

Chapter 13

Health Across the First 1000 Days in the Galápagos Islands



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Abstract This chapter investigates how early developmental health concerns arise and are contended with on San Cristóbal island, where residents live in geographic isolation with limited access to fresh food, potable water, and healthcare options. In particular, the chapter focuses on the “first 1000 days,” the period between conception and a child’s second birthday. This period marks a time of rapid growth that is highly sensitive to environmental conditions and can irreversibly alter a child’s long-term development. Within the categories of pregnancy, birth, and the postpartum, this chapter identifies and discusses the top health risks during the first 1000 days, including maternal overweight and obesity, urinary tract infections, sexually transmitted infections, overmedication and antibiotic use during pregnancy, gestational diabetes, preeclampsia, preterm birth, low birth weight, excess of Cesarean section, infant feeding, and infant growth. The concluding remarks offer pathways for improving maternal and infant health and development within the complex context of the Galápagos.

Keywords First 1000 days · Social and environmental factors · Caesarean section · Breastfeeding · Pregnancy · Low birth weight

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13.1 Introduction

The first 1000 days of development, the period between conception and a child's second birthday, mark a time of rapid growth that is highly sensitive to environmental conditions and set the stage for long-term health and development. Nutritional, psychological, physical, and social conditions all contribute to this essential early development (Martorell 2017; Zijlmans et al. 2015). During this time, exposure to poorer conditions, such as undernutrition or infectious disease, can jeopardize infants' immediate health and survival and shape their risk for metabolic diseases, including obesity, cardiovascular disease, and diabetes (Wells 2010) and neurobehavioral disorders later in life (Zijlmans et al. 2015). With its high prevalence of maternal micronutrient malnutrition, persistent child stunting, and high levels of maternal depression (Page et al. 2013), the Galápagos Islands of Ecuador provide an important context for understanding the social and environmental factors shaping the health of mothers and infants during this critical period.

13.2 Life on the Galápagos Islands

The geographic, political, and social environments of the Galápagos Islands pose a unique suite of daily circumstances for residents. Limited access to clean water and fresh food and high rates of violence against women are major public health concerns for island residents (Grube et al. 2020; Nicholas et al. 2019; Thompson et al. 2020; Villacis and Carrillo 2013; Walsh and Mena 2013). The limited availability of specialized health services on the islands adds another hardship, particularly during and after pregnancy, when women have concerns about the safety of their delivery

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and the health of their child. As a result of these limited services, many women report traveling to the mainland for healthcare, exacerbating their emotional and economic burdens (Page et al. 2013). Further, residents operate in a tourist economy, facing much higher commodity prices on the Galápagos than on the mainland (Villacis and Carrillo 2013), which further contributes to concerns around food security (Thompson et al., Chaps. 6 and 13, this volume).

Literature on the developmental origins of health and disease aims to better understand how health disparities emerge in response to environmental conditions, and residents of the Galápagos, and particularly new and expectant mothers, face a breadth of challenges in everyday life on the islands. The peripartum period offers a particularly important opportunity to understand this process on the islands, since development during this time has intergenerational effects on health, which could perpetuate existing health disparities (Thayer and Kuzawa 2014; Wells 2010). Consequently, we have conducted several studies to examine the factors contributing to maternal and child health across the first 1000 days of life in the Galapagos Islands (Fig. 13.1), with the goal of identifying modifiable physical and social environmental exposures that may lead to poorer health outcomes during this period and across the lifespan.

Data described in this chapter come from three studies conducted between June 2016 and December 2018 on San Cristobal Island, Galápagos. While these results are only from San Cristóbal, the results may also be relevant to Santa Cruz and

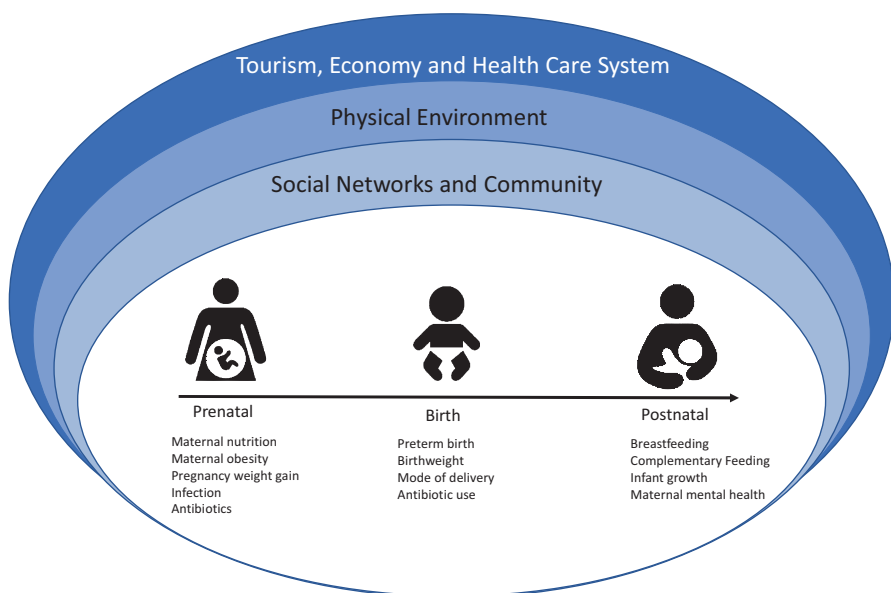


Fig. 13.1 Social and environmental factors influencing maternal and infant health across the first 1000 days in the Galápagos Islands

Isabela islands. The first study, the Birth Practices Study (BPS), was conducted from June to July 2016 and included in-home surveys assessing birth experiences and maternal and child health information from 40 mothers and 41 infants and young children, aged 1 month to 2 years. The second study, the Health Seeking Behavior (HSB) Study, was a qualitative study conducted over two summers, June–July 2016 and June–July 2017. The June–July 2017 wave of the study included in-depth interviews with ten healthcare providers on the islands addressing their perspectives on maternal and child health problems, delivery practices, and healthcare more broadly. The qualitative nature of this investigation aimed to elicit a variety of perspectives on health and healthcare on the island. The third study, the Healthy Moms, Healthy Babies (HMHB) Study, which recruited 38 women at the end of pregnancy and followed them through the first 2 months postpartum, aimed to identify the experiences and stressors of peripartum women and examine how their experiences shaped infant development. Data for this study were collected from January through December 2018 and included semi-structured interviews as well as surveys on stress, depression, and social support. As a part of this study, de-identified data on yearly maternal and infant health characteristics were provided by collaborators at the local hospital.

All three studies received approval for human subject research from the University of North Carolina Institutional Review Board. The BPS and HSB Study received local review approval from Galapagos Science Center and the Universidad San Francisco de Quito. The HMHB Study also received approval from the Institutional Review Board of Universidad San Francisco de Quito (USFQ) and approval from Ecuador's Ministry of Health.

13.2.1 Pregnancy

13.2.1.1 Nutrition and Obesity

Nutrition is a key factor shaping health for mothers and infants across the first 1000 days. Maternal nutritional status, including her diet quality, energy intake, and weight gain, has a direct impact on fetal growth and development. Pregnant women consuming poor quality diets with low intakes of iron and folic acid, for example, are at risk for having infants who are born with complications (Castillo-Lancellotti et al. 2013), preterm (Saccone and Berghella 2016; Symington et al. 2019), or at a low birth weight (Symington et al. 2019), conditions associated with higher morbidity and mortality in early life. Conversely, overweight and obesity prior to and during pregnancy puts women at risk of developing hypertension and gestational diabetes and giving birth to large for gestational age infants. These infants, in turn, are more likely to be obese as preschoolers (Mottola et al. 2010). On the Galápagos, limitations in food availability, reflected in a high prevalence of micronutrient deficiencies, and poor diet quality, associated with the high prevalence of overweight

and obesity, among reproductive aged women may contribute to poor health outcomes for women and infants. Data collected in the Galápagos, in 2012, as part of the nationally representative ENSANUT-ECU study (Freire et al. 2015), documents that 13% of reproductive aged women (15–45 years) were iron-deficient and 56% were zinc-deficient. At the same time, 74% of reproductive-aged women were overweight or obese, contributing to a dual burden of under- and overnutrition that can impact their health and the health of their pregnancies.

Hospital personnel interviewed ($n = 16$) during the HSB study also highlighted food insecurity and poor diet quality, overweight and obesity, and geographic isolation as central and interconnected health challenges for mothers and pregnant women living on the Galápagos. Interviewed doctors and nurses expressed concern about obesity in the general population of the Galápagos, and they estimated that even before pregnancy, half of local women are overweight. Health professionals also identified anemia as an area of concern among pregnant women on the island. Anemia during pregnancy increases the mother's susceptibility to infection and increases her risk for obstetric hemorrhage during birth (Goonewardene et al. 2012). Anemia during pregnancy also increases the risk for adverse perinatal outcomes, including preterm birth, small for gestational age, and the development of anemia in infancy (Goonewardene et al. 2012). Healthcare providers suggested that a more balanced diet of proteins, red meat, vegetables, and fruits could mitigate both obesity and anemia on the island.

In response to the challenges island residents face around the availability and cost of healthy foods, several hospital personnel noted the importance of education in changing the culture around diet. The majority of health professionals that we interviewed also suggested that the culture around food and the lack of education about nutrition manifest in both food choices and ideologies about food and health. Not only do residents not consume enough fresh fruits and vegetables even when they are available, but also cultural misconceptions about nutrition shape intergenerational health during pregnancy. Physicians repeatedly voiced concerns about the misconception among pregnant women that they should “eat for two.” One physician suggested that women “take advantage” of this idea to “eat everything they want, or anything they can,” justifying eating double, instead of interpreting the adage as a more mindful consideration of foods that would be healthy for both the mother's and the baby's growth and development. Research has found that the concept of “eating for two” can be detrimental to maternal and infant health, as overeating during pregnancy has been associated with excessive weight gain during pregnancy (Kraschnewski and Chuang 2014).

Health professionals, including both physicians and nurses, suggested that education on nutrition could serve as a preventative measure against overweight and obesity, particularly during pregnancy, when diet can have intergenerational consequences. To meet this need and address other early parenting concerns, in 2018 Ecuador's Ministry of Health has released an educational program, *Infancia Plena*, which has used health centers to distribute educational books on infant health and

development to pregnant women throughout Ecuador (Gobierno de la República del Ecuador 2020). This program seeks to educate parents on birth and breastfeeding, complementary feeding, infant hygiene, home safety, and general growth trends over the first year of life. Healthcare personnel are hopeful that this resource will provide simple and practical steps that will improve maternal and infant health.

13.2.1.2 Infections

During pregnancy, urinary infections are associated with increased risk of both maternal and neonatal morbidity and mortality, even when the infections are asymptomatic (Gilbert et al. 2013). In low- and middle-income countries, in particular, urinary infections during pregnancy are a prevalent and often under-emphasized risk factor for maternal morbidity and adverse birth outcomes (Gilbert et al. 2013).

On San Cristóbal, maternal infection was often reported by the women in our research studies, and it was offered as a central area of concern for pregnant women by hospital personnel. In 2014, 11% of pregnant women seen by the Ministry of Public Health on the Galápagos were treated for urinary infections. Previous research has suggested that the high incidence of urinary infections may be a consequence of bathing or showering in contaminated water (Houck et al. 2020; Walsh et al. 2010). Urinary infections are of particular concern during pregnancy, since untreated urinary infections during pregnancy have been associated with intrauterine growth restriction, low birth weight, and preterm delivery (Cohen et al. 2019). Research has found that in the long-term, offspring of women who had genitourinary infections during pregnancy had higher risk of infectious morbidity (Cohen et al. 2019), developmental delay (McDermott et al. 2000), childhood epilepsy (McDermott et al. 2010), and attention deficit hyperactivity disorder (Mann and McDermott 2011).

13.2.1.3 Antibiotics

The rising prevalence of antibiotic overprescription now poses worldwide challenges to both the environment and patient health (Ramachandran et al. 2019). Ecuador has the second highest rate of per capita antibiotic consumption in Latin America, as antibiotics have been available over-the-counter and many patients report self-medicating with antibiotics throughout their lives (Hall et al. 2017).

On San Cristóbal, the overprescription of antibiotics, both in the general population and for pregnant women, is now a central health concern. Hospital staff have reported feeling pressured to provide antibiotics to frustrated patients who demand medications for ailments that do not require them, particularly since the hospital is still building trust with the community. Physicians and nurses report witnessing the overprescription of antibiotics in response to feeling the need to satisfy patients by offering them a tangible solution to their ailments. To that end, hospital staff has

discussed the practice of prescribing antibiotics as a form of a placebo, despite the potentially harmful effects of antibiotics for patients who do not need them.

In the HMHB Study, 53% of women reported taking antibiotics at some point during their pregnancies. The reasons that women reported for taking antibiotics included urinary and sexually transmitted infections, the flu, the common cold, and morning sickness. While antibiotics are an effective treatment for urinary and sexually transmitted infections, they do not treat the other conditions mentioned. Further, any prescription of antibiotics during pregnancy should be considered carefully, since antibiotic use during pregnancy has been associated with increased risk for miscarriage (Fan et al. 2019; Muanda et al. 2017a), congenital malformations (Muanda et al. 2017b), and asthma in infants (Stensballe et al. 2013).

13.2.2 Birth

13.2.2.1 Preterm Birth and Low Birth Weight

Preterm birth and low birth weight have been associated with both short- and long-term consequences for health. Preterm birth is a risk factor for later high blood pressure, lung disease, high blood glucose, and mental health disorders (Luu et al. 2017), and low birth weight has been associated with similar outcomes later in life, including metabolic disease, diabetes, mental health disorders, and various types of cancer (Negrato and Gomes 2013).

Most women on the Galápagos give birth in a hospital (97.4%), but the infant mortality rate on the islands (4/1000) is higher than the national average (1.3/1000) (Freire et al. 2015). Physicians on San Cristóbal attribute these rates of mortality to complications from preterm deliveries. According to nationally collected data, the prevalence of preterm birth on the islands is 13.5%, compared to 10.5% nationally (Freire et al. 2015). Data from the BPS, however, suggests that these rates may be higher. Seven out of 39 women (17.9%) reported a delivery earlier than 36 weeks. While this higher figure likely derives from the small sample size and time frame of births represented, this high prevalence in a small population of women likely drives medical personnel's perceptions that preterm birth is a problem for mothers on the islands. Further, concerns about caring for both women in early labor and for preterm infants may derive from the distance of the islands to the mainland and specialized neonatal care facilities. Nurses, for example, expressed concerns about the high prevalence of preterm births on Isabela, the most isolated of the populated islands. Women who go into early labor on Isabela, which lacks a hospital, must wait for transport by air to San Cristobal or the mainland, increasing the risk to themselves and their infants.

The rate of low birth weight (<2500 g) on the islands (6.4%) is comparable to that of the national average (6.8%) (Freire et al. 2015). In the BPS, 5.6% of the infants were born low birth weight, and in the HMHB Study, only 2.6% of infants

were born low birth weight, suggesting that while preterm birth is a concern, low birth weight is not a central challenge to early development on the Galápagos.

13.2.2.2 Cesarean Section

While delivery by Cesarean section (C-section) can be imperative for the immediate health and survival of a woman and her child, unnecessary C-section has been associated with higher morbidity and mortality for both mothers and their infants (Runmei et al. 2012; Villar et al. 2006). Women who deliver by C-section are at higher risk for infection, venous thromboembolism, abnormal placentation, placenta accreta, and uterine rupture than those who deliver vaginally (Boutsikou and Malamitsi-Puchner 2011; Silver 2012). Furthermore, those born by C-section are at higher risk for hypertension (Horta et al. 2013), allergy and asthma (Cho and Norman 2013; Kristensen and Henriksen 2016), diabetes (Cardwell et al. 2008; Chavarro et al. 2020), gastrointestinal disease (Bager et al. 2012), and overweight and obesity (Blustein et al. 2013; Horta et al. 2013) in offspring later in life.

Ecuador's C-section rate has been rising far beyond the 10–15% rate recommended by the World Health Organization (World Health Organization (WHO) 2015) over the past few decades, and the C-section rate on the Galápagos is even higher than that on the mainland (Jahnke et al. 2019; Ortiz-Prado et al. 2017). In the BPS from 2016, 58% of deliveries were by C-section, and in the HMHB Study in 2018, 52% of women delivered by C-section. According to maternal report of the reason for C-section deliveries in these studies, 39% were due to previous C-sections, 13% due to prolonged labor, 13% due to fetal malpresentation, 11% due to the baby being “too big,” 5% due to the mother's “narrow hips,” and the remainder due to preeclampsia, a history of miscarriage, patient choice, and unidentified complications. C-sections, particularly those that occur before the onset of labor, have been linked to a number of inflammatory conditions in childhood and adolescence, including increased allergy and asthma and elevated risk of overweight and obesity (Blustein et al. 2013; Cho and Norman 2013), making the high rate of C-section on the islands a concern for long-term development.

Many healthcare providers discussed the high rate of C-sections as a health concern in the Galápagos, but their explanations for the rate did not align with the reasons provided by maternal report in our research studies. Providers reported that the high C-section rate may be a result of limited resources, explaining that when there are not enough beds to house all the women in labor, the hospital can meet the patient demand by delivering women by C-section to save time. They also suggested that women elect to deliver by C-section for a variety of reasons. First, in the Galápagos, where women frequently travel to the mainland of Ecuador to give birth, scheduling a C-section allows them to have a specific delivery date around which they can plan travel. Second, providers suggested that women's fear of pain during vaginal birth coupled with stigma regarding the lasting effects of sexual displeasure following birth motivated women to elect C-sections. Last, doctors explained that many women who have had a C-section for their first delivery will have C-sections

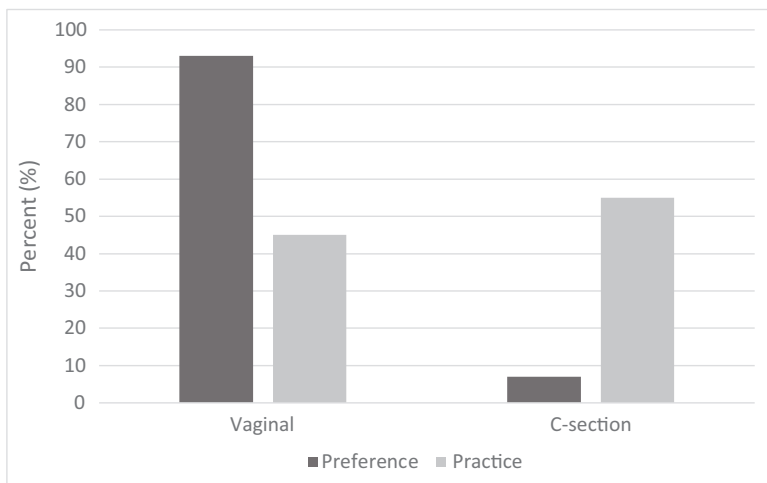


Fig. 13.2 Cesarean delivery preference and practice in the BPS and the HMHB study (combined, $n = 73$)

for all their subsequent deliveries, which is consistent with data from maternal report.

In interviews, women from our studies generally reported a strong desire to deliver vaginally. In the BPS, only 11% of women reported wanting to deliver by C-section, but ultimately 55% did have C-sections. In the HMHB Study, only one woman (3%) reported wanting to deliver by C-section. Figure 13.2 shows the percentage of women from both the BPS and the HMHB Study ($n = 73$) who preferred and ultimately had a natural or Cesarean delivery. Those who reported wanting to deliver by C-section (7%) most often cited their fear of the pain of vaginal delivery as the reason. Those who reported not wanting to deliver by C-section (93%) often reported that worrying about having to deliver by C-section was one of the most central concerns about their pregnancies. Most women in these studies who ultimately delivered by C-section but had not previously had one reported that they attempted to deliver vaginally, but eventually the birthing team suggested C-section due to a determination of prolonged labor or that the infant was too big, the woman's hips were too narrow, or the infant was positioned badly for vaginal delivery.

13.2.3 *The Postpartum*

13.2.3.1 Breastfeeding

Breastfeeding has numerous benefits for infant health, including the conference of passive immunity (Labbok et al. 2004), a high nutrient density (Ballard and Morrow 2013), and protection against the development of overweight and obesity later in

life (Thompson 2012). Breastfeeding is common in Ecuador with nearly universal initiation and an average duration that continues to nearly the first year of life (Freire et al. 2014; Thompson et al. 2019). Similarly, nearly all Galápagos infants receive at least some breastmilk. In the BPS, 99% of infants received breastmilk after birth, and 58.5% of infants were still being breastfed at the time of the interview, which occurred at a median of 7 months after birth (range 1–28 months). Among those still breastfeeding, over 2/3 of infants were aged 10 months or older. At the same time, the use of formula as a supplement was also common. Twenty-five of 40 (62.5%) infants received formula, with most starting within the first 3 months of life. In the HMHB Study, 27% of babies had been formula-fed at least once by 1 month postpartum and 36% of babies had been formula-fed at least once 2 months postpartum. All women reported continuing to breastfeed at 2 months postpartum. These results complement other research in Ecuador, which found that 86% of women initiate breastfeeding within 1 day of the infant's birth, but only 53% of infants are exclusively breastfed in the first month of life, and 35% are exclusively breastfed at 4–5 months of age (Freire et al. 2014).

In our studies, most women reported that breastfeeding was going well, with few or no problems. Those who did voice concerns about breastfeeding often reported difficulties producing enough milk, pain during breastfeeding, or embarrassment at the need to expose themselves to breastfeed in public. Women frequently explained that their insufficient milk production was a result of their high stress or medications they were taking (particularly from C-section). Insufficient milk production was also the primary reason that women reported incorporating formula into their feeding practices. Other reasons for formula feeding included the mother's absence for work or school, the ease and efficiency of formula feeding, and doctor's recommendation due to maternal diabetes.

13.2.3.2 Complementary Feeding and Diet Quality

Along with breastfeeding practices, the timing of introduction and the quality of complementary foods are important for infant growth and development. The WHO recommends that infants receive solid foods beginning at 6 months of age. Earlier introduction has been associated with greater risk of growth faltering, gastrointestinal infections, and, in higher-income settings, child obesity (Przyrembel 2012). Conversely, later introduction has been linked to increased risk of both growth faltering and child obesity (Stewart et al. 2013; Tahir et al. 2018). While the introduction of milks other than breastmilk is relatively common in Ecuador with 71% of infants introduced before 6 months of age, fewer than 25% of infants receive solid foods before 6 months of age (Freire et al. 2015). Similarly, in the BPS, among the 25 infants receiving solids at the time of the interview, the median age of introduction was 6 months with fewer than 10% of infants receiving solid foods at 4 months or younger and only 10% receiving solids after 6 months of age.

Fruits were the most commonly consumed solid food, as all but one infant had been introduced to fruits, and 75% of infants had eaten fruits in the past day

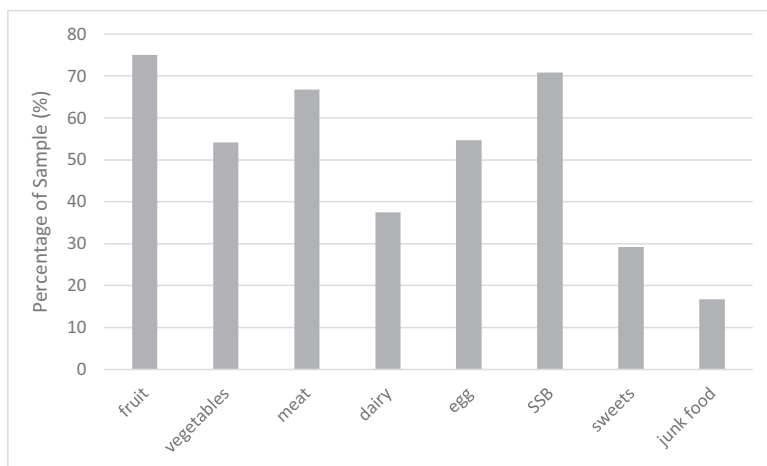


Fig. 13.3 Food consumed by infants in the past 24 h in the BPS ($n = 25$)

(Fig. 13.3). Commonly consumed fruits included apples, pears, mandarins, bananas/plantains, and papaya. Vegetable consumption was less common; 83% of infants had ever received vegetables and just over half (54%) of infants ate vegetables in the past 24 h. The most commonly consumed vegetables were broccoli and carrots. In terms of diet diversity, 75% of infants consumed foods from more than one “healthy” food group (fruits, vegetables, meats, eggs, and dairy) in the past 24 h. However, infants also consumed foods that would be considered empty calorie or highly processed foods. Forty-two percent of infants consumed one or more sweets or junk foods (cookies, sweets, ice creams, fried foods, or junk foods) in the past 24 h. Similarly, the consumption of sugar-sweetened beverages was high. Seventy percent of infants received juice, coladas, yogurt drinks, or soda in the past 24 h. While the sugar level of these drinks varies, juices and coladas (oatmeal drinks) are often prepared at home with added sugars, and yogurt tends to be consumed as a sweetened, flavored drink. Our work complements previous work, which also found that children in the Galápagos consume a high prevalence of processed foods (Pera et al. 2019) and that young children are overweight and obese (Page et al. 2013, 2019).

While mothers were not directly asked about why or how they chose their infants’ foods, many did talk about the quality of food and water on the islands being a concern. Many mothers stated that the water is not drinkable or is “dirty.” While most mothers reported providing their infants with water in the past 24 h, concerns about water quality may lead to the consumption of sodas and other bottled drinks. Similarly, mothers talked about limitations in the quality and quantity of food available on the islands. Common sentiments were that fresh food is expensive and arrives spoiled from the mainland and that the supply and/or variety of fresh foods is limited. Only one mother explicitly linked these concerns to her infant feeding decisions – that the dirty water was a concern, so her infant received breastmilk – however, these factors likely shape mothers’ feeding decisions. The high prevalence

of fruit consumption, for example, may be linked to the availability of local products (bananas, mandarins, and papaya), while the lower prevalence of vegetable consumption might be due to the reliance on vegetables from the mainland (i.e., broccoli). Similarly, concerns about the quality of fresh foods may lead mothers to provide prepared beverages or packaged foods.

13.2.3.3 Infant Growth

As is common in many middle-income settings (Tzioumis et al. 2016), both undernutrition and overnutrition are problems for children in Ecuador. Nationally, 25% of children under the age of 5 are stunted, 6.4% are underweight, and 10–26% are iron deficient (Freire et al. 2015). Alongside this prevalent undernutrition, 8.5% of children under 5 are overweight or obese. In the Galápagos, the prevalence of undernutrition is lower, while the prevalence of overweight is higher. Data from ENSANUT-ECU collected in Galapagos documented that just over 10% of children under 5 were stunted, 16% had anemia, and 12.7% were overweight or obese, while the rest were in normal range (Freire et al. 2014). However, the prevalence of both undernutrition and overweight were considerably higher among children under 2 years participating in our BPS. In our study, 15% of infants and young children under 2 years were stunted, while 70% of infants would be considered overweight (>2 weight-for-length z-scores). No participating infants were considered underweight (low weight-for-age z-score) or wasted (low weight-for-height z-score); however, iron deficiency remained a common micronutrient deficiency with 57.5% of infants having hemoglobin less than 11 gm/100 mL. In the HMHB Study, none of the participants were stunted or underweight, but 8% of infants were overweight and 8% of infants were wasted at 2 months of age.

Mothers on San Cristóbal generally thought that their infants were healthy and that the social and physical environment of Galapagos promoted healthy growth in children. Mothers noted that there was little illness on the islands and that children were able to play outside, breathe good air, and eat good foods. They noted that the close social ties of community members created an environment which fostered child growth and development. At the same, mothers in the BPS described water quality and the food environment in contrasting ways. Some mothers thought there was plenty of food available, leading to good growth in children, though others commented on the lack of fresh foods and the presence of processed and junk foods. Similarly, some mothers thought the water quality had improved and that children's rashes and other illness had declined, while the majority noted poor water quality as a continued problem preventing optimal growth in children. These differing perspectives may reflect differences in mothers' expectations based on their own experiences. Mothers coming from cities on the mainland, for example, may find the air quality better in the Galapagos, but may find the water quality to be poorer. Those born on the island (34% in the BPS) may be more sensitive to changes in the food environment, with shifts from local products to processed foods, but may also find the social environment to be closer due to stronger familial and social ties.

13.2.3.4 Perinatal Mood and Anxiety Disorders

Maternal mental health is also important for infant development. While maternal postpartum depression has been the focus of much of this research, other conditions, including anxiety, may persist under the umbrella of perinatal mood and anxiety disorders (PMADs). PMADs may affect caregiver-infant relationships, and thus growth and development trajectories for infants (Hoffman et al. 2017). In particular, maternal PMADs have been associated with poorer infant cognitive development (Smith-Nielsen et al. 2016), higher risk for nonverbal communication delays (Kawai et al. 2017), and dysregulated infant sleep and feeding (Sharkey et al. 2016).

On San Cristóbal, at 1 month postpartum, 29% of women scored as depressed (using the Patient Health Questionnaire) and 26% of women scored as highly stressed (using the Perceived Stress Scale) in the HMHB Study. Both of these constitute a marked increase from scores for depression and high stress during pregnancy, which were 26% and 0%, respectively. Previous research on the islands found that 25% of women in the study scored above 15 on the CES-D depression scale, indicating a significant level of psychological distress (Page et al. 2013). Despite the high prevalence of stress and depression in new mothers, many women report not having the mental healthcare and support they require on San Cristóbal island, which only has one psychologist.

13.3 Conclusions and Recommendations

Development during the perinatal period shapes long-term health through a variety of pathways. On the Galápagos, prenatal environments, including maternal nutrition and obesity, maternal infection, and antibiotic use, all may confer risk for aberrant developmental trajectories in offspring. Concerns about the quality and affordability of food on the islands alongside insufficient education on nutrition and healthy eating have been linked with a high prevalence of maternal obesity and overweight, which, during pregnancy, puts infants at risk for obesity later in life (Mottola et al. 2010). Previous research on the Galápagos has also found a high prevalence of obesity both in mothers (Page et al. 2013; Waldrop et al. 2016) and in children (Waldrop et al. 2016). Further, the high prevalence of genitourinary infections on the Galápagos puts infants whose mothers have infections during pregnancy at greater risk of morbidity (Cohen et al. 2019), developmental delays (McDermott et al. 2000), and neurological disorders such as childhood epilepsy (Mann and McDermott 2011; McDermott et al. 2010). Previous research over the past 10 years on Galápagos has also found high rates of genitourinary infections (Houck et al. 2020; Page et al. 2013; Walsh et al. 2010), suggesting that this has been a significant and persistent health concern for residents. Last, the overprescription and overuse of antibiotics during pregnancy on the Galápagos may cause increased risk for miscarriage (Fan et al. 2019), congenital malformations (Muanda et al. 2017b), and asthma later in life (Stensballe et al. 2013).

At parturition, high rates of preterm birth and C-section are of greatest concern on the Galápagos. The prevalence of preterm birth on the Galápagos is higher than that on the mainland, and preterm birth has been associated with metabolic disease and mental health disorders later in life (Luu et al. 2017). Further, the C-section prevalence on the islands is much higher than Ecuador's national rate and the rate recommended by the WHO, and infants born by C-section are at greater risk for metabolic and gastrointestinal disease (Bager et al. 2012; Chavarro et al. 2020; Horta et al. 2013), allergy, and asthma (Kristensen and Henriksen 2016) later in life. The Galápagos Islands' high C-section rate has been examined through both demographic (Jahnke et al. 2019) and developmental lenses, and previous research on the islands demonstrates that infants and children born by C-section have significantly different gut microbiota taxa abundance (Thompson et al. 2019), suggesting that C-section may have long-term effects on development through gut bacteria.

After birth, infant feeding and infant growth can shape long-term development. While our research shows that most Galapaganean women breastfeed for the first few months of life, many women supplement with formula from a young age, and formula does not confer the same nutritional and immunological benefits as breastmilk. Interestingly, throughout Ecuador, exclusive breastfeeding during the first 6 months is associated with a lower maternal education and lower economic status (Freire et al. 2014), suggesting that perhaps work outside the home, nutrition curriculums, or social status may influence infant feeding. Further, our research found that after complementary foods are introduced, many young children consume many sugar-sweetened beverages, sweets, and other calorie-dense, highly processed foods. This is reflected in infant growth, as many participants under 2 years old were considered to be overweight. Last, maternal stress and depression may pose challenges for mothers in their own lives and in their parenting, thus shaping the development of their infants.

In order to address these challenges and improve infant health and developmental trajectories for children on the Galápagos Islands, we must consider how a coordinated intervention, changes in policy, or local practices could most efficiently address these complex and related issues. Promising next steps would work to both prevent the foundation of aberrant development trajectories within the first 1000 days of life and mitigate those that were not preventable through sustained health efforts during childhood and into adulthood. Before and during pregnancy, efforts to improve maternal diet and overweight may help to establish more healthy weight trajectories for offspring. Efforts to improve water sanitation may decrease the incidence of urinary infections, thus decreasing risks from infection as well as risks from the overuse of antibiotics during pregnancy. The sustained overuse of C-sections in the Galápagos demonstrates the need to develop better best practices protocols for C-section indication on the islands, with careful consideration of infrastructural limitations. While challenges in staffing and equipment may necessitate a higher C-section rate than that of the mainland, decreasing the C-section rate will be essential to improving foundational development for children on the islands. After birth, programs that promote the benefits of breastfeeding as well as

information on healthy complementary foods for children under the age of 2 will be necessary to improve infant diet and thus infant growth.

Together, these efforts not only may improve acute concerns for infant morbidity and mortality but also alleviate long-term and chronic health conditions later in life. Since many developmental paths are conferred intergenerationally from mother to child, investing in maternal health now has intergenerational benefits for her children and thus her children's children, establishing a healthier foundation for generations to come.

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