorical variables reported as percent (95% binomial CI)

[2] Data for longitudinal and cross-sectional cohorts pooled for early PP and later PP sampling periods

[3] Within a row, values not sharing a common superscript are significantly different ($p < 0.05$) based on analysis only of the longitudinal cohort, n=129

[4] In the longitudinal cohort, group membership data were collected during pregnancy and early PP, but not later PP; therefore, pregnancy n=155, early PP n=202, later PP n=56

[5] In the longitudinal cohort, social harmony and trust data were only collected during pregnancy; therefore, pregnancy n=155, early PP n=60, later PP n=56

Table 3.3. Maternal obstetric experience of combined longitudinal and cross-sectional cohorts [1,2]

	Population Value
Maternal age, y	24.4 ±6.7
< 20 years, %	31.7 (26.2-37.6)
20-34 years, %	59.4 (53.3-65.3)
≥ 35 years, %	8.9 (5.8-12.9)
Parity, #	2.8 ± 2.2
1st born, %	40.5 (34.3-46.3)
2-4th born, %	41.3 (35.1-47.1)
5th or more, %	18.2 (13.7-23.2)
Birth-spacing, y [3]	2.4 ± 1.3
Average interval < 3 y, %	76.6 (69.2-82.9)
Prior loss of child < 5yrs [3]	25.6 (19.1-33.1)
Prior stillbirth, %	11.3 (6.8-17.2)
Prior loss of child <28 d, %	8.1 (4.4-13.5)
Antenatal care	
Comadrona, %	93.0 (89.3-95.7)
Formal sector private, %	12.2 (8.5-16.7)
Formal sector public, %	76.4 (70.9-81.3)
Comadrona + formal sector, %	73.4 (67.8-78.6)
Antenatal care frequency	7.5 ± 3.8
Never, %	0.8 (0.1-2.8)
1 to 3 times, %	14.3 (10.3-19.2)
4 or more, %	84.9 (80.0-89.1)
Pregnancy supplements	
Vitamins, %	57.6 (51.4-63.5)
Iron, %	83.0 (78.0-87.3)
Folic acid, %	84.5 (79.6-88.6)
Location of delivery	
Own home, %	44.8 (38.7-51.1)
Comadrona home, %	36.4 (30.6-42.6)
Hospital, %	18.8 (14.2-24.1)
Birth attendance	
Comadrona, %	78.9 (73.5-83.7)
Formal sector, %	19.2 (14.6-24.5)
No one, %	1.8 (13.7-23.2)

[1] n = 271; data for early and later cross-sectional cohorts collected at time of recruitment. For longitudinal cohort, data on parity, birth-spacing, and prior loss of a child < 5 y of age collected at time or recruitment; other data collected early PP

[2] Data reported as mean ± SD for continuous variables, and percent (95% binomial confidence interval) for categorical variables

[3] Data from non-primiparous women (n=160); of these women, birth-spacing data were missing for two women

Table 3.4. Maternal nutrition and infection data from combined longitudinal and cross-sectional cohorts, by sampling period [a,b,c]

	Pregnancy (n = 155)	Early Postpartum (n = 202)	Later Postpartum (n = 189)
Maternal height, cm	146.3 ± 5.3	146.5 ± 5.1	146.6 ± 5.4
Maternal weight, kg	53.8 ± 7.9 [A]	51.2 ± 8.1 [B]	50.6 ± 8.2 [B]
Maternal BMI	N/A	23.8 ± 3.3	23.5 ± 3.4
Underweight, %	N/A	3.5 (1.4-7.0)	3.2 (1.2-6.9)
Normal, %	N/A	65.3 (58.4-71.9) [A]	72.0 (64.6-78.0) [B]
Overweight, %	N/A	26.7 (20.8-33.4) [A]	20.4 (14.8-26.8) [B]
Obese, %	N/A	4.5 (2.1-8.3) [A]	4.3 (1.9-8.3) [B]
Dietary diversity [d]			
Dietary Diversity Score	3.4 ± 1.3 [A]	3.4 ± 1.2 [A]	2.8 ± 1.3 [B]
Meet adequate diversity (≥ 5)	22.6 (16.1-30.3) [A]	19.2 (13.9-25.4) [A]	9.9 (6.0-15.3) [B]
Previous-day diet			
All starchy staples, % [e]	100 (97.5-100.0)	100 (98.1-100.0)	100 (98.0-100.0)
Legumes, % [f]	57.5 (49.1-65.7)	56.0 (48.7-63.1)	53.6 (46.0-61.0)
Nuts/seeds, %	2.1 (0.4-5.9) [AB]	2.6 (0.9-5.9) [A]	6.6 (3.5-11.3) [B]
All dairy, % [g]	8.9 (4.8-14.8)	5.2 (2.5-9.3)	4.4 (1.9-8.5)
Flesh foods, % [h]	34.2 (26.6-42.6) [A]	40.9 (33.9-48.2) [A]	23.2 (17.3-30.0) [B]
Eggs, %	19.9 (13.7-27.3)	27.5 (21.3-34.3)	17.7 (12.4-24.0)
Vit A-rich dark green leafy veg., % [i]	33.6 (26.0-41.8) [A]	34.7 (28.0-41.9) [A]	24.3 (18.3-31.2) [B]
Other Vit A-rich veg. & fruits, % [j]	32.9 (25.3-41.1)	30.6 (24.2-37.6)	24.9 (18.8-31.8)
Other vegetables, %	34.9 (27.2-43.3) [A]	30.6 (24.2-37.6) [AB]	23.8 (17.8-30.6) [B]
Other fruits, %	13.7 (8.6-20.4) [A]	7.8 (4.4-12.5) [A]	5.5 (2.7-9.9) [AB]
Previous-day physical activities [k]			
Cooking, % (h/d)	98.6 (3.0 ±1.4)	16.1 (2.3 ±1.4)	98.3 (2.8 ± 1.3)
Housework, % (h/d)	76.2 (1.4 ± 0.8)	18.6 (1.5 ± 1.8)	74.3 (1.6 ± 1.3)
Weaving/sewing, % (h/d)	15.0 (2.9 ± 1.8)	1.0 (3.3 ± 1.8)	17.7 (2.5 ± 1.1)
Washing clothes, % (h/d)	49.7 (1.9 ± 1.2)	1.0 (1.0 ± 0.7)	56.6 (1.9 ± 1.0)
Tending to animals, % (h/d)	8.2 (0.8 ± 0.6)	1.5 (0.6 ± 0.4)	6.3 (1.5 ± 1.4)
Running errands, % (h/d)	17.0 (3.8 ± 2.0)	2.5 (3.3 ± 0.4)	22.9 (3.1 ± 1.7)
Agricultural work, % (h/d)	11.6 (3.4 ± 2.4)	0.0 (0.0)	10.3 (3.5 ± 2.9)
Work outside home, % (h/d)	4.1 (6.2 ± 3.4)	0.5 (8.5)	3.4 (7.3 ± 1.4)
Exercise (walking), % (h/d)	10.2 (1.4 ± 1.2)	27.1 (2.0 ± 2.0)	7.4 (1.6 ± 1.0)
Attending church, % (h/d)	6.8 (3.4 ± 2.1)	0.5 (2.0)	9.1 (3.4 ± 1.7)
Social visits to others, % (h/d)	8.8 (4.4 ± 2.2)	0.0 (0.0)	10.3 (4.1 ± 2.4)
Health visits, % (h/d)	7.5 (2.0 ± 1.1)	1.0 (5.0)	5.1 (3.0 ± 0.9)

Study, % (h/d)	0.7 (3.0)	0.5 (2.0)	2.3 (4.8 ± 4.1)
Watching television, % (h/d)	4.8 (1.6 ± 0.9)	2.0 (2.3 ± 1.5)	3.4 (1.1 ± 0.3)
Intentional rest, % (h/d)	51.0 (2.6 ± 2.0) [A]	100 (12.6 ± 2.6) [B]	34.9 (2.5 ± 1.8) [A]
Physical Activity Intensity Score	1022.1 ± 523.5 [A]	191.2 ± 417.0 [B]	1044.6 ± 579.7 [A]
Self-reported symptoms in previous wk			
Susto, %	49.7 (41.6-57.8) [A]	28.3 (22.2-35.0) [B]	40.3 (33.3-47.6) [A]
Nervios, %	4.5 (1.8-9.1)	0.5 (0.0-2.7)	5.2 (2.5-9.4)
Enojo, %	18.7 (12.9-25.8) [A]	9.8 (6.1-14.7) [B]	12.0 (7.8-17.5) [B]
Fever, %	7.7 (4.1-13.1)	4.9 (2.4-8.8)	4.7 (2.2-8.8)
Headache, %	34.8 (27.4-42.9) [A]	21.5 (16.1-27.8) [B]	15.2 (10.4-21.1) [B]
Cough, %	17.4 (11.8-24.3)	12.7 (8.5-18.0)	11.0 (6.9-16.3)
Vomiting, %	7.1 (7.1-3.6) [A]	2.9 (1.1-6.3) [B]	2.1 (0.6-5.3) [B]
Abdominal pain, %	23.2 (16.8-30.7) [A]	12.7 (8.5-18.0) [B]	16.2 (11.3-22.2) [AB]
Diarrhea, %	4.5 (1.8-9.1)	2.9 (1.1-6.3)	2.6 (0.9-6.0)
Dysuria, %	23.9 (17.4-31.4) [A]	9.3 (5.7-14.1) [B]	7.9 (4.5-12.6) [B]
Vaginal discharge, %	16.1 (10.7-22.9) [A]	6.8 (3.8-11.2) [B]	8.4 (4.9-13.3) [B]
Urine analyses [l]			
Pyuria, %	22.6 (16.3-30.0) [A]	39.8 (32.8-47.1) [B]	13.3 (5.9-24.6) [A]
Clinical infection, %	3.2 (1.1-7.4)	6.3 (3.3-10.7)	5.0 (1.0-13.9)
Stool analyses [m]			
Ascaris lumbricoides, %	2.7 (0.8-6.8)	2.2 (0.1-5.6)	1.2 (0.1-4.4)
Giardia spp., %	6.1 (2.8-11.3)	3.3 (1.2-7.1)	1.9 (0.4-5.4)
Entamoeba histolytica/dispar, %	0.7 (0.0-3.7)	1.1 (0.1-3.9)	0.0 (0.0-2.3)
Blastocystis hominis, %	21.4 (15.0-29.0)	21.6 (15.8-28.3)	19.3 (13.5-26.2)
Entamoeba coli, %	33.1 (25.5-41.4)	42.0 (34.7-49.5)	38.5 (31.0-46.5)
Endolimax nana, %	15.9 (10.3-22.8)	24.3 (18.3-31.2)	19.3 (13.5-26.2)
Iodamoeba butschlii, %	14.5 (9.2-21.3)	16.6 (11.5-22.8)	18.0 (12.4-24.8)
Any non-pathogenic protozoan, %	71.7 (63.7-78.9)	79.6 (72.9-85.2)	73.3 (65.8-80.0)

Abbreviations: BMI, body mass index; CI, confidence interval; h/d, hours/day; N/A, not available; PP, postpartum; SD, standard deviation.

[a] Data collected at each encounter with participants (thrice for participants in the longitudinal cohort, and once for participants in each cross-sectional cohort). Continuous variables reported as mean ± SD; categorical variables reported as percent (95% binomial CI)

[b] Data for longitudinal and cross-sectional cohorts pooled for early PP and later PP sampling periods

[c] Within a row, values not sharing a common uppercase superscript are significantly different ($p < 0.05$) based on analysis of the longitudinal cohort only (n=129)

[d] Pregnancy n=146, early PP n=193, later PP n=181

[e] Maize-based (75%), potato (11%), pasta (6%)

[f] Black beans (39%), broad beans (39%)

[g] Whole milk (44%), powdered milk (28%), fresh cheese (27%)

[h] Chicken (47%), beef (46%)

[i] *Epazote* = wormseed leaves, *Dysphania ambrosioides* (51%); hierba mora = black nightshade leaves, *Solanium nigrum* (26%); hierba nabo = turnip leaves, *Brassica sp.* (21%)

[j] Tomatoes (64%), carrots (18%), peppers (12%)

[k] Excluded 10 early PP women not within 40 days postpartum *cuarentena* period, n=192. Mean and SD for women involved in the activity.

[l] Pregnancy n=155, early PP n=191, later PP data only collected for cross-sectional women and symptomatic longitudinal women (n=60)

[m] Pregnancy n=147, early PP n= 181, later PP n=161

Table 3.5. Comparison of infant anthropometry, feeding practices and illness experience between early and later postpartum and between longitudinal and cross-sectional cohorts[1,2]

	Early postpartum		Later postpartum		
	Cross-sectional (n = 60)	Longitudinal (n = 142)	Cross-sectional (n = 56)	Longitudinal (n = 131)	p-value[3]
Infant age, d	20.5 ± 10.3	18.3 ± 9.6	145.5 ± 17.7	147.5 ± 16.1	<0.001
Female, %	40.0 (27.6-53.5)	47.2 (38.8-55.7)	53.6 (39.7-67.0)	N/A	-
Born premature (<37 wk) [4]	N/A	21.3 (12.9-31.8)	N/A	N/A	-
Reported birth weight, kg [5]	3.0 ± 0.4	3.2 ±0.5 (15.6)	3.0 ± 0.7	N/A	-
Low birth weight (<2.5 kg) [5]	9.3 (3.1-20.3)	8.6 (4.4-14.9)	21.6 (11.3-35.3)	N/A	-
Infant height, cm	49.0 ± 3.0	49.3 ±2.9	59.9 ± 2.9	60.9 ± 2.9	<0.001
Infant weight, kg	3.6 ± 0.8	3.5 ±0.6	6.2 ± 0.8	6.4 ±0.9	<0.001
HAZ (Z-score)	-1.92 ± 1.38	-1.60 ± 1.38	-2.08 ± 1.39	-1.77 ±1.24	0.029
Moderate stunting, %	23.3 (13.4-36.0)	18.3 (12.3-25.7)	30.4 (18.8-44.1)	27.5 (20.0-36.0)	NS
Severe stunting, %	16.7 (8.3-28.5)	15.5 (10.0-22.5)	21.4 (11.6-34.4)	11.5 (6.6-18.2)	NS
WAZ (Z-score)	-0.87 ± 1.21	-0.84 ± 1.18	-1.15 ± 1.11	-0.98 ± 1.15	NS
Moderate underweight, %	13.3 (5.9-24.6)	9.2 (5.0-15.2)	8.9 (3.0-19.6)	9.9 (5.4-10.7)	NS
Severe underweight, %	5.0 (1.0-13.9)	5.6 (2.5-10.8)	3.6 (0.4-12.3)	5.3 (2.2-10.7)	NS
WHZ (Z-score)	0.76 ± 1.34	0.56 ± 1.13	0.52 ± 1.07	0.45 ± 0.98	NS
Moderate wasting, %	3.3 (0.4-11.5)	2.1 (0.4-6.1)	0.0 (0.0-6.4)	0.0 (0.0-2.8)	NS
Severe wasting, %	0.0 (0.0-6.0)	0.0 (0.0-2.6)	0.0 (0.0-6.4)	0.0 (0.0-2.8)	NS
HCZ (Z-score)	-0.77 ± 1.32	-0.58 ± 1.53	-1.12 ± 1.58 [a]	-0.52 ± 1.46 [b]	NS
Macrocephaly, %	1.7 (0.4-8.9)	2.8 (0.8-7.0)	1.9 (0.1-9.9)	3.8 (1.2-8.6)	NS
Moderate microcephaly, %	16.7 (8.3-28.5)	9.8 (5.5-15.9)	14.8 (6.6-27.1) [a]	4.5 (1.7-9.6) [b]	NS
Severe microcephaly, %	5.0 (1.0-13.9)	7.7 (11.6-24.7)	9.3 (3.1-20.3)	6.8 (3.1-12.5)	NS
Breastfeeding practices [6]					
Initiation in first hr PP, %	52.5 (38.4-64.8)	52.2 (43.4-60.9)	66.1 (52.2-78.2)	N/A	NS
Exclusive, %	56.7 (43.2-69.4)	56.0 (47.1-64.0)	44.6 (31.3-58.5)	41.2 (32.7-50.2)	0.017
Predominant, %	41.7 (29.1-55.1)	36.9 (28.7-45.1)	28.6 (17.3-42.2) [a]	16.0 (10.2-23.5) [b]	<0.001
Mixed, %	1.7 (0.0-8.9)	7.1 (3.4-12.6)	26.8 (15.8-40.3) [a]	42.7 (34.2-51.7) [b]	<0.001
Symptoms in previous wk					
Susto, %	10.0 (3.8-20.5)	8.5 (4.4-14.3)	16.1 (7.6-28.3)	20.0 (14.0-28.6)	0.026
Mal de ojo, %	25.0 (14.7-37.9)	19.7 (13.5-27.2)	46.4 (33.0-60.3)	37.0 (29.8-47.1)	0.005
Empujo, %	46.7 (33.7-60.0)	40.8 (32.7-49.4)	25.0 (14.4-38.4)	17.0 (11.5-25.2)	<0.001
Mollera caída, %	10.0 (3.8-20.5)	7.7 (3.9-13.4)	19.6 (10.2-32.4)	14.1 (9.0-21.7)	NS
Fever, %	1.7 (0.0-8.9)	2.8 (0.7-7.1)	16.1 (7.6-28.3)	11.1 (6.6-18.2)	0.013
Cough, %	8.3 (2.8-18.4)	7.7 (3.9-13.4)	32.1 (20.3-46.0)	31.1 (24.2-40.8)	<0.001
Vomiting, %	6.7 (1.9-16.2)	5.6 (2.5-10.8)	1.8 (0.0-9.6)	3.0 (0.8-7.6)	NS

Flu-like illness, %	13.3 (5.9-24.6)	7.7 (3.9-13.4)	12.5 (5.2-24.1)	18.5 (12.8-26.9)	0.012
Diarrhea, %	3.3 (0.4-11.5)	4.2 (1.6-9.0)	7.1 (2.0-17.3)	10.4 (6.0-17.3)	0.035
Stomach discomfort, %	11.7 (4.8-22.6)	10.6 (6.0-16.8)	12.5 (5.2-24.1)	11.9 (7.1-19.1)	NS
Gas, %	6.7 (1.9-16.2)	12.7 (7.7-19.3)	8.9 (3.0-19.6)	3.0 (0.8-7.6)	0.007
Stool leukocytes >10/hpf, %[7]	N/A	N/A	35.4 (22.2-50.5)	37.3 (27.9-47.4)	-

N/A not applicable

[1] Continuous variables reported as mean ± SD; categorical variables reported as percent (95% binomial CI)

[2] Superscripts denote significant difference ($p < 0.05$) between longitudinal and cross-sectional cohorts, within a given sampling period.

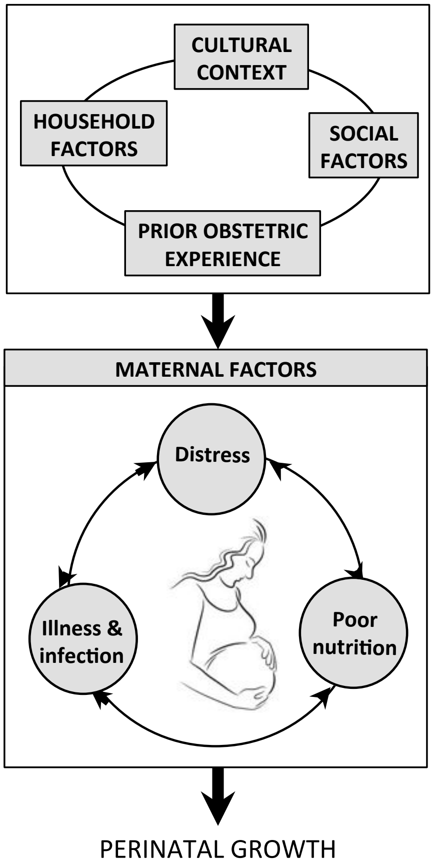
[3] P-value associated with comparison between sampling periods for the longitudinal cohort (n = 129) using Related Samples McNemar Test (categorical variables) and Related-Samples Wilcoxon Signed Rank Test (continuous variables)

[4] Data only for longitudinal infants whose mother recalled date of LMP (n=82)

[5] Data only available for infants whose mother recalled infant birth weight that had been measured by birth attendant (longitudinal n=122, cross-sectional early PP n=49, cross-sectional later PP n=40)

[6] Exclusive breastfeeding - breast milk and certain medications; predominant breastfeeding - breast milk plus certain liquids and medications; mixed feeding - breast milk plus any solid or semi-solid foods [52]

[7] Infant stool samples only collected at the later PP sampling period; longitudinal n=102, cross-sectional n=48



HOUSEHOLD FACTORS	
Socio-demographic factors	Ethnicity Language proficiency Marital status Schooling
Household characteristics	House materials Water, sanitation Ownership of durable assets Household wealth index (HWI)
Food insecurity	Adult food insecurity
SOCIAL FACTORS	
Structural social capital	Household autonomy Social support, general Social support, Infant's father
Cognitive social capital	Trust, perceived harmony
Difficult life experiences	Domestic violence Problems with partner, family Alcohol problem in household
MATERNAL FACTORS	
Prior obstetric experience	Age Prior family planning, age of 1st pregnancy Prior loss of a child Delivery care (formal/informal)
Nutrition	Maternal stunting BMI Dietary diversity Physical activity
Infection	Periodontal Respiratory Gastrointestinal Urinary
Distress	Experience of local idioms of distress (*susto, enojo, nervios*)[1]

Figure 3.1. Conceptual socio-ecological framework that distinguishes three broad categories of stressors affecting the mother (nutrition, infection, psychosocial distress) that may cumulatively impact the health of the maternal-infant dyad. *Susto*, *enojo* and *nervios* are local idioms of distress. *Susto* is believed to result from a frightening or startling experience, which manifests as an array of symptoms and pathologies. *Enojo* is a form of anger that leads to headaches, stomach pains, weakness or fatigue and chronic illness. *Nervios* is an illness due to experiencing strong emotions, particularly grief and sorrow.

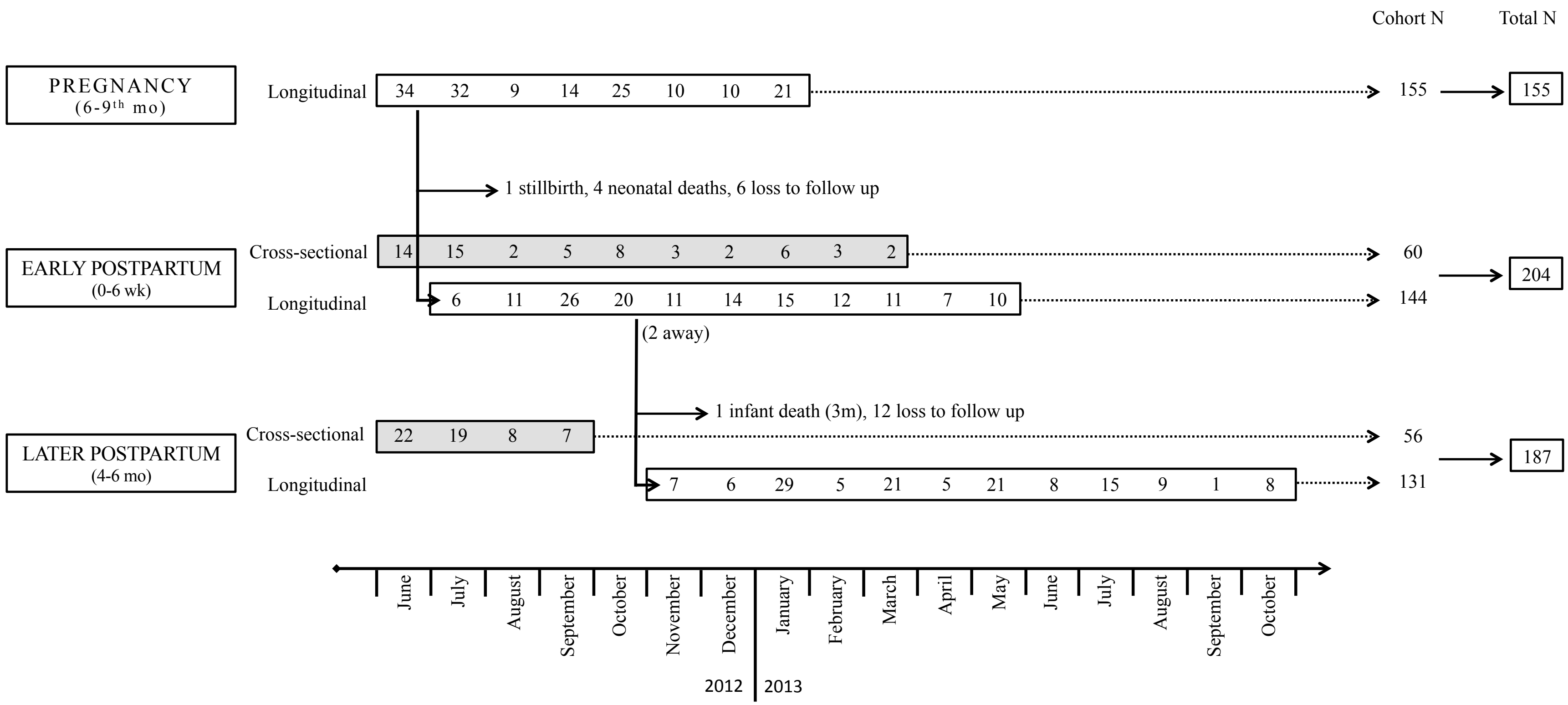


Figure 3.2. Temporal pattern of participant recruitment into the longitudinal (white) and cross-sectional (grey) cohorts, loss to follow-up, chronology of pregnancy, early and later postpartum visits, and cohort and total sample sizes.

Connecting Statement 1

In Chapter 3, I described quantitative methodologies used in my doctoral research, and assessed the construct validity of food security, maternal autonomy, paternal support, social support and trust questionnaires, which guided the building of score and categorical variables. I also presented baseline descriptive data for all study variables, including socio-demographic, obstetric, nutritional, infection and psychosocial. The diversity of quantitative data and the considerable variability detected in such areas as household wealth, maternal autonomy, social support, diet diversity and infant feeding practices provides a rich database that will allow for a transdisciplinary exploration of factors that promote resilience or increase vulnerability of the mother-infant dyad. Infant anthropometric measures confirmed high rate of stunting at both early (36%) and later (43%) postpartum visits. This affirms the appropriateness of the selected study population for exploration of determinants of infant stunting. Finally, based on comparisons between longitudinal and cross-sectional cohorts, participant engagement with the research team did not influence study outcomes, validating our use of the longitudinal cohort for future analyses. In Chapter 4, I assess the association between psychosocial and other variables so as to describe women's psychosocial environment. After characterizing the maternal diurnal salivary cortisol rhythm during pregnancy, early and later postpartum, I then determine which elements of the psychosocial environment are associated with a more "stressed" salivary cortisol rhythm, as defined by lower waking or high evening concentration, and/or a flatter diurnal slope. The research in Chapter 4 allowed me to examine what elements in women's lived environment may be associated with vulnerability, or stress, vs. resilience.

CHAPTER 4

DIURNAL SALIVARY CORTISOL IS INFLUENCED BY MATERNAL AND PSYCHOSOCIAL FACTORS IN PREGNANT AND POSTPARTUM *MAM*-MAYAN MOTHERS IN THE WESTERN HIGHLANDS OF GUATEMALA

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Abstract

Salivary cortisol has been associated with psychosocial stressors and maternal wellbeing, but rarely in rural, marginalized, developing country populations. Our objectives were: (1) to characterize the maternal diurnal salivary cortisol rhythm and psychosocial environment during pregnancy, early and later postpartum (PP) in *Mam*-Mayan populations in the Western Highlands of Guatemala and (2) to determine which elements of the psychosocial environment were associated with a more "stressed" salivary cortisol rhythm (lower waking or higher evening concentration and/or flatter diurnal slope). During pregnancy (n=135), early PP (1-6 wk; n=155) and later PP (4-6 mo; n=151), waking and evening saliva samples were collected. Questionnaires explored maternal autonomy, paternal support, social support, trust, difficult life events, and local idioms of distress, as well as household wealth, food insecurity, maternal age, height and marital status. At all perinatal periods, low/moderate social support (OR = 3.6 to 6.8) and low/moderate paternal support (OR = 3.5 to 6.5) increased the likelihood of high maternal autonomy. Domestic violence (OR = 6.1) and problems with the partner (OR = 27.3) increased the likelihood of being frequently overwhelmed. Domestic violence also increased the likelihood of both *enojo* and *susto,* two local idioms of emotional distress (OR = 2.3 to 5.4). Waking and evening salivary cortisol concentrations were 13.1 ± 5.2 and 5.0 ± 3.0 nmol/l in pregnancy and 6.1 ± 3.1 and 2.2 ± 2.3 nmol/l PP. Our study identified two profiles of mothers whose cortisol rhythm indicated chronic stress. The first included single mothers who had high autonomy in household decision-making but low social and paternal support. The second included mothers who had high paternal support but low autonomy and/or experienced domestic violence. In addition, shorter maternal stature, lower asset-based household wealth, and food insecurity were associated with a more "stressed" cortisol rhythm. These findings suggest that mothers facing the combination of low support, high autonomy, violence and poverty or the combination of high paternal involvement and low decision-making power may be particularly vulnerable to chronic stress as evidenced by a "stressed" cortisol rhythm.

Introduction

Maternal psychosocial stress is a known contributor to adverse pregnancy outcomes (Dunkel-Schetter, 2011). Difficult life events (death of a family member, natural disaster), chronic stressors (strain, poverty, neighborhood crime), anxiety and self-perceived stress all appear to contribute to preterm birth (Dunkel-Schetter, 2009). Similarly, maternal depressive symptoms and distress during pregnancy (Surkan et al., 2011), experience of intimate-partner violence (Valladares et al., 2009) and other chronic stressors (perceived racism, discrimination) have been associated with small-for-gestational-age babies, especially in low-income, low-social-status women. Evidence suggests that women may be better able to counter such stressful situations if they have high self-esteem and self-efficacy (Nierop et al., 2008), effective social support (Campos et al., 2008; Rini et al., 2006), and emotional stability, physical health and an ability to problem-solve (Dunkel-Schetter, 2011). The balance between exposure to factors that are stressful and those that promote resilience is mediated through the hypothalamic-pituitary-adrenocortical (HPA) axis and release of cortisol (Adam & Kumari, 2009). The diurnal pattern of a high salivary cortisol concentration upon waking that declines throughout the day to a nadir around midnight (Adam & Kumari, 2009) is an important indicator of a healthy HPA axis response.

Waking and evening concentrations and the waking to evening slope can provide valuable information on individuals' exposure to stress (Adam & Kumari, 2009). A flatter slope, resulting from lower waking and/or higher evening cortisol concentrations, has been associated with exposure to chronic stressors (Dowd et al., 2009), including in pregnancy when lower waking concentrations of salivary cortisol have been associated with stressful life events (Suglia et al., 2010), depression, anxiety and minority status (O'Connor et al., 2014; Pluess et al., 2010), and higher evening concentrations and/or a flatter slope with discrimination, lower socioeconomic status (Thayer & Kuzawa, 2015), stressful life events (Obel et al., 2005), gender violence (Valladares et al., 2009) and anxiety and depression (O'Keane et al., 2011; Kivlighan et al., 2008). Postpartum, the relationship between psychosocial stress and maternal salivary cortisol is less clear, possibly because it has been the focus of less research (Gonzalez et al., 2009; Taylor et al., 2009), and also because the complex ways in which the HPA axis response to stress is influenced by infant feeding choice (Tu et al., 2006), breastfeeding (Heinrichs et al., 2002), sleep deprivation (Minkel et al., 2015), and adrenal suppression up to 12 weeks postpartum (Mastorakos & Ilias, 2003).

Few studies investigating the effect of psychosocial stress on the maternal cortisol rhythm have occurred in marginalized populations (O'Connor et al., 2014; Suglia et al., 2010), let alone in developing countries (Valladares et al. 2009) or in rural or indigenous contexts, which are consistently characterized by greater disadvantage and worse health statistics (Montenegro & Stephens, 2006). In resource-poor contexts, and perhaps especially in indigenous populations, narratives and terminology relating to emotional distress, to what constitutes a stressful situation, and to available coping strategies, may differ significantly from those characteristic of developed countries (Hatala et al., 2015), hindering the study of psychosocial stress *versus* wellbeing in such populations. Concerned with exploring the indigenous, resource-poor setting, this research was conducted in rural, *Mam*-Mayan communities in the Western Highlands of Guatemala characterized by extreme poverty, food insecurity, high familial social support, low maternal autonomy and frequent perinatal domestic violence, and high rates of early infant stunting (Chomat et al., 2015).

Our objectives were (1) to characterize mothers' psychosocial environment by exploring the interrelationships among household factors (wealth index and food insecurity), maternal factors (age, height and BMI, language, education, marital status, parity, gestational age), social factors (maternal autonomy, paternal support, social support, trust, difficult life events) and emotional distress recorded using local idioms (*susto, enojo, nervios,* frequently overwhelmed); (2) to describe the maternal diurnal salivary cortisol rhythm in pregnancy and both early (1-6 wk) and later (4-6 mo) postpartum (PP); and (3) to explore psychosocial determinants of a chronically "stressed" maternal salivary cortisol rhythm, defined as lower waking and/or higher evening cortisol concentrations and/or a flatter diurnal slope.

Methods

Study setting

The study was conducted in eight small rural *Mam*-Mayan communities in the municipality of San Juan Ostuncalco, in Guatemala's Western Highland department of

Quetzaltenango, where we conducted a mixed-methods, Participatory Action Research study that investigated potential chronic maternal stressors *versus* resilience factors. We did our best to ensure that our research was culturally sensitive, relevant and reciprocal, and that knowledge generated could be translated into action and needed social change that could benefit the population. This approach helped ensure cultural safety and allowed participants to reveal sensitive information such as domestic violence only to those individuals, and in a location, that inspired their confidence. A detailed description of the study setting, design and methods has been presented previously (Chomat et al., 2015).

Study design, ethics and recruitment

This was a cross-sectional study of pregnancy, early and later PP, drawn from longitudinal and cross-sectional cohorts (Chomat et al., 2015). Inclusion criteria were being a woman within the study area who (1) was 6 to 9 mo pregnant as determined by suprapubic height measurement (Collins et al., 2013), or (2) had an infant aged 0-6 wk (early PP) or (3) had an infant aged 4-6 mo (later PP). Exclusion criteria for the present analyses were: (1) mothers of infants < 7 d PP (N = 23) due to the decline in cortisol concentrations in the days following delivery (Mastorakos & Ilias, 2003); (2) mothers who did not provide both waking and evening cortisol samples (N = 16 in pregnancy, 21 early PP, 24 later PP); and (3) mothers whose cortisol concentrations were > or < than 3 SD of the population mean (N = 4 in pregnancy, 3 early PP, 12 later PP). This resulted in sample sizes of 135 in pregnancy (estimated gestational age 7.1 ± 1.2 mo), 155 early PP (20.8 ± 8.6 d PP) and 151 later PP (146.7 ± 16.8 d PP). Of these, 82 participated at all three perinatal stages.

Ethical approval was obtained from the McGill University Faculty of Medicine Institutional Review Board and the Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM) in Guatemala. Permission was also obtained from the local Ministry of Health and community leaders. Fully informed consent was obtained from each participant at the time of enrollment (signature or thumbprint). All participants were recruited by community health workers (CHW) and traditional midwives (*comadronas)*. The data collection team consisted of a physician, two nutritionists, and 20 trained bilingual (*Mam*/Spanish) interviewers, who were either CHWs or *comadronas* from the study communities. Data were collected in the community health-post and in home visits.

Maternal characteristics

Age, spoken languages, schooling, marital status, parity and estimated gestational age were recorded (Chomat et al., 2015). Maternal height, measured to the nearest 0.5cm, was classified as stunted if < 145 cm (Black et al., 2013). Body Mass Index (BMI) was calculated as weight divided by height squared (kg/m^2). Antenatal care (ANC) frequency throughout pregnancy and clinical symptoms experienced by the mother within the last week were also queried. In addition, maternal samples of urine and stool were collected to test for urinary and gastrointestinal infections, respectively (Chomat et al., 2015).

Household characteristics

A *Household Wealth Index* was created (Chomat et al., 2015) as a proxy for household socioeconomic status (Rutstein & Johnson, 2004) using principal components analysis of durable household assets, and categorized into the lowest 40%, middle 40% and highest 20%.

Adult food insecurity was explored using nine of the 14 items from the Panama Food Security Questionnaire (MINSA, 2003). Dichotomous variables based on presence (1) or absence (0) of food insecurity were determined for each item and summed into a cumulative *Food Insecurity Score* (0-9) (Chomat et al., 2015). A categorical variable differentiated no (score = 0) from any (score ≥ 1) adult food insecurity.

Social factors

A 5-item *Maternal Autonomy Questionnaire* inquired about mother's involvement in decision-making relating to food and medicine purchases, health visits for herself or her infant, and household finances (Chomat et al., 2015). For each item, two points were assigned if the mother made the decision on her own and one point was assigned if the decision-making was shared. The cumulative *Maternal Autonomy Score* (0-10) was used both as a continuous and categorical (0-5 low; 6-10 moderate/high autonomy) variable. Households where either the partner or the participant was the sole decision-maker were noted.

A 5-item *Paternal Support Questionnaire* inquired about financial, emotional and childcare support received from the baby's father (Chomat et al., 2015). Each item rated support on a three-point Likert scale (0 never, 1 sometimes, 2 always). The resulting cumulative *Paternal Support Score* (0-10) was used both as a continuous and categorical (0-8 low/moderate paternal support; 9-10 high paternal support) variable.

An 8-item *Social Support Questionnaire* inquired about who could be counted on to provide support, including emotional, informational (i.e. making difficult decisions), childcare, and material (i.e. providing safety, basic needs, health care access) (Chomat et al., 2015). For each of the eight items, a dichotomous variable was created that differentiated mothers who received any support (1) from those who received no support (0). The cumulative *Social Support Score* (0-8) was categorized into low/moderate (< 7) or full (7-8) social support.

Trust was evaluated as a participant's level of trust (0 never/sometimes; 1 always) in family, neighbors and 11 social institutions (church, health center, hospital, police, school, government, mayor, non-governmental organizations, women's group, TV, newspapers) (Chomat et al., 2015). Note was made of mothers who trusted no one.

Difficult life events were explored through a questionnaire that inquired about experience of difficulty with partner, domestic violence and household alcohol abuse during pregnancy or postpartum (Chomat et al., 2015). A physician also queried exposure to these events during the medical evaluation at each visit. Dichotomous variables were created reflecting exposure (1) or no exposure (0) to each of the three types of experience.

Emotional distress

Local idioms of distress (*susto*, *enojo*, *nervios*) and frequency of feeling overwhelmed were explored. *Susto* results from a frightening or startling experience that is thought to affect the body's equilibrium and manifests as a diverse array of symptoms and pathologies (Pies de Occidente, 2006). *Enojo* is a form of anger that leads to headaches, weakness, fatigue and chronic illness. *Nervios* (being nervous or having nerves) is most often characterized by symptoms of anxiety, tension and fear. Current experience of *susto* and *enojo* (0 no; 1 yes) and frequency (0 never/sometimes; 1 almost always/always) of experiencing *nervios* and of feeling overwhelmed were queried (Chomat et al., 2015). A cumulative *Emotional Distress Score* was calculated as the sum of the four scores (0-4).

Salivary cortisol

Salivary cortisol assessment is generally the method of choice relative to serum cortisol because it only measures unbound cortisol, it is more stable, and non-invasive (Adam & Kumari, 2009). Mothers were asked to collect saliva by spitting directly into a 2 ml crytotube both immediately upon waking and prior to going to bed (Adam & Kumari, 2009). Saliva samples were kept at room temperature for up to 72 hours before being stored at -20°C. Salivary cortisol concentrations were measured in duplicate using an enzyme immunoassay kit (Salimetrics, State College, PA, USA) at the Douglas Institute Stress Hormone Research Laboratory at the Douglas Hospital Research Center, Montreal, Canada. Briefly, duplicate samples of 25 µl of saliva were incubated with assay buffer and conjugated in an antibody-coated well. Assay plates were washed several times and then incubated with the color-developing reagent. Three minutes after stopping the reaction, the optical density of each well was determined and the difference in optical densities at 450nm and 492nm was used to calculate salivary cortisol concentration (Biosoft Inc.). The detection range was 0.012-3.0 µg/dl. Intra- and inter-assay coefficients of variation were 2.1% and 7.5%, respectively. Cortisol concentrations were later converted from µg/dl to nmol/l by multiplying values by 27.59. Among our participants, those at the lower end of the range of waking salivary cortisol concentrations, those at the higher end of the range of evening salivary cortisol concentrations, or those at the lower end of the range of slopes were characterized as having a more chronically "stressed" cortisol rhythm.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics Program version 22.0 (SPSS Inc./IBM Chicago, IL, USA). Significance was set at $P < 0.05$ unless otherwise noted. Spearman's correlation was used to test for associations between continuous variables; to correct for multiple comparisons, correlations were considered as significant either if $P < 0.005$, or if findings were consistent ($P < 0.05$) across at least two of the perinatal stages. Multiple logistic regression analyses were used to identify individual factors that were associated with food insecurity, low social support, low paternal support, high autonomy, no trust and components of emotional distress. The Nagelkerke R^2, Hosmer and Lemeshow goodness of fit *P*-value, and overall model *P*-value were calculated; models with both a goodness of fit *P*-value > 0.05 and an overall model $P < 0.05$ are presented. For each variable, the odds ratio (OR), 95% confidence interval (CI) and *P*-value are reported. In addition Student's t-tests and ANOVA were used to test for differences in salivary cortisol variables by time of day and perinatal stage. Analyses (independent sample t-test, ANOVA) were run both to compare cortisol variables (waking, evening, slope) within groupings of categorical variables and to contrast mothers in the lowest 20% and highest 20% of each cortisol variable. Variables associated with cortisol at $P < 0.15$ were included in multivariate analyses. Multiple linear regression analyses were performed on each of three cortisol variables, by perinatal stage, controlling for maternal age, frequency of ANC visits (used as a proxy for morbidity) and estimated gestational age. Unstandardized coefficient (B) ± standard error (SE) is reported for each variable and the adjusted R^2 and model *P*-value are also reported. In each model, collinearity among variables was tested to confirm that the variance inflation factor (VIF) was < 2.5. Because the distribution of cortisol variables was positively skewed, transformation (logarithmic and inverse) was performed, and analyses were run with both transformed and untransformed data; as analyses using both transformed and untransformed data revealed similar results, only models using untransformed values are presented.

Results

Population and household characteristics

Briefly, mothers were 24.3 ± 6.8 yrs old (14 to 43), 18% had no schooling, 32% were married and 61% in a consensual union, 42% were primiparous and 18% grand-multiparous. Mothers had attended a mean of 7.4 ± 3.8 ANC visits. A minority (41%) spoke only *Mam* and 54% spoke both *Mam* and Spanish. Mothers in the lowest 40% of the *Household Wealth Index* typically lived in *adobe* houses with dirt floors whereas those with the highest 20% *Household Wealth Index* typically lived in blockhouses with cement/ceramic floors and were more likely to own a radio, television, stove, refrigerator and/or a motorized vehicle. One third (32%) of the mothers were stunted; postpartum, 4% were underweight and 28% were obese or overweight.

Two-thirds were from food insecure households. One-fourth (22%) reported no autonomy and 60% low maternal autonomy, 71% high paternal support and 83% high social support. Mothers generally reported high trust in family and community-based institutions, but less than half trusted their neighbors or the public hospital, and < 5% trusted government services. Experience of emotional distress expressed using local idioms of distress was frequent, with 42% of mothers reporting *susto*, 15% *nervios* and 13% *enojo*, and 7% feeling overwhelmed. Intestinal parasites, urinary tract infections and reported diarrhea were uncommon (< 5% of mothers) and symptoms of cough, fever, headache, abdominal pain, and vaginal discharge were also reported (10-30% of mothers). Characteristics of this subset of mothers did not differ from those of the larger study population (Chomat et al., 2015).

Characterization of social factors

Maternal autonomy: In pregnancy and postpartum, 12% of mothers reported that her partner was the sole decision-maker. Two-thirds of mothers participated in decisions related to purchasing food or medicine, seeking health care for themselves or their babies, or managing household finances (Table S4.1). Among the few decisions that mothers made on their own, sole maternal decision-making was most frequently related to food purchases (19%) compared with < 10% in the other categories. Only 3% of mothers made all decisions on their own.

Paternal support: Across all perinatal periods, four-fifths of the mothers thought their partner could always be counted on to provide financial or emotional support (Table S4.1) and three-fourths of mothers thought that he showed an interest in caring for the baby, and talked and spent time with her.

Social support: Most mothers (87%) identified their partner as a source of support, 65% identified their mother, 36% their mother-in-law, 21% their father, and 10% a daughter (Table S4.2). Three-fourths of mothers reported that their partners provided support in making difficult decisions, in providing for their basic needs, and in ensuring that medical care was received when needed. Less than 50% reported that their partner's help at home allowed her time to rest and take care of her newborn. Mothers of the participants most frequently provided support by giving advice about pregnancy and newborn care and listening when she needed to talk. Mothers received least support with respect to ensuring safety for herself and her family and to finding time to rest and take care of their baby, with 11% and 16%, respectively, receiving no such support.

Difficult life events: Reports of domestic violence, alcohol problems within the household, and problems with her partner were reported by 21%, 17% and 28% of participants, respectively (Table S4.1).

Correlations among maternal and household characteristics and psychosocial factors

The adult *Food Insecurity Score* was inversely correlated with HWI in pregnancy, early and later PP (r = -0.24, P = 0.004; r = -0.24, P = 0.004; and r = -0.28, P < 0.001, respectively) and with the *Social Support Score* during pregnancy (r = -0.24, P = 0.006) and early PP (r = -0.18, P = 0.028) and the *Food Insecurity Score* was positively correlated with cumulative *Emotional Distress Score* in pregnancy (r = 0.40, P < 0.001). The *Social Support Score* was positively correlated with the *Paternal Support Score* at all three perinatal stages (r = 0.29, P = 0.001; r = 0.17, P = 0.032; and r = 0.22, P = 0.006, respectively). The *Social Support Score* was negatively correlated with the *Maternal Autonomy Score* in pregnancy (r = -0.32, P < 0.001) and early PP (r = -0.36, P < 0.001). The *Paternal Support Score* was also negatively correlated with the *Maternal Autonomy Score* in pregnancy (r = -0.22, P = 0.010) and early PP (r = -0.26, P = 0.001). Finally, the *Maternal Autonomy Score* was positively correlated with maternal age in pregnancy (r = 0.24, P = 0.006) and later PP (r = 0.22, P = 0.008).

Multiple logistic regression models of household characteristics and psychosocial variables

Adult food insecurity: In pregnancy, mothers with low/moderate paternal support had an increased likelihood of food insecurity (P = 0.038) and those who did not speak Spanish had a reduced likelihood of food insecurity (P = 0.002) (Table 4.1). Early PP, mothers in the lowest 40% of the *Household Wealth Index* (P = 0.041) and those with moderate/high autonomy (P = 0.005) had an increased likelihood of food insecurity. Later PP, mothers in the lowest 40% of the *Household Wealth Index* (P = 0.021) and stunted mothers (P = 0.008) had an increased likelihood of food insecurity.

Low/moderate paternal support: In pregnancy, single mothers (P = 0.026), mothers who had low/moderate social support (P = 0.023) and those with moderate/high autonomy (P =

0.043) had an increased likelihood of low/moderate paternal support (Table 4.1). Early PP, single mothers (*P* = 0.003) and mothers who had moderate/high autonomy (*P* = 0.007) had an increased likelihood of low/moderate paternal support. Later PP, mothers who had moderate/high autonomy (*P* = 0.009) and non-Spanish speakers (*P* = 0.010) had an increased likelihood of low/moderate paternal support.

Low/moderate social support: In pregnancy, mothers with low/moderate paternal support (*P* = 0.002) had an increased likelihood of low/moderate social support (Table 4.1). Early PP, mothers with moderate/high autonomy (*P* = 0.024) and mothers with no trust (0.015) had an increased likelihood of low/moderate social support. Later PP, mothers who trusted no one had an increased likelihood of low/moderate social support (*P* = 0.033).

No trust: Later PP, mothers who had moderate/high maternal autonomy had an increased likelihood of reporting no trust (*P* = 0.026) (Table 4.1).

Moderate/high autonomy: During pregnancy, increasing age (*P* = 0.002), single mothers (*P* = 0.023) and mothers with low/moderate paternal support (*P* = 0.007) had an increased likelihood of moderate/high autonomy and mothers who did not speak Spanish (*P* = 0.004) had a reduced likelihood of moderate/high autonomy (Table 4.1). Both early and later PP, mothers with low/moderate social support (*P* = 0.001 and 0.035, respectively) and low/moderate paternal support (*P* = 0.002 and 0.015, respectively) had an increased likelihood of having moderate/high autonomy and those who did not speak Spanish had a reduced likelihood of moderate/high autonomy (*P* = 0.004 and 0.006, respectively). Additionally, later PP, increasing age (*P* = 0.038) and mothers with no trust (*P* = 0.024) had an increased likelihood of having moderate/high autonomy.

Susto: Early PP, increasing age (*P* = 0.003), low/moderate paternal support (*P* = 0.008), and domestic violence (*P* = 0.023) increased the likelihood of *susto*, and adult food insecurity (*P* = 0.016) reduced the likelihood of experiencing *susto.* Later PP, stunted mothers (*P* = 0.046) had an increased likelihood of *susto* and mothers who spoke *Mam* had a reduced likelihood of *susto* (*P* = 0.040).

Enojo: Later PP, mothers who reported domestic violence had an increased likelihood of *enojo* ($P = 0.002$) and those who spoke *Mam* had a reduced likelihood of *enojo* ($P = 0.024$) (Table 4.1).

Frequently nervios: During pregnancy, single mothers ($P = 0.014$) and mothers with no trust ($P = 0.029$) had an increased likelihood of experiencing frequent *nervios* (Table 4.1). Later PP, mothers who spoke *Mam* had a reduced likelihood of experiencing *nervios* ($P = 0.049$).

Frequently overwhelmed: Later PP, mothers who had problems with their partner had an increased likelihood of being frequently overwhelmed ($P = 0.022$).

Characterization of the cortisol rhythm

Waking and evening cortisol concentrations were higher during pregnancy (13.1 ± 5.2 nmol/l, median 13.2; 5.0 ± 3.0 nmol/l, median 4.4, respectively) than postpartum (6.1 ± 3.1 nmol/l, median 5.8; 2.2 ± 2.3 nmol/l, median 1.4, respectively) ($P < 0.001$), but did not differ between early (6.2 ± 3.4 nmol/l; 2.4 ± 2.6 nmol/l) and later PP (6.0 ± 2.8 nmol/l; 2.0 ± 2.0 nmol/l) (Fig. 4.1). In pregnancy, estimated gestational age was positively correlated with evening cortisol ($r = 0.26$, $P = 0.002$) and negatively with the diurnal cortisol slope ($r = -0.23$, $P = 0.007$).

Among comparisons between the highest and lowest quintiles of cortisol variables, several significant differences emerged. In pregnancy, mothers in the highest ("stressed") *versus* lowest quintile for evening cortisol (9.7 ± 2.2 vs. 1.9 ± 0.8 nmol/l, respectively) had a lower *Household Wealth Index* (-0.37 ± 1.21 *vs* 0.20 ± 0.85, respectively, $P = 0.040$), a higher *Food Insecurity Score* (2.80 ± 2.95 *vs* 0.95 ± 1.18, $P = 0.015$), and a lower *Social Support Score* (6.93 ± 1.47 *vs* 7.58 ± 0.76, $P = 0.038$). Early PP, mothers in the lowest ("stressed") *versus* highest quintile for diurnal slope (0.6 ± 0.3 *vs.* 8.8 ± 1.7 nmol/l, respectively) had a higher *Maternal Autonomy Score* (4.07 ± 2.89 *vs* 2.47 ± 2.57, $P = 0.027$). Later PP, mothers in the highest ("stressed") *versus* lowest quintile for evening cortisol (5.4 ± 1.2 vs. 0.1 ± 0.1 nmol/l, respectively) had a lower *Household Wealth Index* (-0.37 ± 1.27 and 0.28 ± 0.91, $P = 0.027$) and a higher *Food Insecurity Score* (2.22 ± 2.62 and 0.67 ± 1.30, $P = 0.008$).

Multiple linear regression models of cortisol variables

In pregnancy, lower waking cortisol was associated with shorter maternal stature (P = 0.002) and not speaking Spanish (P = 0.010) (model R^2 = 0.136) (Table 4.2). Higher evening cortisol was associated with greater estimated gestational age (P = 0.015), speaking Spanish (P = 0.039), low/moderate social support (P = 0.014), and a lower *Household Wealth Index* (P = 0.031) (R^2 = 0.144). A flatter slope was associated with shorter maternal stature (P < 0.001), longer estimated gestational age (P = 0.001) and a higher *Paternal Support Score* (P = 0.033) (R^2 = 0.171).

Early PP, lower waking cortisol was associated with more frequent ANC visits (P = 0.003), not speaking Spanish (P = 0.001), being in a relationship (P < 0.001) and having a higher *Maternal Autonomy Score* (P = 0.032) (R^2 = 0.177) (Table 4.2). Higher evening cortisol was associated with speaking Spanish (P = 0.028), being single (P = 0.001) and experiencing domestic violence (P = 0.038) (R^2 = 0.088). A flatter slope was associated with taller maternal stature (P = 0.033), more frequent ANC visits (P = 0.003) and having a higher *Maternal Autonomy Score* (P = 0.001) (R^2 = 0.147).

Later PP, higher evening cortisol was associated with younger maternal age (P = 0.028) and shorter maternal stature (P = 0.025) (R^2 = 0.082) (Table 4.2). A flatter slope was associated with younger maternal age (P = 0.049), not speaking Spanish (P = 0.041), not being in a relationship (P = 0.003) and having a higher *Paternal Support Score* (P = 0.030) (R^2 = 0.097).

Discussion

The Mayan population in Guatemala has a long history of economic and social subjugation extending into the 1990's through political violence that scarred many communities including those within our study area (RHEMI, 1999) and into the present day through disruption of local economies and socio-cultural structures and persistent poverty, marginalization and poor access to health services (MSPAS, 2010, Watanabe, 2010). The confluence of these factors has resulted in Mayan populations having poorer health indicators than their non-indigenous counterparts (MSPAS, 2010). By using a Participatory Action Research approach (CIHR, 2007), we sought to develop an environment of mutual trust and collaboration with study communities and to focus on issues already of concern to the local population. Our research team included individuals from the communities and representatives of both the formal and traditional health systems, which helped ensure cultural safety and uncover both expected and unexpected dimensions of the mother's psychosocial environment that contributed to a chronically "stressed" cortisol rhythm across perinatal periods.

Several key findings emerged from this study. In addition to maternal and household characteristics, a "stressed" cortisol rhythm was associated with low/moderate social support and higher paternal support during pregnancy, with a higher *Maternal Autonomy Score* and with experiencing domestic violence early PP, and with a higher *Paternal Support Score* later PP. Low/moderate social support and low/moderate paternal support increased the likelihood of high maternal autonomy, and reports of *susto* and feeling overwhelmed were more common in mothers who reported domestic problems. These findings suggest that, within an overriding context of food insecurity and extreme poverty, and throughout the perinatal period, heightened vulnerability was associated with low/moderate social support, high paternal support, high autonomy and domestic violence. On the other hand, resilience was associated with relatively higher wealth, taller stature, speaking Spanish and low/moderate autonomy reflective of shared decision-making.

Compared with the literature, both waking and evening cortisol concentrations were in the lower range of population means reported previously both in pregnancy (deWeerth & Buitelaar, 2005; Kivlighan et al., 2008; Obel et al., 2005; O'Connor et al., 2014; Valladares et al., 2009) and postpartum (Gonzalez et al., 2009; Taylor et al., 2009; Tu et al., 2006), including among a small sample (N = 68) of indigenous Tsimane' women in the Bolivian Amazon (Nyberg, 2012). According to prevailing hypotheses (Edwards et al., 2011; Nyberg et al., 2012), the comparatively low basal mean cortisol concentrations within our study population would suggest that exposure to chronic psychosocial stress and/or chronic infections led to dysregulation of the HPA-axis and a state of hypocortisolism. However chronic infections were rare (Chomat et al., 2015) and thus unlikely to account for our findings. Instead, psychosocial stressors were frequently reported and were associated with the "stressed" cortisol rhythm. This is a novel finding both in an indigenous setting and in pregnant or postpartum women, but is consistent with findings in populations living in disadvantaged neighborhoods in the US (Dowd et al., 2009) with potential stressors including poverty, marginalization, discrimination and high levels of violence, both past and current. On the other hand, several factors (maternal autonomy, social support, paternal support, exposure to domestic violence) differentiated between mothers in our study who were either exposed to additional sources of stress or had weaker coping strategies, based on the more or less "stressed" cortisol rhythms observed. These findings highlight the need for highly contextualized interventions – even within such a small area as that covered by our research

A novel finding uncovered by our analyses, perhaps made possible by the high prevalence of maternal stunting in our population, at 33% (Chomat et al., 2015), was that mothers of shorter stature generally had more "stressed" cortisol rhythms in pregnancy and later postpartum compared to their taller counterparts. Both *in utero* and postpartum exposure to psychosocial stress has been associated with growth retardation and early HPA-axis programming that may have lifetime repercussions on an individual's growth and stress response (Gunnar & Vazquez, 2011). Therefore, the link between short stature and a "stressed" cortisol rhythm may be linked to women's early life exposure to adversity as stunted children also have been found to have a "stressed" cortisol profile (Gunnar & Vazquez, 2011; Nyberg et al., 2012), which our data suggest might persist into adulthood. Furthermore, the reduced socioeconomic opportunity and impaired reproductive, cognitive and physical capacity associated with stunting may also contribute to chronic stress and an altered diurnal cortisol rhythm, independent of any pathophysiological associations between stature and the HPA-axis (Dewey & Begum, 2011; Pollet & Nettle, 2008).

Paradoxically, mothers with high paternal support had a more "stressed" cortisol rhythm during pregnancy and later PP. Greater partner involvement may not equate to effective support (Rini et al., 2006), especially if a partner is overly protective and/or dominates household decision-making and familial activities (Carlson et al., 2015; Mumtaz & Salway, 2009). In fact, several studies have found negative consequences associated with support that is insensitive to recipients' capacities, needs and desire for autonomy (Bolger et al., 2000; Martire et al., 2002). Similarly, the extent to which individuals believe that their partners understand, validate and care for them appears to mediate the effectiveness of support received (Chapman et al., 1997; Selcuk & Ong, 2012). It is likely that mothers with both high paternal involvement and low household-decision making power have poor access to and control over resources. In addition, male-dominated household decision-making has been associated with domestic violence in the Guatemalan context (MSPAS, 2010).

In contrast to the dominating autonomy paradigm that promotes women's individualism and independence as desirable, our results support the critique (Mumtaz & Salways, 2009) that maternal autonomy may not be desirable if autonomous mothers are the sole decision-makers out of necessity, indicating marginalization and vulnerability, rather than empowerment (Carlson et al., 2015). Indeed, although greater maternal control over household decisions may result in certain benefits, female-headed households also tend to be more impoverished (Haidar & Kogi-Makau, 2009) and it is unlikely that women choose lack of support of their partner unless faced with an abusive or conflictive relationship. Hence increased maternal responsibility for household decisions is perhaps mislabelled as "autonomy" in this indigenous population. Mothers with higher autonomy in decision-making were more likely to be single and to have low/moderate paternal and social support, generalized mistrust, and a more "stressed" cortisol rhythm. Furthermore, higher maternal autonomy, lower paternal support, being single, experiencing domestic violence, problems with partner and household alcoholism were all associated with one or more forms of emotional distress. This association between maternal autonomy and intimate-partner violence has been reported previously (d'Oliveira et al., 2009; Hidin & Adair, 2002; Koenig et al. 2003) and further highlights the vulnerability of mothers with high autonomy in decision-making in some contexts. It is important to note that the maternal autonomy questionnaire did not explore social security (i.e. improved wealth and food security) provided by partners, prevailing social norms relating to gender equality, or ways in which women negotiate gender relations (Mumtaz & Salway, 2009). Nevertheless, as in other areas of Guatemala (Carter 2002) and the world (Hidin & Adair, 2002, Mumtaz & Salway, 2009) characterized by patriarchal societies and close nuclear families, more equitable, joint-decision-making (rather than either no or high maternal autonomy) may represent a context of greater equity, increased resilience and reduced stress for mothers.

Although the American Psychiatric Association (APA, 2013) recently likened *susto* to major depressive disorder, posttraumatic stress disorder and somatic symptom disorder, and *nervios* to both depressive and anxiety disorders, social and cultural psychiatrists have consistently argued that local idioms of distress instead represent distinct entities (Alarcon, 2009). In the *Mam* mothers, emotional distress was captured both by local idioms and by the concept of being frequently overwhelmed. However, analyses failed to show an association between maternal diurnal cortisol rhythm and either local idioms of distress or being frequently overwhelmed, perhaps because local idioms of distress may not reflect those depression- and anxiety-type symptoms (Alarcon, 2009; Hatala et al., 2015) that have been shown to be related to the maternal diurnal cortisol rhythm (Kivlighan et al., 2008; Obel et al., 2005; O'Connor et al., 2014; O'Keane et al., 2011; Suglia et al., 2010). Moreover, that speaking *Mam* decreased the likelihood that a woman would report *nervios, enojo* or *susto* suggests either that those who spoke *Mam* either experienced less symptoms of distress or that the conceptualization of health and wellbeing differed within our study population based on language and, possibly, degree of acculturation. These observations highlight the need to better characterize local idioms of distress specifically within the *Mam*-speaking population and develop a more culturally sensitive tool for screening emotional distress in *Mam*-Mayan mothers.

Our study has several limitations. Our findings are based on cross-sectional data, which limits causal inferences. We measured only one component of autonomy (decision-making) and of paternal support (involvement), but other aspects of gender norms relevant to the *Mam*-Mayan sociocultural context may be informative. With regard to cortisol, measures from one-day collection do not account for day-to-day variation. Moreover, cross-study comparisons relating to the measurement of cortisol need to be made with caution due to differences in timing within the perinatal period and use of different methodologies in cortisol sampling and analysis (Adam & Kumari, 2009). Finally, although several potential confounders of the cortisol rhythm were measured, it would have been helpful to also collect data on sleep characteristics (Minkel et al., 2015), time of saliva collection relative to waking and sleeping, and experience of stressful experiences on the day of collection (Adam & Kumari, 2009) which have been shown to influence cortisol. In order to explore the relative contributions of psychosocial and infection variables, further work will be required in a population with higher infections levels.

This study has several public health implications. The association between psychosocial stressors and maternal cortisol rhythm and evidence of a flatter diurnal cortisol rhythm among the most disadvantaged mothers suggest that certain mothers, especially those who are single and have lower *Household Wealth Index* and ineffective or disempowering social relationships, may be particularly vulnerable to chronic stress. The resulting maternal hypocortisolism may in turn contribute to early life stunting (Gunnar & Vazquez, 2011), and thus have health implications not only for mothers but also for their infants. Further qualitative work that unpacks gender relations, local idioms of distress, and sources of support and resilience would allow a more subtle and contextualized assessment of psychosocial wellbeing and effective maternal autonomy and paternal support in this population. Along with efforts to reduce poverty, food insecurity, and improve the efficacy of support received from partners, cognitive-behavioral strategies aimed at increasing mother's coping skills and self-efficacy and strengthening the effectiveness and cultural relevance of existing social networks and community services emerge as key areas of intervention.

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Table 4.1. Multiple logistic regression models for food insecurity, social factors and emotional distress, by perinatal stage [1]

	Pregnancy		Early postpartum		Later postpartum	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
HOUSEHOLD FACTORS						
Adult food insecurity[2]						
Spanish not spoken (N, Y)	0.3 (0.1-0.6)	0.002				
Lowest 40% of HWI (N, Y)			2.1 (1.0-4.2)	0.041	2.4 (1.1-5.1)	0.021
Maternal stunting (N, Y)					3.0 (1.3-6.8)	0.008
Low/moderate paternal support[3] (N, Y)	2.8 (1.1-7.4)	0.038			2.0 (0.9-4.7)	0.108
Moderate/high autonomy[4] (N, Y)			3.7 (1.5-9.1)	0.005		
Model summary[5]	*R^2 = 0.141 (0.541)*	*0.003*	*R^2 = 0.103 (0.662)*	*0.007*	*R^2 = 0.171 (0.498)*	*0.001*
SOCIAL FACTORS						
Low/moderate paternal support[3]						
Spanish not spoken (N, Y)					2.8 (1.3-6.2)	0.010
Single (N, Y)	11.8 (1.3-107.6)	0.026	10.5 (2.1-552.0)	0.003		
Low/moderate social support[6] (N, Y)	3.2 (1.2-8.7)	0.023				
Moderate/high autonomy[4] (N, Y)	3.4 (1.0-11.0)	0.043	3.3 (1.4-8.1)	0.007	3.5 (1.4-8.9)	0.009
Model summary	*R^2 = 0.239 (0.346)*	*<0.001*	*R^2 = 0.206 (0.404)*	*<0.001*	*R^2 = 0.109 (0.151)*	*0.009*
Low/moderate social support[6]						
Single (N, Y)			3.8 (0.9-15.5)	0.065		
Maternal education, yrs					0.3 (0.1-1.0)	0.054
Low/moderate paternal support[3] (N, Y)	4.1 (1.7-10.4)	0.002				
Moderate/high autonomy[4] (N, Y)			4.9 (1.8-13.3)	0.002	3.5 (1.2-10.2)	0.024
Trusted no one (N, Y)					8.3 (1.5-45.3)	0.015
Model summary	*R^2 = 0.133 (0.246)*	*0.003*	*R^2 = 0.177 (0.997)*	*0.001*	*R^2 = 0.189 (0.762)*	*0.002*
No trust						
Spanish not spoken (N, Y)					6.9 (0.9-51.2)	0.059
Low/moderate social support[6] (N, Y)					5.4 (0.9-31.7)	0.062
Moderate/high autonomy[4] (N, Y)					9.2 (1.3-65.5)	0.026
Model summary					*R^2 = 0.327 (0.377)*	*0.003*
Moderate/high autonomy[4]						
Maternal age, yrs	1.2 (1.1-1.3)	0.002			1.1 (1.0-1.2)	0.038
Spanish not spoken (N, Y)	0.1 (0.0-0.5)	0.004	0.2 (0.1-0.6)	0.004	0.2 (0.1-0.6)	0.006
Single (N, Y)	17.4 (1.5-205.0)	0.023				
Low/moderate social support[6] (N, Y)			6.8 (2.2-20.6)	0.001	3.6 (1.1-11.8)	0.035

Low/moderate paternal support[3] (N, Y)	6.5 (1.7-25.1)	0.007	4.5 (1.7-11.5)	0.002	3.5 (1.3-9.8)	0.015
Trusted no one (N, Y)					9.6 (1.4-68.2)	0.024
Domestic violence (N, Y)	0.1 (0.0-1.2)	0.073				
Model summary	*R^2 = 0.444 (0.959)*	*<0.001*	*R^2 = 0.298 (0.902)*	*<0.001*	*R^2 = 0.262 (0.420)*	<0.001
EMOTIONAL DISTRESS						
Susto						
Maternal age, yrs			1.1 (1.0-1.1)	0.003		
Speaks *Mam* (N, Y)					0.2 (0.1-0.9)	0.040
Maternal stunting (N, Y)					2.1 (1.0-4.3)	0.046
Low/moderate paternal support[3] (N, Y)			3.0 (1.3-6.8)	0.008		
Adult food insecurity[2] (N, Y)			0.4 (0.2-0.8)	0.016		
Domestic violence (N, Y)			2.9 (1.2-7.1)	0.023		
Household alcohol problem (N, Y)					2.1 (1.0-4.5)	0.055
Model summary			*R^2 = 0.185 (0.229)*	<0.001	*R^2 = 0.106 (0.470)*	*0.015*
Enojo						
Maternal age, yrs			1.1 (1.0-1.2)	0.074		
Spanish not spoken (N, Y)			2.6 (0.8-8.2)	0.109		
Speaks *Mam* (N, Y)					0.2 (0.0-0.8)	0.024
Domestic violence (N, Y)					5.4 (1.8-15.7)	0.002
Model summary			*R^2 = 0.098 (0.244)*	0.026	*R^2 = 0.172 (0.746)*	*0.003*
Frequently *nervios*						
Speaks *Mam* (N, Y)					0.2 (0.0-1.0)	0.049
Single (N, Y)	6.1 (1.4-25.8)	0.014				
Adult food insecurity[2] (N, Y)					4.0 (0.8-18.9)	0.084
Trusted no one (N, Y)	6.1 (1.2-30.6)	0.029				
Model summary	*R^2 = 0.126 (0.714)*	*0.012*			*R^2 = 0.162 (0.122)*	*0.040*
Frequently overwhelmed						
Problems with partner (N, Y)					27.3 (1.6-463.0)	0.022
Model summary					*R^2 = 0.377 (0.238)*	*0.031*

[1] N = 135 in pregnancy, 155 early PP (1-6 wk), 151 later PP (4-6 mo)
[2] Adult food insecurity = FSQ ≥ 1
[3] Low/moderate paternal support: Paternal Support Score < 9
[4] Moderate/high maternal autonomy: Maternal Autonomy Score > 5
[5] Nagelkerke R^2 (*P*-value of Hosmer & Lemeshow goodness of fit) and overall model *P*-value
[6] Low/moderate social support: Social Support Score < 7

Table 4.2. Multiple linear regression models for waking and evening cortisol concentrations and diurnal slope (nmol/l) [1,2]

	Waking cortisol		Evening cortisol		Diurnal slope	
	B ± SE[3]	p-value	B ± SE	p-value	B ± SE	p-value
Pregnancy						
Maternal Height, cm	0.26 ± 0.08	0.002			0.34 ± 0.09	<0.001
ANC Frequency	-0.22 ± 0.11	0.057				
Estimated Gestational Age, mo	-0.67 ± 0.38	0.080	0.56 ± 0.23	0.015	-1.36 ± 0.40	0.001
Speaks Spanish (N, Y)	2.32 ± 0.88	0.010	1.07 ± 0.51	0.039		
Household Wealth Index			-0.51 ± 0.23	0.031		
Low/moderate social support[4]			1.70 ± 0.68	0.014		
Paternal Support Score			0.19 ± 0.10	0.054	-0.38 ± 0.17	0.033
Intercept	*-17.89 ± 12.53*	*0.156*	*10.61 ± 7.29*	*0.148*	*-25.85 ± 13.18*	*0.052*
Model Summary[5]	*$R^2 = 0.136$*	*<0.001*	*$R^2 = 0.144$*	*0.001*	*$R^2 = 0.171$*	*<0.001*
Early postpartum						
Maternal Height, cm					-0.10 ± 0.05	0.033
ANC Frequency	-0.21 ± 0.07	0.003			-0.19 ± 0.06	0.003
Speaks Spanish (N, Y)	1.83 ± 0.54	0.001	0.96 ± 0.43	0.028		
Relationship (N, Y)	-3.96 ± 1.05	<0.001	-2.85 ± 0.85	0.001		
Maternal Autonomy Score	-0.23 ± 0.11	0.032			-0.32 ± 0.09	0.001
Paternal Support Score					-0.17 ± 0.09	0.054
Domestic Violence (N, Y)			1.12 ± 0.53	0.038		
Adult food insecurity[6] (N, Y)					-0.25 ± 0.12	0.051
Intercept	*21.97 ± 7.47*	*0.004*	*-0.19 ± 6.12*	*0.976*	*23.48 ± 6.83*	*0.001*
Model Summary	*$R^2 = 0.177$*	*<0.001*	*$R^2 = 0.088$*	*0.004*	*$R^2 = 0.147$*	*<0.001*
Later postpartum						
Maternal Age, yrs			-0.05 ± 0.02	0.028	0.07 ± 0.04	0.049
Maternal Height, cm			-0.07 ± 0.03	0.025		
Speaks Spanish (N, Y)					1.02 ± 0.50	0.041
Relationship (N, Y)					3.95 ± 1.30	0.003
Paternal Support Score					-0.25 ± 0.11	0.030
Food Insecurity Score			0.15 ± 0.08	0.063		
Intercept			*13.22 ± 4.44*	*0.003*	*-7.52 ± 6.73*	*0.266*
Model Summary			*$R^2 = 0.082$*	*0.003*	*$R^2 = 0.097$*	*0.003*

[1] N = 135 in pregnancy, 155 early PP (1-6 wk), 151 later PP (4-6 mo)
[2] All models controlled for maternal age and ANC frequency, and pregnancy models for estimated gestational age (only shown when significant).

[3] Unstandardized coefficient ± standard error
[4] Low/moderate social support: Social Support Score < 7
[5] R^2 refers to each model's coefficient of determination, reported as adjusted R^2
[6] Adult food insecurity = FSQ ≥ 1

Table S4.1. Adult food insecurity, social factors and experience of psychosocial stress during pregnancy and lactation in indigenous *Mam*-Mayan mothers from the Western Highlands of Guatemala [1,2]

	Pregnancy	Early postpartum	Later postpartum
Maternal Autonomy			
Partner is sole decision maker	11.9	9.2	11.5
Woman is sole decision maker	3.0	3.9	4.0
Maternal involvement in decision-making			
Food purchases			
Woman alone decides	16.3	19.6	21.6
Woman and partner decide	49.6	46.4	45.9
Spouse alone decides	21.5	17.6	17.6
Medicine purchases			
Woman alone decides	8.1	10.5	10.1
Woman and partner decide	57.0	58.2	60.1
Spouse alone decides	25.9	22.9	20.3
Where to go for infant illness			
Woman alone decides	5.9	8.5	8.1
Woman and partner decide	62.2	61.4	62.8
Spouse alone decides	18.5	21.6	20.9
Where to go for own illness			
Woman alone decides	5.2	7.8	8.1
Woman and partner decide	58.5	55.6	58.1
Spouse alone decides	26.7	26.8	24.3
Household finances			
Woman alone decides	5.9	8.5	8.1
Woman and partner decide	57.0	49.7	52.7
Spouse alone decides	25.9	28.1	25.0
Areas where partner provided support			
Financial support when needed			
Never	7.4	7.5	8.1
Always	82.2	77.4	81.5
Talking about things important to her			
Never	8.1	9.6	10.4

Always	81.5	78.1	79.3
Providing her with affection			
Never	8.9	9.6	9.6
Always	86.7	82.2	84.4
Showing interest in helping care for baby			
Never	11.1	10.3	10.4
Always	70.4	66.4	76.3
Talking and spending time with her			
Never	15.6	13.0	10.4
Always	71.9	73.3	78.5
Trust in select social institutions			
None	5.2	2.6	4.7
Family	86.6	90.3	87.3
Neighbors	37.6	37.9	33.6
Church	75.4	76.6	72.0
Community health center	72.4	79.2	74.7
School	66.4	70.8	71.3
Hospital	42.5	46.8	46.0
Police	9.0	7.1	11.3
Mayor	7.5	8.4	8.0
Experience of difficult life events [3]			
Number of difficult life events	1.2 ± 1.4	1.0 ± 1.3	1.0 ± 1.3
Any difficult life event	50.7	43.5	46.3
Domestic violence	24.2	19.4	19.9
Problems with partner	20.1	14.3	16.0
Household alcohol	31.9	25.2	26.5

[1] n = 135 in pregnancy, 155 early PP (1-6 wk), 151 later PP (4-6 mo)

[2] Values represent mean ± standard deviation, or percent (%)

[3] Experience of respective difficult life event at any time during pregnancy or since delivery

Table S4.2. Social support, pooled data across the three perinatal stages[1]

Who can you really count on to …	Partner	Mother	Mother-in-law	Father	Sibling	Other relatives[2]	Other[3]	No one
MATERIAL SUPPORT								
… look after your safety, and the safety of your family?	56.0	28.0	4.7	6.0	0.7	4.7	0.0	11.3
… help you and your family ensure you have enough money to buy food and all basic needs?	73.3	13.3	2.7	8.0	2.0	6.7	0.7	8.7
… make sure that you or your child get needed medical care if severely ill?	71.1	28.9	6.7	6.7	0.7	2.1	1.3	4.0
EMOTIONAL SUPPORT								
… listen to you when you need to talk?	66.2	47.3	10.1	6.8	4.0	2.4	0.0	4.1
INFORMATIONAL SUPPORT								
… help you make a difficult decision?	71.1	41.6	8.1	10.1	2.3	0.0	0.0	4.0
… give you useful advise about your pregnancy and the care of your newborn?	51.4	50.0	15.5	2.0	2.1	0.7	6.0	4.1
CHILDCARE SUPPORT								
… help you take care of your children (including newborn)?	55.3	28.0	15.3	0.0	3.4	12.1	1.4	8.0
… help you at home so that you have time to rest, take care of your newborn?	45.3	24.3	16.9	0.7	6.8	14.9	1.4	16.2

[1] Pooled data, with n = 135 in pregnancy, 155 early PP (1-6 wk), 151 later PP (4-6 mo)
[2] Other relatives includes father-in-law, siblings-in-law and children
[3] Other includes midwife, formal health sector, neighbor, friend, maid and God

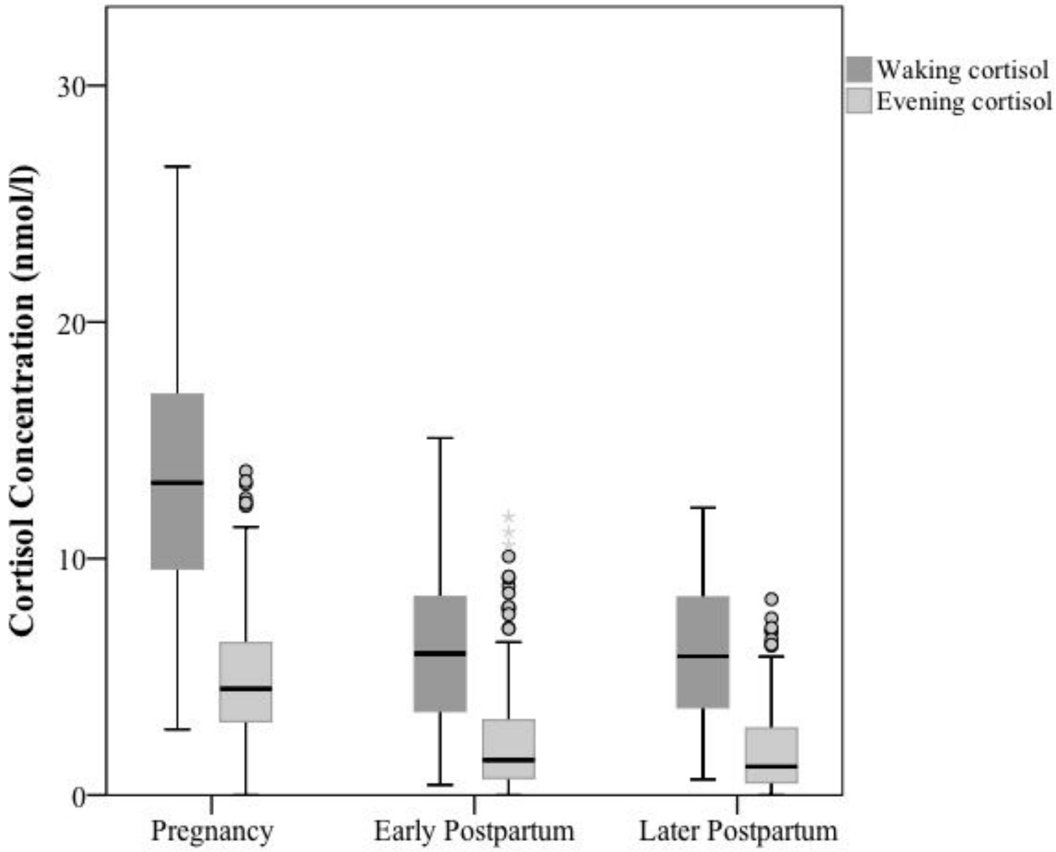

Figure 4.1. Tukey boxplots of waking and evening cortisol concentrations (nmol/l) by perinatal stage. N = 135 in pregnancy, 155 early PP (1-6 wk), 151 later PP (4-6 mo). The box extends from the 25^{th} to the 75^{th} percentiles, and the line in the middle of the box is plotted at the median. The interquartile distance (IQR) is equal to the difference between the 25^{th} and 75^{th} percentiles. The lower end of the whiskers represents the lowest datum still within 1.5 IQR of the lower quartile, and the higher end of the whiskers represents the highest datum still within 1.5 IQR of the highest quartile. Circles and stars represent outliers. The difference between waking and evening cortisol concentrations was statistically significant at all perinatal stages, $P < 0.001$. Both waking and evening cortisol concentrations were significantly higher during pregnancy than early and later PP ($P < 0.001$).

Connecting Statement 2

In Chapter 4, I have shown that basal pregnancy and postpartum salivary cortisol concentrations were on the lower end of normal of those previously reported in the literature, within our population of *Mam*-Mayan mothers. Moreover, shorter maternal stature as well as various household and social factors present in the women's environment were significantly associated with the maternal cortisol stress response. More specifically, mothers facing the combination of high autonomy in household decision-making, low support, violence and poverty or of high paternal involvement and low decision-making power may be particularly vulnerable to chronic stress. In Chapter 5, I consider whether sociodemographic, obstetric, nutritional, infection and psychosocial variables may be associated with infant height-for-age and stunting early PP, and with change in height-for-age between earlier and later PP visits, and assess the role of maternal cortisol rhythm as a biological mediator of maternal stress. Chapter 5 allowed me to examine what elements of women's lived environments may be associated with compromised growth of their infants, and whether the vertical transmission of stress may be mediated through maternal cortisol.

CHAPTER 5

THE ASSOCIATION OF BIOLOGICAL AND PSYCHOSOCIAL FACTORS, AND OF PERINATAL MATERNAL SALIVARY CORTISOL, WITH INFANT LINEAR GROWTH IN THE FIRST SIX MONTHS POSTPARTUM, IN A RURAL *MAM*-MAYAN AREA OF QUETZALTENANGO, GUATEMALA

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Abstract

Background: Despite decades of nutrition interventions, Guatemala still has one of the highest rates of child stunting in the world, and the indigenous populations are disproportionately affected. Impaired linear growth may be a consequence of maternal stresses associated not only with malnutrition and infection but also with psychosocial factors, the effects of which may be mediated by the maternal cortisol rhythm. **Objectives**: To explore the combined association of household, maternal and psychosocial factors on early infant stunting and linear growth, and to assess the role of cortisol role as a biological mediator of maternal stress. **Methods**: A longitudinal cohort of 117 mother-infant dyads was evaluated in pregnancy (6-9 mo), early postpartum (PP, 0-6 wks) and later PP (4-6 mo). Maternal and infant anthropometry was recorded, maternal fecal, urine and saliva samples were collected, and questionnaires were used to explore household factors (socioeconomic status, food security), social factors (autonomy, paternal and social support, domestic violence), and maternal-level factors (diet, infections, emotional distress). Multiple regression models were constructed for early PP HAZ and stunting, and for linear growth from early to later PP (ΔHAZ). **Results**: Early PP, dirt floor, lack of prior day meat consumption, insufficient breast milk, and short maternal stature were associated with lower HAZ and increased likelihood of stunting. Also, infants of mothers with greater paternal support, autonomy and emotional distress were more likely to be stunted. ΔHAZ was positively associated with maternal height, maternal BMI, female gender and early PP stunting, and negatively with maternal autonomy, problems with partner and difficulty breastfeeding. Higher concentrations of early PP evening salivary cortisol increased the likelihood of stunting, whereas later PP waking cortisol was positively associated with ΔHAZ. **Conclusion**: This study suggests that, in addition to poor nutrition, the psychosocial context of high autonomy, high paternal support, problems with the partner, and maternal emotional distress – and the associated "stressed" cortisol response – are associated with compromised infant linear growth. Study results make a strong case for interventions that include psychosocial factors as determinants of early infant stunting.

Introduction

At 47%, Guatemala has one of the highest rates of child stunting in the world (MSPAS 2015) and the highest rate in Latin America (UNICEF 2013). Indigenous populations are disproportionately affected, with stunting in 58% of indigenous children overall (MSPAS 2015), and up to 80% in the historically marginalized communities in the Western Highlands (Saenz de Tejada 2009), compared to 34% among their non-indigenous counterparts (MSPAS 2015). Despite decades of intensive nutrition research and interventions in Guatemala, maternal-child health metrics have improved only minimally over the last 30 years (MSPAS 2015). This may in part be attributed to the difficulty of implementing programs in the complex multiethnic, multi-linguistic context that modern post-civil war Guatemala represents (Anckermann et al. 2005). However it may also reflect a gap in our understanding of factors that contribute to stunting as it is estimated that scaling-up use of the top-ten proven, nutrition-specific interventions to 90% of children in the 34 countries where most stunted children live (which include Guatemala), would reduce the number of stunted children by only one-fifth (Bhutta et al. 2013).

Psychosocial conditions have received increasing attention in efforts to explain impaired child growth. The literature relating maternal emotional distress and pregnancy outcome generally differentiates between depression-type symptoms, which have most consistently been associated with infant stunting, especially in developing countries (Surkan et al. 2011), and "stress" or anxiety-type symptoms (variably measured as perceived stress, trait anxiety, state anxiety, life events stress, pregnancy-related anxiety), which have most often – but less consistently (Bolten et al. 2011, Littleton et al. 2010) and mostly in developed countries – been associated with preterm delivery and low birth weight (Broekman et al. 2014, Dunkel-Schetter 2011). Poor maternal social support, including that received from the baby's father, has been associated with low birth weight in developed countries including among immigrant populations (Dunkel-Schetter 2011), although evidence suggests differential effects of social support depending on context, degree of acculturation and ethnicity (Campos et al. 2008, Dyer et al. 2011). Maternal experience of intimate-partner violence has been implicated with low birth weight (Valladares et al. 2009) and infant stunting (Heaton & Forste 2008, Rico et al. 2011) in both developed and developing countries. Finally, higher maternal autonomy, frequently measured as autonomy in household decision-making, has generally been associated with greater infant length across developing country contexts (Carlson et al. 2015, Smith et al. 2003), although several studies, especially in Latin America and the Caribbean, found no such association (Carlson et al. 2015, Smith et al. 2003).

There are myriad potential pathways linking psychosocial factors with infant growth, including biological and behavioural. In particular, growing evidence suggests that psychosocial stress-induced alterations in neuroendocrine function during pregnancy, as mediated by the maternal hypothalamic-pituitary-adrenal (HPA) axis and an altered diurnal cortisol rhythm, may contribute to intrauterine growth restriction (Dunkel-Schetter 2011). A healthy HPA axis involves a diurnal pattern of high salivary cortisol concentration upon waking that declines throughout the day to a nadir around midnight (Adam & Kumari 2009). Exposure to chronic stressors has most consistently been associated with lower waking cortisol concentrations, higher evening cortisol concentrations, and/or a flatter diurnal slope in both pregnant (Obel et al. 2005, Suglia et al. 2010, Valladares et al. 2009) and non-pregnant (Dowd et al. 2009) populations. Although short-term activation of the HPA axis is adaptive and necessary for everyday functioning, chronic activation is associated with pathological, long-term consequences (Pervanidou & Chrousos 2012) and during pregnancy, with low birth weight (Bolten et al. 2011, D'Anna-Hernandez et al. 2012, Hompes et al. 2012, Kivlighan et al. 2008, Valladares et al. 2009). As stunting is an indicator of chronic adversity (Dewey & Begum 2011), chronic activation of the HPA axis may also be associated with infant stunting. Consistent with this hypothesis, lower birth length was associated with a higher rise in salivary cortisol after awakening late in pregnancy (measured as area under the cortisol awakening response curve) in a study of German mothers (Bolten et al. 2011), although neither low birth weight nor cortisol was associated with self-perceived stress or pregnancy-related anxiety. To our knowledge, this is the only study to explore the relationship between maternal stress, maternal cortisol and infant length.

The Mayan population has faced long-standing racial and ethnic oppression, and continues to live excluded from most political, economic and social programs (Anckermann et al. 2005). Indigenous women additionally face high rates of gender inequality, prevalent throughout Guatemala and often characterized by violence and a concentration of resources and decision-making in the hands of men (MSPAS 2015). Among indigenous *Mam*-Mayan women in the rural Western Highlands of Guatemala, we previously reported (Chomat et al. *submitted*) evidence of a chronically "stressed" cortisol rhythm during the perinatal period in women who were single, food insecure, with lower household wealth, higher autonomy and higher paternal support, and who experienced domestic violence. Our finding that 36% of infants in these communities was stunted soon after birth is evidence that the perinatal period has a determining impact on early infant growth in this setting where 20% of mothers had no schooling and 33% were stunted, and women generally reported low autonomy, highly involved partners, small social support networks, high trust in family and common domestic violence (Chomat et al. 2015).

Within a socio-ecological framework (Chomat et al. 2015), the objectives of the present study were (1) to determine which household factors (socioeconomic status, food security), social factors (autonomy, social and paternal support, domestic violence) and maternal factors (nutritional, infectious, emotional distress) experienced during pregnancy and lactation were associated with infant length, and (2) to assess the role of cortisol as a biological mediator of the cumulative chronic stress experienced by the mother.

Materials and Methods

Design, Inclusion and Exclusion Criteria, and Ethics

Between 2011 and 2013, this observational, longitudinal study, followed mother-infant dyads during pregnancy (6-9 mo) and at 0-6 weeks and 4-6 mo postpartum (early and later PP, respectively). It was grounded in ongoing Participatory Action Research and involved data collection, repeated at each visit, through questionnaires on socio-economic status, food insecurity, maternal autonomy, paternal and social support, experience of difficult life events, emotional distress, diet, and obstetric history, a clinical exam and anthropometry of mother and infant, and maternal fecal, urine and saliva samples. Inclusion criteria were being a woman within the study area (consisting of eight small, rural *Mam*-Mayan communities in the municipality of San Juan Ostuncalco, in the Western Highland department of Quetzaltenango) who was 6 to 9 mo pregnant as determined by suprapubic height measurement (Evans 2007). Based on power and loss-to-follow-up calculations (Chomat et al. 2015), a total of 155 women were enrolled with the help of community health workers and traditional midwives. For the purpose of this paper, we excluded women who were not seen at all three visits and for whom we did not have complete anthropometric data on mother (height, weight) and infant (birth weight, early and later PP length) (n = 35). We also excluded women whose infant had a height-for-age Z score (HAZ) greater or less than three standard deviations of the population mean (n = 3), for a final sample size of 117 mother-infant dyads. Further details of the design, methods and study population have been previously reported (Chomat et al. 2015).

The study was approved by the ethics committees in Canada of McGill University (Faculty of Medicine) in Canada and the Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM) in Guatemala. Community leaders and the local Ministry of Health approved all activities. All participants provided fully informed consent (signature or thumbprint if illiterate) at the time of enrollment and were given a snack and small gift for their participation at each visit.

Procedures

Household factors

Women were asked about languages spoken (*Mam*, Spanish), marital status (married/consensual union, single/widow), schooling (none, primary, ≥ secondary), household floor type (earth, cement/ceramic) and sanitation (toilet, pit latrine/other). An asset-based *Household Wealth Index* (HWI) was constructed (Chomat et al. 2015) as a proxy for household socioeconomic status using principal components analysis of the following durable household assets: dirt floor, ceramic/cement floor, *adobe/lamina* walls, cement block walls, electricity, radio, television, mobile phone, sewing machine, oven, refrigerator, bicycle and car/truck. A nine-item adult *Food Insecurity Score* was adapted from the 14-item experience-based Food Security Questionnaire used by the Panama Ministry of Health (MINSA 2003). A cumulative score (range 0-9) was calculated as the sum of the nine items, with each item scoring 0 for no, and 1 for any food insecurity.

Social factors

Maternal autonomy was calculated using a 5-item questionnaire that assessed women's involvement in household decision-making relating to food and medicine purchases, health visits for herself or infant, and household finances, with each item scoring 0 for no, 1 for shared, and 2 for sole involvement (Chomat et al. 2015). The cumulative score (range 0-10) was divided into three categories: no (0), low (1-5), and moderate/high (6-10) levels of maternal autonomy.

A *Paternal Support Score* (PSQ) was calculated using a 5-item questionnaire that inquired about material support, emotional support and childcare support received from the baby's father, with each item scored as no (0), occasional (1) or ongoing (2) paternal support (Chomat et al. 2015). The resulting cumulative score (range 0 to 10) was used as a continuous variable.

A *Social Support Score* (SSS) was calculated using an 8-item questionnaire that inquired about whom women could count on in the provision of emotional, informational, childcare, and material support (Chomat et al. 2015). A dichotomous variable was created for each item that differentiated women who did (1) or did not (0) receive support from at least one person and the SSQ was calculated as the sum of the eight.

Difficult life events were explored through a questionnaire that inquired about experience of problems with partner, domestic violence and household alcohol abuse during pregnancy or postpartum (Chomat et al. 2015). A physician also queried exposure to these events at each visit during the medical evaluation. Dichotomous variables were created reflecting exposure (1) or no exposure (0) to each of the three types of experience.

Maternal factors

Obstetric experience: Maternal age was determined based on the mother's reported date of birth. Parity, defined as number of live births, was queried.

Nutrition: Maternal height was measured to the nearest 0.5cm; heights < 145 cm were categorized as stunted (Black et al. 2013). Weight was measured to the nearest 100 g using a digital scale (SECA803, Hamburg, Germany). Body Mass Index (BMI) was calculated in PP women as weight divided by height squared (kg/m^2), and classified as underweight (< 18.5 kg/m^2), normal (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2) or obese (≥ 30.0 kg/m^2) (WHO 1995). Maternal Dietary Diversity was derived from a single previous-day dietary recall at each sampling period. Each of nine food groups (starchy staples, beans/peas, nuts/seeds, dairy, flesh foods, eggs, vitamin A-rich dark green leafy vegetables, other vitamin A-rich vegetables/fruits, other vegetables, other fruits) (FAO 2014) was categorized as consumed (1) or not (0). Physical activity was assessed through a previous-day recall; activities were grouped according to type and assessed for frequency and duration (Chomat et al. 2015).

Infections: Periodontal disease was diagnosed through detection of dental cavities (caries) or gum inflammation (gingivitis). A urine sample was analyzed using dipstick analysis and urine microscopy to yield bacteria and leukocytes; a culture was performed if infection was suspected (positive leukocyte esterase and nitrites by dipstick; bacteriuria $\geq 10^2$ colony-forming units (cfu)/ml. In pregnant women, asymptomatic bacteriuria $\geq 10^5$ cfu/ml was considered pathological, whereas only symptomatic bacteriuria was considered pathological in non-pregnant women. Stool samples were analyzed for leukocytes, nematodes and protozoa using direct smear; both pathogenic and non-pathogenic protozoa were recorded, with the latter (≥ 2 stool protozoa detected in a given sample) being used as a measure of exposure to contaminated food and water sources.

Emotional distress: Women were asked about their experience of the local idioms of distress of *susto*, *enojo* and *nervios* (Pies de Occidente 2006). *Susto* results from a frightening or startling experience, which affects a person's equilibrium and manifests as a diverse array of symptoms and pathologies. *Enojo* is described as an anger that upsets the body's equilibrium and leads to headaches, stomach pains, weakness or fatigue and chronic illness. *Nervios* (being nervous or having nerves) is most often characterized by symptoms of anxiety, tension and fear. Current experience of *susto* and *nervios* (0 no, 1 yes) and frequency (0 never/sometimes, 1 almost always/always) of experiencing *enojo* and of feeling overwhelmed were queried and the cumulative psychosocial distress score (range 0-4) was calculated at each visit.

Infant factors

Infant age and sex were recorded. Infant birth weight (measured by the birth attendant using variable methods) was recorded based on mother recall. Recumbent supine length (cm) was measured thrice according to standardized procedures using an infantometer (SECA210, Hamburg, Germany) and recorded to the nearest 0.5 cm. Length-for-age Z score (HAZ) were calculated using WHO Anthro software (3.1); stunting was defined as HAZ < -2.0 SD below the

WHO reference median (WHO 2006). Change in HAZ (ΔHAZ) was calculated as the difference in HAZ between later and early PP visits, divided by the number of months elapsed.

Infant feeding practices were classified at each of the two postpartum visits as exclusive breastfeeding, predominant breastfeeding, and mixed feeding based on reported feeding practices since birth (Wren et al. 2015). Women were also asked (1 yes, 0 no) if they had any trouble breastfeeding, and if they perceived having sufficient breast milk.

Infant stool samples were collected later PP and analyzed for leukocytes, nematodes and protozoa using a direct smear by an experienced laboratory technician. A leukocyte count > 10 per high power field was considered pathological (Mercado et al. 2011).

Salivary cortisol as a potential biological mediator

At each of the three visits, women collected saliva samples upon waking and at bedtime. Saliva samples were kept at room temperature for up to 72 hours before being stored at -20°C. Cortisol concentrations were measured in duplicate using an enzyme immunoassay kit (Salimetrics, State College, PA, USA) at the Douglas Institute Stress Hormone Research Laboratory at the Douglas Hospital Research Center, Montreal, Canada. Waking and evening salivary cortisol concentrations were converted from µg/dl to nmol/l, and the diurnal decline between waking and evening levels (slope) was calculated (Chomat et al. *submitted*).

Statistical Analysis

IBM SPSS Statistics Program version 22.0 (SPSS Inc./IBM Chicago, IL, USA) was used for all analyses. Significance was set at $p < 0.05$ and variables are reported as mean ± SD. The correlation between early PP and later PP HAZ was explored using Pearson correlation analysis. Stunted infants were compared with infants of normal height, both early and later PP, using x^2 for categorical variables and independent t-test for continuous variables; those variables where $p < 0.15$ were included in multivariate analyses.

Exploratory multivariate models of early PP stunting (logistic regression), early PP HAZ (linear regression) and ΔHAZ/mo (linear regression) considered groupings of household factors, social factors, maternal-level factors, infant-level factors, as well as each of the maternal salivary cortisol variables (waking concentration, evening concentration, diurnal slope) and controlled for maternal age as well as gestational age in months when pregnancy salivary cortisol values were included. Models that included early PP cortisol variables only included the 99 samples collected ≥ 7 days postpartum, due to the decline in cortisol concentrations following delivery (Mastorakos & Ilias 2003). Final composite linear and logistic models were built, first without including cortisol variables and then adding each cortisol variable separately. Variables that either weakened the model or whose significance was > 0.15 were not included in the composite models, unless they were potential confounders. As both transformed and untransformed salivary cortisol yielded the same result in all models, untransformed values were reported. For logistic regression models, the Nagelkerke R^2, Hosmer and Lemeshow goodness of fit p-value, and overall model p-value were calculated; only those models with both a goodness of fit p-value > 0.05 and an overall model $p < 0.05$ are presented. For each variable, the odds ratio (OR), 95% confidence interval (CI) and *P*-value is reported. For linear regression models, unstandardized coefficient (B) ± standard error (SE) is reported for each variable and the adjusted R^2 and model p-value are also reported. Collinearity among variables was tested to confirm that the variance inflation factor (VIF) was < 2.5.

Results

Characterization of infant length and linear growth early and later PP

HAZ was higher early PP (1.48 ± 1.21; median -1.46; range -4.40 to 1.91) than later PP (-1.68 ± 1.12; median -1.73; range -4.84 to 2.09) (paired sample t-test, p = 0.068). One third (32.5%) of infants were stunted early PP (12.0% severe), and 37.6% later PP (9.4% severe). Three fifths (60.5%) of early PP stunted infants remained stunted later PP. HAZ was positively correlated between early and later PP (r = 0.48; p < 0.001).

Variables associated with early PP infant HAZ and stunting

Univariate analyses of stunted vs. normal growth infants, early and later PP

Early PP, dirt floors were more common and cement/ceramic floors less common in stunted children (Table 5.1). Fewer mothers of stunted infants had eaten meat the previous-day, and maternal height and reported birth weight were lower in stunted infants. Later PP, latrines were more common and toilets less common in stunted infants, maternal BMI both early and later PP was lower in stunted infants, and reported birth weight was lower. None of the following variables differed between stunted and normal length infants: maternal social support, physical activity (including time spent resting), periodontal disease, maternal infection (urinary, gastrointestinal), maternal dietary diversity, infant feeding practices (breastfeeding frequency, exclusive vs. complementary feeding, consumption of *agüitas*), salivary cortisol variables and infant stool leukocytosis.

Exploratory multiple regression models of early PP HAZ and stunting

Having a dirt floor was negatively associated with early PP HAZ ($P = 0.001$) (Table 5.2). Taller maternal height ($p = 0.018$) and prior day meat consumption ($p = 0.034$) were positively associated with early PP HAZ. Reported birth weight was also positively associated with early PP HAZ ($p < 0.001$).

Having a dirt floor increased the likelihood of early PP stunting (OR = 2.6, $p = 0.035$) (Table 5.2). Younger maternal age (OR = 0.9, $p = 0.047$), higher paternal support during pregnancy (OR = 1.2, $p = 0.032$) and higher autonomy early PP (OR = 2.7, $p = 0.003$) also increased the likelihood of stunting. Taller maternal height (OR = 0.9, $p = 0.007$), prior day meat consumption (OR = 0.3, $p = 0.010$), and reported birth weight (OR = 0.3, $p = 0.007$) reduced the likelihood of stunting.

None of the salivary cortisol measures (waking, evening, slope) in pregnancy or early PP were associated with either early PP HAZ or stunting (data not shown).

Composite multivariate models of early PP HAZ, and of stunting

Hierarchical linear regression models of early PP HAZ revealed, prior to inclusion of cortisol variables (step 1), that higher HAZ was associated with not having a dirt floor ($p < 0.001$), taller maternal stature ($p = 0.050$), prior-day meat consumption ($p = 0.016$), higher reported birth weight ($p < 0.001$) and a mother's perception of having sufficient breast milk ($p = 0.046$) (Table 5.3.A). The model captured 31% of variability in early PP HAZ. In step 2, all cortisol measures failed to significantly enter the model.

Hierarchical logistic regression models of early PP stunting revealed, prior to inclusion of cortisol variables (step 1), that having a dirt floor (OR = 7.8, p = 0.008), higher paternal support (OR = 1.5, p = 0.005) and emotional distress during pregnancy (OR = 1.7, p = 0.21), higher autonomy early PP (OR = 3.7, p = 0.009) and insufficient breast milk (OR = 12.5, p = 0.022) increased the likelihood of early PP stunting (Table 5.3.B1). Taller women (OR = 0.9, p = 0.022), and those who had eaten meat the previous day (OR = 0.1, p = 0.003) had a lower likelihood of having a stunted infant early PP. In step 2, early PP waking cortisol entered the model at p = 0.058, and altered the significance of three variables: older age newly emerged as reducing the likelihood of early PP stunting (OR = 0.9, p = 0.009) and the significance of emotional distress during pregnancy and having insufficient breast milk on early PP stunting was lost (Table 5.3.B2). Early PP evening cortisol also entered the model, with higher concentrations increasing the odds of early PP stunting (OR = 1.3, p = 0.023) and resulting in dirt floor, emotional distress and having insufficient breast milk loosing significance (Table 5.3.B3).

Determinants of change in HAZ (ΔHAZ) per month between early and later PP

Infants who were stunted early PP showed an increase in linear growth by 4-6 mo PP (0.13 HAZ units/mo) whereas those who were of normal height early PP did not (-0.13 HAZ units/mo) (student t-test, p < 0.001).

Exploratory multiple linear regression models of ΔHAZ, controlling for early PP stunting

In the exploratory models, ΔHAZ was negatively associated with later PP food insecurity in the household factor model (Table 5.4). No social factors were significant. Among maternal factors, ΔHAZ was positively associated with early PP maternal BMI (p = 0.030) and negatively with presence of ≥ 2 maternal stool protozoa early PP (p = 0.021). Among the infant factors, ΔHAZ was negatively associated with difficulty breastfeeding (p = 0.019). ΔHAZ was positively associated with waking cortisol concentration measured later PP (p = 0.034).

Composite linear regression model for ΔHAZ

Hierarchical linear regression models of ΔHAZ revealed, prior to inclusion of cortisol variables (step 1), that the rate of linear growth was positively associated with maternal height (p = 0.030) and BMI (p = 0.022), infants being female (p = 0.014) and early PP stunting (p < 0.001).

Conversely, ΔHAZ was lower in women who experienced problems with their partner ($p = 0.043$) and who had difficulty breastfeeding ($p = 0.040$) (Table 5.5.1). The model captured 35% of the variance in ΔHAZ. Later PP waking cortisol entered the model, with higher concentrations being positively associated with ΔHAZ ($p = 0.037$), and altered the significance of three variables: maternal autonomy newly emerged as negatively associated with ΔHAZ ($p = 0.034$) and maternal height and BMI lost their association, resulting in a modest reduction in the model R^2, to 0.336 (Table 5.5.2).

Discussion

Within a context of extreme poverty, our study provided evidence that several indicators of maternal psychosocial stress were negatively associated with infant linear growth and that variables associated with poor living conditions and malnutrition also contributed to infant stunting. Among psychosocial factors, emotional distress and higher paternal support during pregnancy and higher maternal autonomy early PP increased the likelihood of early PP stunting. Change in HAZ between early and later PP visits was lesser if the mother had higher autonomy during pregnancy and experienced problems with her partner. With regard to salivary cortisol, higher evening cortisol concentrations measured early PP increased the likelihood of early PP stunting and higher waking cortisol concentrations measured later PP were associated with a greater ΔHAZ. Furthermore, when salivary cortisol concentrations were included in composite multiple regression models, having insufficient breast milk and emotional distress lost statistical significance in the model for early PP HAZ, and maternal height and BMI lost significance in the model for ΔHAZ, suggesting a potential interaction between cortisol and these variables. Together, these data indicate that, in addition to the well-documented role of maternal nutrition and infection and poor living standards, stressful social conditions and emotional distress experienced by the mother contributed to impaired linear growth of these *Mam*-Mayan infants.

Study findings provide evidence that certain maternal nutritional status and dietary factors influenced infant linear growth in the first six months postpartum. Analyses confirmed the association of infant stunting with shorter maternal stature, especially well described in developing countries (Black et al. 2013, Ozaltin et al. 2010, Prendergast & Humphrey 2014) including in Guatemala (Berngard et al. 2013, Frojo et al. 2014). In a pooled adjusted model of over half a million children from 54 low- and middle-income countries (Ozaltin et al. 2010), stunted mothers were 2.1 times as likely as non-stunted mothers to have a stunted child. In Chimaltenango (Frojo et al. 2014), a different indigenous area of Guatemala, stunted mothers had a 2.6-fold increased likelihood of having a stunted child – comparable to the 2.7-fold increased risk in our study population.

Our findings are similar to those in several other indigenous areas of Guatemala that showed positive (Frojo et al. 2014) or no association (Berngard et al. 2013) between maternal BMI and infant growth. Interestingly, prior day consumption of meat by mothers was more consistently and strongly associated with infant growth than was BMI. Although meat consumption may be associated with household wealth, it may also represent improved maternal protein intake, known to reduce intrauterine growth retardation in infants of malnourished women (Kramer & Kakuma 2003).

Our ability to explore the association of maternal infection with early infant growth was limited. Maternal nematode (Mpairwe et al. 2014) and urinary tract (Nicolle et al. 2005) infections, previously associated with intrauterine growth retardation, were rare among study women (Chomat et al. 2015). However, stool protozoa emerged in exploratory models for growth, and having a dirt floor in both exploratory and composite models, suggesting that unsanitary living conditions may contribute to impaired infant growth – either through intermittent infection or immune modulation (Black et al. 2013). On the other hand, periodontal disease, previously associated with intrauterine growth retardation (Srinivas et al. 2009), showed no association with infant growth in our population, despite being prevalent (Chomat et al. 2015). Conversely, the negligible prevalence of maternal infection as measured in this study may have increased our ability to tease out that of psychosocial stress.

Consistent with the literature (Black et al. 2013, Jones et al. 2014), infant feeding practices were not associated with linear growth. Although previous research in nearby urban Quetzaltenango (Doak et al. 2013) suggested that infants introduced to ritual fluids, or *agüitas*, before 3 wk of age were more likely to be stunted, we found no such association. However, maternal perception of insufficient breast milk and difficulty breastfeeding were negatively associated with infant HAZ, which may be explained by the “insufficient milk syndrome” (Gatti

2008), emblematic of poor maternal self-efficacy, whereby mothers lose confidence in their ability to breastfeed and therefore supplement or terminate breastfeeding. Infant gender is a potentially related factor. Indeed, although the compromised growth in baby boys found in our data has been well described (Berngard et al. 2013, Frojo et al. 2014, Tumilowicz et al. 2015), gendered feeding practices have been noted in a nearby *K'iche*-Mayan area (Tumilowicz et al. 2015), where mothers reported baby boys as hungrier, not as satisfied with breastfeeding, and requiring earlier complementary feeding compared to girls. These findings highlight the need to address maternal concerns in relation to breastfeeding and infant feeding practices.

Maternal experience of certain psychosocial factors were negatively associated with infant length postpartum. Our findings are consistent with the finding that maternal emotional distress is associated with impaired infant linear growth in developing countries (Surkan et al. 2011), although it is debatable the extent to which our cumulative score of local idioms of distress can be likened to western diagnoses of mental illness (Alarcon 2009). Independent of any direct effect on infant growth, maternal emotional distress negatively impacts parenting behaviour, caregiving practices, and duration of breastfeeding (Lovejoy et al. 2000, Papinczak & Turner 2000). In addition, emotional distress in our study context (Chomat et al. *submitted*), as in other indigenous areas of Guatemala (Sullivan 2007), is associated with factors such as poverty, food insecurity, and problems with partner – all of which could indirectly impact growth.

Maternal autonomy and high paternal support were both associated with impaired linear growth, consistent with the interpretation of stress described previously in this population (Chomat et al. *submitted*). Maternal autonomy is generally considered a measure of empowerment and improved self-efficacy and has been associated with speaking Spanish and higher maternal schooling and earnings in Guatemala (Becker 2006, Glei et al. 2003). However, our data indicate that greater autonomy occurs in a context of heightened vulnerability for study women, characterized by lower household wealth, being single and low paternal and social support, as well as a more "stressed" cortisol rhythm (Chomat et al. *submitted*), all of which in turn have independently been associated with compromised infant growth (Carlson et al. 2015, Dunkel-Schetter 2011, Feldman et al. 2000). Indeed, although maternal autonomy is usually positively associated with infant linear growth (Carlson et al. 2015, Smith et al. 2003), studies in several other countries in the Americas, including Bolivia, Brazil and Haiti (Heaton & Forste 2008, Smith et al. 2003), also found a reverse association. These findings could be explained in several ways. Women with high autonomy may be less likely to breastfeed or spend time with children due to work or house chore obligations (Smith et al. 2003), or may experience more domestic violence (Carlson et al. 2015) possibly due to marital tensions due to shifts in gender relations and women having greater power within the household (Mumtaz & Salway 2009). Finally, increased maternal decision-making may not be a true reflection of autonomy, although this is the dimension most commonly assessed in maternal autonomy questionnaires (Carlson et al. 2015), including in Guatemala (Pebley & Goldman 1995). Indeed, female-headed households tend to be more impoverished and many women may not choose to lack the support of a partner unless faced with an abusive or conflictive relationship (Carlson et al. 2015).

Interestingly, high paternal support was also associated with a more "stressed" cortisol rhythm, despite being associated with low maternal autonomy (Chomat et al. *submitted*). Only a handful of other studies (Dunkel-Schetter 2011) have assessed the association between paternal support and infant growth, measured however as birth weight, generally finding them positively associated, although poor quality and intimacy of the relationship (Chapman et al. 1997, Maisel & Gable 2009, Selcuk & Ong 2012), or support that is not sensitive to recipients' capacities, needs and desire for autonomy (Bolger et al. 2000, Martire et al. 2002), may exert a negative effect. Both lack of support and support that is ineffective, controlling or abusive may have a negative impact on a mother's self-esteem and mental health, reduce a mother's self-efficacy and household decision-making power, and limit access to food and health care (Bonomi et al. 2006, Smith et al. 2003), all of which could negatively impact a mother's ability to provide for her child.

Having previously demonstrated that psychosocial factors were associated with a "stressed" salivary cortisol rhythm in pregnancy and postpartum (Chomat et al. *submitted*), we had hypothesized that a "stressed" maternal salivary cortisol rhythm would be associated with compromised infant linear growth. Unlike other studies which had found a stressed prenatal salivary cortisol response to be associated with impaired infant growth measured either through birth weight (d'Anna-Hernandez et al. 2012, Valladares et al. 2009) or birth length (Bolten et al. 2011), we found no such association, possibly due to the heterogeneity in gestational age among participants and to the difficulty in accurately assessing, and controlling for, gestational age.

However, consistent with our hypothesis, postpartum elevations in maternal evening cortisol concentration were associated with an increased likelihood of early PP stunting.

In the non-pregnant, non-lactating population, higher waking cortisol has generally been associated with a less “stressed”, healthier cortisol profile (Dowd et al. 2009). During pregnancy, lower waking concentrations of salivary cortisol have been associated with stressful life events (Suglia et al. 2010), depression, anxiety and minority status (O’Connor et al. 2014, Pluess et al. 2010). The relationship between waking cortisol and chronic stress is less well understood postpartum. Two studies of mother-infant dyads within the first six months postpartum (Gonzalez et al. 2009, Taylor et al. 2009) found an association between higher waking cortisol and both maternal depression (Taylor et al. 2009) and early life adversity (Gonzalez et al. 2009) whereas we have recently reported that women who did not speak Spanish, were single, and had higher maternal autonomy had lower waking cortisol concentrations in the period up to 6 weeks PP (Chomat et al. *submitted*). The data reported here show that, early PP, higher waking cortisol later PP was associated with greater increase in linear growth between the early and later PP visits. These data highlight the need for further studies on how the stress response shifts during the postpartum period.

We acknowledge certain limitations. The homogeneity of our study population limited our ability to test the effects of ethnicity, altitude, and socioeconomic status on infant linear growth. The small sample size also limited analyses of sub-populations of interest, for instance, infants with early PP stunting. The low prevalence of many maternal infections (Chomat et al. 2015) limited our ability to explore their association with infant growth. We measured only one component of autonomy (decision-making) and of paternal support (involvement), but other dimensions relevant to the *Mam*-Mayan sociocultural context may be informative. Not being able to precisely assess gestational age limited our ability to control for it and therefore limited our analyses of salivary cortisol collected during pregnancy and precluded us from being able to control for prematurity in postpartum analyses. Finally, our analyses were cross-sectional, limiting inferences as to causality.

In conclusion, although findings suggest that a diverse range of maternal factors were associated with compromised linear growth postpartum, associations between infant growth and maternal psychosocial factors were dominant. In particular, infants of mothers who experienced emotional distress, had greater maternal autonomy, were single, and/or had ineffective or disempowering social relationships were most vulnerable to compromised linear growth. Overall, higher waking cortisol concentrations appear to be associated with greater growth between birth and six months postpartum, whereas higher evening cortisol concentrations appear to be associated with increased likelihood of stunting early PP. Study results make a strong case for interventions that include psychosocial factors as determinants of early infant stunting.

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Table 5.1. Association of household, social, maternal and infant variables and salivary cortisol with stunting early and later PP [1,2]

	Early postpartum Stunted (n =38)	Normal length (n = 79)	p-value	Later postpartum Stunted (n = 44)	Normal length (n = 73)	p-value
Household factors						
Household floor type						
Cement/ceramic	65.8	83.5	0.031	70.5	82.2	0.139
Dirt	34.2	16.5		29.5	17.8	
Household sanitation						
Pit latrine, none	86.8	86.1	0.910	95.5	80.8	0.026
Toilet	13.2	13.9		4.5	19.2	
Food insecurity, pregnancy	2.2±2.4	1.5±1.8	0.126	1.9±2.0	1.6±2.1	0.430
Food insecurity, later PP	2.3±2.2	1.1±2.0	0.007	1.9±2.4	1.2±2.)	0.102
Social factors						
Maternal autonomy, early PP	4.4±2.2	3.5±2.9	0.084	3.9±2.8	3.7±2.7	0.159
Maternal autonomy, early PP						
None	10.5	30.4	0.040	25.0	23.3	0.572
Low	60.5	53.2		50.0	58.9	
Moderate-high	28.9	16.5		25.0	17.8	
Paternal support, pregnancy	9.0±2.2	8.1±3.0	0.108	8.5±2.6	8.4±2.9	0.878
Maternal factors						
Maternal age, yrs	23.1±6.0	24.8±7.4	0.215	22.5±6.3	25.3±7.2	0.025
Maternal height, cm	144.4±5.3	147.5±5.1	0.003	144.7±5.7	147.5±4.8	0.007
Maternal BMI, early PP	23.3±3.2	24.0±3.3	0.286	22.7±3.1	24.4±3.2	0.006
Maternal BMI, later PP				22.5±3.5	24.0±3.5	0.026
Prior day meat, early PP						
No	76.5	50.0	0.009	56.1	59.6	0.733
Yes	23.5	50.0		43.9	40.6	
Stool, pregnancy						
<2 organisms	71.4	72.7	0.887	81.0	67.1	0.114
≥2 organisms recovered	28.6	27.3		19.0	32.9	
Emotional distress, pregnancy	1.5±1.5	1.0±1.2	0.060	1.1±1.3	1.2±1.3	0.514
Infant factors						
Reported birth weight, kg	3.0±0.4	3.2±0.5	0.002	3.0±0.4	3.3±0.5	0.004
Infant gender						
Girl	52.6	45.6	0.474	36.4	54.8	0.053
Boy	47.4	54.4		63.6	45.2	

Insufficient breast milk						
No	86.8	96.2	0.110	86.4	97.3	0.051
Yes	13.2	3.8		13.6	2.7	
Difficulty breastfeeding						
No				81.8	93.1	0.075
Yes				18.2	6.9	
Salivary cortisol (nmol/l)[3]						
Waking cortisol, early PP	0.26±0.15	0.22±0.12	0.664	0.25±0.15	0.22±0.12	0.225
Evening cortisol, early PP	0.13±0.12	0.09±0.08	0.381	0.12±0.13	0.09±0.09	0.230
Waking cortisol, later PP				0.21±0.10	0.22±0.12	0.557
Evening cortisol, later PP				0.09±0.09	0.07±0.08	0.199

[1] Continuous variables analyzed using independent-sample t-test, categorical values using chi-square, retained for inclusion in stepwise regression models if p-value < 0.150. Continuous variables are reported as mean ±SD, and categorical variables as prevalence (%)

[2] Infant stunting defined as HAZ < -2SD, and normal growth as HAZ ≥ -2SD

[2] For all early PP cortisol analyses, mother-infant dyads seen at < 7 d PP are excluded, resulting in n = 99

Table 5.2. Exploratory multiple linear and logistic regression models of infant HAZ and stunting early PP [1,2]

	Multiple linear regression Predictors of HAZ score		Multiple logistic regression Predictors of HAZ < -2SD	
	B ± SE	p-value	OR (95% CI)	p-value
Household factors (n=116)				
Household dirt floor [3]	-0.86 ± 0.26	0.001	2.6 (1.1-6.5)	0.035
Intercept	*-0.91 ± 0.50*	*0.072*		
Model summary[4]	*Adj. R^2 = 0.086, p = 0.002*		*Nag. R^2 = 0.070 (0.891), p = 0.049*	
Social factors (n=116)				
Maternal age, yrs			0.9 (0.9-1.0)	0.047
Maternal autonomy, early PP [5]			2.7 (1.4-5.3)	0.003
Paternal support, pregnancy			1.2 (1.0-1.5)	0.032
Intercept				
Model summary			*Nag. R^2 = 0.166 (0.421), p = 0.002*	
Maternal factors (n=116)				
Maternal height, cm	0.02 ± 0.02	0.018	0.9 (0.8-1.0)	0.007
Prior day meat, early PP [3]	0.47 ± 0.22	0.034	0.3 (0.1-0.7)	0.010
Emotional distress, pregnancy			1.3 (0.9-1.8)	0.109
Intercept	*-9.34 ± 2.98*	*0.002*		
Model summary	*Adj. R^2 = 0.089, p = 0.005*		*Nag. R^2 = 0.250 (0.068), p <0.001*	
Infant factors (n=117)				
Reported birth weight, kg	0.87 ± 0.21	<0.001	0.3 (0.1-0.7)	0.007
Insufficient breast milk[3]	-0.77 ± 0.41	0.063	4.0 (0.9-18.4)	0.072
Intercept	*-4.24 ± 0.69*	*<0.001*		
Model summary	*Adj. R^2 = 0.142, p <0.001*		*Nag. R^2 = 0.146 (0.873), p = 0.005*	

[1] All controlled for maternal age, in years (only shown if p-value < 0.150.
[2] Only those variables that had a p-value ≤ 0.15 were tested for inclusion in the models.
[3] Variable coding: 0=no, 1=yes
[4] R^2 refers to each model's coefficient of determination, reported as adjusted R^2
[5] Autonomy coded as 0=none, 1=low, 2=mod-high

Table 5.3. Composite multiple linear and logistic regression models: variables associated with infant HAZ or stunting early PP [1,2]

A. Multiple linear regression model for infant HAZ

	Model 1 (n=109)	
	B ± SE	p-value
Household dirt floor [3]	-0.85 ± 0.23	<0.001
Maternal height, cm	0.04 ± 0.02	0.050
Prior day meat, early PP [3]	0.47 ± 0.19	0.016
Reported birth weight, kg	0.89 ± 0.19	<0.001
Insufficient breast milk [3]	-0.74 ± 0.37	0.047
Intercept	*-8.68 ± 2.67*	*0.002*
Model summary[4]	*Adj. R^2 = 0.306, p < 0.001*	

B. Multiple logistic regression models for stunting early PP, without and with cortisol measures

	Model 1 (n=117) No cortisol		Model 2 (n=99) Early PP waking cortisol		Model 3 (n=99) Early PP evening cortisol	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Household dirt floor [3]	7.8 (1.7-35.6)	0.008	6.9 (1.3-37.0)	0.010	4.3 (1.0-19.3)	0.058
Maternal Autonomy, early PP [5]	3.7 (1.4-9.8)	0.009	4.4 (1.4-13.9)	0.010	3.8 (1.3-11.4)	0.016
Paternal support score, pregnancy	1.5 (1.1-1.9)	0.005	1.7 (1.2-2.3)	0.002	1.6 (1.2-2.1)	0.003
Maternal age, yrs	0.9 (0.9-1.0)	0.119	0.9 (0.8-1.0)	0.009	0.9 (0.8-1.0)	0.006
Maternal height, cm	0.9 (0.8-1.0)	0.022	0.8 (0.7-1.0)	0.017	0.8 (0.7-0.9)	0.006
Prior day meat, early PP [3]	0.1 (0.0-0.5)	0.003	0.2 (0.0-0.7)	0.020	0.1 (0.0-0.6)	0.011
Emotional distress, pregnancy	1.7 (1.1-2.6)	0.021	1.4 (0.9-2.2)	0.123		
Reported birth weight, kg	0.3 (0.1-1.2)	0.086				
Insufficient breast milk [3]	12.5 (1.5-107.2)	0.022				
Waking cortisol (nmol/l), early PP[6]			1.2 (1.0-1.5)	0.058		
Evening cortisol (nmol/l), early PP[6]					1.3 (1.0-1.6)	0.023
Model summary[7]	*Nag. R^2 = 0.558 (0.526), p <0.001*		*Nag. R^2 = 0.532 (0.237), p <0.001*		*Nag. R^2 = 0.513 (0.792), p <0.001*	

[1] All controlled for maternal age (shown only if p-value < 0.150)
[2] Only those variables that had a p-value ≤ 0.15 in prior exploratory models were tested for inclusion in the models.
[3] Variable coding: 0=no, 1=yes

[4] R^2 refers to each model's coefficient of determination, reported as adjusted R^2
[5] Autonomy coded as 0=none, 1=low, 2=mod-high
[6] For all early PP cortisol analyses, mother-infant dyads seen at < 7 d PP are excluded
[7] Nagelkerke R^2 (Hosmer & Lemeshow goodness of fit *P*-value) and model *P*-value

Table 5.4. Exploratory linear regression models for ΔHAZ/mo between early and later PP, for all infants (n=117) [1]

	All infants	
	B ± SE	p-value
Household factors		
Household toilet [2]	0.13 ± 0.07	0.059
Food Insecurity, later PP	-0.11 ± 0.05	0.039
Intercept	*-0.58 ± 0.12*	*<0.001*
Model summary[3]	*Adj. R^2 = 0.248, p <0.001, n = 112*	
Social factors		
Maternal autonomy, pregnancy [4]	-0.13 ± 0.70	0.071
Problem with partner [2,5]	-0.11 ± 0.06	0.069
Intercept	*-0.41 ± 0.12*	*0.001*
Model summary	*Adj. R^2 = 0.220, p <0.001, n = 115*	
Maternal factors		
Maternal height, cm	0.01 ± 0.01	0.072
Maternal BMI, early PP	0.02 ± 0.01	0.030
Prior day meat, early PP [2]	-0.09 ± 0.05	0.078
Stool with ≥ 2 organisms, early PP [2]	-0.12 ± 0.05	0.021
Intercept	*-2.72 ± 0.74*	*0.006*
Model summary	*Adj. R^2 = 0.314, p <0.001, n = 95*	
Infant factors		
Infant gender: girl [2]	0.07 ± 0.45	0.115
Difficulty breastfeeding [2]	-0.17 ± 0.07	0.019
Intercept	*-0.57 ± 0.13*	*<0.001*
Model summary	*Adj. R^2 = 0.230, p <0.001, n = 115*	
Salivary cortisol (nmol/l), later PP		
Waking cortisol	0.02 ± 0.01	0.034
Intercept	*-0.51 ± 0.13*	*<0.001*
Model summary	*Adj. R^2 = 0.178, p <0.001, n = 102*	

[1] All controlled for maternal age and infant stunting early PP (1 yes, 0 no).
[2] Variable coding: 0=no, 1=yes
[3] R^2 refers to each model's coefficient of determination, reported as adjusted R^2
[4] Autonomy coded as 0=none 1=low, 2=mod-high
[5] Domestic violence also entered the model (instead of problem with partner), but weaker model

Table 5.5. Composite multiple linear regression of ΔHAZ/mo between early and later PP, without and with cortisol measures [1,2]

	Model 1 (n=113) No cortisol		Model 2 (n=100) Later PP waking cortisol	
	B±SE	p-value	B±SE	p-value
Household toilet [2]	0.10 ± 0.06	0.127		
Maternal autonomy, pregnancy [3]	-0.11 ± 0.06	0.097	-0.14 ± 0.07	0.042
Problem with partner [2,4]	-0.11 ± 0.06	0.043	-0.13 ± 0.06	0.034
Maternal height, cm	0.01 ± 0.00	0.030	0.01 ± 0.01	0.058
Maternal BMI, early PP	0.02 ± 0.01	0.022	0.01 ±0 .01	0.064
Infant gender: girl [2]	0.11 ± 0.04	0.014	0.11 ± 0.05	0.014
Early PP stunting [2]	0.30 ± 0.05	<0.001	0.30 ± 0.05	<0.001
Difficulty breastfeeding [2]	-0.14 ± 0.07	0.040	-0.17 ± 0.08	0.036
Waking cortisol (nmol/l), later PP			0.02 ±0.01	0.037
Intercept	*-2.24 ± 0.70*	*<0.001*	*-2.13 ± 0.74*	*0.005*
Model summary	*Adj. R^2 = 0.350, p <0.001*		*Adj. R^2 = 0.336, p <0.001*	

[1] Only those variables that had a p-value ≤ 0.15 in prior hierarchical models were tested for inclusion in the models.

[2] Variable coding: 0=no, 1=yes

[3] Autonomy coded as 0=none, 1=low, 2=mod-high

[4] Domestic violence also entered the model (instead of problem with partner), but weaker model

[5] R^2 refers to each model's coefficient of determination, reported as adjusted R^2

Connecting Statement 3

In Chapter 5, I have shown that many of the same factors previously identified (Chapter 4) as being associated with a more "stressed" maternal cortisol stress response were also associated with compromised infant linear growth, including shorter maternal stature, higher maternal autonomy in household decision-making, higher paternal support, and problems with partner. Additional factors associated with compromised linear growth included having a dirt floor, lower maternal BMI, no prior day meat consumption, perceived insufficient breast milk, emotional distress in pregnancy, and/or difficulty breastfeeding, and being a baby boy. That higher evening cortisol concentrations early PP was associated with stunting, and that lower waking cortisol concentrations later PP was associated with reduced linear growth between early and later PP visits further supports our hypothesis that cortisol is a biological mediator in the vertical transmission of stress between mother and infant. In Chapter 6, I document the qualitative narratives emerging from 23 *Mam*-Mayan women (15 of whom were community fieldworkers in our study) from study communities through their participation in Photovoice activities. I particularly focus on their representation of self, and on the sources of stress vs. resilience that characterize local women's lives. Chapter 6 allowed me to validate and contextualize quantitative findings, and to explore in greater depths than had been possible with quantitative methods the complex nature of women's lived environment, and why greater autonomy, or higher paternal involvement may constitute a source of stress for some pregnant and postpartum women.

CHAPTER 6

PHOTOVOICE REVEALS NARRATIVES OF HARDSHIP AND RESILIENCE AMONG RURAL *MAM*-MAYAN WOMEN IN THE WESTERN HIGHLANDS OF GUATEMALA

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Research Highlights

- Domestic violence and low autonomy were main sources of hardship for married women
- Poor social/infrastructural support and gender inequality limited women's ability to sustain themselves independently
- Family, nature, owning livestock, traditional practices and spirituality were sources of resilience
- PhotoVoice was an effective tool for self-representation among indigenous women
- Findings on sources of increased vulnerability for women validated data obtained in parallel quantitative research

Abstract

Critical to the goal of improving health of marginalized populations is an improved understanding of their lived experiences and how they define and understand notions of stress and wellbeing. This study aimed to explore personal narratives of *Mam*-Mayan women living in marginalized, rural communities in the Western Highlands of Guatemala using Photovoice, a photography-based participatory action research method. The objectives were to (1) explore participants' photographs and photo-elicited narratives to better understand how women perceive, experience and engage their lived environments, particularly with regard to sources of vulnerability and resilience, and (2) use these narratives to validate and contextualize findings from a parallel quantitative study. To this end, 23 women from 7 communities, including four traditional midwives and 10 community health workers, were given a personal camera to photograph things that were important to them over the course of 4 months. Groups of 2-6 women met every 2-4 wk to discuss photographs, for a total of 6 sessions. Thematic content analysis of photographs and photo-elicited narratives highlighted 2 scenarios of vulnerability: (1) experiencing domestic violence, low autonomy and socioeconomic dependence, and (2) being a single mother with few employment options and limited rights. Additional sources of stress were poverty, poor social support and the absence of social services. Sources of resilience included family, nature, livestock, traditional knowledge/practices and spirituality. Findings were consistent with those derived from quantitative methodologies. Photovoice emerged as an effective mechanism for women to voice their needs and concerns, while fostering resilience. Women in these communities are marginalized, and require support, yet their very own strength, resourcefulness and resilience are key leverage points for any intervention targeting community health and development.

Introduction

Persisting and in some cases widening ethnic- and socioeconomic-based health disparities have been extensively documented throughout the world (CSDH, 2008), including among indigenous populations (MSPAS, 2015; Mumtaz et al. 2014; Stephens et al., 2006). The need for an improved understanding of the experiences lived by populations that face intersecting social, political, cultural, economic and gender inequalities has been well documented (CSDH, 2008; Napier et al., 2014). However such populations have often been the subject of research and interventions by "outsiders", who largely determine the questions asked, the tools to be used, the interventions to be developed, and the kind of results and outcomes to be showcased. Such an approach may inadvertently neglect what the community deems important and reinforce a sense of impotence, inferiority and resentment (Wang & Burris, 1997). Moreover, conventional research strategies typically view marginalized communities through a vulnerability lens that highlights their dependence on outside assistance (CIHR, 2007; Napier et al., 2014). Local resources, endogenous strengths and knowledge may foster resilience and enable individuals to overcome adversity and thrive, yet are rarely considered (Kirmayer et al., 2011).

Growing interest in finding new ways to understand and address complex health and social problems has intersected in recent years with increasing demands for research that is *community-based*, rather than merely *community-placed* (CIHR, 2007; Gillespie et al., 2013; Napier et al., 2014). This highlights the potential of Participatory Action Research (PAR), an action-oriented approach that attempts to equitably involve community partners in research, drawing on their knowledge and experience, sharing decision-making responsibilities, and building community capacity (Minkler & Wallerstein, 2008). Overarching goals of PAR include equalizing power differences, building trust and creating local ownership in an effort to bring about social justice and change (Castleden et al., 2008).

Critical to the goal of improving health in marginalized populations is an understanding of the local reality affecting vulnerability and resilience. This study used a photography-based PAR method to explore personal narratives of *Mam*-Mayan women living in rural communities in the Western Highlands of Guatemala, with some of the worst maternal-child health indicators in the country (MSPAS, 2015). By giving cameras to individuals who might otherwise not have access to such a tool, PhotoVoice enabled them to document reality through their own eyes, share experiences and knowledge and catalyze change, rather than stand as passive subjects of other people's intentions, perceptions and interpretations, as has been previously reported (Catalani & Minkler, 2010; Wang & Burris, 1997). The objectives of this paper were to (1) explore participants' photographs and photo-elicited narratives to better understand how women perceive, experience and engage their lived environments, particularly with regard to sources of vulnerability and resilience, and (2) to use these narratives to validate and contextualize findings from a parallel quantitative study evaluating factors contributing to maternal stress (Chapter 5).

Methods

Study setting

The *Mam* constitute the fourth largest Mayan population in Guatemala (INE, 2003) and live in the Western Highland departments of Huehuetenango, San Marcos and Quetzaltenango. The *Mam* have lived a long history of marginalization beginning prior to the 1524 Spanish Conquest, when they vied for control of their lands with the more powerful *K'iche'*, and had to relocate to more rugged terrain (Watanabe, 2010). They were later forced to reorganize their social, economic and political lives under Spanish rule (Watanabe, 2010). In the 1980s, political violence between leftist insurgents and the Guatemalan government subjected the *Mam* to brutal counterinsurgency warfare, leaving many communities scarred and their social fabric weakened (CEH, 1999; REMHI, 1999). Lasting effects have included heightened levels of fear, distrust and domestic and social violence (Burrell, 2009), increasing inequality, and large-scale work migration to the United States (US) (Foxen, 2007).

This study was conducted in seven small rural *Mam*-Mayan communities, located in the peripheries of the town of San Juan Ostuncalco, in the department of Quetzaltenango, where we conducted a larger mixed-methods study investigating vulnerability and resilience factors among women during pregnancy and the first six months postpartum (Chomat et al., 2015). A detailed description of population characteristics has been presented previously (Chomat et al., 2015). Briefly, three-fourths of women living in the study area faced extreme poverty and two-thirds were from food-insecure households. The majority (94%) were housewives; 31% were married and 62% in a consensual union; 41% spoke only *Mam* and 54% spoke both *Mam* and Spanish.

Most women had low autonomy in household decision-making, but high levels of paternal support and social support from a close family nucleus. One-fourth experienced domestic violence and/or reported problems with alcohol in the household. Women generally trusted their family and community-based institutions (church, school, health post), but less than half trusted their neighbours or the public hospital.

Study design, ethics and recruitment

The PhotoVoice study was conducted between September 2012 and December 2013, overlapping with quantitative data collection (June 2012 to December 2013) (Chomat et al., 2015). Purposeful- and snowball-sampling techniques were used for recruitment so as to include a mix of traditional midwives (*comadronas*), community health workers (CHWs) and other community women. To this effect, women engaged as fieldworkers in the overarching study were invited to participate. The 15 women (including 10 CHW and one *comadrona*) in turn invited other women, resulting in the addition of four *comadronas* and five other women. Of these 24 women, an elderly *comadrona* did not participate beyond the introductory workshop, resulting in a final sample size of 23 women, aged 16 to 64 years. All gave signed fully informed consent at the beginning of the project, agreeing to participate, and at termination, agreeing that the photographs and photo-elicited narratives could be used for publication.

PhotoVoice

PhotoVoice was first developed by Wang & Burris (1994) for use by Chinese village women to explore the topic of reproductive health and its use has since expanded significantly (Catalani & Minkler, 2010). Most relevant to our work, it has been used to explore stories of daily life and survival among various indigenous communities (Berrang-Ford et al. 2012; Genuis et al., 2015), including in Guatemala (Cooper & Yarbrough, 2010; Lykes, 2001). Three major theoretical underpinnings support PhotoVoice (Wang & Burris, 1997). A participatory approach to documentary photography promotes a grassroots approach to representation, using visual image to facilitate personal voice (Wang & Burris, 1997). Freire's theory of critical consciousness seeks to engage individuals in questioning their historical-social situation (Freire, 1970). Feminist theory seeks to empower vulnerable populations, value experiential knowledge grounded, decolonize dominating discourses of power and representation, and recognize local expertise and insight (Hesse-Biber & Yaiser, 2004; Smith, 1999).

PhotoVoice participants were divided into five groups of two to six women, based on the community where they lived. An initial workshop provided training on how to use personal cameras and relevant ethical considerations. Six group sessions held every two to four weeks allowed participants to meet and discuss their photographs. Participants had 10 to 20 days to complete photography assignments between sessions. Although themes were assigned at the end of each session, participants often simply photographed what was most important to them. In the days prior to the group sessions, participants met individually with the research staff to select the five photographs they wished to have printed. Five women participated in two sessions; one in three; two in four; seven in five; and eight completed the six planned sessions. Of the latter, six women (in two groups) wished to continue, which they did for an extra two sessions. Hence analyses were drawn from a total of 34 sessions.

Two moderators (AMC, EP) and a bilingual Spanish/*Mam* assistant (MGM) facilitated all group sessions. Each participant was given her photographs at the beginning of the session and had the opportunity to share them and explain why they were important to her. Other participants could ask questions or interject. Participants then collectively organized all pictures and discussed the overall themes that emerged. Each woman then selected the picture(s) or theme(s) that spoke most to her, explaining her motives. Discussions lasted for as long as the participants wished to continue. At the conclusion of the six sessions, the women were asked to evaluate PhotoVoice activities.

All group sessions were conducted privately in a location of participants' choice and lasted 60 to 120 minutes. Participants were allowed to keep their photographs and also received a CD of all photographs if they wished to have them printed in the nearby town.

Data Analysis

Group discussions were audio-recorded and transcribed verbatim in Spanish (translated from *Mam* as needed). Participants were involved in an initial, three-stage process: (1) selecting photographs, (2) contextualizing them and (3) identifying issues, themes and theories that emerged. AMC and PL independently tallied all photographs in categories consistent with study aims and participant-identified themes. AMC, the lead author, was present at all sessions and involved in the larger mixed-methods study, whereas PL only became involved for PhotoVoice analyses. Thematic content analysis was also performed on the transcribed photo-elicited narratives, using grounded theory. AMC and PL independently read all transcripts before coding segments and categorizing the codes into emergent themes using MAXQDA 11 (version 11.2.1). Multiple cycles of coding were performed until all themes were coded. Relationships between themes, and the relative importance of each theme, were explored. Inter-coder agreement was verified. EP and MGM, who had been present as moderators in most sessions, independently reviewed the final results to verify that they accurately represented women's narratives as they remembered them. AMC and PL translated into English those excerpts selected for inclusion.

Results

Participants discussed a total of 566 photographs. The main topics are represented in Table 6.1. People were the focus of 72% – most frequently women (64%) and babies/children (38%). Of the remaining photographs, 9% represented spaces of daily living (houses, churches, schools, health posts, parks, roads, vehicles), 6% nature (woods, mountains, trees), 5% agriculture (cornfields, potatoes, black beans, squash, broccoli), 5% animals (dogs, cats, cows, pigs, sheep, chicken, ducks, geese, turkeys), 2% food (mostly maize-based) and 2% trash. The five groups varied in the themes they photographed, some showing greater interest in people, and others in nature or pollution.

Several broad themes emerged from the analyses: representation of a woman's world, gender roles, contexts of vulnerability and hardship, and sources of resilience (Table 6.2).

Representation of a woman's world

The centrality of motherhood in women's lives was clear. All 20 participants who were mothers had taken between one to 12 photographs of a child. Half the women (11) had photographed their mother, six a sister, four a sister-in-law and four a mother-in-law, mostly partaking in activities of daily living. Male family members were represented infrequently. They figured in only 3% of photographs taken by one-third of the participants: six women had photographed a partner/husband, one her father and two brothers, and one her father-in-law.

Most photographs (92%) were taken in the participants' community, and of these, 63% inside a home. Other community spaces included agricultural land, nature, roads, schools, community health posts, churches, street processions, shops, communal washing areas, and cemeteries. Photographs reflected a desire to document and speak of the local reality (Fig. 6.1A):

> "The house is made of adobe. It is a simple house. It is from the community, but it is simple. It is a poor house. It is important because it is a house of the community. It is not a community that has nice houses. It has simple houses." [Group 2]

Photographs illustrated how women lived closely connected to the natural world, on which their livelihoods depended. Maize in particular was present in 8% of all photographs, most often as cornfields (Fig. 6.1B) – from small sprout in April to drying stalk in October – and *nixtamal* (kernels) ready for grinding or soughing.

Some women chose to represent the "other", as illustrated by the 46 photographs taken outside the communities, most frequently in nearby San Juan Ostuncalco where the women went to market (Fig. 6.1C), but also of Quetzaltenango, neighboring volcanoes, Guatemala City's airport, the beach, the coastal area, Mayan ruins, and an amusement park. Representations of the non-indigenous (3) were scarce. Non-indigenous women from San Juan Ostuncalco, represented in two photographs, were described as "being proud" for "their height, their color, their everything." Another woman commented, in reference to domestic violence, "Only with us [the indigenous] do these things happen, with the Ladinos it doesn't happen." Yet another woman mentioned that city folks perceived indigenous people as dirty because of the trash in their communities. Another woman, a *comadrona*, described the fear of one of her patients to go the hospital because she couldn't speak Spanish, and of another because hospital birthing practices broke with indigenous customs, norms and beliefs.

Gender roles

Activities of daily living

Photographs and discussions highlighted clear gendered delineations in all spheres of daily living: "The work of the woman is at home. A man goes out to work and returns only to eat and relax." Two-thirds (69%) of the photographs representing women involved domestic chores: cooking (32%), tending to livestock (20%), weaving (14%), washing clothes (5%) and sweeping (2%) (Fig. 6.2A-E). Women's activities outside of the house were: store keeping (5%), selling goods in the market (4%), cutting wood (3%), working in the fields (3%) and engaging in religion-based activities (2%). Women's involvement in childcare was omnipresent. Health-related activities were depicted in 5% of the photographs, including visits with formal health workers, traditional healers or *comadronas*. Conversely, among the photographs depicting men, 39% represented agricultural activities (Fig. 6.2F), and 26% religion-based activities. Most were taken outside of the home.

Within this division of work and space, participants generally recognized that both men and women worked hard:

> "I think that the work of both men and women is hard, but the woman´s schedule lasts longer. She gets up earlier, she goes to bed later, because of all that she has to do. It is difficult because she does not sit down one moment in the whole day. But men… working in the field is difficult, it is difficult to be under the sun, with back pain and body pain. Bending over is very difficult." [Group 3]

> "A man´s life is difficult, because the one who gives money is the man. Of course, we give men food, and we give them everything. He earns money, however we only stay in the kitchen, we wash and cook and nothing else. But the man goes out to work and his life is under the rain and under the sun." [Group 3]

However, although women often helped men in their activities, most in turn received little help at home. One woman stated, "Certainly, if women can do fieldwork, men can work in the kitchen", and, "Us women can sow, carry manure, plow. But men cannot wash. I say maybe they can't because I have never seen a man wash, never!" Another woman commented, "They cannot even prepare coffee. I have even heard that some have everything served to them at the table. They don´t move a finger!"

Women recognized the strong role of family upbringing and local norms in this division of labor:

> "The mother says, "The boy should not touch a broom, because he is a boy, that it is the work of the girls." So one gets used to the fact that the boy cannot touch a broom, dishes, or anything in the kitchen. And so they grow up with this mentality, and when they are older, they repeat the same story." [Group 4]

Nevertheless, there were exceptions within the community. Indeed, one woman had been raised by her brothers and father, who remained her main source of support. Her photographs showed her adult brothers working in the kitchen, cooking and sweeping, and were often a source of laughter – and envy – within the group.

Household decision-making and autonomy

Discussions highlighted a clear concentration of power and decision-making in the hands of men. As one woman stated, "We, women, are never taken into account. Because God made us women, we have to endure until death. It is the man who is in charge." The participants had several explanations for this. One stated that, "Maybe one as a woman lets herself [be controlled]…" Another commented, "A woman is weaker." Yet another shared, "they still have the same mentality as before, that the man is worth more than a woman."

Limited autonomy extended across all aspects of women's lives. Several participants spoke of men – and sometimes mothers-in-law – not allowing women to use contraception or visit a doctor because "the doctor will see [your reproductive parts]." Partners often decided whether a woman would go to the hospital, even in the setting of a complicated pregnancy, expressing inability to afford costs or mistrust in health professionals' recommendations. In addition, women reported that some men blamed or mistreated their partner if she was unable to conceive, or if she gave birth to an infant of the "wrong" gender. Other areas where men exerted control included in making household purchases and in allowing (or not) women to leave the house, pursue further education, work (with some women being forced to work and others prohibited from doing so), and keep her earnings.

Women's experience of hardship

Partner infidelity, alcohol abuse and violence

A woman's experience of domestic abuse or of alcoholism in her household were each represented by seven participants. Alcohol abuse by men was perceived as a common and grave problem, as illustrated by a photograph depicting the burial of a 25-year-old who had "drunk himself to death." Only once was alcoholism mentioned in a woman, who was abandoned by her husband and struggled to survive. Domestic violence, most often perpetuated by a partner, was also perceived as common, including verbal, emotional and physical. Alcohol, jealousy, infidelity, control over household decisions, and dissatisfaction with a woman's reproductive capacity were often mentioned in association with violence.

> "She was abandoned by her husband. The man drinks every day, and he has another woman. The woman is alone in her house. Sometimes the man comes to hit her and force her out of her house." [Group 5]

> "She cannot go out and work because her husband is alcoholic and very jealous. He does not want her to go out. That is why she stays at home. But she does not have work and has no money to buy food." [Group 5]

Participants reported that most women who suffered from violence usually did so in silence, hiding from their own families and fearful to denounce their partner because of what might ensue. As one woman stated, "Many women endure, even though they are all black and blue, they endure because of fear." Some women's lives were threatened if they left. Women simply found ways to cope:

> "She didn´t sleep at home. When she returned home in the morning, her husband was still there, so she hid in the cornfields. After her husband went to work [she and her daughters] went in and made breakfast." [Group 5]

> "She goes out to work in the fields, or she goes to wash [clothes] so that she can survive with her children. I think maybe she feels ashamed [because her husband drinks], and now more than anything she tries to see how she can keep on going, alone, without anybody's help." [Group 4]

Other perpetuators of violence included sons, mothers- and/or sisters-in-law, nephews and other women. In two cases, women who lived with their in-laws but whose husbands were absent were subject, along with their children, to discrimination, food rationing and beatings. Women felt limited in their ability to leave a difficult situation: "She has nowhere to go, and so she has to endure the life she has. Where can she go with so many children?" If a woman wished to separate from her partner, she could have to leave her children with her in-laws. Others rarely got involved ("Everyone has his own problems, no one can say anything to another person") and women were often reluctant to seek the help of local authorities, who did not always intervene.

Isolation and precariousness of single women

Many women lived alone because their partner had left to work in the US, considered one of the only ways a family could build a house or buy land. These women often had more secure lives through the remittances they received. However, their partners sometimes got involved with other women or stopped sending money back home. If a woman started working, her partner, from afar, sometimes reprimanded her and forbade her to leave the home. Many women felt unsafe without a male figure in the household. Finally, women whose partner had left for the US were often the brunt of gossip:

> "When her husband left she didn't have anything, not even clothes. But when her husband arrived there, he sent money, and so people started talking about her. "Why does she wear new clothes?" or "Maybe she has another man." Or they laugh if the husband doesn't return, or doesn't send money. People gossip about everything." [Group 2]

Women who were single, widowed, or could not rely on their partner lived precarious lives and had limited social support. As one woman stated, "Women almost don´t have anyone. Sometimes they talk with friends if they have friends, but if they don´t, sometimes only with their mother or sister." One woman who received no support from her alcoholic, abusive husband had delivered all her children alone. Women who lived with their parents worried that they would have nowhere to go when they died. A woman's own parents were not always available; fathers had left with another woman or were not particularly vested in their many children, whereas mothers sometimes left for the US to find work.

Single women had few rights, and were sometimes not able to keep land left for them by a deceased spouse or relative. Single mothers supported themselves with difficulty. Their homes were usually of nylon, *adobe* or *lamina*, they had little to eat, and their children were often malnourished and ill. Women were generally seen as ill-prepared to sustain a family, due to low levels of schooling, economic dependence and few employment options. These women resorted to weaving and selling goods in the market, engaged in manual labor, worked as seasonal labor in the low-lying coastal area, or left to work in the US.

> "She wants her children to better themselves, to finish studying and everything, so she decided to leave [for the US]. She is married to a husband who has another woman. That is why she left, because he will not take responsibility for her children. She left six children behind. The youngest girl is two years old." [Group 3]

Finally, many participants wished to document the lives of widows and elderly women, especially those who lived alone and faced extreme poverty. Their homes were characteristically barren and women often lived in one room in which they slept and cooked on the floor. These women were shown working, cooking, tending sheep, weaving, selling produce in the market, or receiving charitable donations from church groups.

Stories of individual and collective resilience

Women's resilience

Women's resilience was striking. One photograph showed a 19-year-old mother of two, who was taking contraceptives secretly because her husband and mother-in-law did not wish for her to control her pregnancies. Most photographs showed women working hard. One photograph showed a 12-year-old girl tending sheep to contribute to her family's livelihood. Her father had died and her mother worked outside of the community as a maid. The girl still went to school and was responsible for fixing meals for her younger siblings. Another photograph showed a 15-year-old girl working her corn mill. She lived with her grandmother and sustained herself alone.

Participants' narratives were largely void of negativity and victimization, despite the adversity they faced. It was uncommon for women to vent their emotions or concerns and talk about their hardships, often due to feelings of shame, mistrust and fear. PhotoVoice participants themselves rarely spoke of experiencing hardships, and if they did, did so with matter-of-fact humor, defiance or wisdom:

> "I am living difficult moments. I took this picture because my life is very difficult because I am carrying my baby. He weighs so much!!! But he will only weigh more and more and more!" [Group 1]

> "When he hit me, he hit me hard, and he kicked me. So I took a bottle of milk and hit him here, and he was bloodied. My mother-in-law entered and told me, "You bloodied my son!" So I ran. He was going to hit me again, so I took a broom and defended myself! Hahaha …"" [Group 5]

Nature

Nature emerged as an important source of resilience, offering a space where women could relax and feel well. Most women photographed trees or flowers and showed sensitivity to the beauty and bounty of nature. One woman shared, "The lemon brings happiness, and the chili pepper brings happiness, because they are useful in the kitchen." The women valued the earth, water, trees, mountains and crops for being a source of life, and for sustaining them.

> "Without trees human beings cannot live. It is the trees that give air, that give breathing. The river also is the health of the human being. It is from water that we drink. Without water we cannot live." [Group 1]

> "Land is very important in the community. Without the earth we cannot live, and we cannot make a community, and we cannot eat. Here in the community the cornfield is very important, because without it people cannot live." [Group 5]

Crops, especially potato, broccoli and cauliflower, were valued for being a source of income, and maize, for being the base of their life and strength. As one woman stated, “If we don´t eat tortilla, or tamal, we faint. We don´t have the same energy, we do not feel like doing things, as if we were malnourished.”

Animals

Animals emerged as a significant source of companionship and the women spoke of them with affection and pride: “I like my cow. I just like her.” Another woman stated, “I [take pictures] so that I can have a memory of [my animals], for when they leave us.” Dogs and geese provided protection; cats caught mice; cows provided milk, manure and meat; and sheep provided manure and wool (Fig. 6.3). Livestock provided an important source of income: “We women do not have work, but we have a few animals that grow, and so we sell them to help ourselves.” Selling a chicken could allow a woman to buy clothes for her children when her husband did not have enough money.

Solidarity and social support

Family, especially children, was a significant source of strength for women, household help, a more secure household economy, and physical security if one had boys. Children were often mentioned as a woman’s only source of support. Several participants mentioned communities coming together to help someone in need, such as to provide shelter or help build a house. Women often came together to cook for community events (Fig. 6.4A-B).

The community health post provided free maternal and child health services. However, participants had heard that these services would be dismantled, which they ultimately were, highlighting the precariousness of public services. Schools taught children to read and write and allowed them to “become someone.” Church groups, catholic and evangelical, supported individuals living precarious lives and organized charity events for widows and poor families, providing them with wood and staple foods. Several photographs represented “praying groups” who visited the homes of the poor or ill. One church provided support to alcoholic men and their families: “Sometimes the brothers visit those who drink, because their wives live in violence. But when they arrive in this church is when peace enters their home.”

Traditional perspectives

Several women documented traditional knowledge and practices, such as using a grinding stone to grind corn or making thread from sheep's wool. Participants believed that mechanical mills (*molinos*) and running water had made life easier – although some women, especially the elderly or poorest, still ground their own corn and fetched water, and most women still used communal washhouses. In a context where most women could not readily access, or did not trust, formal health services, the traditional healers and *comadronas* were an important resource. Medicinal herbs used in the communities (*ruda, hinojo, manzanilla, hoja de naranja*) as remedies for gastritis, diarrhea, parasites or *susto* (i.e., fright) were shown in eight photographs. Finally, women's wearing of the Mayan traditional clothing, and the many photographs depicting women weaving (Fig. 6.2B), also represented Mayan tradition and beliefs, as many patterns covertly carry deep Mayan symbolism (Fig. 6.4C).

Mayan spirituality

Mayan ceremonies were shown in four photographs (Fig. 6.4D). Although some women mentioned disapproval for such practices ("There are many who think that the Mayan ceremony is of witches"), they also spoke of their continued practice by some and of sacred sites nearby. These ceremonies were used to give thanks for life or for a good harvest, for protection against harm, for successful studies or to be cured from illness. Several participants' narratives revealed that Mayan spiritual concepts provided with meaning and a sense of connection with nature. These involved "giving thanks for everything that is of this earth", including "the darkness, because the darkness has the night", and "water, sun, air, hills, and, how do you call them, the volcanoes too." Several women referred to Mother Earth:

> "[It is important to give] thanks to the earth, because the earth is that which gives, like one's mother. The earth is like the mother of human beings, because it gives life, and the harvest, and the air." [Group 5]

Informal process evaluation

The women rarely spoke directly of their own lives, instead voicing the hardships lived by other women in their communities. Over time, many participants became more confident in speaking about issues that concerned them. Several women became increasingly engaged with storytelling and identified themes that they wished to document. One participant was especially concerned about the pollution in her community, and brought her photographs to the local authorities, wishing to raise awareness. Another participant, a *comadrona*, wished to tell the story of her patients, and how they navigated the traditional and formal health systems, especially emphasizing how they felt discriminated against.

Many women were proud that they had learned to take photographs. Women described the sessions as a place where " I can laugh, and speak about everything and anything, and so forget about my troubles and worries for a while", and "open my mind." Participants also commented that having a camera and taking photographs allowed them to escape from their own difficult realities, visit with other women, and learn about others' lives. Several thought this had helped them put their own troubles in perspective: "I speak of my worries with the women, and they speak to me of theirs, and so I feel more at peace, because when I was only locked up in my home, I thought that I was alone in suffering from such problems." Another women saw in this process a source of personal healing, where she was able to find meaning:

> "One goes through certain troubles, and it is very difficult to confront them. But through them you learn to see and value things. Sometimes if one doesn't go through a difficult time, it is hard to understand the problems that another woman is suffering. But when one has lived that, and one hears about the life of someone else that is very difficult, then you are able to understand why you yourself had to go through hardship." [Group 5]

Finally, participants indicated that the photographs were affective records of daily life for themselves and for the individuals they photographed.

Discussion

PhotoVoice was an effective tool for self-representation by rural indigenous *Mam* women. The women were able to articulate, frame, and openly discuss personal and communal experiences in ways that led to a nuanced read of their everyday lives and represented how they experienced their lives.

Triangulation with quantitative analyses and findings

The study's qualitative narratives validate and complement data obtained in parallel quantitative research (Chapter 5), illustrating that mixed-methods research provides a better understanding of the subject under study than either qualitative or quantitative methods alone (Bryman, 2006). Quantitative analyses revealed that mothers who were single, with lower household wealth and food insecurity, higher autonomy in household decision-making, greater paternal involvement, and/or who experienced domestic violence experienced more stress in, as assessed through women' diurnal cortisol rhythm (Chapter 5). Two contexts of increased vulnerability emerged from qualitative analyses that helped to contextualize these findings. In the first, women experienced domestic violence, usually from an intimate-partner but also from in-laws or parents, and low autonomy in household decision-making and reproductive health, yet difficulty to leave and build a better life, most often due to fear, economic dependence, and the burdens of motherhood. In the second, generally perceived as that of worst adversity, women lived alone with their children, either due to abandonment or to the loss of a partner or other family members, and struggled to sustain themselves on their own in a society that offers few employment options for women, few rights to protect them, and limited social services.

PhotoVoice narratives hence helped give life to categorical measures relating to women's sociocultural environment, adding new insights and layers of meaning relevant to interventions targeting maternal and child health and wellbeing in this area of Guatemala. Such understanding will help improve measurement instruments, which will enable to more reliably assess the impact of psychosocial factors on maternal and child health. Most importantly, the cross-validation between quantitative and qualitative findings strengthens our overriding conclusion, that addressing a woman's psychosocial environment, namely factors such as gender relations, self-agency and availability of effective social support, are critical elements of public health initiatives serving this marginalized population.

Strength-based narratives

Although PhotoVoice narratives spoke of women's vulnerability, they spoke yet stronger of resilience. Women emerged as being resourceful in finding strategies that allowed them to navigate through adversity, survive and create better opportunities for their children. This provides an interesting contrast to quantitative methodologies, which conversely highlighted vulnerability rather than resilience (Chomat et al., 2015; Chapter 5). This is partly because we did not have sufficient insider view of the local culture at the study's outset to design instruments that could fully capture local sociocultural norms, beliefs and practices, which are shaped by complex local histories and geographies, as well as by broader structural inequalities (Foxen, 2010). Nevertheless, our findings are representative of the tendency in epidemiological research to focus studies involving indigenous populations on risk and vulnerability (Kirmayer et al., 2011; Napier et al., 2014), and reaffirm the need to better integrate endogenous sources of strength and resilience into such studies.

Women's narratives described an interconnectedness and interdependence of the individual within family and community, and a strong connection to traditional knowledge and the natural world reminiscent of the sociocentric (van Uchelen, 2000) and ecocentric (Kirmayer et al., 2011) narratives of self characteristic of many indigenous communities. Adherence to Mayan spiritual beliefs and practices was clearly both a source of resilience and a taboo practiced only covertly, which most women were hesitant to speak of. The covert nature of Mayan ceremonies has been well described in indigenous areas of Guatemala and is expected given their historical repression (Anckermann et al., 2005; Hart, 2008). PhotoVoice narratives are a powerful reminder that populations perceived as poor and marginalized might in fact possess unique knowledge and coping skills, allowing for survival despite adversity. Concepts of harmony and interconnectedness; local traditional medicine knowledge and healing practices; close family networks; and women's resilience and resourcefulness are examples of potentially powerful leveraging points in community health and development programs.

PhotoVoice as intervention

The group sessions facilitated women's engagement in active, transformative listening and allowed a context of support and solidarity to develop, although achieving trust within the group was an important prerequisite, as found in other indigenous-based Photovoice projects (Castleden et al., 2008). Evident in women's narratives is the extent to which the process of facilitating other women's – rather than their own – stories, common as well in other studies in Guatemala (Lykes & Crosby, 2015; Nolin & Shankar, 2000), allowed participants to safely speak of their own truths in their search for meaning and wellbeing. It also allowed the women to hear of other women's hardships and develop empathy and solidarity, as similarly was observed in a PhotoVoice project with Ixil women in Chajul, Guatemala (Lykes, 2001). Finally, when participants experienced a sense of wellbeing and belonging with their group, they moved from isolation and victimization to become protagonists in their own lives. These observations add to those from previous studies in Guatemala (Anckermann et al., 2005; Lykes & Crosby, 2015) in suggesting that participatory women's groups and creative methodologies may be effective, culturally sensitive strategies allowing indigenous women to overcome hardship and personal stress and build not only personal, but also collective, resilience.

Limitations

Photography presents particular limitations for research, in part because that which is not photographed is unobservable (Castleden et al., 2008). For instance, because of the gendered nature of lives in the study area, women's narratives were biased towards women's and men's worlds were for the most part absent. The home base of the majority of the photos could be due to a certain hesitancy to walk around in the community with a camera. Limiting discussions and analyses only to women's "best" photographs may have skewed the study's results by not taking into consideration the full range of data collected. Finally, trust was difficult to achieve with some women, especially in one group comprised of women from three distinct communities; these women participated yet only discussed neutral topics. Finally, data analyses and presentation of the data was primarily an academic enterprise, which might have biased the information chosen for presentation, and how it was organized and interpreted.

Conclusion

A localized ethnographic approach is key to understanding the complex layers of psychosocial wellbeing in the predominantly indigenous Western Highlands of Guatemala. PhotoVoice emerged as an effective tool for women to voice their needs and concerns, while also fostering resilience. Women in these communities are marginalized, and require support, yet women's strength, resourcefulness and resilience are key leverage points that ought to be fully engaged in any intervention targeting community health and development.

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Table 6.1. Themes photographed, by Photovoice group [1]

	Group 1	Group 2	Group 3	Group 4	Group 5	Total
Number of sessions (n)	6	8	6	6	8	34
Number of photos (n)	132	90	102	55	187	566
Attended ≥ 2 sessions (n)	6	4	5	2	6	23
Attended all sessions (n)	1	2	0	1	4	8
Main focus of photograph						
People	57%	47%	78%	76%	89%	72%
Daily spaces	10%	17%	14%	5%	4%	9%
Nature	14%	14%	0%	5%	1%	6%
Agriculture	8%	7%	4%	9%	2%	5%
Animals	7%	7%	4%	4%	3%	5%
Food	4%	4%	0%	0%	0%	2%
Trash, pollution	1%	4%	0%	0%	2%	2%
People photographed						
Women	34%	32%	53%	44%	59%	46%
Children, infants	19%	20%	35%	28%	32%	27%
Men	5%	7%	16%	11%	12%	10%
Elderly	2%	3%	4%	5%	11%	6%
Family members photographed						
Self	2%	2%	4%	4%	4%	3%
Child	11%	8%	12%	13%	11%	11%
Mother	4%	2%	1%	2%	2%	2%
Sister	2%	3%	0%	0%	1%	1%
Partner	0%	1%	5%	0%	2%	2%
Brother or father	0%	0%	0%	4%	1%	1%
Hardship intentionally represented						
Poverty	5%	17%	6%	11%	13%	10%
Domestic violence	0%	6%	0%	2%	9%	4%
Alcoholism	0%	2%	1%	0%	7%	3%
Difficult life	15%	23%	11%	20%	21%	18%

[1] Prevalence (%) calculated as number of photographs out of total number of photographs discussed

Table 6.2. Main themes and sub-themes that emerged from photographs and photo-elicited narratives

Representations of a woman's world	Gender roles	Vulnerability & hardship	Sources of resilience
• Most photos (92%) taken in community, 2/3 in the home • Motherhood • Mother, sister are closest relatives • Rare male figures • The "other"	• Activities of daily living • Gendered division of space • Household decision-making	• Partner infidelity, alcoholism, violence • Low autonomy • Single mothers • Poor support • Psychosocial stress • Poverty, no food	• Strong women • Nature, animals • Small earnings • Children support • Church groups • Mayan spirituality • Traditions

Figure 6.1. A woman's world: A. Typical *adobe* house from the communities [Group 5]. B. "In the community, most people sow corn [*milpa]*." [Group 1]. C. Market day in San Juan Ostuncalco [Group 2].

Figure 6.2. Gender roles: A. "It used to be the custom for women to grind their corn by hand" [Group 5]. B. "My sister-in-law's daughter is weaving a *huipil* [traditional Mayan blouse]." [Group 5]. C. "All women wash their clothes. They work hard, every day they wish their clothes in the morning" [Group 3]. D. Woman tending sheep [Group 5]. E. "She is tilling the earth so that the potatoes will grow" [Group 1]. F. "This man is going to work in the field." [Group 5]

Figure 6.3. Animals: A. “Dogs help to guard the house, or to be your friend” [Group 2]. B. “This is my cat. He helps protect the house and eats the rats” [Group 1]. C. “These are my animals. I gave them grain to eat” [Group 4]. D. “These geese help guard the house, like dogs” [Group 2]. E. “Here are our cows. We dedicate ourselves to raise them, so that we can sell them. This is our work.” [Group 5]. F. “I am happy for my pigs. Women who don’t have work put her animals in her house, to protect her, and they are also useful for fertilizer, to sow” [Group 4].

Figure 6.4. Sources of resilience: A. Elderly women cooking together [Group 5]. B. "We were sad for a 25-year old young man who died. Here we are cleaning meat for lunch" [Group 3]. C. "This holds the symbolism of the woven *huipil* [traditional Mayan blouse]" [Group 3]. D. "My father is a Mayan [priest]. It is customary to pray to God for the harvest." [Group 5]

CHAPTER 7

GENERAL DISCUSSION

Major findings

The overall objectives of this thesis were to (1) evaluate individual-, social- and household-level sources of vulnerability vs. resilience for mother-infant dyads living in a rural, *Mam*-Mayan area in the Western Highlands of Guatemala, using mixed-methods (2) assess these variables' association with the maternal stress response, measured via the maternal diurnal cortisol rhythm, (3) explore the extent to which determinants of poor infant growth include not only maternal nutrition and infection factors, but also psychosocial factors, and (4) assess the role of maternal cortisol as a biological mediator in the vertical transmission of stress. The goal was to do so through Participatory Action Research (PAR), so as to ground research in the local reality as much as possible, optimize local relevance, engagement and participation, and lay building blocks towards empowering local populations to become agents of change in their own lives and communities, be able to translate research findings into action, and ultimately break the vicious, intergenerational cycle of early life stunting affecting most local families.

First, we were able to demonstrate that rural, *Mam*-Mayan women had basal hypocortisolism (i.e. waking and evening cortisol concentrations on the lower range of those previously reported in the literature). This could be explained by chronic stress experienced at the community-level and resulting in chronic HPA axis activation, as could result from repeated infections (Edwards et al. 2011) or from ongoing psychosocial stress due to poverty, discrimination and crime (deSantis et al. 2015, Edwards et al. 2011, Karb et al. 2012, Miller et al. 2007) – all of which emerged as lived experiences in qualitative narratives. Second, within this context and throughout the perinatal period, social environments characterized by either (1) low social and paternal support, poorer wealth, food insecurity and mother-driven household decision-making, or (2) a highly involved partner, low maternal involvement in decision-making and domestic violence were sources of increased vulnerability for women, as illustrated by a diurnal cortisol profile suggestive of relatively greater exposure to chronic stress (i.e. low waking cortisol, high evening cortisol, and/or flatter diurnal slope) than their non-affected peers. Third, maternal emotional distress, as captured by local idioms of distress, was associated with experiencing low social support, problems with a partner or domestic violence, but was not associated with the diurnal cortisol rhythm.

Fourth, household and maternal nutrition factors (having a dirt floor, short maternal stature, lower BMI, not eating meat the previous day) and infant-level factors (male gender, low birth weight) were not the only factors to negatively impact HAZ in the first six weeks postpartum or growth up to six months postpartum. Indeed, so did psychosocial factors such as emotional distress, higher maternal autonomy, higher paternal support and having problems with an intimate-partner. Finally, insufficient breast milk and difficulty with breastfeeding, which could either relate to compromised maternal nutrition status (Black et al. 2013) or to poor self-efficacy (i.e. "insufficient breast milk syndrome", Gatti 2008), were also associated with compromised early infant growth.

Fifth, mothers' postpartum – but not prenatal – salivary cortisol was associated with infant growth, with higher evening concentrations in the first six weeks postpartum being associated with shorter HAZ and increased risk of stunting, and higher waking concentrations measured four to six months postpartum being associated with greater linear growth since birth. Hence mothers' cortisol may act as a biological mediator between the maternal and the infant environment. In particular, cortisol may mediate the effect on infant growth of maternal height and BMI, and emotional distress, given that these variables lost their significance in the multiple regression models after the addition of cortisol variables. Study findings hence highlighted the multiplicity of factors influencing maternal wellbeing and early infant growth and some potential pathways for the vertical transmission of stress, including biological (i.e. cortisol) and behavioural (i.e. the effect of self-efficacy on breast feeding).

Sixth, women's own narratives with regard to local women's experience of vulnerability vs. resilience were for the most part highly consistent with findings uncovered by quantitative methodologies, validating study findings. Further, these narratives added depth to quantitative analyses, highlighting for example that perpetrators of domestic violence were most frequently partners, but also in-laws, that contexts of violence often co-occurred with alcoholism, infidelity and jealousy that limited women's activities, that partners sometimes exerted their control over household-decisions, including a woman's ability to leave the house, even if living abroad, and that women who had ineffective or no partner support often had the most precarious lives of all, characterized by poverty, food insecurity and sometimes lack of shelter. Women's narratives also highlighted the importance of several new dimensions that emerged as important factors for women's wellbeing and resilience, including satisfaction with social support received, partner fidelity, mobility-autonomy, safety within the home, independent source of income, ownership of livestock, connection with animals and the natural world, and spirituality. Finally, the Photovoice methodology showed that engaging in the process of story telling and sharing with other women created a space of empathy, solidarity and critical consciousness that allowed participants to place their own lives in perspective, interrogate everyday experiences of powerlessness and suffering, create their own, strength-based narratives, and encounter together possibilities for growth, action and change.

Lastly, highlighting the poor local uptake of biomedical concepts of health and illness, women reported local idioms of distress – both in themselves and their infants – more frequently than they did symptoms characteristic of a biomedical understanding of health and illness. The overwhelming use of *comadronas* for both prenatal and delivery care was undoubtedly tied to local cultural norms and preferences and greater trust in traditional practices. In addition, study findings included an unexpectedly high occurrence of estimated preterm births, affecting one-fourth of the 82 infants for whom maternal last menstrual period was known; a high rate of microcephaly, affecting one-sixth of infants; and a high rate of neonatal mortality, at 27 per 1,000 live births, compared to 18 overall in Guatemala and 21 within its indigenous population (MSPAS 2010).

Reflections on main study findings

Early infant stunting

The high prevalence in our population of early infant stunting is concerning, and may be associated with our observation of a high neonatal mortality rate. From an epidemiological perspective, these rates are based on a very small number of cases (i.e. 36 stunted infants early PP, four neonatal deaths) in a small population, and may be concealed within health survey data covering larger populations (MSPAS 2010). However, from a marginalized, small community perspective, even a few cases can have devastating effects on community wellbeing (Stephens et al. 2006). Health statistics in marginalized, minority populations will not affect targets such as those set by the Millennium Development Goals, which focus on large targets at national and international levels (UN 2000), and can be achieved even as small, marginalized sub-populations continue to experience poor or even declining health statistics (Stephens et al. 2006). This is a critical point, as it may jeopardize political will to understand and address the needs of the most marginalized, and highlights the need for documenting the health status of marginalized populations separately.

Only recently has linear growth faltering in infants less than six months of age been considered (Solomons et al. 2015, Victora et al. 2015), as anthropometric data collected prior to this period has historically focused on infant weight, which is however thought to have a very different pathophysiology (Victora et al. 2015). The focus on linear growth during this period is important as is it associated with deleterious long-term outcomes (Victora et al. 2008), and highlights the need for prenatal interventions.

Low prevalence of detection of infection

Laboratory-diagnosed gastrointestinal infection was rare. Despite a high prevalence (~75%) of non-pathogenic protozoans, a potential indicator of an unsanitary environment, women exhibited a low prevalence of helminth (*Ascaris lumbricoides*) or other parasitic infections (*Giardia spp., E. histolytica/dispar*) compared to that found in prior research in Guatemala (Anderson et al. 1993, Cook et al. 2009, Jensen et al. 2009), including in regions at similar altitudes to our study area (Cook et al. 2009, Jensen et al. 2009). One study in particular (Cook et al. 2009) evaluated the stool of children aged 5-15 y in a nearby rural area, Palajunoj Valley, where prevalences of specific parasites were high: *A. lumbricoides* 18%, *E. histolytica* 16%, *G. lamblia* 11%, *H. nana* 5% and *B. hominis* 3%.

Explanation of a lower than expected infection burden among study women could be due to the specific demographics of our population, or the particular ecology of our study area, including altitude, water source, soil content, precipitation and temperature, all of which have been associated with parasite burdens in other studies (Chammartin et al. 2013, Gunawardena et al. 2011, Mabaso et al. 2003), including in high-altitude areas of Bolivia (Chammartin et al. 2013) and Nepal (Kunwar et al. 2006). Others have similarly found significant differences in infection prevalence between neighbouring rural communities through spatial clustering analyses

(Halpenny et al. 2013). Alternatively, the low prevalence of helminth infection in study women could be due to the lower sensitivity of direct smears compared with Kato-Katz for detecting nematode eggs (Montresor et al. 1998), although the direct smear methodology was validated for detection of nematodes via Kato-Katz on 30 specimens, with a finding of 100% concordance in detecting no infection in women of reproductive age from our study area. Nevertheless, maternal stool non-pathogenic protozoa emerged in exploratory models for growth, and having a dirt floor in both exploratory and composite models, suggesting that unsanitary living conditions may contribute to impaired infant growth – either through intermittent infection or immune modulation (Black et al. 2013). Our study observations are intriguing, and further evaluation of the communities' distinct ecology may prove informative with regard to factors (environmental and human) that may reduce the risk of infection in this area of Guatemala.

Moreover, our study design excluded testing for various potentially immune-modulatory infections, including cervicitis and bacterial vaginosis/vaginitis – detected at a high prevalence in an infection study of pregnant Ngäbe and lactating women in Panama (González-Fernández et al. 2015) – and other subclinical infections (i.e. respiratory) that may have a profound effect on growth. A more focused study on maternal infection in this population may help better elucidate the true infection burden (clinical and subclinical) within this study population, and the extent to which infection and inflammation play an active role in early infant growth – something we were not able to fully assess with our study's data.

The absence of pathogenic intestinal parasites recovered from the stool of infants less than six months of age is not surprising, as infants are minimally exposed at this young age to food sources that may carry fecal contamination. Intestinal parasite infections have most consistently been associated with preschool and school-aged children (Bethony et al. 2006), as previously reviewed in Chapter 2. Nevertheless, one-third of study infants aged four to six months had evidence of fecal leukocytosis, indicative of intestinal inflammation and most likely due to bacterial infection and/or environmental enteropathy (Keusch et al. 2014). Environmental enteropathy is common in developing countries and can develop as early as 2-12 weeks after birth due to chronic exposure to fecal contamination (Korpe & Petri 2012) or, perhaps more likely in this population, to early nutritional deficits, including *in utero*, leading to intestinal microbial colonization (Keusch et al. 2014).

Cortisol as a biological marker of the maternal stress response

Our study findings provide support for the theory that HPA axis activity – and cortisol – may play a role in associations among maternal experience (i.e. low household wealth, experience of psychosocial stressors), cumulative maternal stress, and the health of the mother-infant dyad, as assessed through infant linear growth. As reviewed extensively in Chapter 2, these findings are consistent with prior findings in the literature. First, prior associations have been uncovered, both in pregnant and non-pregnant populations, between the diurnal cortisol rhythm and socioeconomic status (deSantis et al. 2015, Thayer & Kuzawa 2014), social support (Karb et al. 2012, Valladeres et al. 2009), and domestic violence (Miller et al. 2007, Valladares et al. 2009). Second, compromised infant growth – usually measured as birth weight – has been associated with emotional distress (Surkan et al. 2011), lower household wealth (Black et al. 2013), lower social support (Dunkel-Schetter 2011), both low and high autonomy (Smith et al. 2003, Carlson et al. 2015), and domestic violence (Murphy et al. 2004). Finally, maternal prenatal cortisol has also been associated with both infant birth weight (d'Anna-Hernandez et al. 2012, Hompes et al. 2012, Kivlighan et al. 2008, Valladares et al. 2009) and length (Bolten et al. 2011). Taken together, these findings support the hypothesis that deviations from normal HPA activity, associated with a variety of stressors, is a plausible biological mechanism for the observed relationship between maternal experience and early infant growth.

Nevertheless, it remains a challenge to disentangle the multiple, cumulative sources of stress that any one woman may experience – or have experienced in the past – and the specific mechanisms through which each may influence cortisol activity. In particular, mechanisms might be distinct depending on the stressor. For instance, it is likely that maternal height, socioeconomic status and experience of domestic violence all impact the maternal stress response differently, and along different timelines. On the one hand, maternal height and HPA activity may have both been co-programmed in early life as a response to adversity experienced within the first 1,000 days (see Chapter 4, discussion). On the other hand, socioeconomic status may have resulted in cumulative economic strain throughout the life course (DeSantis et al. 2015). Finally, domestic violence may cause both acute and chronic stress, depending on the timing and nature of the violence, and a woman's own resilience and coping skills. This emerges as an important area for further research. In order to elucidate the effect of cumulative, multi-factorial stressors on the cortisol stress response, a life course perspective may be necessary, as employed by DeSantis et al. (2015) in a large, socioeconomically diverse birth cohort in the Philippines to study the effect of chronically low socioeconomic status from infancy through to early adulthood on the adult diurnal cortisol rhythm. To this effect, it would be insightful to better be able to characterize the impact of the maternal cortisol rhythm during pregnancy on foetal and early infant linear growth, which was limited in our present study likely due to our inability to accurately assess – and thereby control for – gestational age. Additionally, measuring infant's postnatal HPA function would help determine when psychosocial stressors experienced by the mother and/or infant may become "biologically embedded" in the form of cortisol changes.

Further research is also necessary to determine the etiology – and both beneficial and detrimental long-term impacts – of the flatter diurnal cortisol profiles observed in populations experiencing greater cumulative stress. Flattened rhythms may be adaptive and serve as a protective factor against exposure to stressful environments (DeSantis et al. 2015), which could help limit the detrimental impact of maternal stress on the growing foetus/infant (Edwards et al. 2011). Alternatively, the observed flatter cortisol pattern could reflect the impact of stress exposure in early childhood (DeSantis et al. 2015, Lupien et al. 2000). However, accumulating literature supports the notion that flatter diurnal cortisol rhythms may have important implications for mental and physical health (Heim et al. 2000, Sephton et al. 2000). For instance, Kumari et al. (2011) found, in British civil servants, that a 1-SD flatter slope predicted a 1.87 higher hazard risk of mortality from cardiovascular causes and a 1.3 higher hazard risk of all cause mortality, and higher evening, but not waking, cortisol significantly predicted mortality.

Finally, disadvantaged populations have only rarely been the focus of cortisol research (DeSantis et al. 2015, Karb et al. 2012). Focusing more stress research in resource-poor contexts could provide critical insights into alternative, stress-related pathways that may contribute – along with nutrition and infection pathways – to the intergenerational transmission of stunting and other indicators of poor health. Such insights in turn could unlock key and novel areas for intervention, specifically to improve psychosocial wellbeing and resilience of the mother-infant dyad.

Gender relations and their impact on maternal and child health

Gender relations (maternal autonomy, paternal support, domestic violence) emerged as a significant determinant of maternal stress vs. wellbeing, as assessed by emotional distress, salivary cortisol and early infant growth. Contemporary scholarship in diverse developing-country contexts has emphasized women's limited autonomy as a key barrier to improvements in their reproductive health (Malhotra et al. 2002). This women's autonomy paradigm has been prominent in many international health and development programs (Mullany et al. 2005, UN 1994). However, our study findings lead us to question the adequacy and appropriateness of women's autonomy as the conceptual framework for understanding gendered influences on maternal and child health within our study context. Rather, our findings suggest that a powerful ideology of togetherness and inter-dependence binds the activities and resources of women with their partners and other family members, as found previously in other areas of Guatemala (Carter 2002). Our findings therefore support the critique (Mumtaz & Salway 2009) of the dominating autonomy paradigm that promotes women's individualism and independence as desirable, especially with regard to its applicability to patriarchal and/or more communal societies (Pu Tzunux 2007). Within such a context, male involvement/couple friendly programs that emphasize communication and negotiation between partners in making decisions (UNFPA 2004) may be important complements to women's empowerment programs that focus on giving women the power of decision-making over their own life choices, along with those basic resources that enable single women to secure access to shelter, food, health and safety.

The negative influence of paternal support on both the maternal cortisol rhythm and early infant growth may be contrary to expectation, but such findings are not unique in the literature. Although there are clear benefits from perceiving that support is available if needed (Dunkel-Schetter 2011), numerous studies have found negative health consequences associated with receiving support. For instance, Martire et al. (2002) found that older women with osteoarthritis reacted less negatively to receiving instrumental support from their husbands when being functionally independent was not of central importance to them. Several studies (Bolger et al. 2000, Bolger & Amarel 2007) have shown that the most effective support provided by a partner or colleague was support that went unnoticed by the recipient, while visible support was found to be either ineffective or to exacerbate reactivity, likely because it reduced recipients' sense of self-efficacy. Similarly, the extent to which individuals believe their partners understand, validate and care for them appears to mediate the effectiveness of support received (Chapman et al. 1997, Maisel & Gable 2009, Selcuk & Ong 2012). Although few studies (Chapman et al. 1997) examine these associations during pregnancy or postpartum, when important shifts in support needs may occur, it is likely that, to be effective, delivered support must similarly be sensitive to the recipients' needs and desire for autonomy.

There is currently a dearth of data suitable for more holistic examinations of male support and gender relations in indigenous communities in Guatemala (Carter 2002). Areas in Guatemala dependent on subsistence agriculture have been characterized as more egalitarian than other types of economies (Ehlers 2000, Bossen 1984, Rosenbaum 1993). Historically, indigenous groups have also been characterized as more gender egalitarian than their non-indigenous counterparts, and household relations to be more harmonious and supportive (Bossen 1984, Rosenbaum 1993) – although interaction with the non-indigenous, more patriarchal ideology may have affected indigenous gender norms. A key area for future research is how male support and involvement and maternal autonomy in household decision-making fit within the local ideologies of masculinity and femininity. Such research would help answer important questions about what men and women think about male versus male involvement in various spheres of daily living, and how to holistically promote gender relations in a way that is beneficial to the maternal-infant dyad but also to the household.

Tensions between indigenous and biomedical health systems

Of particular concern in Guatemala, many biomedical practitioners shun remote areas either because they cannot earn enough money there, because they discriminate against indigenous populations, and because government programs simply do not cover such areas (Cabrera et al. 2009) – as illustrated by the loss in recent years of primary health care services in study communities due to government cuts in health care spending, which affected more than 2.6 million individuals, or one-fifth of Guatemala's population (La Hora 2014). Hence the overwhelming use of *comadronas* for both prenatal and delivery care is undoubtedly only in part due to the cultural meaningfulness of local health beliefs and practices. Besides often poor access to formal services, previous ethnographic studies have cited a number of sociocultural factors that explain low utilization of formal health services by rural, indigenous women in Guatemala, including lack of confidence in biomedical treatments, perception of poor quality of care, discriminating or condescending treatment by medical personnel, inability of medical staff to speak indigenous languages, embarrassment over being examined, and greater confidence in midwives (Cosminsky 2001, Hurtado & Saenz de Tejada 2001, Glei & Goldman 2003, Cordero Munoz 2010).

With this in mind, increasing the number of health staff that speak Mayan languages and are sensitive to indigenous norms and practices and hence able to deliver culturally appropriate care to indigenous women, could greatly increase the utilization of formal health services. Yet relations between formal and traditional providers often are tense, due to social, ethnic and cultural differences, and a strong history of discrimination and devaluation of indigenous knowledge and practices (Hurtado & Saenz de Tejada 2001). Current efforts aimed at incorporating *comadronas* into the formal health system often focus on the modification of *comadrona* practices rather than on the provision of culturally appropriate, high-quality services by traditional and biomedical providers alike. Doing so would require bridging differences and creating space for an equal and bidirectional flow of knowledge between the formal and traditional health systems, intent on sensitizing health workers to the existence, value and importance of traditional systems of health knowledge and indigenous norms and practices.

The need for a paradigm-shift in conceptualizing early infant growth

Our study findings call us to reconsider previous frameworks of the multi-level determinants of stunting, such as that proposed by UNICEF – which continue to frame the discourse surrounding maternal and child undernutrition in the global health community (see for instance Bhutta et al. 2013, Black et al. 2013). Indeed, such frameworks have placed the emphasis almost exclusively on dietary-intake and infection factors as the "immediate causes" of child malnutrition, relegating household food insecurity, inadequate care, unhealthy household environment, lack of health services and income poverty as "underlying causes", and all other factors (lack of financial, human, physical, social and natural capital, and social, economic and political context) to "basic causes." However, our data suggest that many "basic causes" additionally affect infant growth much more directly and through a different, interfacing pathway, namely the biological stress response. Our findings emphasize the importance of replacing the dominating discourse with a more holistic concept of health and illness that also includes stress, and the impact of the biological stress response on child growth and development. Further, our findings call for a paradigm-shift able to recognize the critical role of psychological, social and cultural aspects of human health and wellbeing, and their direct association with physical health.

Such a paradigm shift is in line with critiques (Engel 1977, Krieger 2001, Schafer 1988) of the biomedical model, the hallmark of modern medicine since only the last century. Indeed, the biomedical model focuses on purely biological processes, such as pathophysiology and biochemistry of disease, and views body, mind and society as separate entities (Hewa & Hetherington 1995). Early critics of the biomedical model (Engel 1977, Schafer 1988) suggested instead a bio-psychosocial model that recognizes the unity of the body and mind, with the latter encompassing psychological, social and cultural aspects of human existence. Krieger (2001) has proposed an eco-social approach to health, which embraces a social production of disease perspective through the concept of *embodiment* – which refers to how humans literally incorporate, biologically, the material and social world in which they live. Cortisol research has recently provided evidence of how the environment and psychosocial factors "get under the skin" and directly affect pathophysiology (Edwards et al. 2011, McEwen 2012). The field of epigenetics has also recently shed light on the biological inheritance of environmental factors, including nutrition and stress (Skinner 2014).

Interestingly, although these are fairly new concepts in modern medicine, this holistic approach to health and wellbeing is the basis of many longstanding indigenous systems (Bala & Joseph 2007). As commented, for example, by Icú Perén (2007), in Mayan medicine, health is understood in terms of harmony and illness, with disequilibrium – be it in the environment, in the emotions or in the body. As synthesized by both Icú Perén (2007) and King et al. (2009), because a balance between the body and the soul extends beyond the individual realm, health and healing require that individuals live in harmony with others, their community, Mother Nature and the spirit worlds. In this way, local idioms of distress act as metaphors in communicating a wide range of social and psychological concerns that may ultimately translate into manifestations of physical or emotional health (Hatala et al. 2015, Pedersen et al. 2010). Hence, the interactions between mental, emotional and spiritual stress with physical health are relevant and important concepts in indigenous health systems (Stephens et al. 2006).

The overlap between these traditional, indigenous concepts of health and illness and newly emerging scientific findings is striking and ought to be leveraged for two important reasons. First, modern medicine and science certainly can draw extensively from the unique, time-honoured and holistic approaches to health and wellbeing of indigenous populations; greater respect and harmonization between both systems would certainly be of benefit to all. Second, these observations present a unique opportunity to reframe concepts of health and illness in a way that makes sense to all of the world's populations. This would facilitate health care delivery to all, including those who need it most but are currently suffering from the worst health care statistics, in part because of modern medicine's historical neglect of culture (Napier et al. 2014) and indigenous ways of "knowing" and living.

Reflection on the methodological approach

Variability of variables within the population

To assess which factors had sufficient variability to warrant future exploration of their associations with the health of the mother-infant dyad, one of our hypotheses was that only those continuous variables with a CV > 15%, and those categorical variables with a prevalence > 5% and < 95% would have sufficient variability to be informative in future analyses. The variables that emerged in analyses (Chapters 4 and 5) had been identified as having sufficient variability in descriptive analyses (Chapter 3), with the exception of maternal height, which had a CV of 4%; maternal BMI, which had a CV of 14% early PP and 15% later PP; and being single, with a borderline prevalence of 6%. Conversely, variables that we hypothesized would be associated with outcome variables, but that likely had either insufficient variability or prevalence to emerge significantly, included ethnicity (4% non-indigenous), urinary tract infection in pregnancy (3%), and maternal parasitic gastrointestinal infection (depending on perinatal stage, 1-3% *Ascaris lumbricoides,* 2-6% *Giardia spp.,* 0-1% *Entamoeba histolytica/dispar*). For the most part, our hypothesis held true, except for a small number of variables. Indeed, while indigenous ethnicity and infection did not emerge as associated with outcome measures in any analyses, which we presumed to be due to too low prevalence, both maternal height and being single were consistently associated with outcome measures, possibly because of the strength of the association despite the low variability in the population.

Participatory Action Research: challenges and successes

Researchers that embrace a PAR approach frequently are confronted with a number of challenges, especially if outsiders to the community under study (Minkler 2004). Although a key feature of PAR involves ensuring that the topic to be investigated comes from the community (Brown & Tandon 1983), such projects often would not occur without the initiative of someone with time, expertise and commitment, who almost inevitably is a member of a privileged, educated group (Minkler 2004), as was the case with this project. To overcome this challenge, meetings with community leaders and women at the outset of the project involved determining what were the issues that were most important to them, and confirming that maternal and child health, nutrition and psychosocial stress was one of them. I subsequently enlisted the support of a liaison person, María García, a middle aged *Mam*-Mayan woman with prior experience working on maternal and child health community projects, who could act as a cultural guide and play a key role in helping to bridge worlds.

Power dynamics and other sources of tension between outsiders and local populations have been widely discussed in the PAR literature (Nyden & Wiewel 1992). Historical trauma (the ongoing impact of colonization and slavery), internalized oppression (people's acceptance of the negative messages they receive about their race or ethnicity) and institutional racism (Brave Hearth & De Bruyn 1998, Jones 2000) may all contribute to significant power imbalances between outsiders and community participants, and in difficulty in speaking truth to power (Chavez et al. 2003). A legacy of paternalism and discrimination carried out by state institutions and organizations in indigenous communities (Cabrera et al. 2009, Saravia & Kolstrup 2006), and low female participation in decision-making that normatively cast women in passive and subservient roles (MSPAS 2010), made it challenging to engage community women as equal PAR partners, to seek their input and receive critical feedback that may help us better meet their interests. In addition, a high level of mistrust reigns in indigenous communities in Guatemala (Anckermann et al. 2005), as confirmed by our study findings (Chomat et al. 2015). The roots of this mistrust are most likely historical, based on centuries of social exclusion, exploitation, ethnic discrimination and economic injustice, and more recently to the internal armed conflict (1969-1996), in which the government and military forces combated not only insurgent forces but also other popular social movements, systematically destroyed entire villages, engaged in forced disappearances and attempted to destroy cultural values and break the cohesion of Mayan communities (Anckermann et al. 2005, CEH 1999). Such activities strongly impacted our study area in the early 1980s (REHMI 1999, personal communication). The many years of civil war are believed to have left profound traces in indigenous populations, including fear, uncertainty, and loss of trust, hope and social participation and interaction (Anckermann et al. 2005). In addition, discrimination against the Mayan population and their cultural practices remains strong, including within public and health services (Cabrera et al. 2009, Saravia & Kolstrup 2006).

As an unmarried white woman arriving from North America, a medical doctor, a doctoral student, and the recipient of funding that could support a project in their communities, my presence was likely intimidating to the women, while they also perceived me as someone who ought to be able to help them. Even my research team, consisting of Maria and of two nutritionists, all of whom lived in urban Quetzaltenango, were perceived as outsiders and also became folded into the category of "gringa", a colloquial term typically used by Central Americans to refer to foreigners from the United States, although it is sometimes applied to any foreigner. These factors presented several challenges. During our first interactions, several women and community leaders expressed concerns of being used for research that would accrue no benefit to those being studied, as they had seemingly experienced before. These and other experiences highlighted the reality of historical trauma, internalized oppression and mistrust in study communities, which likely contributed to bias in study participation and impacted data collection, despite the measures we implemented to counter it.

Several activities were critical in building trust and equalizing power dynamics. First, designing the research around an issue of importance to community women was essential. Second, active listening, ongoing consultations, and the inclusion of women's insights, concerns and suggestions into the work plan helped the women realize that their input and collaboration were valued. In addition, monthly participatory workshops were spaces where the community staff could increase their knowledge about topics that were important to them or that emerged during data collection, engage in critical thinking and become more comfortable expressing their thoughts and opinions. By playing an active role in data collection (i.e. administering the questionnaires), the community staff started building greater awareness of the problems that other women faced, and progressively grew in their confidence, knowledge and engagement with the research. The women were offered a stipend per day of work, which not only made it possible for them to devote their time to research activities, but also made them feel respected. The Photovoice activities, in which nearly all community staff participated, proved particularly helpful in building trust. The participants had the opportunity to represent themselves the way they wished to be represented, and the photographs and stories we shared created bonds and the opportunity for identification with others and of reciprocity. Spending time together outside of regular research activities, cooking together in each other's homes or sharing a meal were also helpful. By the end of research activities, exchanges finally started to feel horizontal, and in most communities, women's narratives had shifted from speaking about a "gringo" project to "our own" project.

Despite the prior challenges described, it is in bridging academic and local knowledge, expectations and divides that I have met most difficulty in implementing PAR. It was challenging ensuring that project concepts and procedures were fully understood by community staff, most of which had no more than a primary school education. It was also not possible to expect local women to be able to contribute equally in analyzing and interpreting data, and in offering their own interpretation of results. In addition, doctoral thesis requirements, time limitations, funding, and academia's definition as to what constitute "good science", such as scientific rigor and the use of methods that will enable one to achieve valid and reliable findings, further limited my ability to include local voices in data analysis, interpretation and publication. Research activities involved co-learning and constant inquiry and dialogue, and I cannot but acknowledge how I have been transformed in the process, yet I cannot claim to represent local views and interpretations. The local narratives that emerged from Photovoice activities helped validate quantitative findings and confirmed that results captured most of the themes and issues articulated by the women themselves. Nevertheless, although many academicians argue that scientists have a duty to make all of their findings public, the women may have thought to disseminate study findings in a different way (Hall 1992, Minkler & Wallerstein 2003).

The final PAR commitment is that for action. Involving community women as research staff and collaborators constituted local capacity building. The women noticeably became more knowledgeable about the maternal and child health issues within their communities, and more empowered to work professionally, think critically, and problem solve. Ultimately, several women voiced that they wished to learn how to help other women in their communities. From the lessons we learned from two years working in the field together emerged the idea of creating Women Circles which would be spaces of pedagogy, socialization and both individual and collective healing, using problem-based and cognitive-behavioural therapy, and arts-based, participatory activities. Trained community women – the very same women who formed my doctoral research community staff – would lead Women Circles, and invite participants who were women within the first 1,000 days who experienced psychosocial distress due to poor social support, domestic violence, economic hardship, young age, or marginalization. These ideas have been implemented in the last two years since my doctoral thesis fieldwork came to an end, supported by a Grand Challenges Canada Global Mental Health seed grant. Although quantitative analyses of impact have yet to be performed, the intervention has had a clear positive impact. First, this intervention has been well accepted within study communities. Second, the Women Circle leaders have become stronger leaders and agents of change in their own lives and communities, and have improved abilities to take a proactive stance on maternal and child health and wellbeing and respond to challenges as they arise. Third, both they and the Women Circle participants exhibit increased self-esteem and self-agency, reduced emotional distress, improved communication skills, increased coping strategies, and diminished experience of domestic violence within the household.

In summary, there is an important role for PAR in research involving indigenous communities in Guatemala. Participatory activities, including Photovoice, were key in establishing equal community partners in this historically marginalized and poorly autonomous community and project sustainability over time. Future effort will need to be placed within academia on finding ways to better integrate local collaborators, and indigenous perspectives, into data analysis, interpretation and dissemination of findings.

Mixed-methods

Central to this thesis was the need to value multiple ways of knowing. Several tools were instrumental. These included various epidemiological surveys that enabled us to measure sociodemographic, infectious and nutritional factors; the creation of the asset-based Household Wealth Index via principle component analysis; psychosocial instruments that underwent cross-cultural equivalence (Flaherty et al. 1988) and enabled us to measure various social factors (social support, paternal support, maternal autonomy, trust); the measure of maternal salivary cortisol as a stress biomarker; various qualitative research methods, the most effective of which was Photovoice; and last but not least, various methodologies to internally and externally validate study findings. This mixed-methods research enabled us to examine the effect of multiple dimensions, and provide a more complete picture of the multiple pathways influencing infant growth outcomes than has been done before.

Reducing bias and increasing validity of findings

The community staff was trained to administer study questionnaires to study participants in either *Mam* or Spanish, and hence collected most of the study's data. This likely reduced bias that would have resulted from mistrust or intimidation, if administered by either myself or another member of the "outsider" research team as it enabled horizontal exchanges between interviewer and interviewee, and reduced bias that might have resulted from differential power relations or linguistic mistranslations. The community staff was also uniquely placed to intuitively understand the study participants' reality, which may have increased the reliability of the survey responses. On the other hand, that many women were involved in data collection may have reduced reliability.

I reviewed all completed questionnaires to check for any inconsistencies or omissions, and asked study participants more sensitive questions, which they might have been reluctant to reveal to someone in their community, including women leaders such as our community staff. This reduced bias that may have been caused by reluctance to reveal sensitive information to other community women. Despite the length of the questionnaires administered, many women thanked us for asking questions that they had never been asked before, such as how they were feeling, and if they felt safe, and for showing an interest in their lives – which may indicate that many of the women felt comfortable with the study's tools, which further attests to the reliability of the data provided. Finally, triangulating survey-based, quantitative results with women's open-ended Photovoice narratives enabled validation of study findings.

Transdisciplinarity

This study required an understanding of parasitology, nutrition, transcultural psychiatry, neuroendocrine stress biology, social capital and social network analysis, feminist theory, and education for critical consciousness using arts-based methods and participatory activities. The study also thought to consider how biological through to societal factors influenced maternal stress and early infant growth. Creation of a unified, multi-level conceptual framework, informed by multiple disciplines, required extensive reading across disciplines. Throughout the process, concepts and methodologies from specific fields were integrated around the central theme of maternal factors that influence infant growth. By examining multiple levels, it was possible to detect the different effects of individual, household and social level factors on the maternal-infant dyad. Such transdisciplinary conceptualizations represent a challenge to researchers attempting to capture and study the complex nature of disparities in health (Gehlert et al. 2010), such as that represented by stunting. Due to this complexity, it was challenging to take into equal account all levels that impact stunting (i.e. pathophysiological pathways, individual risk factors, social relationships, living conditions, neighbourhoods and communities, institutions and social and economic policies), nor of all interactions within and between levels.

Limitations

The homogeneity of our study population limited our ability to test the effects of ethnicity, altitude, and socioeconomic status on infant growth. Sampling bias may have occurred as only half of potentially eligible women living in study communities presented for enrolment, as assessed by later review of a census. It is likely that our recruitment methods did not reach all women and that some women could not present themselves on the specific clinic days, but we acknowledge the possibility that non-participants might constitute a distinct population (i.e. working mothers, women facing particularly harsh living conditions, women not given permission by a partner or parent to participate, and women who did not have confidence in our team). Our loss to follow-up in the longitudinal cohort was higher in one community relative to the other seven, where fewer families owned land and families often traveled to the coast for work, early PP maternal underweight was more common, women's social support score was lower, and more infants were severely stunted both early and later PP. Unfortunately, the sample size precluded analyses of sub-populations, for instance to assess for variances in sources of vulnerability vs. resilience between communities.

The low prevalence of maternal infection limited our ability to explore its impact on the study's outcome variables. Intestinal infections may have been underreported due to limitations in locally available diagnostic methods. Further, compliance among women in the longitudinal cohort in providing fecal samples declined over the three visits, perhaps because women were for the most part asymptomatic. Many women did not know the date of their last menstrual period, and birth weight data, collected using varying methods, depended on mother recall, limiting our ability to accurately determine gestational age, prematurity, and birth weight, which limited our ability to control for these important variables. With regard to cortisol, measures from one-day collection do not account for day-to-day variation. Analyses were based on cross-sectional data, limiting causal inferences. Moreover, although several potential confounders of the cortisol rhythm were measured, it could have been helpful to also collect data on sleep characteristics (Minkel et al. 2015), time of saliva collection, and experience of stressful experiences at the time, or on the day, of collection (Adam & Kumari 2009). However, we still found significant associations, attesting to the robustness of the identified associations between cortisol and other variables.

Local narratives and terminology relating to emotional distress, to what constitutes a stressful situation, and to available coping strategies, differ significantly from those of other populations, limiting the cross-cultural equivalence of most psychosocial instruments. Survey questionnaires did not capture the full complexity of the local, *Mam*-Mayan psychosocial environment, as evidenced by triangulation with Photovoice-elicited narratives. For instance, we measured only one component of autonomy (decision-making) and of paternal support (involvement), but other aspects of gender norms relevant to the local context may have been informative, such as the social security (i.e. improved wealth and food security) provided by partners; prevailing social norms relating to gender equality and to what constitutes acceptable behaviour (i.e. gender violence, marginalization of single women); and ways in which women are able to negotiate gender relations and norms and influence decision-making (Mumtaz & Salway 2009). It is difficult to assess whether our data collection methodology (i.e. questionnaires administered by community staff, and sensitive questions by myself) increased or reduced bias, and both are possible, depending on each participant's personal situation, including level of trust and prior experiences; nevertheless, that significant associations between variables were found suggests that the methodology used was at the very least adequate.

Finally, because of the highly gendered nature of lives in the area of study, and the difficult access by women to a man's world, narratives are strongly biased towards woman's realities and perspectives, and men's own narratives are for the most part absent. Last but not least, study findings may not be generalizable to other communities in Guatemala.

Public Health implications

Our observations reiterate the need for an open and informed dialogue between local and global health actors that is respectful and inclusive of indigenous and other local beliefs and practices. In addition, our findings call for a paradigm-shift in global health that allows better integration of psychosocial factors and indigenous and other local perspectives in conceptual models guiding research and intervention, especially of complex health issues such as stunting.

Findings suggest that certain *Mam*-Mayan mothers, especially those with shorter stature, poorer living conditions, inadequate nutrient intake, poor self-efficacy in breastfeeding, who experience emotional distress, and are single or have ineffective or disempowering social relationships may be particularly vulnerable to the intergenerational cycle of stunting and poor health. Our findings make a strong case for interventions that can empower women within their social context, especially reinforcing self-efficacy and positive and effective social support, and targeting those women who face social isolation, low decision-making power and/or domestic violence. Along with efforts to reduce poverty, food insecurity, and improve the efficacy of support received from partners, cognitive-behavioural strategies aimed at increasing mother's coping skills and self-efficacy and strengthening the effectiveness and cultural relevance of existing social networks and community services emerge as key areas of intervention. Partner involvement/couple friendly programs that emphasize communication and negotiation between partners in making decisions also emerge as potentially beneficial in this context, and is an area that would benefit from further investigation.

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APPENDIX

RESEARCH QUESTIONNAIRES

The following questionnaires have been translated from Spanish for the purpose of the thesis. Please note that only the questionnaire administed to women postpartum is included, as it includes all questions inquired to pregnant women, plus those relevant to the postpartum periods.

Code: _ _ / _ / _ _ Interviewer: ____________________ Date __ / __ / __ (month/day/year)

SECTION A: SOCIODEMOGRAFIC INFORMATION

I would like to start by asking you some general questions about yourself.

A.1	**How old are you?**	___________ years
A.2	**What is your birthdate?**	____/____/____ (month/day/year)
A.3	**What languages do you speak** **(MARK ALL THAT APPLY)**	□ Spanish □ Mam □ Other ____
A.4	**Are you able to read and write?**	□ Yes □ No
A.5	**Did you go to school, and if so, until which grade did you attend?**	□ Didn't go to school □ Primary ➔ For how many years? ____ □ Secondary ➔ For how many years? ________ □Higher education
A.6	**What kind of work do you do?**	____________________________________
A.7	**In the last year, have you earned any money yourself?**	□ Yes ➔ **How? (Mention all ways, activities)** ________________________________ □ No ____
A.8	**Do you practice a religion?**	□ Evangelical □ Catholic □ Maya cosmovision □ Other ____________________________________ □ No religion

Code: _ _ / _ / _ _   Interviewer: ____________________   Date __ / __ / __ (month/day/year)

I will now ask you some questions about your home and living situation.

A.11	**Where do you get your water (for cooking, drinking)?** **(MARK ALL THAT APPLY)**	☐ Faucet ➔ ☐ own or ☐ public ☐ Well ☐ Cistern ☐ Rain water	☐ River ☐ Spring (ojo de agua) ☐ Other ______________________________
A.12	**Where do you go to relieve yourself?**	☐ Toilet with septic tank ☐ Flush toilet ☐ Latrine ☐ Other ____________________ ☐ Nothing	
A.13	**How many bedrooms are there in your house?** #______		
A.14	**What do you cook with in your house?** **(MARK ALL THAT APPLY)**	☐ with wood → ☐ with gas ☐ other __________	**a. How many hours a day do you keep the fire lit?** # _____ hours **b. Is there generally a lot of smoke in your home when you are cooking?** ☐ not much smoke ☐ some smoke ☐ a lot of smoke
A.15	**What are the exterior walls of your house made out of?**	☐ Block ☐ Adobe ☐ Wood ☐ Other ______________________	
A.16	**What kind of floor do you have in your house?**	☐ Ceramic ☐ Cement ☐ Earth ☐ Other ______________________	

Code: _ _ / _ / _ _ Interviewer: ____________________ Date __ / __ / __ (month/day/year)

A.17	**Do you have any of the following in your house?** **(MARK ALL THAT APPLY)**	◻ Electricity ◻ A radio ➔ **Does it work?** ◻ Yes ◻ No ◻ A television ➔ **Does it work?** ◻ Yes ◻ No ◻ A cell phone ➔ **Does it work?** ◻ Yes ◻ No ➔ Are you able to use it? ◻ Yes ◻ No ➔ Why not? ______________________ ◻ A refrigerator ➔ **Does it work?** ◻ Yes ◻ No ◻ A sewing machine ➔ **Does it work?** ◻ Yes ◻ No ◻ None of these
A.18	**Do you have in your house any of the following vehicles?** **(MARK ALL THAT APPLY)**	◻ A bicycle ➔ **Does it work?** ◻ Yes ◻ No ◻ A motorcycle ➔ **Does it work?** ◻ Yes ◻ No ➔ Are you/your household able to use it? ◻ Yes ◻ No If no, why not? ______________________ ◻ A car, pick-up, truck ➔ **Does it work?** ◻ Yes ◻ No ➔ Are you/your household able to use it? ◻ Yes ◻ No If no, why not? ______________________ ◻ None of these
A.19	**Does your household work in agriculture (*en el campo*)?**	◻ Yes ➔ **Is the land you work on…** ◻ owned by your family ◻ rented ◻ other ______________________ ◻ No
A.20	**The house that you live in is…?**	◻ owned by your family ◻ rented
A.21	**What crops are grown in your household?**	◻ Maize ◻ Potatoes ◻ Frijol ◻ Broad beans (haba) ◻ Vegetables ◻ Fruit ◻ Other ______________________ ◻ Nothing

Code: _ _ / _ / _ _ Interviewer: ____________ Date __ / __ / __ (month/day/year)

SECTION B: NUTRITION

B.1 The following questions are about food in your home. Can you tell me how often the following situations occur? You can respond: Always (A), Almost always (AW), Sometimes (S), or Never (N).

			A	AW	S	N
a.	There is not enough money in your home to buy food					
b.	Less food that is important for children is bought, because of a lack of money	□ no children live in home				
c.	Someone in your household eats less than he or she would like to, due to a lack of money for food					
d.	The usual number of meals is reduced in your home due to a lack of money for food					
e.	An adult reduces the number of meals he or she eats due to a lack of money for food.					
f.	An adult eats less during the main meal, because there is not enough food for everyone					
g.	A child eats a smaller number of meals due to a lack of money for food.	□ no children live in home				
h.	A child eats less during the main meal, because there is not enough food for everyone.	□ no children live in home				
i.	An adult remains hungry due to a lack of food in the home.					
j.	A child remains hungry due to a lack of food in the home.	□ no children live in home				
k.	An adult goes to bed hungry due to a lack of money to buy food.					
l.	A child goes to bed hungry due to a lack of money to buy food.	□ no children live in home				
m.	There is a lack of food in the home due to droughts, floods, or other similar situation.					
n.	There is a lack of food in the home because of resources such as water, land, seeds, fertilizers, or other.					

Code: __ __ / __ / __ __   Interviewer: ____________________   Date ___ / ___ / ___ (month/day/year)

B.3 <u>24-hour recall of the mother #1</u>

<u>Yesterday</u>:   □ Did not eat due to illness or other reason   □ Was not a usual day   □ Day of the week ___________________

Time	Food or drink item	Ingredients/brand	Quantity	Serving size

Code: __ __ / __ / __ __   Interviewer: ____________________   Date ___ / ___ / ___ (month/day/year)

B.4 24-hour recall of the mother #2

Yesterday: ☐ Did not eat due to illness or other reason ☐ Was not a usual day ☐ Day of the week __________________

Time	Food or drink item	Ingredients/brand	Quantity	Serving size

Code: __ __ / __ / __ __ Interviewer: ____________________ Date ___ / ___ / ___ (month/day/year)

B.5 Daily activity schedule (24 hour recall of last non-weekend day)

Yesterday: □ Was not a usual day □ Day of the week ________________

Type of activity (for example: sleeping, cooking, breastfeeding, working in the field, going to church, etc.)	**Frequency** How many times did you do this activity in the day?	**Intensity** 1= very light 2=light 3=a little bit hard 4= hard 5=very hard	**Total time** How many minutes or hours did you do this activity throughout the day?

Code: _ _ / _ / _ _ Interviewer: ____________________ Date __ / __ / __ (month/day/year)

SECTION C: SOCIO-ECONOMIC INFORMATION, AND SOURCES OF SOCIAL SUPPORT

I would like to ask you a little bit more about your home situation, and how you are doing in your community and in your family.

C.1 What is your civil status? □ Married □ In a union □ Widowed □ Divorced/separated □ Single

If you are not married or in a union, go directly to question C.3.

C.2 **Does your husband/partner sometimes leave your house for more than a week at a time (for work, for travel)?**

□ No
□ Yes ➔

a.	**Why does he leave?**	
b.	**How often?**	□ Not often □ Often □ He is always gone
c.	**Where does he go?**	

C.3 **In general, who is in charge of deciding what food to buy?**

□ You alone
□ You with your husband or partner
□ Your husband or partner decides
□ Your father decides
□ Other ____

C.4 **In general, who is in charge of deciding what medicines to buy**

□ You alone
□ You with your husband or partner
□ Your husband or partner decides
□ Your father decides
□ Other ____

C.5 **When you are sick, who decides where to go for help?**

□ You alone
□ You with your husband or partner
□ Your husband or partner decides
□ Your father decides
□ Other ____

Code: __ __ / __ / __ __ Interviewer: ____________________ Date ___ / ___ / ___ (month/day/year)

C.6	**When one of your children is sick, who decides where to go for help?**	□ You alone □ You with your husband or partner □ Your husband or partner decides □ Your father decides □ Other ____
C.7	**Who is in charge of the money for household expenses?**	□ You alone □ You with your husband or partner □ Your husband or partner □ Your father □ Other ____

The following questions ask about the support you have from your community, friends, and family.

C.13 **Do you attend any reunions, and/or participate in one of the following organizations in your community?**

(MARK ALL THAT APPLY)

Type of organization	Check if yes	If you are involved, what is your level of participation?
a. **Cooperative, guild or union**	□	□ Very involved □ Somewhat involved □ Not very involved
b. **Community association**	□	□ Very involved □ Somewhat involved □ Not very involved
c. **Women's association**	□	□ Very involved □ Somewhat involved □ Not very involved
d. **Religious group**	□	□ Very involved □ Somewhat involved □ Not very involved
e. **Health organization**	□	□ Very involved □ Somewhat involved □ Not very involved
f. **Political group**	□	□ Very involved □ Somewhat involved □ Not very involved
f. **Other**_________________	□	□ Very involved □ Somewhat involved □ Not very involved

C.14	**In your community, do most people get along well?**	□ Yes □ More or less □ No

Code: __ __ / __ / __ __ Interviewer: ____________________ Date ___ / ___ / ___ (month/day/year)

C.15	**Please indicate how much you trust, in general, the following individuals and organizations:**	a. Your family	☐ very much	☐ quite a lot	☐ not very much
		b. Your neighbours	☐ very much	☐ quite a lot	☐ not very much
		a. The evangelical church	☐ very much	☐ quite a lot	☐ not very much
		b. The catholic church	☐ very much	☐ quite a lot	☐ not very much
		c. The press	☐ very much	☐ quite a lot	☐ not very much
		d. Television	☐ very much	☐ quite a lot	☐ not very much
		e. The federal government	☐ very much	☐ quite a lot	☐ not very much
		f. The local government	☐ very much	☐ quite a lot	☐ not very much
		g. The public hospital	☐ very much	☐ quite a lot	☐ not very much
		h. The health center and health post	☐ very much	☐ quite a lot	☐ not very much
		i. Schools in your community	☐ very much	☐ quite a lot	☐ not very much
		j. Women's organizations	☐ very much	☐ quite a lot	☐ not very much
		k. Charitable or humanitarian organizations	☐ very much	☐ quite a lot	☐ not very much
		l. The police	☐ very much	☐ quite a lot	☐ not very much

C.16	**Do you feel safe when you…:**	a. …**are in your house**	☐ yes	☐ no
		b. …**walk in your community**	☐ yes	☐ no
		c. …**go to the market**	☐ yes	☐ no
		d. …**leave your community and visit another community nearby**	☐ yes	☐ no
		e. …**leave your community to go to San Juan Ostuncalco**	☐ yes	☐ no
		f. …**leave your community to go to Xela**	☐ yes	☐ no
		g. …**take the local bus**	☐ yes	☐ no

C.17	**Is the father of your baby someone…**	**a. … you can count on for financial support when you need it?**	□ no, never □ only sometimes □ yes, always
		b. … you can talk with about things that are important to you?	□ no, never □ only sometimes □ yes, always
		c. … who is affectionate towards you?	□ no, never □ only sometimes □ yes, always
		d. … who wants to be involved in caring for the baby?	□ no, never □ only sometimes □ yes, always
		e. … who talks with you and spends time with you?	□ no, never □ only sometimes □ yes, always

Code: __ __ / __ / __ __ Interviewer: ____________________ Date ___ / ___ / ___ (month/day/year)

The following questions ask about people in your life who provide you with help and support. List all the people you know whom you can count on for help or support in the manner described. You can give just the person's relationship to you (name is not required).

C.18 **Who can you really count on to listen to you when you need to talk (about any problems, preoccupations, difficulties, etc.)?**

1)________________________ 4) ________________________ 7) ________________________ □ No one

2) ________________________ 5) ________________________ 8) ________________________

3) ________________________ 6) ________________________ 9) ________________________

C.19 **Who can you really count on to help you make a difficult decision?**

1)________________________ 4) ________________________ 7) ________________________ □ No one

2) ________________________ 5) ________________________ 8) ________________________

3) ________________________ 6) ________________________ 9) ________________________

C.20 **Who can you really count on to give you useful advise about your pregnancy and the care of your newborn infant?**

1)________________________ 4) ________________________ 7) ________________________ □ No one

2) ________________________ 5) ________________________ 8) ________________________

3) ________________________ 6) ________________________ 9) ________________________

Code: _ _ / _ / _ _ Interviewer: ____________ Date __ / __ / __ (month/day/year)

C.21 **Who can you really count on to look after your safety, and the safety of your family?**

1)____________ 4) ____________ 7) ____________ □ No one

2) ____________ 5) ____________ 8) ____________

3) ____________ 6) ____________ 9) ____________

C.22 **If you or your child became very sick, whom do you know would help you make sure that you get the medical care that you need?**

1)____________ 4) ____________ 7) ____________ □ No one

2) ____________ 5) ____________ 8) ____________

3) ____________ 6) ____________ 9) ____________

C.23 **Whom can you really count on to help you at home so that you have time to rest, take care of your newborn, etc. ?**

1)____________ 4) ____________ 7) ____________ □ No one

2) ____________ 5) ____________ 8) ____________

3) ____________ 6) ____________ 9) ____________

C.24 **Whom can you really count on to help you and your family ensure that you have enough money to buy food and all your basic necessities?**

1)____________ 4) ____________ 7) ____________ □ No one

2) ____________ 5) ____________ 8) ____________

3) ____________ 6) ____________ 9) ____________

Code: __ __ / __ / __ __ Interviewer: ____________________ Date __ / __ / __ (month/day/year)

C.25 **Whom can you really count on to help you take care of your children (including your newborn)?**

1)________________________ 4) ________________________ 7) ________________________ □ No one

2) ________________________ 5) ________________________ 8) ________________________

3) ________________________ 6) ________________________ 9) ________________________

SECTION D: MEDICAL HISTORY OF THE MOTHER

The following questions are about your medical and obstetric history.

D.1 **Do you have any medical problems?**

(MARK ALL THAT APPLY)

a. □ High blood pressure
b. □ Diabetes
c. □ Heart problems
d. □ Breathing problems
e. □ Skin problems
f. □ Headaches
g. □ Epilepsy, seizures
h. □ Stomach problems
i. □ Intestinal problems
j. □ Arthritis
k. □ Blood problems
l. □ Anemia
m. □ Tuberculosis
n. □ Emotional or nerve problem
o. □ Other ______________________
p. □ Other ______________________

D.2 **Do you smoke?** □ Yes □ No

D.3 **Do you drink alcohol?** □ Yes ➔ **How many glasses do you drink each day?** _________
□ No

Code: __ __ / __ / __ __ Interviewer: ____________________ Date ___ / ___ / ___ (month/day/year)

D.4	**How many pregnancies have you had in total?** # ________	
	◻ This is her first pregnancy	
	◻ This is NOT her first pregnancy ➔ **How old is your last-born child?** ___ months ____ years ◻ Last born child has died	
	➔**Are you still breastfeeding your last-born child?** ◻ Yes ◻ No	
D.5	**How many children do you have?**	#____living # ____ died ➔ # ____ born dead ; #_____ died during the first month; #_____ died after the first month
D.6	**How old were you during your first pregnancy?** ______ years	
D.7	**How old were you when you had your first period?** ______ **years**	
D.8	**Generally, when you are not pregnant or breastfeeding, are your periods regular (each month)?** ◻ Yes ◻ No ◻ Don't know	
D.9	**Do you use any form of family planning?**	◻ Yes ➔ What kind? ______________________________ ◻ No ➔ Why not? ______________________________
D.10	**Have you had any illness or injuries due to violence (something someone did to you)?**	◻ Yes ➔ What happened? ______________________________ ◻ No ______________________________ ______________________________

Code: __ __ / __ / __ __ Interviewer: ____________________ Date __ / __ / __ (month/day/year)

D.11 **Do you use the *tamascal* (steam bath)?** ☐ No ☐ Yes →

a. How many times in a week?	___________
b. For how long at a time?	___________ min
c. How do you think the *tamascal* affects your ability to breastfeed (if at all)?	

The following questions are about your last pregnancy, when you were pregnant with your newborn

D.12 **How long ago did you deliver?** ________ days __________ weeks ____________ months

D.13 **What was the date of your delivery?**
___/___/___ (month/day/year)

D.14 **Did you receive antenatal care during this pregnancy?** ☐ No ☐ Yes → With whom?

(MARK ALL THAT APPLY)

	Check if seen	Indicate number of times seen during this pregnancy
a. *Comadrona*	☐	
b. Private doctor/nurse	☐	
c. Someone in the health center	☐	
d. Health promoter	☐	
e. Public hospital	☐	
d. Other	☐	

Code: _ _ / _ / _ _ Interviewer: ________________ Date __ / __ / __ (month/day/year)

D.15 Did you take any treatments during this pregnancy?

(MARK ALL THAT APPLY)

- □ Vitamins
- □ Nutritional supplements (specify: ______________________________)
- □ Iron
- □ Folic acid
- □ Antibiotics (specify:_________________) For what kind of an infection? __________
- □ Vaccine
- □ Traditional treatments (specify:________________________)

D.16 **Did you have any problems during this pregnancy?**

(MARK ALL THAT APPLY)

	Check if had	Who did you see for help with this problem?	What treatments did you receive?
a. Urinary tract infection	□		
b. Diarrhoea	□		
c. Respiratory infection	□		
d. High blood pressure	□		
e. Bleeding/haemorrhage	□		
d. Swelling of the hands or face	□		
e. Fright ("susto")	□		
f. Evil eye ("mal de ojo")	□		
g. Anger ("Enojo")	□		
h. Too much heat	□		
i. Too much cold	□		
j. Other ____________	□		
k. Other ____________	□		

D.17	Where did you deliver?	☐ Your home ☐ Comadrona's home ☐ Health center or post ☐ Private clinic ☐ Hospital ☐ Other ________________________________
D.17	**Who assisted the delivery?** **(MARK ALL THAT APPLY)**	☐ Comadrona (traditional midwife) ☐ Private doctor/nurse ☐ Someone in the health center ☐ Health promotor ☐ Other ________________________________ ☐ No one
D.18	**Did you deliver by C-section?**	☐ Yes ☐ No

Code: __ __ / __ / __ __ Interviewer: ____________________ Date ___ / ___ / ___ (month/day/year)

The following questions are about your current health ***(to be administered by a medical doctor or nurse)***

D.19	**Are you currently sick, or do you have any symptoms?**	□ Yes ➔ □ No	What? ______________________________ ______________________________

D.20 **Do you have any of the following symptoms?**

	Yes, currently	Please describe (since how long, how severe)	Have you seen anyone for this?	Have you taken any treatments?
a. Fright ("susto")	□			
b. Evil eye ("mal de ojo")	□			
c. Anger ("Enojo")	□			
d. Too much heat	□			
e. Too much cold	□			
f. Malnutrition/lack of food	□			
g. Fever	□			
h. Cough	□			
i. Vomiting	□			
j. A cold	□			
k. Diarrhoea	□			
l. Stomach pain	□			
m. breast infection	□			
n. skin infection	□			
o. parasites	□			
p. pain with urination	□			
q. vaginal discharge	□			
j. Other _____________	□			
k. Other _____________	□			

SECTION E: MEDICAL HISTORY OF THE NEWBORN

The following questions are about the general health of your newborn

Code: _ _ / _ / _ _   Interviewer: ____________________   Date __ / __ / __ (month/day/year)

E.1	**Birthdate:**	____/____/____ (month/day/year)	
E.2	**Age:**	__________ days _____________ weeks ________________ months	
E.3	**Gender**	□ male □ female	
E.4	**Length at the time of birth:**	________ cm	□ doesn't know
E.5	**Weight at the time of birth:**	_____ pounds	□ doesn't know

The following questions are about the feeding practices of your newborn.

E.6	**How long after delivery did you start breastfeeding your newborn?**	_______ hours ________ days	□ I never breastfed
E.7	**When do you think is the best time to initiate breastfeeding? Please explain why.**	____ ____	
E.8	**Since the time of delivery, have you been exclusively breast-feeding your infant?**	□ Yes □ No ➔ Why not?______________________________ ____	
E.9	**Have you had any problems with breastfeeding your newborn?** (MARK ALL THAT APPLY)	□ Yes ➔ Why? □ No	□ Pain in the breasts □ Doesn't have enough milk □ The baby has been sick □ The mother has been sick □ Because of work obligations □ Other ____________________
E.10	**Where would you go for breastfeeding advise or support if you needed it?**	____ ____	

Code: _ _ / _ / _ _ Interviewer: ____________________ Date __ / __ / __ (month/day/year)

E.11	**Did your mother breast feed you when you were an infant?**	□ Yes □ No □ Doesn't know
E.12	**Is it possible to transmit anything bad for your infant through breastfeeding? If yes, please describe.**	____________________ ____________________
E.13	**Is it possible to transmit anything good (other than nutrition) for your infant through breastfeeding? If yes, please describe.**	____________________ ____________________
E.14	**Do you think that fear ("susto") or anger ("enojo") can be transferred to your baby through breastmilk?**	□ Yes □ No □ Don't know

E.15 **Have you been feeding your newborn aguitas?**

□ Yes →

□ No

	Check if yes	**If yes, at which age for the first time?**	**Reason why aguitas were given**
a. Agua de manzanilla	□	___ days ___weeks ___ months	
b. Agua azucarada	□	___ days ___weeks ___ months	
c. Hierbabuena	□	___ days ___weeks ___ months	
d. Agua de anis	□	___ days ___weeks ___ months	
e. Agua de naranja	□	___ days ___weeks ___ months	
f. Agua de salviasanta	□	___ days ___weeks ___ months	
g. Agua de alfalfa	□	___ days ___weeks ___ months	
h. Agua de cebada	□	___ days ___weeks ___ months	

Code: __ __ / __ / __ __ Interviewer: ____________________ Date ___ / ___ / ___ (month/day/year)

E.16 **Other than breast milk and aguitas, are you feeding your newborn any other liquid or drink?**

□ No

□ Yes →

	Check if yes	At what age for the first time?
a. water	□	___ days ___weeks ___ months
b. pediatric syrup	□	___ days ___ weeks ___ months
c. bottled milk	□	___ days ___weeks ___ months
d. fruit juice	□	___ days ___ weeks ___ months
e. coffee	□	___ days ___weeks ___ months
d. other	□	___ days ___weeks ___ months

E.17 Other than breast milk, are you feeding your newborn any other kinds of food?

□ No

□ Yes →

	Check if yes	At what age for the first time?
a. incaparina	□	___ days ___weeks ___ months
b. oats	□	___ days ___weeks ___ months
c. rice	□	___ days ___weeks ___ months
d. fruits	□	___ days ___weeks ___ months
e. vegetables	□	___ days ___weeks ___ months
f. bread	□	___ days ___weeks ___ months
g. compota	□	___ days ___weeks ___ months
h. potato	□	___ days ___weeks ___ months
i. other	□	___ days ___weeks ___ months

Code: __ __ / __ / __ __ Interviewer: ____________________ Date ___ / ___ / ___ (month/day/year)

The following questions are about your current health (to be administered by a medical doctor)

E.18	**Has your newborn had any illnesses or any symptoms since birth?**	□ Yes □ No	➔	Please describe (what, when) ____________________ ____________________ ____________________

Code: _ _ / _ / _ _ Interviewer: ___________________ Date __ / __ / __ (month/day/year)

E.19 **Has your newborn had any of the following illnesses or symptoms since delivery?**

	Yes, currently	Yes, but not currently	Please describe (since how long, how severe)	Have you seen anyone for this?	Has your newborn received any treatments?
a. Fright ("susto")	☐	☐			
b. Evil eye ("mal de ojo")	☐	☐			
c. Anger ("Enojo")	☐	☐			
d. Too much heat	☐	☐			
e. Too much cold	☐	☐			
f. Malnutrition/lack of food	☐	☐			
f. Dehydration	☐	☐			
g. Fever	☐	☐			
h. Cough	☐	☐			
i. Vomiting	☐	☐			
j. A cold	☐	☐			
k. Diarrhoea	☐	☐			
l. Stomach pain	☐	☐			
n. skin infection	☐	☐			
o. parasites	☐	☐			
j. Other ____________	☐	☐			
k. Other ____________	☐	☐			