9-16-2015

Factors associated with early growth in Egyptian infants: implications for addressing the dual burden of malnutrition.

Justine A Kavle
George Washington University

Valerie L Flax

Ali Abdelmegeid

Farouk Salah

Seham Hafez

See next page for additional authors

Recommended Citation

Kavle, J. A., Flax, V. L., Abdelmegeid, A., Salah, F., Hafez, S., Ramzy, M., Hamed, D., Saleh, G. and Galloway, R. (2015), Factors associated with early growth in Egyptian infants: implications for addressing the dual burden of malnutrition. Maternal & Child Nutrition. doi: 10.1111/mcn.12213

Authors
Justine A Kavle, Valerie L Flax, Ali Abdelmegeid, Farouk Salah, Seham Hafez, Magda Ramzy, Doaa Hamed, Gulsen Saleh, and Rae Galloway

Maternal & Child Nutrition

DOI: 10.1111/mcn.12213

Original Article

Factors associated with early growth in Egyptian infants: implications for addressing the dual burden of malnutrition

Justine A. Kavle*†‡, Valerie L. Flax§, Ali Abdelmegeid*¶, Farouk Salah¶, Seham Hafez¶, Magda Ramzy††, Doaa Hamed††, Gulsen Saleh¶†† and Rae Galloway*†**

*Maternal and Child Survival Program (MCSP), Washington, District of Columbia, USA, †Maternal, Newborn, Child Health and Nutrition Division, PATH, Washington, District of Columbia, USA, ‡Department of Prevention and Community Health, George Washington University, Milken Institute School of Public Health, §Department of Nutrition, Gillings School of Global Public Health, University of North Carolina, Chapel Hill, North Carolina, USA, ¶SMART Project, MCHIP, Cairo, Egypt, **Jhpiego, Baltimore, Maryland, USA, and ††National Nutrition Institute of Egypt, Cairo, Egypt

Abstract

Optimal nutrition is critical to the attainment of healthy growth, human capital and sustainable development. In Egypt, infants and young children face overlapping forms of malnutrition, including micronutrient deficiencies, stunting and overweight. Yet, in this setting, little is known about the factors associated with growth during the first year of life. A rise in stunting in Lower Egypt from 2005 to 2008 prompted this implementation research study, which followed a longitudinal cohort of infants from birth to 1 year of age within the context of a USAID-funded maternal and child health integrated programme. We sought to determine if growth patterns and factors related to early growth differed in Lower and Upper Egypt, and examined the relationship between weight loss and subsequent stunting at 12 months of age. Growth patterns revealed that length-for-age *z*-score (LAZ) decreased and weight-for-length *z*-score (WLZ) increased from 6 to 12 months of age in both regions. One-quarter of infants were stunted and nearly one-third were overweight by 12 months of age in lower Egypt. Minimum dietary diversity was significantly associated with WLZ in Lower Egypt ($\beta = 0.22$, $P < 0.05$), but not in Upper Egypt. Diarrhoea, fever and programme exposure were not associated with any growth outcome. Weight loss during any period was associated with a twofold likelihood of stunting at 12 months in Lower Egypt, but not Upper Egypt. In countries, like Egypt, facing the nutrition transition, infant and young child nutrition programmes need to address both stunting and overweight through improving dietary quality and reducing reliance on energy-dense foods.

Key words: infant, growth, stunting, overweight, double burden of malnutrition, infant and young child nutrition.

Correspondence: Dr Justine A. Kavle, Maternal and Child Health and Nutrition (MCHN), PATH, 455 Massachusetts Ave. NW, Suite 1000, Washington, DC 20001, USA. E-mail: jkavle@path.org

Introduction

Global recognition, attention and investment in malnutrition was recently brought to the forefront by a World Health Assembly Resolution with six nutrition targets, including the goal of a 40% reduction in the number of stunted children under 5 years of age by 2025 (World Health Organization 2012, 2014). The double burden of malnutrition, defined as the co-existence of stunting and overweight in a population, is a major public health concern in many countries globally, including the Middle and Near East regions (World Food Program 2011; Asfaw 2007b; Austin *et al*. 2013; Breisinger *et al*. 2013; International Food Policy Research Institute (IFPRI) & World Food Programme 2013). Optimal nutrition is considered the foundation of healthy growth in infancy and early childhood as it is critical to the attainment of well-being, cognitive functioning, human capital and sustainable development (World Bank 2006; Victora *et al*. 2008; Stewart *et al*. 2013; International Food Policy Research Institute 2014; Tzioumis & Adair 2014). A number of factors, including diarrhoeal illness, febrile infections, breastfeeding practices, and dietary quantity and quality of complementary foods, are known to be associated with growth (Scrimshaw *et al*. 1968; Allen 1994; Dewey & Mayers 2011). The presence of these factors and their relative importance in influencing growth vary by setting and the child's age (Calloway *et al*. 1993; Allen 1994; Baird *et al*. 2005; Dewey & Mayers 2011; Black *et al*. 2013).

Stunting remains an important problem in Egypt, with approximately one-third of children <5 years of age affected (Food and Agriculture Organization 2006; El-Zanaty & Way 2009) alongside increasing prevalence of overweight and obesity, micronutrient deficiencies and food insecurity (Asfaw 2007b; Austin *et al*. 2013). During the past several years, food prices and food insecurity have risen in Egypt as a consequence of the avian influenza (AI) epidemic (2006) and food, fuel and financial crises (2007–2009), which have added to the complexity of malnutrition in the country (International Food Policy Research Institute (IFPRI) & World Food Programme 2013; World Food Programme 2013b). An increase in the prevalence of stunting from 2005 to 2008 was documented in Lower Egypt, a semi-urban area in northern Egypt, near the capital city of Cairo (El-Zanaty & Way 2006; El-Zanaty and Way 2009), which coincided with an AI outbreak. Recent analyses revealed decreased dietary diversity, reduced poultry consumption and substitution of nutritious foods with sugary foods as a consequence of the AI outbreak (Kavle *et al*. 2015b). During the same time period, a similar increase in stunting prevalence did not occur in Upper Egypt, a rural, agricultural area, in the southern part of the country.

The primary objective of this study was to determine if there were differences in growth patterns and in factors related to growth in Lower Egypt as compared to Upper Egypt within the context of a US government-funded integrated maternal and child health programme. Our secondary objective was to examine the relationship between weight and length to ascertain if weight loss in any two-month interval contributed to stunting at 12 months of age. This information can guide future infant and young child nutrition programming to prevent stunting and overweight in Egyptian children.

Materials and methods

Study design and sites

From 2009 to 2014, Maternal and Child Health Integrated Program (MCHIP) was the United States Agency for International Development (USAID) flagship project on maternal, newborn and child health focused on addressing the underlying causes of maternal, newborn and child mortality. MCHIP carried out the Community-based Initiatives for a Healthy Life (SMART) project in Egypt to improve health service delivery and nutritional status through private sector community development association (CDA) clinics and community health workers (CHWs). The project implemented a nutrition education and rehabilitation programme at the community level to address childhood malnutrition using a positive deviance approach (Sternin *et al*. 1998). This implementation research study employed scientific

Key messages

- Growth patterns in Egyptian infants indicated that length-for-age *z*-score (LAZ) decreased and weight-for-length *z*-score (WLZ) increased from 6 to 12 months of age, culminating in one-quarter of infants stunted, and one-third overweight by 12 months of age.
- Weight loss during any period in the first year of life was associated with a twofold likelihood of stunting at 12 months of age in Lower Egypt.
- Infant and young child nutrition programmes need to address stunting and overweight, within the wider context of the nutrition transition, by promoting dietary quality while addressing reliance on energy-dense junk foods.

inquiry to answer questions concerning how data can inform implementation in a 'usual practice setting' (Peters *et al*. 2013). The study sites reflect two of six SMART project governorates and allowed for comparisons of infant and young child feeding practices and other related factors between regions with the highest (Lower Egypt) and the lowest (Upper Egypt) levels of stunting according to the 2008 Egypt Demographic and Health Survey (El-Zanaty & Way 2009).

The two study sites were Qaliobia governorate in Lower Egypt and Sohag governorate in Upper Egypt. Qaliobia governorate is a semi-urban region, north of Cairo in the Egypt Delta, with an estimated population of 4.2 million. Qaliobia is the top producer of chicken and eggs in the country and 11% of the population are considered poor (United Nations Development Program (UNDP) & Institute of National Planning Egypt 2010). Sohag governorate is an agricultural rural region, which produces sugar cane, grains and clover for animal husbandry (United Nations Development Program (UNDP) & Institute of National Planning Egypt 2010). Nearly half of the population (3.7 million) of Sohag is considered poor.

Sample characteristics

The sample of mother–infant pairs for this study was drawn from SMART project sites composed of five villages in Lower Egypt and five villages in Upper Egypt. In the study areas, the SMART project identified pregnant women, all of whom were invited to participate in the study, and recruited at SMART project CDA private clinics during a 2-month period from February to March 2013. With five clusters per governorate and with an average of 28 participants per cluster, we calculated that this study would have at least 80% power to detect a moderate effect size of 0.45 standard deviation (SD) units in z-scores if the intra-cluster correlation was 0.01.

During routine project home visits, SMART Project CHWs obtained oral consent from women and their husbands for participation of the mother–infant pairs. SMART project volunteers notified CHWs of births in designated study catchment areas, so that infant growth and related information could be collected prospectively from birth until infants were 12 months of age. Eligibility criteria for women to participate in the study included: ≥18 years or age, last trimester of pregnancy, participation in the SMART project and residence in Kafr Shokr district, Qaliobia, Lower Egypt, or El-Maragha District, Sohag, Upper Egypt.

Data collection

Data were collected from April 2013 to June 2014. Ethical approval for the study protocol was obtained from the Egyptian Society for Health Care and Development Research Ethics committee and the PATH Ethics Committee in the United States. Study-affiliated CHWs routinely visited mother–infant pairs every two months, as part of the SMART project, and collected data, as indicated in Table 1, from birth until study infants were 12 months of age.

Anthropometric measurements

Infant weight and recumbent length were measured at 0 (birth), 2, 4, 6, 8, 10 and 12 months of age. Infant weight was measured using SECA digital infant scales, to the nearest 0.1 kg. Infant length was measured in duplicate, to the nearest 0.1 cm, using plastic length boards made according to UNICEF specifications. An average of the two length measurements, taken at each time point, was used in the analysis. Maternal height was measured two months after birth (to the nearest 0.1 cm increment) using tape measures fixed to the wall.

SECA scales were checked for accuracy at the beginning of each day, using a known weight (5.0 kg) by study-affiliated CHWs. The study coordinator and study-affiliated CHWs were trained by the research team, which included local nutritionists, on proper procedures for accurate anthropometric measures of weight and length, using standard guidance from the World Health Organization (WHO 2008b). Infants were measured with minimal clothing, and diapers were removed prior to weighing. The study coordinator provided ongoing quality control for measurement and recording of weight and length through routine visits to study sites and review of data collection forms throughout the study. With the exception

Table 1. Data collection and MCHIP/SMART programme elements in Lower Egypt and Upper Egypt

Study visits	Data collection elements	Elements of MCHIP/SMART programme	SMART programme exposure levels
Birth	Infant weight and length Socio-demographic information		
2 months	Infant and maternal weight and length Exposure to programme elements	• Counselling session on what to expect during the first pregnancy • Monthly session on good nutrition during pregnancy • Message on danger signs during pregnancy • Receipt of iron pills • Message on importance of iron pills to avoid anaemia • Message on plan for childbirth • Message on mother and infant health after delivery	Low = 0–5 elements Medium = 6–10 elements High =1–15 elements
4 months	Infant weight and length Exposure to programme elements Infant dietary intake	• Receipt of a medical examination • Attendance of husband/mother-in-law at any awareness session • CHW weighed and measured the length of the child in the last 2 months • Messages on feeding when sick, care of child when sick, family planning and handwashing	Low = 0–3 elements Medium = 3–5 elements High = 6–8 elements
6, 8, 12 months	Infant weight and length Exposure to programme elements Infant dietary intake	• Receipt of a medical examination • Attendance of husband/mother-in-law at any awareness session • CHW weighed and measured the length of the child in the last 2 months • Messages on feeding when sick, care of child when sick, family planning and handwashing • Messages on complementary feeding	Low = 0–3 elements Medium = 4–6 elements High = 7–9 elements

CHW, community health worker.

of the birth visit, all measurements were conducted at private sector CDA clinics, as part of routine SMART project measurements. SMART project CHWs took birth measurements during routine project home visits within the first 36 h after the birth of the infant, regardless of where the delivery took place.

Anthropometric z-scores were calculated using the WHO growth standard (de Onis *et al*. 2006; WHO Multicentre Growth Reference Study Group 2006). Underweight was defined as weight-for-age z-score (WAZ) less than –2 SD, stunting was defined as length-for-age z-score (LAZ) less than –2 SD, wasting was defined as weight-for-length z-score (WLZ) less than –2 SD, and overweight was defined as WLZ greater than +2 SD.

Information on maternal and socio-demographic characteristics, child morbidity and programme exposure was collected by questionnaire, which was administered to SMART project mothers, by study-affiliated CHWs in Upper and Lower Egypt.

Maternal and socio-demographic characteristics

Data on maternal and socio-demographic characteristics, including age, occupation and marital status, were obtained at 2 months post-partum. Maternal education was coded into two categories (less than secondary or completed secondary or higher) for the analysis.

Infant morbidity

Maternal reports of infant illness were collected at 2, 4, 6, 8, 10 and 12 months of age. Fever was defined as maternal report of any fever experienced in the last two weeks by study infants. Diarrhoea was defined as maternal report of study infants who experienced three or more loose or watery stools per day for a period of ≥7 days in the last two weeks.

Programme exposure to the SMART project

Programme exposure level was divided into three categories (low, medium and high) and was calculated for each visit starting from 2 months. The programme exposure variable took into account receipt by mothers or their family members of various programme elements offered at different time points. Details of the programme elements and the definitions of programme exposure levels by study visit are described in Table 1.

Infant dietary diversity

Infant dietary intake during the previous 24 h was collected from mothers by trained Egyptian nutritionists using local, standard dishes and utensils to calculate quantities of food consumed at four time points during the first year of life. At 4, 6, 8 and 12 months, mothers were asked about the types of food, frequency of feeding their child and number of meals the child ate on the previous day. These time points were chosen to reflect infant and young child feeding milestones within the first year of life and to capture early introduction of complementary foods at 4 months of age, which is a common cultural practice in Egypt. From the recall data, we created seven food group variables, as recommended by the WHO for measuring dietary diversity in infants and young children 6–23 months of age (WHO 2008b). The groups are (1) grains, roots and tubers; (2) legumes and nuts; (3) dairy products (milk, yogurt, cheese); (4) flesh foods (meat, fish, poultry, liver/organ meat); (5) eggs; (6) vitamin A-rich fruits and vegetables; and (7) other fruits and vegetables. We summed the number of different food groups to create a continuous dietary diversity score and further generated a categorical minimum dietary diversity variable using a cut-off of at least four food groups starting from 6 months of age (WHO 2008a). We used a lower cut-off for dietary diversity (two food groups) at 4 months of age because there were few infants who consumed three or four food groups at that age. Further, this cut-off allowed for inclusion of the data on early introduction of foods in our statistical models.

Statistical analysis

Descriptive statistics by governorate were calculated as means or proportions. Differences by governorate in background characteristics and predictor variables were tested using linear regression for continuous variables and logistic regression for categorical variables. Models were adjusted for clustering at the village level.

A single multivariate mixed model for each outcome (WAZ, LAZ, WLZ) was used to examine patterns and predictors of infant growth in Upper and Lower Egypt. Mixed models were selected for this analysis because they allowed us to account for clustering at the village level and within the same individuals measured over time. Models included data at 4, 6, 8 and 12 months when all covariates were available, and controlled for sex, maternal height, parity, maternal education and birth z-score. Predictors were selected based on the literature and the implementation research goals of this analysis. All predictors were retained in the models and included governorate, diarrhoea for 7 days or longer, fever, minimum dietary diversity and programme exposure level. Study visit was also included in the models to allow us to assess patterns of growth and examine differences in growth outcomes in the governorates over time. We tested for the interactions between all predictors and governorate. For significant interactions of categorical variables (such as visit) and governorate, we used Wald's tests to determine overall significance of the interaction. Tests for interactions were considered significant at $P < 0.10$; tests of association were significant at $P < 0.05$. Stata 13.0 was used to conduct statistical analysis.

To understand how weight loss was related to stunting, we calculated losses in weight between adjacent study visits (e.g. 2 and 4 months) and then created an indicator variable for any weight loss during the study. Using logistic regression accounting for clustering at the village level, we examined the association between any weight loss and stunting at 12 months, controlling for sex, maternal height, parity, maternal education and LAZ at birth. We also tested for an interaction of weight loss and governorate.

Results

Study participants

Three hundred women enrolled in the study during their third trimester of pregnancy. One infant died and four mother–infant pairs were lost to follow-up. Of the remaining 295 mother–infant pairs, complete anthropometric data were obtained for 277 (Lower Egypt, $n = 142$; Upper Egypt, $n = 135$). Mothers in Upper Egypt were significantly older ($P < 0.01$), had higher parity ($P < 0.01$) and had less schooling ($P < 0.001$) (Table 2).

Table 2. Characteristics of mothers and infants in Lower and Upper Egypt

Characteristic	Lower ($n = 142$)	Upper ($n = 135$)
Maternal		
Mean age at delivery (±SD), years	25.7 ± 4.3	27.8 ± 5.7**
Mean height at 2 months postpartum (±SD), cm	159.5 ± 6.8	158.5 ± 5.0
Mean parity (±SD)	1.1 ± 1.2	1.7 ± 1.7**
Education, % (*n*)		
Less than secondary	24 (34)	41 (55)
Completed secondary or higher	76 (108)	49 (80)***
Married, % (*n*)	100 (142)	100 (135)
Infant's sex, % (*n*)		
Female	46 (66)	51 (69)
Male	54 (76)	49 (66)

$^{**}P < 0.01$, $^{***}P < 0.001$. Significance was determined using logistic regression for categorical variables and linear regression for continuous variables. All models adjusted for clustering at the village level.

Nutritional status in Egyptian infants

The proportion of infants who were underweight was low throughout the first year of life in both Lower and Upper Egypt (Table 3). Wasting was most common at birth and the proportion declined considerably in both Lower and Upper Egypt until 12 months of age. In Lower Egypt, the proportion of infants who were stunted increased nearly fivefold from 6 to 12 months of age, rising from 5% to 24%. In Upper Egypt, stunting peaked at 6 months (18%), stagnated at 8 months and then declined to 11% by 12 months of age. In Lower Egypt, the proportion of infant who were overweight increased from 6 to 12 months of age, steadily rising, with nearly one-third of infants overweight at 12 months of age. In Upper Egypt, a different pattern was noted, as the proportion of infants who were overweight peaked at 8 months (17%) and decreased by 12 months of age.

Predictors of growth in Egyptian infants

On average, infants had approximately one illness episode during the last 2 months. Fever was quite common, especially from the 4-month visit onwards (Table 4). The proportion of infants with diarrhoea peaked at 6 months in Upper Egypt and 8 months in Lower Egypt. No differences in the proportions of

Table 3. Percent of infants underweight, stunted, wasted and overweight in Lower and Upper Egypt ($n = 277$)

	Underweight (WAZ ≤ −2)		Stunted (LAZ ≤ −2)		Wasted (WLZ ≤ −2)		Overweight (WLZ >+2)	
	Lower % (*n*)	Upper % (*n*)	Lower % (*n*)	Upper % (*n*)	Lower % (*n*)	Upper % (*n*)	Lower % (*n*)	Upper % (*n*)
Birth	3 (4)	2 (3)	8 (12)	10 (13)	10 (14)	14 (19)	13 (19)	11 (15)
4 months	3 (4)	6 (8)	6 (9)	3 (4)	4 (6)	7 (9)	6 (9)	2 (3)
6 months	1 (1)	5 (7)	5 (7)	18 (24)	1 (1)	5 (7)	10 (14)	15 (21)
8 months	0 (0)	4 (6)	12 (17)	16 (21)	1 (1)	2 (3)	19 (27)	17 (23)
12 months	0 (0)	4 (6)	24 (33)	11 (15)	0 (0)	1 (1)	30 (42)	10 (14)

LAZ, length-for-age *z*-score; WAZ, weight-for-age *z*-score; WLZ, weight-for-length *z*-score.

Table 4. Predictors of growth among infants in SMART project areas in Lower and Upper Egypt ($n = 277$)

	4 months		6 months		8 months		12 months	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Morbidity								
Diarrhoea[†], % (*n*)	16 (23)	17 (23)	20 (29)	21 (29)	21 (30)	10 (14)	12 (17)	13 (18)
Fever[‡], % (*n*)	41 (58)	42 (57)	50 (71)	50 (68)	46 (66)	54 (72)	39 (56)	53 (71)
Breastfeeding								
Breastfed, % (*n*)	96 (136)	97 (131)	96 (136)	96 (129)	96 (133)	94 (126)	92 (131)	88 (119)
Dietary diversity								
Mean (SD) number of food groups[§]	0.5 ± 0.8	0.8 ± 0.8	2.0 ± 0.8	1.7 ± 1.0	2.9 ± 1.0	2.7 ± 1.1	3.6 ± 1.0	3.6 ± 1.1
Minimum dietary diversity[¶], % (*n*)	17 (24)	21 (28)	7 (10)	9 (12)	27 (38)	32 (43)	52 (74)	59 (79)
Grains, roots and tubers, % (*n*)	16 (23)	11 (15)	82 (114)	56 (72)	89 (127)	81 (110)	96 (137)	89 (121)
Legumes and nuts, % (*n*)	1 (1)	0 (0)	6 (9)	9 (12)	17 (24)	16 (21)	15 (21)	33 (44)
Dairy products, % (*n*)	30 (43)	52 (70)	81 (115)	76 (102)	89 (127)	86 (116)	96 (136)	91 (123)
Flesh foods, % (*n*)	0 (0)	0 (0)	4 (5)	7 (9)	17 (24)	21 (28)	37 (52)	35 (47)
Eggs, % (*n*)	0 (0)	0 (0)	6 (9)	2 (3)	18 (25)	14 (19)	31 (44)	38 (51)
Vitamin A-rich fruit and vegetables, % (*n*)	0 (0)	1 (2)	2 (3)	1 (1)	9 (13)	7 (10)	23 (32)	17 (23)
Other fruit and vegetables, % (*n*)	1 (1)	9 (12)	13 (18)	16 (22)	32 (45)	26 (35)	51 (73)	37 (50)
SMART programme exposure[††]								
Low, % (*n*)	40 (55)	33 (43)	59 (83)	56 (75)	69 (96)	76 (100)*	66 (92)	76 (101)***
Medium, % (*n*)	38 (53)	39 (50)	32 (46)	33 (45)	12 (16)	17 (22)	17 (24)	24 (32)
High, % (*n*)	22 (31)	28 (36)	9 (13)	11 (15)	19 (27)	8 (10)	17 (23)	0 (0)

*$P < 0.05$, ***$P < 0.001$. [†]Diarrhoea is defined as maternal report of ≥7 days of diarrhoea in the last 2 weeks. [‡]Fever is defined as maternal report of fever in last 2 weeks. [§]Dietary diversity scores range from 0 to 7 food groups. [¶]Minimum dietary diversity is defined as two or more food groups at 4 months of age and four or more food groups from 6 to 12 months of age. [††]The definition of the programme exposure categories varies by visit, depending on the activities implemented by infant's age (see Table 1).

infants with diarrhoea or fever were detected by governorate at any study visit.

Nearly all infants were breastfed throughout the study period and there were no differences in the proportion breastfed by governorate (Table 4). The mean number of food groups consumed in the previous 24 h was low throughout the study, as was the proportion of infants 6–12 months of age who achieved minimum dietary diversity. Neither of these variables differed significantly by governorate at any visit. The most commonly consumed food groups were dairy and grains, roots and tubers. Other food groups, including vitamin A-rich fruits and vegetables and meat, were consumed by few infants, even at 12 months of age. The data also revealed delayed introduction of some types of food. At 6 months of age, food variety was minimal. The proportion of infants given meat/flesh foods, eggs, vitamin A-rich fruits and vegetables doubled from 8 to 12 months of age.

Participants were exposed to more elements of the SMART project during the early visits, with exposure generally declining over time (Table 4). Participants in Upper Egypt had greater exposure to some individual programme elements than those in Lower Egypt (data not shown). For example, child weight and height were more frequently measured as part of the SMART project in Upper Egypt than Lower Egypt at 4, 6, 8 and 10 months (all visits, $P < 0.05$). The pattern of exposure to programme elements differed by governorate at 8 and 12 months, indicating that participants in Upper Egypt had lower levels of exposure than those in Lower Egypt ($P < 0.05$ at 8 months, $P < 0.001$ at 12 months).

Predicted patterns of infant growth

As compared with the 4-month visit, all subsequent study visits were associated with higher WAZ and WLZ and with lower LAZ (Table 5). Wald's tests indicated that overall there were significant interactions between visit and governorate, showing that the slopes differed by governorate for LAZ ($P < 0.01$), but not for WAZ or WLZ. The predicted patterns of growth based on the models are shown in Fig. 1.

Table 5. Factors associated with infant growth in Upper and Lower Egypt ($n = 277$)

	WAZ			LAZ			WLZ		
	β	95% CI	*P*-value	β	95% CI	*P*-value	β	95% CI	*P*-value
Governorate†	−0.04	−0.40, 0.32	0.835	0.14	−0.46, 0.75	0.636	−0.41	−1.04, 0.23	0.209
Diarrhoea‡	−0.08	−0.20, 0.04	0.195	0.08	−0.07, 0.24	0.290	−0.12	−0.29, 0.05	0.171
Fever§	0.09	−0.03, 0.21	0.160	0.00	−0.11, 0.12	0.976	0.14	−0.03, 0.31	0.101
Fever*gov	−0.16	−0.33, 0.02	**0.080**	–	–	–	−0.34	−0.58, −0.10	**0.006**
Programme exposure††									
Medium	−0.02	−0.14, 0.10	0.720	−0.04	−0.20, 0.11	0.586	−0.15	−0.40, 0.10	0.239
High	−0.02	−0.22, 0.17	0.807	−0.11	−0.337, 0.14	0.394	−0.26	−0.64, 0.13	0.198
Programme exp*gov									
Medium	–	–	–	–	–	–	0.26	−0.08, 0.60	0.130
High	–	–	–	–	–	–	0.55	0.00, 1.11	**0.049**
Minimum dietary diversity¶	0.03	−0.07, 0.13	0.588	−0.04	−0.18, 0.09	0.519	0.22	0.01, 0.43	**0.039**
Min dd*gov	–	–	–	–	–	–	−0.30	−0.59, −0.02	**0.038**
Visit (ref – 4 months)									
6 months	0.16	0.01, 0.31	**0.032**	−0.37	−0.57, −0.18	**<0.001**	0.45	0.23, 0.67	**<0.001**
8 months	0.42	0.27, 0.57	**<0.001**	−0.61	−0.81, −0.42	**<0.001**	0.89	0.66, 1.11	**<0.001**
12 months	0.57	0.41, 0.72	**<0.001**	−0.98	−1.19, −0.78	**<0.001**	1.17	0.94, 1.40	**<0.001**
Visit*gov (ref – 4 months)									
6 months	−0.03	−0.24, 0.18	0.784	−0.21	−0.49, 0.06	0.123	0.27	−0.05, 0.58	**0.094**
8 months	−0.07	−0.29, 0.14	0.496	−0.03	−0.31, 0.24	0.815	0.21	−0.12, 0.54	0.215
12 months	−0.17	−0.39, 0.05	0.131	0.27	−0.02, 0.55	**0.067**	−0.07	−0.42, 0.27	0.676

LAZ, length-for-age *z*-score; WAZ, weight-for-age *z*-score; WLZ, weight-for-length *z*-score. †Lower Egypt is used as the reference governorate. ‡Diarrhoea is defined as maternal report of ≥7 days of diarrhoea in the last 2 weeks. §Fever is defined as maternal report of fever in the last 2 weeks. ¶Minimum dietary diversity is defined as two or more food groups at 4 months of age and four or more food groups from 6 to 12 months of age. ††The definition of the programme exposure categories varies by visit, depending on the activities implemented by infant's age (see Table 1). Results were obtained using a single mixed model for each outcome including 4, 6, 8 and 12 months and accounting for clustering at the village and individual levels. Models control for infant sex and birth *z*-score, maternal height, parity and education. Significance of bold-faced are *P*-value < 0.10.

We observed significant interactions of governorate with fever for WAZ and WLZ and of programme exposure and minimum dietary diversity with WLZ (Table 5). However, further examination of the interactions revealed that minimum dietary diversity was significantly associated with WLZ in Lower Egypt ($\beta = 0.22$, $P < 0.05$), but not in Upper Egypt. There was no significant association of fever in either governorate with WAZ or WLZ and no significant association of programme exposure in either governorate with WLZ. No interaction between governorate and diarrhoea was detected and diarrhoea was not associated with any growth outcome.

Association of weight loss with stunting at 12 months

We observed a significant interaction of governorate and weight loss between any adjacent study visits ($P < 0.05$). Weight loss, in any 2-month interval during the first year of life, was associated with a greater odds of stunting at 12 months in Lower Egypt [odds ratio (OR) 2.0, $P < 0.05$], but no association was detected in Upper Egypt (OR 0.83, $P = 0.59$).

Discussion

Growth patterns in this cohort of Egyptian infants indicated that LAZ decreased and WLZ increased from 6 to 12 months of age. The slopes for both outcomes were steeper in Lower Egypt than Upper Egypt, culminating in stunting prevalence of ~25% and overweight prevalence of ~30% at 12 months of age in Lower Egypt. We found a positive association of minimum dietary diversity with WLZ (Lower Egypt only). Other factors, including diarrhoea, fever and programme exposure, were not associated with any continuous growth outcome. Weight loss during

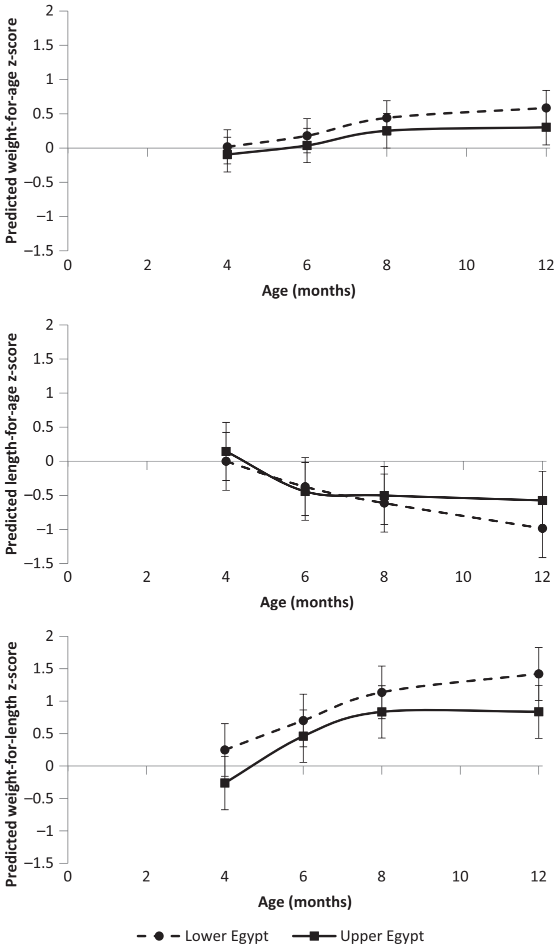

Fig. 1. Predicted weight-for-age *z*-score, length-for-age *z*-score and weight-for-length *z*-score in Egyptian infants. Predicted *z*-scores were calculated based on mixed models of factors related to growth, including fever, diarrhoea, programme exposure, minimum dietary diversity and visit. Models accounted for clustering and controlled for maternal height, parity, maternal education, infant sex and birth *z*-score.

any period was associated with greater odds of stunting at 12 months in Lower Egypt, but not in Upper Egypt.

Dietary diversity in this population of infants was poor, with only about half of them meeting the WHO cut-off for adequate diversity even at 12 months. Our recent implementation research shows that Egyptian infants and young children <2 years of age frequently consume energy-dense 'junk' foods (i.e. high in fat, low in nutrients) in conjunction with a limited variety of small quantities of nutritious foods, a pattern which was more pervasive in Lower Egypt (Kavle *et al*. 2014b, 2015a). Egyptian children, overall, had inadequate intakes of multiple nutrients, including energy, zinc, vitamin A and iron, and junk foods comprised about 20% of energy intake from 6 to 11 months of age (Kavle *et al*. 2014b, 2015a). In this cohort, at 6, 8 and 12 months of age, approximately 15–20% of energy intake was composed of junk foods in both regions. Lower Egypt had a lower percentage of families that were deemed poor in comparison to Upper Egypt (11% vs. 50%). It may be that a greater proportion of families in Lower Egypt chose to utilise their resources in purchasing processed foods, which was likely supported by greater access to these foods and higher incomes. Government subsidies of sugar and oil have permeated the Egyptian food base, which can also contribute to the problem of feeding low-nutrient, high-calorie foods (Asfaw 2007a,b; Austin *et al*. 2013; Kavle *et al*. 2014a). This type of dietary pattern may explain why we detected a positive association between dietary diversity and WLZ.

In Egypt, static stunting rates and rising levels of overweight and obesity in infants and young children have emerged as an escalating public health concern within the 'nutrition transition' (Food and Agriculture Organization 2006; El-Zanaty & Way 2009), typified by a growing reliance on energy-dense, low-in-nutritional value foods and a shift away from traditional diets (Musaiger 2011; World Food Programme 2013a,b). Countries in the midst of the nutrition transition have shown the existence of the dual burden of malnutrition within the same household (Garrett & Ruel 2005). A stunted child and an overweight mother in the same home have been documented with higher frequency (>10% of households) in Egypt and several Latin American countries, in contrast to countries that have not yet experienced the depth or extent of this phenomenon (Garrett & Ruel 2005). In comparison with normal and non-obese households, child consumption of sugary snack foods is associated with 51% higher likelihood of being part of a 'stunted child and obese mother' household (Aitsi-Selmi 2015). A diet high in energy that provides excess calories may contribute to overweight while at the same time lacking the micronutrients needed to prevent stunting (Tzioumis & Adair 2014). The association we detected between higher energy intake and higher WAZ is consistent with Egypt's stage in the nutrition transition and with dietary patterns in this age group. Timing of introduction of complementary foods also may have played a role in the progression of overweight in the first year of life. In Egypt, early introduction of 'junk foods' (i.e. sugary biscuits, cream-filled sponge cakes) and other foods defined locally as 'age-appropriate' is a common cultural practice (Kavle *et al*. 2014b, 2015a). Evidence from another setting indicates that infants who received foods prior to 16 weeks of age had significantly higher weight gain in the first year of life than infants who started eating food later (>16 weeks) (Baker *et al*. 2004). Egyptian mothers often choose to feed 'simple' and 'light foods', such as yogurt, biscuits, potatoes and withhold nutrient-rich foods (i.e. meat) prior to 12 months of age, which can explain the reduced dietary diversity (Kavle *et al*. 2015a).

In this study, weight loss in any interval during the first year of life was associated with a twofold likelihood of a child being stunted by 12 months of age. This finding is consistent with the research showing a relationship between WLZ and subsequent stunting (Dewey *et al*. 2005; Richard *et al*. 2012). In Egypt, our data indicate that rates of wasting were low, while a notable proportion of infants were stunted or overweight and 25% of those who were stunted at 12 months of age were also overweight. Mechanisms governing growth are not well understood, although some evidence indicates that linear growth may be regulated, in part, by initial body mass or fatness (Dewey *et al*. 2005). Stunting and wasting have been described as distinct processes, which respond to stressors in different ways and are dependent on the timing and severity of the stressors (Martorell & Young 2012). It also has been hypothesised that minimal or 'marginal' insults will result in loss in length while weight-for-length is conserved (Walker *et al*. 1996).

Limitations

This study had several limitations. Firstly, the study sample was limited to the 300 pregnancies that occurred during the enrolment period, all of which were included in the study. A larger sample size may have aided in our ability to detect associations between growth, dietary diversity and illness, as well as programme exposure. Secondly, our study focused on the period of infancy, although stunting peaks at 18–23 months of age in Egypt, when relationships with factors related to growth may be more pronounced (El-Zanaty & Way 2009). Thirdly, infants were reported to be ill frequently, yet there was no association of diarrhoea or fever with any growth outcomes. Negative associations of diarrhoea with weight in the short term and length in the long term are well established (Richard *et al*. 2013), and diarrhoea has previously been associated with linear growth faltering in Egyptian children (Neumann & Harrison 1994). The lack of association of illness with growth in this study may reflect the difficulty of obtaining data on the severity of illness by maternal interview. Maternal perceptions of what constitutes diarrhoea are not always consistent with biomedical definitions of the condition (Killewo & Smet 1989; Bentley 1992; Hadad *et al*. 2002; Mwambete & Joseph 2010).

Conclusion

These data reveal that overweight and stunting begin in the first year of life among Egyptian infants and have implications for nutrition programmes in this setting. The SMART project implemented in these areas of Egypt focused on a positive deviance approach, which targets infants who are underweight. Given that many infants in this population were overweight and stunted, rather than underweight, and no association of programme exposure with growth outcomes was demonstrated in this analysis, there is a need to develop new intervention strategies to address the double burden of malnutrition in this population. In Egypt, infant and young child nutrition programmes should target prevention of stunting and overweight by promoting dietary quality and addressing dietary intake patterns, including reliance on energy-dense junk foods.

Acknowledgements

We gratefully acknowledge USAID Egypt and USAID Washington for their funding and support of the study. We would like to thank our MCHIP/SMART project team and local counterparts for their contributions, including Murad Habib, who developed the database for data entry, and Mahmoud Abdo, Ebtesam Seddik and Rasha Hosni of Smart Project, who provided data entry support. We appreciate statistical advice for this manuscript from Mark Weaver at the University of North Carolina.

Source of funding

This manuscript was made possible by the generous support of the American people through the United States Agency for International Development (USAID), under the terms of the Leader with Associates Cooperative Agreement GHS-A-00-08-00002-00 and Cooperative Agreement AID-OAA-A-14-00028. The contents are the responsibility of The Maternal and Child Health Integrated Program (MCHIP) and The Maternal and Child Survival Program (MCSP), and do not necessarily reflect the views of USAID or the United States Government.

Conflicts of interest

Valerie Flax was engaged as a consultant to lead data analyses presented in this manuscript.

Contributions

JAK was involved in the study design, collection, analyses and interpretation of data and writing of the paper. VLF led analyses, contributed to interpretation of findings, and writing of the paper. AA, FS, DH, MR and SH were involved in study design and data collection. MH, DH and GF aided in collection, analyses and interpretation of the 24 hour recall dietary data. RG was involved in study design, and provided comment to manuscript draft. All authors were involved in the decision to submit the paper for publication.

References

Aitsi-Selmi A. (2015) Households with a stunted child and obese mother: trends and child feeding practices in a middle-income country, 1992–2008. *Maternal and Child Health Journal* **19**, 1284–1291.

Allen L.H. (1994) Nutritional influences on linear growth: a general review. *European Journal of Clinical Nutrition* **48** (Suppl. 1), S75–S89.

Asfaw A. (2007a) Do government good price policies affect the prevalence of obesity? Empirical evidence from Egypt. *World Development* **35**, 687–701.

Asfaw A. (2007b) Micronutrient deficiency and the prevalence of mothers' overweight/obesity in Egypt. *Economics and Human Biology* **5**, 471–483.

Austin A.M., Hill A.G. & Fawzi W.W. (2013) Maternal obesity trends in Egypt 1995–2005. *Maternal and Child Nutrition* **9**, 167–179.

Baird J., Fisher D., Lucas P., Kleijnen J., Roberts H. & Law C. (2005) Being big or growing fast: systematic review of size and growth in infancy and later obesity. *BMJ (Clinical Research Ed.)* **331**, 929.

Baker J.L., Michaelsen K.F., Rasmussen K.M. & Sorensen T.I. (2004) Maternal prepregnant body mass index, duration of breastfeeding, and timing of complementary food introduction are associated with infant weight gain. *The American Journal of Clinical Nutrition* **80**, 1579–1588.

Bentley M.E. (1992) Household behaviors in the management of diarrhea and their relevance for persistent diarrhea. *Acta Paediatrica Supplement* **381**, 49–54.

Black R.E., Victora C.G., Walker S.P., Bhutta Z.A., Christian P., de Onis M. *et al*. (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* **382**, 427–451.

Breisinger C., Al-Riffai P., Ecker O., Abuismail R., Waite J., Abdelwahab N. *et al*. (2013) Tackling Egypt's Rising Food Insecurity in a Time of Transition. Joint Policy Note International Food Policy Research Institute (IFPRI) and World Food Programme (WFP), Washington, DC.

Calloway D.H., Murphy S.P., Beaton G.H. & Lein D. (1993) Estimated vitamin intakes of toddlers: predicted prevalence of inadequacy in village populations in Egypt, Kenya, and Mexico. *The American Journal of Clinical Nutrition* **58**, 376–384.

Dewey K.G. & Mayers D.R. (2011) Early child growth: how do nutrition and infection interact? *Maternal and Child Nutrition* **7** (Suppl. 3), 129–142.

Dewey K.G., Hawck M.G., Brown K.H., Lartey A., Cohen R.J. & Peerson J.M. (2005) Infant weight-for-length is positively associated with subsequent linear growth across four different populations. *Maternal and Child Nutrition* **1**, 11–20.

El-Zanaty F. & Way A. (2006) Egypt Demographic and Health Survey 2005. Ministry of Health and Population, National Population Council, El-Zanaty and Associates, and ORC Macro, Cairo, Egypt.

El-Zanaty F. & Way A. (2009) Egypt Demographic and Health Survey 2008. Ministry of Health and Population, National Population Council, El-Zanaty and Associates, and ORC Macro, Cairo, Egypt.

Food and Agriculture Organization (2006) The double burden of malnutrition: Case studies from six developing countries. In: *Food & Nutrition Paper* (ed. Food and Agriculture (FAO) Nutr Paper), Vol. 84, pp. 1–334. FAO: Rome, Italy.

Garrett J.L. & Ruel M.T. (2005) Stunted child-overweight mother pairs: prevalence and association with economic development and urbanization. *Food and Nutrition Bulletin* **26**, 209–221.

Hadad S., Franca E. & Uchoa E. (2002) Preventable infant mortality and quality of health care: maternal perception of the child's illness and treatment. *Cadernos de Saude Publica* **18**, 1519–1527.

International Food Policy Research Institute (2014) *Global Nutrition Report 2014: Actions and Accountability to Accelerate the World's Progress on Nutrition*. IFPRI: Washington, DC.

International Food Policy Research Institute (IFPRI) & World Food Programme (2013) Tackling Egypt's rising food insecurity in a time of transition. IFPRI-WFP Country Policy Note. Cairo, Egypt.

Kavle J., Mehanna S., Khan G., Hassan M., Saleh G. & Galloway R. (2014a) Cultural Beliefs and Perceptions of Maternal Diet and Weight Gain during Pregnancy and Postpartum Family Planning in Egypt. USAID Report.

Kavle J., Mehanna S., Saleh G., Foaud M., Ramzy M., Hamed D. *et al*. (2014b) Examining Factors Associated with Stunting in Lower Egypt in comparison to Upper Egypt: Bridging the gap between cultural beliefs and feasible feeding practices through Trials for Improved Practices (TIPs). USAID Report.

Kavle J., Mehanna S., Saleh G., Foaud M.A., Ramzy M., Hamed D. *et al*. (2015a) Exploring why junk foods are 'essential' foods and how culturally tailored recommendations improved feeding in Egyptian children. *Maternal and Child Nutrition* **11** (3), 346–370.

Kavle J.A., El-Zanaty F., Landry M. & Galloway R. (2015b) The rise in stunting in relation to avian influenza and food consumption patterns in lower Egypt in comparison to upper Egypt: results from 2005 and 2008 demographic and health surveys. *BMC Public Health* **15**, 285–303.

Killewo J.Z. & Smet J.E. (1989) Mothers' definition of diarrhoea in a suburban community in Tanzania. *Journal of Diarrhoeal Diseases Research* **7**, 21–23.

Martorell R. & Young M.F. (2012) Patterns of stunting and wasting: potential explanatory factors. *Advances in Nutrition* **3**, 227–233.

Musaiger A.O. (2011) Overweight and obesity in eastern mediterranean region: prevalence and possible causes. *Journal of Obesity* **2011**, 1–17.

Mwambete K.D. & Joseph R. (2010) Knowledge and perception of mothers and caregivers on childhood diarrhoea and its management in Temeke municipality, Tanzania. *Tanzania Journal of Health Research* **12**, 47–54.

Neumann C.G. & Harrison G.G. (1994) Onset and evolution of stunting in infants and children. Examples from the human nutrition collaborative research support program. Kenya and Egypt studies. *European Journal of Clinical Nutrition* **48** (Suppl. 1), S90–S102.

de Onis M., Garza C., Onyango A.W. & Martorell R. (2006) WHO child growth standards. *Acta Paediatrica Supplement* **450** (Suppl.), 1–101.

Peters D.H., Adam T., Alonge O., Agyepong I.A. & Tran N. (2013) Implementation research: what it is and how to do it. *BMJ (Clinical Research Ed.)* **347**, f6753.

Richard S.A., Black R.E., Gilman R.H., Guerrant R.L., Kang G., Lanata C.F. *et al*. (2012) Wasting is associated with stunting in early childhood. *The Journal of Nutrition* **142**, 1291–1296.

Richard S.A., Black R.E., Gilman R.H., Guerrant R.L., Kang G., Lanata C.F. *et al*. (2013) Diarrhea in early childhood: short-term association with weight and long-term association with length. *American Journal of Epidemiology* **178**, 1129–1138.

Scrimshaw N.S., Taylor C.E. & Gordon J.E. (1968) Interactions of nutrition and infection. *World Health Organization Monograph Series* **57**, 3–329.

Sternin M., Sternin J. & Marsh D.R. (1998) Field guide: designing a community-based nutrition education and rehabilitation program using the 'positive deviance' approach. Westport, CT, USA.

Stewart C.P., Iannotti L., Dewey K.G., Michaelsen K.F. & Onyango A.W. (2013) Contextualising complementary feeding in a broader framework for stunting prevention. *Maternal and Child Nutrition* **9** (Suppl. 2), 27–45.

Tzioumis E. & Adair L.S. (2014) Childhood dual burden of under- and overnutrition in low- and middle-income countries: a critical review. *Food and Nutrition Bulletin* **35**, 230–243.

United Nations Development Program (UNDP) & Institute of National Planning Egypt (2010) Egypt Human Development Report: Youth in Egypt 2010. UNDP: Cairo, Egypt.

Victora C.G., Adair L., Fall C., Hallal P.C., Martorell R., Richter L. *et al*. (2008) Maternal and child undernutrition: consequences for adult health and human capital. *Lancet* **371**, 340–357.

Walker S.P., Grantham-McGregor S.M., Himes J.H. & Powell C.A. (1996) Relationships between wasting and linear growth in stunted children. *Acta Paediatrica* **85**, 666–669.
WHO (2008a) *Indicators for Assessing Infant and Young Child Feeding Practices. Parts 1,2,3 Series*. World Health Organization: Geneva, Switzerland.
WHO (2008b) *World Health Organization (WHO) Child Growth Standards: Training Course on Child Growth Assessment*. WHO: Geneva, Switzerland.
WHO Multicentre Growth Reference Study Group (2006) *WHO Child Growth Standards: Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age: Methods and Development*. WHO: Geneva, Switzerland.
World Food Program (2011) Status of Food Security and Vulnerability in Egypt, 2009. World Food Programme: Cairo, Egypt.
World Food Programme (2013a) Cost of Hunger in Egypt: Implications of Child Undernutrition on the Social and Economic Development in Egypt. The Social and Economic Impact of Child Undernutrition in Egypt. Egyptian Cabinet Information Decision Support Center: Cairo, Egypt.
World Food Programme (2013b) Status of Poverty and food Security in Egypt: Analysis and Policy Recommendations. Preliminary Summary Report. World Food Programme: Egypt.
World Health Organization (2012) Comprehensive implementation plan on maternal, infant and young child nutrition. In: *Resolution WHA65.6* (ed. World Health Assembly), pp. 11–13. WHO: Geneva, Switzerland.
World Health Organization (2014) *Global Targets 2025. To Improve Maternal, Infant and Young Child Nutrition* [Online]. Available at: www.who.int/nutrition/topics/nutrition_globaltargets2025/en/ (Accessed 12 December 2014).
World Bank (2006) *Repositioning Nutrition as Central to Development: A Strategy for Large-Scale Action*. World Bank: Washington, DC.

