Published by Oxford University Press on behalf of the International Epidemiological Association
International Journal of Epidemiology 2011;**40**:47–62
doi:10.1093/ije/dyq155

Infant-feeding patterns and cardiovascular risk factors in young adulthood: data from five cohorts in low- and middle-income countries

Caroline HD Fall,[1]* Judith B Borja,[2] Clive Osmond,[1] Linda Richter,[3] Santosh K Bhargava,[4] Reynaldo Martorell,[5] Aryeh D Stein,[5] Fernando C Barros,[6] Cesar G Victora[7] and the COHORTS group[†]

[1]MRC Epidemiology Resource Centre, University of Southampton, Southampton General Hospital, Southampton, UK, [2]Office of Population Studies Foundation, University of San Carlos, Cebu City, Philippines, [3]Human Sciences Research Council, University of Witwatersrand, South Africa, [4]Sunder Lal Jain Hospital, New Delhi, India, [5]Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, USA, [6]Postgraduate Programme in Health and Behavior, Universidade Catolica de Pelotas, Pelotas, Brazil and [7]Postgraduate Programme in Epidemiology, Universidade Federal de Pelotas, Pelotas, Brazil

*Corresponding author. MRC Epidemiology Resource Centre, University of Southampton, Southampton General Hospital, Tremona Road, Southampton SO16 6YD, UK. E-mail chdf@mrc.soton.ac.uk

[†]The members of the COHORTS group are listed in the Acknowledgements.

Accepted 4 August 2010

Background Infant-feeding patterns may influence lifelong health. This study tested the hypothesis that longer duration of breastfeeding and later introduction of complementary foods in infancy are associated with reduced adult cardiovascular risk.

Methods Data were pooled from 10 912 subjects in the age range of 15–41 years from five prospective birth-cohort studies in low-/middle-income countries (Brazil, Guatemala, India, Philippines and South Africa). Associations were examined between infant feeding (duration of breastfeeding and age at introduction of complementary foods) and adult blood pressure (BP), plasma glucose concentration and adiposity (skinfolds, waist circumference, percentage body fat and overweight/obesity). Analyses were adjusted for maternal socio-economic status, education, age, smoking, race and urban/rural residence and infant birth weight.

Results There were no differences in outcomes between adults who were ever breastfed compared with those who were never breastfed. Duration of breastfeeding was not associated with adult diabetes prevalence or adiposity. There were U-shaped associations between duration of breastfeeding and systolic BP and hypertension; however, these were weak and inconsistent among the cohorts. Later introduction of complementary foods was associated with lower adult adiposity. Body mass index changed by −0.19 kg/m^2 [95% confidence interval (CI) −0.37 to −0.01] and waist circumference by −0.45 cm (95% CI −0.88 to −0.02) per 3-month increase in age at introduction of complementary foods.

Conclusions There was no evidence that longer duration of breastfeeding is protective against adult hypertension, diabetes or overweight/adiposity in these low-/middle-income populations. Further research is required to determine whether 'exclusive' breastfeeding may be protective. Delaying complementary foods until 6 months, as recommended by the World Health Organization, may reduce the risk of adult overweight/adiposity, but the effect is likely to be small.

Keywords Infant feeding, breastfeeding, complementary feeding, blood pressure, diabetes, body composition

Introduction

The World Health Organization (WHO) recommends exclusive breastfeeding from birth to 6 months, the introduction of nutritious complementary foods at 6 months and continued breastfeeding for $\geqslant 2$ years.[1] Breastfeeding reduces morbidity and mortality from infection during infancy, and the timely introduction of nutritious complementary foods prevents stunting.[2,3] Optimal infant feeding may also have long-term benefits. Adults and children who were breastfed have lower blood pressure (BP) and lower rates of obesity and type 2 diabetes than those who were bottle-fed,[4–8] with benefit proportionate to the duration of breastfeeding.[9–14] This has been attributed to better appetite regulation and/or lower weight gain in breastfed infants, and/or effects of nutrients or bioactive constituents in breast milk.[6] Fewer studies have investigated long-term associations with the timing of initiation of complementary feeding, but lower rates of childhood obesity have been reported among those who started complementary foods later.[15–17]

A limitation of the published evidence linking breastfeeding to later health is reliance on maternal recall of infant-feeding practices, sometimes many years later.[6–14] Few studies had data on duration of breastfeeding, and almost none had information on complementary feeding. The majority were conducted in high-income countries, where mothers who follow prescribed infant-feeding guidelines tend to be from higher socio-economic and more educated groups.[18,19] Associations of infant feeding with later adiposity and other risk factors are usually attenuated after adjusting for these confounding factors, suggesting that generally healthier family lifestyles, rather than infant feeding, explain the lower disease risk.

In low- and middle-income countries (LMICs), breastfeeding tends to be the norm, but many mothers introduce complementary foods and stop breastfeeding too early.[2] Obesity, diabetes and cardiovascular disease are rising rapidly in these countries.[20] Promoting optimal infant-feeding practices could be a low-cost intervention to improve lifelong health. Data from LMICs may help address confounding issues, because relationships between infant-feeding practices and social class differ from those in high-income settings. The current study analyses data from the COHORTS collaboration (Consortium on Health Orientated Research in Transitional Societies)[21] comprising birth-cohort studies in five LMICs. Our objective was to test the hypothesis that initial breastfeeding, longer duration of breastfeeding and later introduction of complementary foods are associated with lower adult BP, glucose concentrations and adiposity.

Methods

Description of the cohorts

The collaboration among the five cohorts (Table 1) was originally established to contribute a paper for a Lancet Series on Maternal and Child Nutrition.[22] One author (C.G.V.) approached the principal investigators of all follow-up studies in LMICs with 1000 or more subjects aged $\geqslant 15$ years; all agreed to participate. The cohorts include the 1982 Pelotas (Brazil) Birth Cohort;[23] the Institute of Nutrition of Central America and Panama Nutrition Trial Cohort (INTCS, Guatemala);[24] the New Delhi (India) Birth Cohort Study;[25] the Cebu (Philippines) Longitudinal Health and Nutrition Survey (CLHNS)[26] and the Birth to Twenty (BTT—South Africa) cohort.[27] The Guatemala cohort was based on a randomized controlled trial of protein-energy supplementation for the pregnant mothers of the cohort members, and for the cohort themselves as young children;[24] the others were observational studies. All studies were approved by institutional research ethics committees, and participants gave informed consent.

Feeding data

The methods used to collect infant-feeding data varied among the cohorts (Table 1). We defined complementary foods as semi-solid or solid foods. Variables used in the analysis were (i) whether an individual was ever breastfed (yes/no), available for all five cohorts; (ii) total duration of breastfeeding (nine categories from 0 to >24 months), available for all cohorts except India and (iii) age at which complementary foods were introduced (six categories

Table 1 Characteristics of the five cohort studies and how infant-feeding data were collected

Cohort name	Design	Cohort inception (year), and initial sample (N)	Last follow-up visit (year), and number examined (N)	Number included in this analysis (N) and percentage of original cohort	Initial cohort	How the infant-feeding data were collected	Ever breast fed	Total duration of *any* breast-feeding	Duration predominant breast-feeding	Duration exclusive breast-feeding	Age at introduction of complementary foods
Pelotas, Brazil[22]	Prospective cohort	1982, 5914	2005, 4297	4446 (75%)	Children born in the city's maternity hospital (>99% of all births) in 1982. All social classes included.	Mothers were asked at 6, 12, 20 and 48 months if they were breastfeeding and, if not, when they stopped. At 12 months (33% sub-sample) and 20 months (full cohort), they were asked at what age other liquids and foods were added (separately for other milks, herbal teas, juices, fruits, legumes, full family foods). 'Predominant' breastfeeding was defined as breast milk plus water or herbal teas only. Data from earlier visits were used preferentially.	Yes	Yes	Yes	No	Yes
INTCS, Guatemala[23]	Community trial	1969–77, 2392	2004, 1571	1272 (53%)	Intervention trial of a high-energy and protein supplement in women, and children <7 years in 1969 and born during 1969-1977 in 4 villages.	Mothers were asked every 15 days, starting at birth, if they were breastfeeding. From the age of 15 months to 5 years, 24-h recalls were performed every 3–6 months to record detailed dietary intakes.	Yes	Yes	No	No	No
New Delhi, India[24]	Prospective cohort	1969–72, 8181	1998–2002, 1583	1526 (19%)	Babies born to an identified population of married women living in a defined area of Delhi. Primarily middle-class sample.	At each visit (birth, 3, 6, 9, 12, 18 and 24 months) project staff assigned babies to the *highest* applicable category from: 1) Entirely breastfed; 2) Breast + bottle-fed; 3) Entirely bottle-fed; 4) First solids; 5) 3–4 solid foods; 6) Adult diet. For example, if an infant had just started solid feeds, they were classified as category 4, even if they were still receiving breast milk.	Yes	No	No	No	Yes
CLHNS Philippines[25]	Prospective cohort	1983–84, 3080	2005, 2032	2048 (66%)	Pregnant women living in 33 randomly selected	Data were collected every 2 months from 0 to 24 months, to determine if the baby was	Yes	Yes	Yes	Yes	Yes

(continued)

Table 1 Continued

Cohort name	Design	Cohort inception (year), and initial sample (N)	Last follow-up visit (year), and number examined (N)	Number included in this analysis (N) and percentage of original cohort	Initial cohort	How the infant-feeding data were collected	Ever breast fed	Total duration of *any* breast-feeding	Duration predominant breast-feeding	Duration exclusive breast-feeding	Age at introduction of complementary foods
					neighbourhoods; 75% urban. All social classes included.	breastfed and whether it was fed any other foods/liquids. At each 2-monthly visit, a 24-h recall of all foods and liquids was performed, allowing quantification of nutrient intakes.					
Birth-to-twenty South Africa[26]	Prospective cohort	1990, 3273	2005, 2100	1620 (49%)	Babies born to pregnant women living in a defined urban geographical area. Predominantly poor, black sample.	Questionnaires were administered at 3, 6, 12 and 24 months. Mothers were asked if they had ever breastfed the baby; if they were still breastfeeding; if stopped, when they stopped; and if and when a) other milk feeds and b) semi-solid or solid foods were introduced.	Yes	Yes	Yes	No	Yes
Variables used in this analysis							Yes	Yes	No	No	Yes

In Brazil and the Philippines, the number included in this analysis exceeds the number of participants in the last follow-up study, because some data (e.g. height) was utilised from previous follow-up rounds.

from <3 to >18 months), available for all cohorts except Guatemala.

Adult outcomes

Except for the South African participants who were adolescents (mean age 15 years), all others were young adults. For simplicity, these measures are referred to as 'adult' outcomes.

Systolic BP (SBP) and diastolic BP (DBP) were measured by aneroid sphygmomanometer in Brazil, mercury sphygmomanometer in the Philippines and digital devices elsewhere (Guatemala: UA-767, A&D Medical; India: Omron 711; South Africa: Omron M6), using appropriate cuff sizes, after 5–10 min of being seated. The average of two or three measurements was used.[21] Hypertension was defined as SBP $\geqslant$140 mmHg or DBP $\geqslant$90 mmHg and pre-hypertension as SBP $\geqslant$130 mmHg or DBP $\geqslant$80 mmHg. In South Africa, we defined pre-hypertension as SBP or DBP $\geqslant$90th percentile of age-, sex- and height-specific cut-off points.[28] Across all cohorts, <0.5% of participants were on anti-hypertensive medication.

Fasting glucose concentrations were measured in venous plasma (India and South Africa) or capillary plasma (Guatemala) using standard laboratory enzymatic methods, and in venous whole blood (Philippines) using a glucometer ('One Touch', Johnson & Johnson Ltd). In Brazil, random fingerprick capillary whole blood glucose was measured by glucometer (Accu-Check Advantage, Roche Ltd); values were adjusted for time since the last meal.[29] Glucometers overestimate glucose concentrations in whole venous blood compared with standard laboratory methods;[30,31] we subtracted 0.97 mmol/l from the Philippine values.[30] Diabetes was defined as a glucose concentration $\geqslant$7.0 mmol/l, and impaired fasting glucose (IFG) as a concentration $\geqslant$6.1 and <7.0 mmol/l.[32]

Body-composition outcomes included body mass index (BMI = weight/height^2), waist circumference, body fat percentage, triceps and subscapular skinfolds, overweight (BMI $\geqslant$25 kg/m^2) and obesity (BMI $\geqslant$30 kg/m^2).[33] Percentage body fat was estimated in Brazil using bioimpedance and a Deuterium-validated equation;[34] in Guatemala, using weight, height and waist circumference with an equation developed using hydrostatic weighing;[35] in India and the Philippines, using skinfold equations validated for Asian populations;[36,37] and in South Africa, using dual-energy X-ray absorptiometry (Hologic Delphi).

Confounding variables

Earlier research in these cohorts[38–42] indicated that the following should be considered as possible confounding factors: maternal socio-economic status (SES), education, age, smoking, rural/urban residence and race and infant birth weight. For SES at birth, a five-level variable was created for each cohort (1 = least and 5 = most advantaged), using a principal components analysis of household income and/or assets and services (Brazil, Guatemala, Philippines and South Africa) or the father's occupation (India). Information on maternal smoking was not available for Guatemala and India, where maternal smoking was almost non-existent at that time; we assumed all were non-smokers. Brazil and South Africa had racial/skin colour subgroups; we created variables for white, black, mixed-race and Asian groups. The Brazil, India and South Africa cohorts were urban, and the Guatemala cohort rural; in the mixed rural and urban Philippine cohort, an 'urbanicity index' was used.[43]

Missing data and final analysis sample

There was minimal missing data in Brazil, the Philippines and South Africa (Table 2). In the Guatemala cohort, age of introduction of complementary foods was not recorded, and duration of breastfeeding was missing for 48% of the participants. Missing data arose from the study design; recruitment included pregnant women and children $\leqslant$7 years at baseline; infant feeding was not recorded for children >15 months of age at recruitment. Participants with missing data were older, more adipose and more likely to have diabetes or hypertension. In India, duration of breastfeeding was not recorded, and age of introduction of complementary foods was missing for 61% of the participants. Those with missing data were younger and less adipose.

The analysis sample ($n = 10\,912$) included participants with data on at least one of the three infant-feeding variables and at least one adult outcome (BP, glucose concentration or body composition), and excluded women who were pregnant at the time of the outcome measurements.

Statistical methods

Variables with skewed distributions were log transformed (glucose concentrations, skinfolds). Associations among feeding variables, potential confounders and adult outcomes were assessed within each cohort and in pooled data, using linear or logistic regression or chi-square tests. Categorized duration of breastfeeding and age at introduction of complementary foods were treated as continuous variables in linear regression models, and non-linear associations were tested using quadratic terms. Models were initially adjusted for age and sex only, and then for the set of confounding variables, adult BMI (not done for the adiposity outcomes) and height. Parameter estimates given in the text are fully adjusted. All pooled models were adjusted for cohort location and included interaction terms between cohort location and each confounding variable. We tested for heterogeneity of associations across the five sites by using (for continuous variables) *F*-tests from nested linear regression models and (for binary outcomes)

Table 2 Patterns of infant feeding in the five cohorts

	Brazil ($n = 4446$) N (%)	**Guatemala ($n = 1272$) N (%)**	**India ($n = 1526$) N (%)**	**Philippines ($n = 2048$) N (%)**	**South Africa ($n = 1620$) N (%)**
Ever breastfed					
Yes	3964 (92.2)	739 (99.7)	1446 (99.9)	1934 (94.9)	1519 (94.9)
No	336 (7.8)	2 (0.3)	2 (0.1)	104 (5.1)	81 (5.1)
Data missing (n)	146	531	78	10	20
Duration of breastfeeding (months)					
None	336 (7.8)	2 (0.3)		104 (5.1)	81 (5.7)
0.01–1.00	997 (23.2)	2 (0.3)		120 (5.9)	103 (7.3)
1.01–3.00	1282 (29.8)	2 (0.3)		113 (5.5)	207 (14.6)
3.01–6.00	621 (14.4)	12 (1.8)		134 (6.6)	145 (10.2)
6.01–9.00	290 (6.7)	39 (5.8)		106 (5.2)	94 (6.6)
9.01–12.00	164 (3.8)	60 (8.9)		163 (8.0)	110 (7.8)
12.01–18.00	176 (4.1)	258 (38.1)		563 (27.6)	194 (13.7)
18.01–24.00	55 (1.3)	197 (29.1)		440 (21.6)	170 (12.0)
>24.00	379 (8.8)	105 (15.5)		295 (14.5)	315 (22.2)
Data missing (n)	146	595		10	201
Age of introduction of complementary foods (months)					
0–3.00	2874 (69.4)		0 (0.0)	117 (5.9)	922 (58.3)
3.01–6.00	1167 (28.2)		6 (1.0)	1630 (81.7)	592 (37.4)
6.01–9.00	81 (2.0)		50 (8.3)	238 (11.9)	53 (3.4)
9.01–12.00	22 (0.5)		254 (42.2)	10 (0.5)	12 (0.8)
12.01–18.00	0 (0.0)		220 (36.5)	0 (0.0)	1 (0.1)
>18.00	0 (0.0)		72 (12.0)	0 (0.0)	1 (0.1)
Data missing (n)	302		924	53	39

Data not available on duration of breastfeeding for India. Data also not available on age of introduction of complementary foods for Guatemala.

chi-square tests based on the difference in deviance between nested models; where there was significant heterogeneity ($P < 0.05$), we present data separately for each site. Sex differences were tested using interaction terms.

Results

The number of participants included in this analysis, as a percentage of the original live births in each cohort, ranged from 19% in India to 75% in Brazil (Table 1). More than 90% of babies in all cohorts were initially breastfed (Table 2). The most frequent duration of breastfeeding was 1–3 months in Brazil, 12–18 months in Guatemala and the Philippines and >2 years in South Africa, and the most frequent age at introduction of complementary foods was 0–3 months in Brazil and South Africa, 3–6 months in the Philippines and 9–12 months in India.

Predictors of infant-feeding variables

Associations between the confounding variables and infant-feeding variables are presented in Supplementary Tables A–G; Supplementary data are available at *IJE* online. To summarize these data: in Brazil, women of lower SES/education were less likely to initiate breastfeeding, and tended to breastfeed for either a short or long duration (Supplementary Tables A and B; Supplementary data are available at *IJE* online). In the Philippines and South Africa, women of lower SES/education were more likely to initiate breastfeeding and breastfed for longer. In Brazil, India and the Philippines, more affluent/educated mothers introduced complementary foods earlier. In Brazil and Guatemala, women who breastfed for longer tended to be older (Supplementary Table C; Supplementary data are available at *IJE* online). In Brazil and South Africa, mothers who smoked (35 and 6%, respectively) stopped breastfeeding earlier; the opposite association was seen in the Philippines (13%) (Supplementary Table D; Supplementary data are available at *IJE* online). In Brazil and South Africa, there were racial differences in feeding patterns (Supplementary Table E; Supplementary data are available at *IJE* online). In the Philippines, rural mothers were more likely to initiate breastfeeding, breastfed for longer and introduced complementary foods later (Supplementary Table F; Supplementary data are available at *IJE* online). Babies who were breastfed for a shorter duration tended to have lower birth weight in all cohorts (Supplementary Table G; Supplementary data are available at *IJE* online); in Brazil and India, babies who started complementary foods earlier had higher birth weight.

Mean age at adult follow-up ranged from 16 years (South Africa) to 32 years (Guatemala) (Table 3). The prevalence of hypertension ranged from 1% (Philippines, females) to 17% (Brazil, males), of diabetes from <1% (Philippines and South Africa) to 4% (Brazil and India, males) and of obesity from 1% (Philippines, females) to 25% (Guatemala, females).

Ever vs never breastfed

In the pooled data, there were no differences in BP, glucose or body-composition outcomes between participants who were initially breastfed compared with those not breastfed (Tables 4 and 5). There was heterogeneity between sites for DBP (Table 4); in Brazil, DBP was lower among participants who were breastfed [−1.5 mmHg, 95% confidence interval (CI) −2.7 to −0.3], whereas in the Philippines and South Africa there was a trend in the opposite direction (Philippines: 1.3 mmHg, 95% CI −0.5 to 3.1; South Africa: 1.4 mmHg, 95% CI 0.6–2.2). There was also heterogeneity between sites for prevalence of overweight (Table 5), with a lower risk in Brazil among participants who were breastfed [odds ratio (OR) 0.76, 95% CI 0.59–0.98], and opposite trends in the Philippines (OR 1.4, 95% CI 0.4–2.8) and South Africa (OR 1.4, 95% CI 0.5–4.2).

Breastfeeding duration

In the pooled data, there were U-shaped associations between breastfeeding duration and all the BP outcomes (Table 4, Figure 1). For SBP and hypertension, these remained after adjustment for confounding factors, adult BMI and height. The lowest mean BPs were observed among participants who had been breastfed for 3–6 months; there was a difference of ~2 mmHg between the lowest and highest mean values (Figure 1). Several of these U-shaped associations showed borderline heterogeneity across the cohorts (Table 4). A U-shaped association was clear only in Brazil (Figure 1); there was an upward trend in Guatemala, and no apparent trends with duration of breastfeeding in the Philippines and South Africa. After excluding the Brazil data, there were no linear or U-shaped associations between breastfeeding duration and any BP outcome.

There was no heterogeneity among the cohorts for glucose or body-composition outcomes. There was a U-shaped association between breastfeeding duration and IFG + diabetes mellitus (DM) (Table 4), and an inverse association between breastfeeding duration and adult skinfold thickness (Table 5). However, these associations were attenuated after adjusting for confounding variables.

There were no changes in the findings if the Guatemala cohort, in which duration of breastfeeding was missing for 48% of participants, was excluded from the analysis. In the Guatemala data, there was an interaction between intervention group and duration of breastfeeding for only one outcome (adult BMI); there were no changes in the findings when the two intervention groups were considered as separate populations.

Introduction of complementary foods

The age at introduction of complementary foods was unrelated to the BP and glucose outcomes (Table 4). There was no significant heterogeneity among the cohorts.

Later introduction of complementary foods was associated with lower adult BMI, waist circumference and percentage body fat, thinner skinfolds, and a lower risk of overweight/obesity (Table 5, Figure 2). The findings were similar after excluding the India cohort, which had a higher mean age at introduction of complementary foods, and in which data were missing for 61% of participants. Inverse associations were still present for BMI, waist circumference and subscapular skinfolds, which fell by 0.19 kg/m^2 (95% CI 0.01–0.37), 0.45 cm (95% CI 0.02–0.88) and 3.1% (95% CI 0.6–5.4; the percentage change in skinfolds is cited here rather than the change in millimetres, because the skinfold values were logged for analysis), respectively, per category increase in age of introduction of complementary foods. When the analysis was limited to the period up to 6 post-natal months, these associations were attenuated; BMI, waist circumference and subscapular skinfold thickness fell by 0.21 (95% CI −0.03 to 0.45), 0.45 cm (95% CI −0.11 to 1.01) and 2.6% (95% CI −0.9 to 6.1), respectively, per 3-month category.

Earlier introduction of complementary foods was associated with higher infant weight at 2 years (Supplementary Table H; Supplementary data are available at *IJE* online). After adjusting for 2-year weight, the inverse associations between age of introduction of complementary feeds and adult adiposity were no longer present.

There was no consistent evidence of differences according to sex, or the age at which outcomes were measured, in any of the associations described.

Table 3 Characteristics of the cohort at adult follow-up

	Brazil		**Guatemala**		**India**		**Philippines**		**South Africa**	
	Men Mean (SD)	Women Mean (SD)	Men Mean (SD)	Women Mean (SD)	Men Mean (SD)	Women Mean (SD)	Men Mean (SD)	Women Mean (SD)	Men Mean (SD)	Women Mean (SD)
Age	22.7 (0.4)	22.7 (0.4)	32.3 (4.1)	32.5 (4.1)	29.2 (1.3)	29.2 (1.4)	21.3 (0.8)	21.1 (1.0)	15.6 (0.3)	15.6 (0.3)
BP outcomes										
n	2208	1980	578	634	880	631	1080	962	753	834
SBP (mmHg)	123 (14)	111 (13)	117 (11)	108 (131)	118 (11)	107 (11)	112 (11)	99 (10)	118 (13)	111 (12)
DBP (mmHg)	76 (12)	72 (11)	72 (9)	70 (9)	78 (10)	73 (9)	76 (10)	68 (9)	68 (10)	69 (9)
Hypertension (%)	16.7	5.9	5.2	3.3	12.2	5.2	10.8	1.1	7.3	4.0
Pre-hypertension (%)	43.2	22.2	24.0	13.9	43.6	24.7	44.8	11.2	41.4	25.1
Glucose outcomes										
n	1856	1758	437	558	869	623	933	837	570	616
Glucose (mmol/l)[a]	5.5 (5.0,5.9)	5.2 (4.8,5.6)	5.1 (4.8,5.4)	5.1 (4.7,5.4)	5.4 (4.9,5.9)	5.3 (4.8,5.8)	4.7 (4.4,5.0)	4.5 (4.2,4.8)	5.1 (4.8)	4.9 (4.6,5.2)
Diabetes (%)	4.3	3.2	1.8	3.6	3.7	3.4	0.3	0	0.4	0.2
IFG (%)	19.4	12.4	5.3	7.2	20.5	14.4	0.9	1.0	2.6	1.9
Body composition										
n	2207	1979	557	594	886	640	1079	958	753	831
Height (cm)	173.7 (6.9)	160.8 (6.2)	162.8 (6.0)	150.7 (5.6)	169.7 (6.4)	154.9 (5.7)	163.0 (5.8)	151.2 (5.5)	166.3 (8.1)	158.7 (6.2)
BMI (kg/m^2)	23.8 (4.1)	23.4 (4.6)	24.7 (3.6)	27.0 (4.8)	24.9 (4.3)	24.6 (5.1)	21.0 (3.1)	20.2 (3.1)	19.7 (3.4)	22.1 (4.5)
Waist (cm)	80.9 (10.1)	74.9 (10.6)	86.7 (9.1)	92.3 (12.1)	90.2 (12.1)	79.6 (12.4)	72.0 (7.5)	67.6 (7.2)	69.7 (8.3)	71.1 (9.6)
Fat (%)	16.3 (3.8)		20.5 (6.6)	35.1 (7.3)	24.2 (5.9)	34.2 (7.0)	16.7 (5.1)	32.7 (4.8)	15.7 (7.8)	32.1 (7.2)
Subscapular skinfold (mm)[a]	9.8 (8.2,13.0)		12.9 (9.2,18.6)	22.3 (16.2,28.2)	23.0 (16.3,30.3)	25.4 (17.5,34.2)	11.0 (9.0,14.0)	17.3 (13.3,21.7)		
Triceps skinfold (mm)[a]	8.8 (6.8,13.0)		8.6 (6.2,11.6)	20.1 (15.4,24.6)	16.3 (11.1,21.1)	26.1 (18.1,32.7)	9.0 (7.0,13.7)	19.3 (15.7,24.0)		
Overweight (%)	30.6	26.0	40.4	62.6	47.3	45.1	9.7	7.5	7.9	23.2
Obese (%)	7.5	8.8	9.3	24.7	9.6	13.1	2.0	1.0	3.1	6.8

[a] Median and inter-quartile range for logged variables.

Fat percentage and skinfolds were not measured for women in Brazil; skinfolds were not measured in South Africa.

Table 4 Pooled analysis of blood pressure and glucose outcomes with infant-feeding exposures

	Model 1			Model 2			
	Effect size			Effect size			
	B	OR	95% CI	*B*	OR	95% CI	***p*-het**
Ever breastfed							
SBP (mmHg)	−1.06		−2.17 to 0.06	−0.71		−1.84 to 0.41	0.30
DBP (mmHg)	−0.81		−1.73 to 0.11	−0.55		−1.49 to 0.40	0.03
Hypertension		0.78	0.59 to 1.05		0.81	0.59 to 1.11	0.56
Pre-hypertension		0.88	0.72 to 1.07		0.94	0.75 to 1.17	0.05
Glucose (mmol/l, logged, ×100)	0.26		−1.11 to 1.62	0.58		−0.86 to 2.02	0.96
Diabetes		1.26	0.63 to 2.50		1.25	0.63 to 2.51	0.97
IFG + DM		0.88	0.64 to 1.21		0.92	0.67 to 1.27	0.54
Duration of breastfeeding (per category[a])							
SBP (mmHg)	0.14		0.02 to 0.26	0.12		−0.01 to 0.24	0.28
DBP (mmHg)	0.10		0.00 to 0.20	0.10		−0.01 to 0.20	0.31
Hypertension		1.01	0.98 to 1.05		1.02	0.98 to 1.05	0.92
Pre-hypertension		1.02	0.99 to 1.04		1.02	0.99 to 1.04	0.05
Glucose (mmol/l, logged, ×100)	0.07		−0.07 to 0.20	0.06		−0.09 to 0.21	0.75
Diabetes		1.05	0.98 to 1.13		1.05	0.98 to 1.13	0.80
IFG + DM		1.00	0.96 to 1.04		0.99	0.96 to 1.04	0.25
Duration of breastfeeding (quadratic per category[a])							
SBP (mmHg)	0.09		0.04 to 0.14	0.08		0.03 to 0.14	0.08
DBP (mmHg)	0.05		0.00 to 0.09	0.04		−0.01 to 0.08	0.05
Hypertension		1.02	1.00 to 1.03		1.02	1.00 to 1.03	0.26
Pre-hypertension		1.01	1.00 to 1.02		1.01	1.00 to 1.02	0.03
Glucose (mmol/l, logged, × 100)	0.04		−0.02 to 0.10	0.02		−0.05 to 0.08	0.99
Diabetes		1.03	1.00 to 1.06		1.03	1.00 to 1.06	0.71
IFG + DM		1.02	1.00 to 1.03		1.01	1.00 to 1.03	0.89
Age at introduction of complementary foods (per category[a])							
SBP (mmHg)	0.11		−0.37 to 0.60	0.23		−0.28 to 0.73	0.62
DBP (mmHg)	−0.14		−0.54 to 0.26	0.03		−0.40 to 0.45	0.74
Hypertension		1.09	0.95 to 1.25		1.12	0.97 to 1.30	0.82
Pre-hypertension		1.00	0.92 to 1.09		1.02	0.92 to 1.12	0.84
Glucose (mmol/l, logged, × 100)	0.12		−0.44 to 0.68	0.02		−0.59 to 0.62	0.70
Diabetes		1.07	0.81 to 1.40		1.01	0.76 to 1.35	0.17
IFG + DM		0.99	0.87 to 1.13		0.95	0.82 to 1.09	0.28

Data were analysed using linear regression (continuous outcomes, *B* is the regression coefficient) or logistic regression (dichotomous outcomes, OR). Model 1 adjusted for subject's age and sex only; Model 2 further adjusted for confounders (maternal SES, education, age, smoking, race, rural/urban residence and birth weight) and adult BMI and height; *p*-het is the test for heterogeneity of the coefficient across studies in Model 2.

[a] Categories are as indicated in Table 2. There were no non-linear associations with age at introduction of complementary foods, and these data have been omitted.

Associations of duration of breastfeeding and age of introduction of complementary foods with selected outcomes are presented by individual cohort in Supplementary Figures J–N (Supplementary data are available at *IJE* online).

Discussion

We combined data from five birth cohorts in LMICs, to examine associations between infant feeding and risk factors for cardiovascular disease (BP, glucose concentrations and adiposity) in >10 000 young

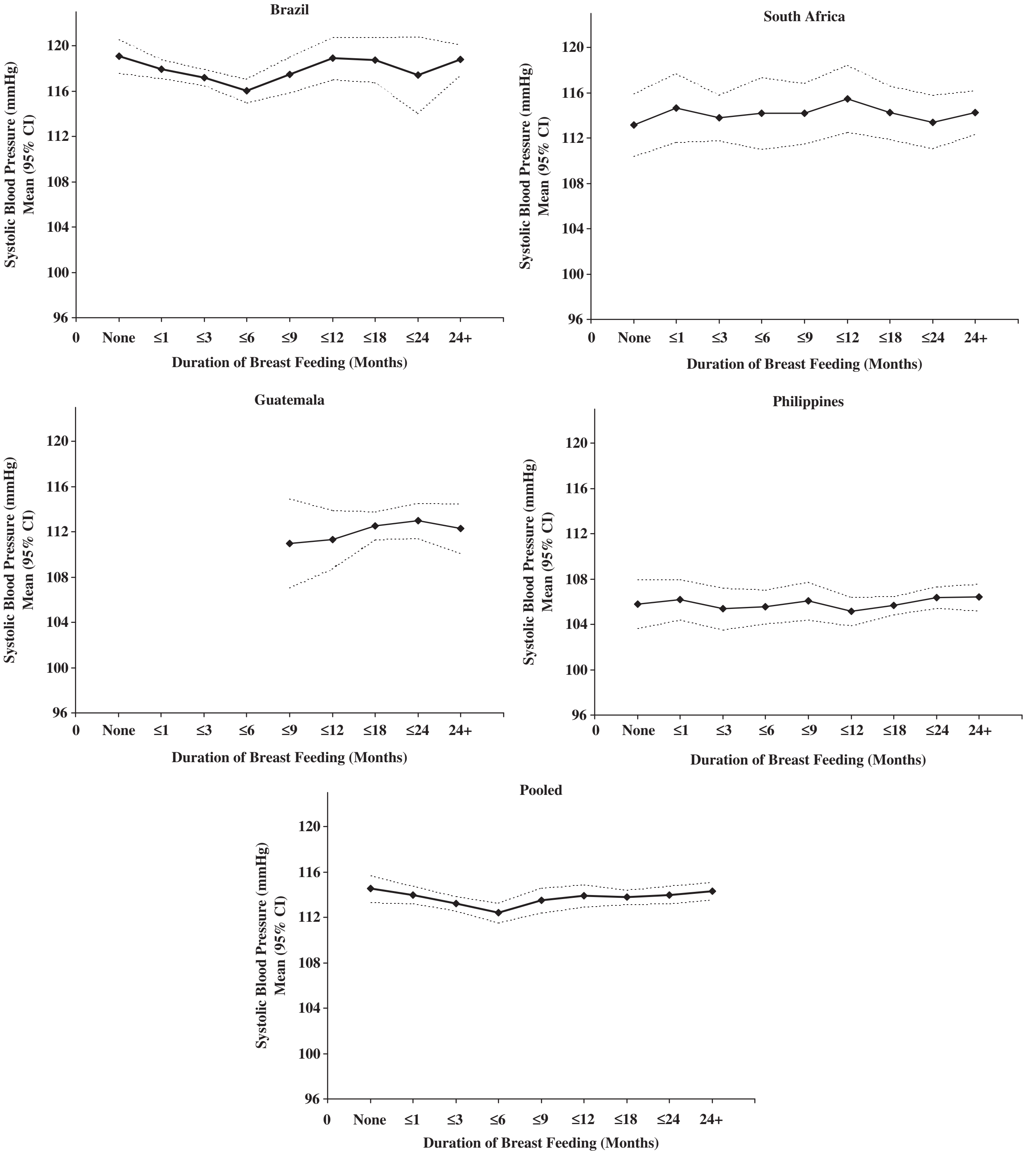

Figure 1 Associations of duration of breastfeeding with SBP in the four cohorts with available data, and in the pooled data

adults. There were no differences in risk factors between participants who were initially breastfed compared to those who were never breastfed. There were U-shaped associations between duration of breastfeeding and adult BP, with the lowest mean SBP among those breastfed for 3–6 months; however, these were small and inconsistent effects. After adjusting for confounding factors, there were no associations between duration of breastfeeding and adult glucose concentrations, DM + IFG or body composition. Participants who started complementary foods later in infancy were less adipose and

Table 5 Pooled analysis of body composition outcomes with infant-feeding exposures

	Model 1			Model 2			
	Effect size			Effect size			
	B	OR	95% CI	*B*	OR	95% CI	***p*-het**
Ever breastfed							
BMI (kg/m^2)	−0.12		−0.49 to 0.25	−0.21		−0.60 to 0.17	0.33
Waist (cm)	−0.62		−1.52 to 0.27	−0.67		−1.59 to 0.25	0.09
Percentage fat	−0.17		−0.82 to 0.47	−0.06		−0.70 to 0.59	0.33
Subscapular (mm, logged)	−0.03		−0.09 to 0.02	−0.02		−0.07 to 0.03	0.33
Triceps (mm, logged)	−0.05		−0.10 to 0.01	−0.03		−0.09 to 0.02	0.13
Obesity		0.78	0.55 to 1.11		0.77	0.54 to 1.11	0.75
Overweight/obesity		0.87	0.70 to 1.09		0.84	0.67 to 1.06	0.05
Duration of breastfeeding (per category[a])							
BMI (kg/m^2)	0.03		−0.01 to 0.07	0.04		0.00 to 0.08	0.12
Waist (cm)	−0.01		−0.10 to 0.08	0.05		−0.05 to 0.15	0.18
Percentage fat	−0.05		−0.12 to 0.01	0.001		−0.07 to 0.07	0.33
Subscapular (mm, logged)	−0.009		−0.014 to −0.003	−0.002		−0.008 to 0.003	0.67
Triceps (mm, logged)	−0.011		−0.017 to −0.006	−0.004		−0.01 to 0.002	0.65
Obesity		1.03	0.99 to 1.07		1.04	1.00 to 1.09	0.35
Overweight/obesity		1.01	0.99 to 1.04		1.02	0.99 to 1.04	0.66
Duration of breastfeeding (quadratic per category[a])							
BMI (kg/m^2)	0.002		−0.015 to 0.019	0.011		−0.007 to 0.029	0.21
Waist (cm)	0.006		−0.033 to 0.046	0.030		−0.012 to 0.072	0.53
Percentage fat	−0.016		−0.044 to 0.012	0.006		−0.022 to 0.034	0.84
Subscapular (mm, logged)	−0.001		−0.003 to 0.002	0.001		−0.001 to 0.003	0.68
Triceps (mm, logged)	−0.001		−0.003 to 0.002	0.001		−0.001 to 0.004	0.26
Obesity		1.01	0.99 to 1.03		1.01	0.99 to 1.03	0.33
Overweight/obesity		1.00	0.99 to 1.01		1.01	0.99 to 1.02	0.33
Age at introduction of complementary foods (per category[a])							
BMI (kg/m^2)	−0.25		−0.41 to −0.10	−0.23		−0.40 to −0.06	0.74
Waist (cm)	−0.70		−1.08 to −0.33	−0.58		−0.97 to −0.18	0.40
Percentage body fat	−0.31		−0.56 to −0.06	−0.19		−0.44 to 0.07	0.84
Subscapular (mm, logged)	−0.05		−0.07 to −0.02	−0.03		−0.05 to −0.01	0.38
Triceps (mm, logged)	−0.03		−0.06 to −0.01	−0.01		−0.03 to 0.02	0.55
Obesity		0.90	0.77 to 1.06		0.91	0.77 to 1.08	0.84
Overweight/obesity		0.88	0.80 to 0.97		0.88	0.80 to 0.98	0.60

Data were analysed using linear regression (continuous outcomes, *B* is the regression coefficient) or logistic regression (dichotomous outcomes, OR). Model 1 adjusted for subject's age and sex only; Model 2 further adjusted for confounders (maternal SES, education, age, smoking, race, and rural/urban residence, and birth weight) and adult height; *p*-het is the test for heterogeneity of the coefficient of Model 2 across studies.

[a] Categories are as indicated in Table 2. There were no non-linear associations with age at introduction of complementary foods, and these data have been omitted.

overweight in adult life. These associations were robust to adjustment for the set of confounding variables, but attenuated by adjustment for 2-year weight.

Strengths of the study were that infant-feeding data were collected prospectively, reducing the risk of misclassification due to inaccurate maternal recall, and included duration of breastfeeding and introduction of complementary foods. Limitations were missing infant-feeding data and losses to follow-up in the older Guatemala and India cohorts. Missing data

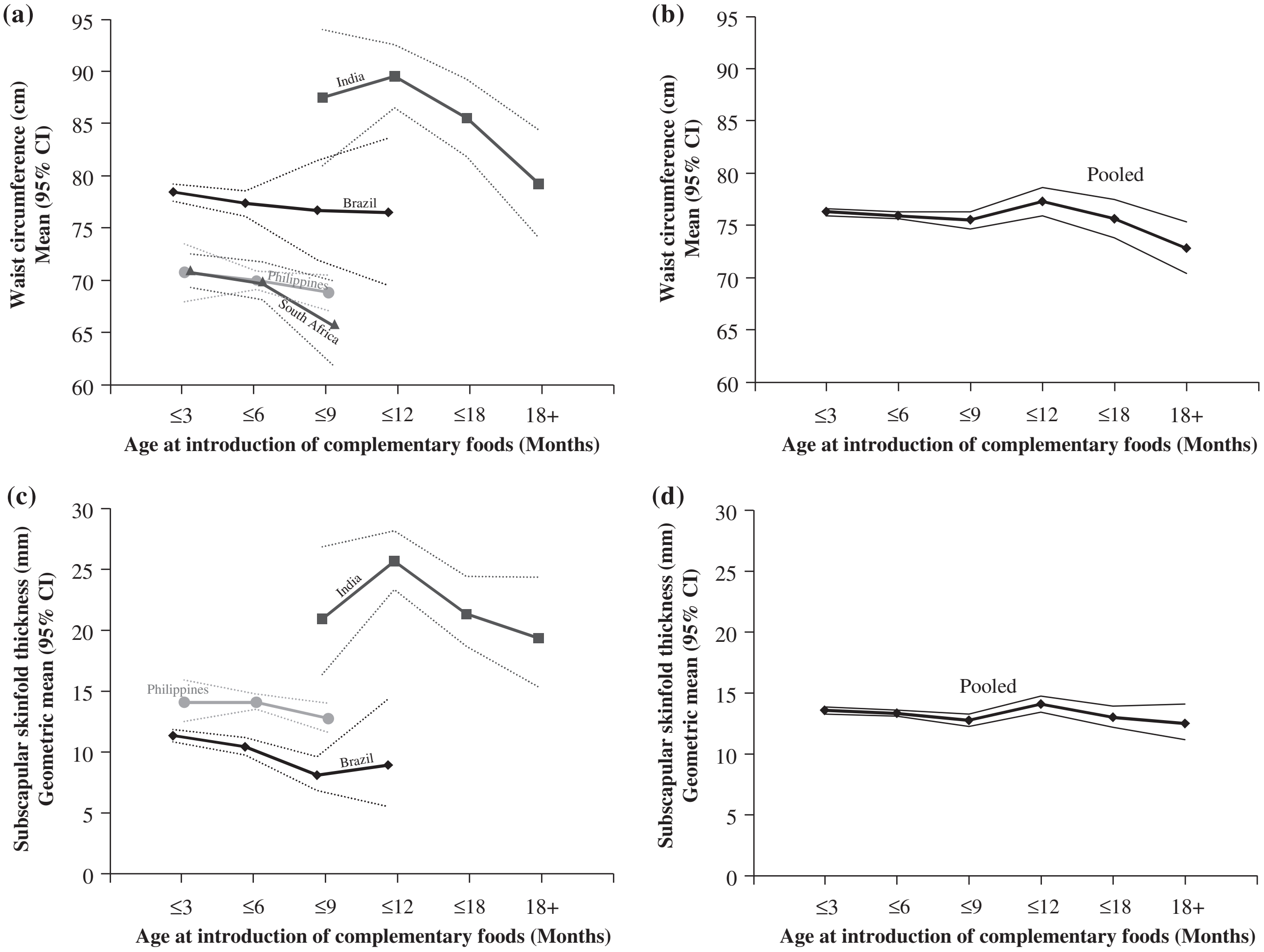

Figure 2 Associations of age of introduction of complementary foods with adult waist circumference (a and b), and subscapular skinfold measurement (c and d) (fully adjusted models) in the four cohorts with available data separately and pooled

would influence population means and prevalence values for both exposures and outcomes, but the within-cohort associations of interest, between infant feeding and adult outcomes, would be less vulnerable to bias. Associations of duration of breastfeeding and age of introduction of complementary foods were little changed if the Guatemala and India cohorts were excluded from the relevant analyses. A further limitation of the study was heterogeneity among the cohorts in the methods for recording infant-feeding data. This reduced the number of exposures we could include (e.g. exclusive breastfeeding and predominant breastfeeding were definable in only one and three of the cohorts, respectively, and were not included), and we defined introduction of complementary foods as the introduction of solids rather than nutritious liquids and solids, the more generally used definition. The different methods would tend to reduce the precision of the exposure variables and thus attenuate any estimates of association with adult outcomes. The methods used for measuring adult outcomes also varied among the cohorts, although are all accepted techniques for epidemiological studies. BP was measured using a variety of devices, all of which perform to international standards, although systematic under- or overestimation of BP is recognized.[44–47] Blood glucose was measured using standard laboratory assays or by glucometers, and although the latter are not recommended for clinical diagnosis of individual patients, their use in epidemiological studies is accepted.[48] Four studies measured fasting glucose; the Pelotas study used random glucose, adjusted for time since the last meal.[29] Adiposity was measured using similar anthropometric protocols in all studies, and percentage body fat was measured using a variety of techniques that have been validated in appropriate populations. Different techniques would influence the precision of measurements, which could obscure associations but is unlikely to create spurious associations. Systematic over-/underestimation of (say) BP or the prevalence of hypertension would not affect the ranking of the participants, and would not, therefore, substantially change the associations of interest.

A consistent finding was that later introduction of complementary foods was associated with lower adult adiposity. Previous literature on this topic is mixed; some studies have reported findings similar to ours.[15–17] Others have reported no association[4,49,50] or an opposite association.[51] In our pooled data, there was a linear decrease in adult adiposity across the range of ages at which complementary foods were started (<3 months to >18 months; Figure 2). Introduction of complementary foods >6 months is associated with nutritional inadequacy and growth faltering[1,2] and cannot be recommended. However, in our data, there was a downward trend in adiposity with later introduction of complementary foods even in the first 6 post-natal months (Figure 2), although this was very small and likely to be of limited health significance. Earlier introduction of complementary foods is associated with greater infant weight gain,[52] and our results, showing no association after adjusting for 2-year weight, suggest that this could be a mediating factor.

There were no differences in outcomes between ‘ever’ vs ‘never’ breastfed groups. This contrasts with results from meta-analyses of observational studies, mainly in high-income settings, which have shown lower SBP (approximately −1 mmHg) and DBP (less than −0.5 mmHg), a 30–40% lower risk of type 2 diabetes and a 20% lower risk of overweight or obesity in children or adults who were breastfed.[6–9] Possible explanations for our negative findings are that initiation of breastfeeding was almost universal in these cohorts (hence reducing power), and/or that the associations in the above studies result from residual confounding, not seen in our cohorts because of the different relationships between infant feeding and maternal SES.

There were U-shaped associations between duration of breastfeeding and BP outcomes. These trends were inconsistent among the five cohorts (Figure 1). Overall, there was no evidence that longer duration of breastfeeding protects against the later development of hypertension or diabetes. Again, these findings differ from those reported from high-income settings, where most studies,[9,10,12,53,54] although not all,[55,56] found lower BP and/or a lower risk of type 2 diabetes in children or adults who were breastfed for longer. Explanations could be, again, residual confounding in high-income populations; imprecision in the exposure measure due to different data-collection methods; or differences in other post-natal factors related to the adult outcomes, e.g. childhood growth, between low- and high-income populations.

A recent systematic review of studies in children and adults found a linear inverse association between duration of breastfeeding and risk of overweight/obesity in about half the studies.[14] The associations were diminished after adjusting for confounders, but remained in some studies. We found that participants who were breastfed for longer in infancy had thinner skinfolds, but the associations were attenuated by adjusting for confounding variables. Confounding has been a major limitation of studies linking infant feeding to later health. The ultimate solution to this problem would be randomized controlled trials, but it is not possible to randomize healthy babies into breastfed and non-breastfed groups. Helpful data will come from a large randomized trial of breastfeeding promotion, in Belarus, which greatly increased initiation rates and duration of breastfeeding.[57] In this trial, there were no differences in BP or adiposity between children from the intervention and control groups at 9 years. In another trial, among pre-term newborns, there was no difference in BP in childhood between those randomized to receive breast milk or formula,[58] but BP was lower in the breast-milk group in adolescence.[59] We know of no randomized trials of early vs late introduction of complementary foods.

In conclusion, in five high-quality birth cohorts in LMICs, we found no evidence that initial breastfeeding, or longer duration of breastfeeding, were protective against adult hypertension, diabetes or overweight/obesity. There are many proven benefits of breastfeeding, but the evidence that it reduces the risk of adult chronic disease is not compelling, at least in LMICs. We were not, however, able to examine ‘exclusive breastfeeding’ as an exposure, since this was available for only one of the cohorts. There was a consistent linear inverse association between age of introduction of complementary foods and adult adiposity. Our data suggest there may be modest protection against adult adiposity from delaying the introduction of complementary foods to the recommended 6 months. This association should be examined in other studies.

Supplementary Data

Supplementary data are available at *IJE* online.

Funding

The COHORTS collaboration is funded by the Wellcome Trust, UK. Funding sources for each of the COHORTS sites are as follows: Brazil: Wellcome Trust. Guatemala: US National Institutes of Health, US National Science Foundation, Nestle Foundation, Thrasher Foundation and American Heart Association. India: US National Center for Health Statistics, Indian Council of Medical Research, British Heart Foundation, Medical Research Council UK. The Philippines: US National Institutes of Health, Fogarty International Center. South Africa: Wellcome Trust, Human Sciences Research Council, South African Medical Research Council, Mellon Foundation, South-African Netherlands Programme on Alternative Development and the Anglo American Chairman's Fund. All authors/researchers are independent of the funding bodies.

Acknowledgements

COHORTS group members not included as named authors for this paper: Denise Gigante, Pedro Hallal and Bernardo Horta (Universidade Federal de Pelotas, Brazil), Manuel Ramirez-Zea (Institute of Nutrition of Central America and Panama, Guatemala City, Guatemala), Andrew Wills (MRC Epidemiology Resource Centre, University of Southampton, Southampton, UK), Harshpal Singh Sachdev (Sitaram Bhartia Institute of Science and Research, New Delhi, India), Linda Adair (University of North Carolina at Chapel Hill, Chapel Hill, USA), Darren Dahly (University of Leeds, UK), Christopher Kuzawa (Department of Anthropology, Northwestern University, Illinois, USA), Shane Norris, Daniel Lopez and Mathew Mainwaring (Department of Paediatrics, MRC Mineral Metabolism Research Unit, University of the Witwatersrand, Johannesburg, Bt20).

Special thanks to other major contributors to the 5 studies: **Brazil:** Rosangela Lima (Universidade Católica de Pelotas); **India:** Lakshmi Ramakrishnan, Nikhil Tandon (All-India Institute of Medical Sciences, New Delhi), Dorairaj Prabhakaran (Centre for the Control of Chronic Diseases, New Delhi), Siddharth Ramji (Maulana Azad Medical College, New Delhi), K Srinath Reddy (Public Health Foundation of India); SK Dey Biswas (Indian Council of Medical Research); Vinod Kapani (Bureau of Labor Statistics, Washington DC, USA); **Guatemala:** Ann DiGirolamo Rafael Flores (US Centers for Disease Control and Prevention), Usha Ramakrishnan, Kathryn Yount (Emory University), Ruben Grajeda (PAHO), Paul Melgar, Humberto Mendez, Luis Fernando Ramirez (INCAP), Jere Behrman (University of Pennsylvania), John Hoddinott, Agnes Quisumbing, Alexis Murphy (IFPRI), John Maluccio (Middlebury College); **Philippines:** Barry Popkin (University of North Carolina at Chapel Hill), Sororro Gultiano, Josephine Avila, Lorna Perez (Office of Population Studies Foundation, University of San Carlos, Cebu), ThomasMcDade (Northwestern University); **South Africa:** Noel Cameron (Loughborough University, UK), John Pettifor (University of Witwatesrand). The manuscript and figures were prepared by Jane Pearce.

Conflict of interest: None declared.

KEY MESSAGES

- Previous research suggests that optimal breastfeeding and complementary feeding practices during infancy may reduce the risk of adult obesity, hypertension and type 2 diabetes.
- This evidence, mainly from high-income populations, is controversial because of confounding factors such as SES. We present data from five adult birth cohorts in low-/middle-income settings.
- We found no evidence that a longer duration of breastfeeding was associated with reduced adult adiposity, blood pressure or plasma glucose concentrations.
- Later introduction of complementary foods (solids) was associated with a small reduction in adult BMI, waist circumference and skinfold thickness.

References

[1] Daelmans B, Martines J, Saadeh R (eds). Special issue based on a World Health Organization expert consultation on complementary feeding. *Food Nutr Bulletin*. 2003;**24:**1–134.

[2] Black RE, Allen LH, Bhutta Z *et al*. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* 2008;**371:**243–60.

[3] Bhutta Z, Ahmad T, Black RE *et al*. What works? Interventions to affect maternal and child undernutrition and survival globally. *Lancet* 2008;**371:**417–40.

[4] Kramer MS. Do breast-feeding and delayed introduction of solid foods protect against subsequent obesity? *J Pediatr* 1981;**98:**883–87.

[5] Horta BL, Bahl R, Martines JC, Victora CG. *Evidence on the Long-Term Effects of Breastfeeding: Systematic Reviews and Meta-analyses*. Geneva: WHO, 2007.

[6] Owen CG, Whincup PH, Gilg JA, Cook DG. Effect of breast feeding in infancy on blood pressure in later life: systematic review and meta-analysis. *BMJ* 2003;**327:** 1189–95.

[7] Owen CG, Martin RM, Whincup PH, Davey Smith G, Cook DG. Does breastfeeding influence the risk of type 2 diabetes in later life? A quantitative analysis of published evidence. *Am J Clin Nutr* 2006;**84:**1043–54.

[8] Owen CG, Martin RM, Whincup PH, Davey Smith G, Cook DG. Effect of infant feeding on the risk of obesity across the life course: a quantitative review of published evidence. *Pediatrics* 2005;**115:**1367–77.

[9] Taittonen L, Nuutinen M, Turtinen J, Uhari M. Prenatal and postnatal factors in predicting later blood pressure among children: cardiovascular risk in young Finns. *Pediatr Res* 1996;**40:**627–32.

[10] Lawlor DA, Riddoch CJ, Page AS *et al*. Infant feeding and components of the metabolic syndrome: findings

from the European Youth Heart Study. *Arch Dis Child* 2005;**90:**582–88.

[11] Martin RM, Ben-Shlomo Y, Gunnell D, Elwood P, Yarnell JWG, Davey Smith G. Breast feeding and cardiovascular disease risk factors, incidence, and mortality: the Caerphilly Study. *J Epidemiol Community Health* 2005;**59:**121–29.

[12] Young TK, Martens PJ, Taback SP *et al*. Type 2 diabetes mellitus in children; prenatal and early infancy risk factors among Native Canadians. *Arch Pediatr Adolesc Med* 2002;**156:**651–55.

[13] Rich-Edwards JW, Stampfer MJ, Manson JE *et al*. Breastfeeding during infancy and the risk of cardiovascular disease in adulthood. *Epidemiology* 2004;**15:** 550–56.

[14] Arenz S, Ruckerl R, Koletzko B, von Kries R. Breastfeeding and childhood obesity; a systematic review. *Int J Obes Relat Metab Disord* 2004;**28:**1247–54.

[15] Wilson AC, Forsyth JS, Greene SA, Irvine L, Hau C, Howie PW. Relation of infant diet to childhood health: seven year follow up of cohort of children in Dundee infant feeding study. *BMJ* 1998;**316:**21–25.

[16] Reilly JJ, Armstrong J, Dorosty AR *et al*. Early life risk factors for obesity in childhood: cohort study. *BMJ* 2005; **330:**1357.

[17] Hawkins SS, Cole TJ, Law CM and the Millennium Cohort Study Child Health Group. An ecological systems approach to examining risk factors for early childhood overweight: findings from the UK Millennium Cohort Study. *J Epidemiol Community Health* 2009;**63:**147–55.

[18] Heck KE, Braveman P, Cubbin C, Chavez GF, Kiely JL. Socioeconomic status and breastfeeding initiation among California mothers. *Public Health Rep* 2006;**121:**51–59.

[19] Bolling K, Grant C, Hamlyn B. *Infant Feeding Survey 2005*. London: The Information Centre, 2007.

[20] Fall CHD. Non-industrialised countries and affluence: relationship with type 2 diabetes. *Br Med Bull* 2001;**60:** 33–50.

[21] Adair LS, Martorell R, Stein AD *et al*. Size at birth, weight gain in infancy and childhood and adult blood pressure in five low and middle income country cohorts: When does weight gain matter? *Am J Clin Nutr* 2009;**89:** 1383–92.

[22] Victora CG, Adair L, Fall C *et al*. the Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: consequences for adult health and human capital. *Lancet* 2008;**371:**340–57.

[23] Victora CG, Barros FC. Cohort profile: the 1982 Pelotas (Brazil) birth cohort study. *Int J Epidemiol* 2006;**35:**237–42.

[24] Stein AD, Melgar P, Hoddinott J, Martorell R. Cohort Profile: the Institute of Nutrition of Central America and Panama (INCAP) Nutrition Trial Cohort Study. *Int J Epidemiol* 2008;**37:**716–20.

[25] Bhargava SK, Sachdev HS, Fall CH *et al*. Relation of serial changes in childhood body-mass index to impaired glucose tolerance in young adulthood. *N Engl J Med* 2004; **350:**865–75.

[26] Adair LS. Size at birth and growth trajectories to young adulthood. *Am J Hum Biol* 2007;**19:**327–37.

[27] Richter L, Norris S, Pettifor J, Yach D, Cameron N. Cohort Profile: Mandela's children: the 1990 Birth to Twenty study in South Africa. *Int J Epidemiol* 2007;**36:**504–11.

[28] National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics* 2004;**114:**555–76.

[29] Horta BL, Gigante DP, Victora CG, Barros FC, Oliveira I, Silveira V. Early determinants of random blood glucose among adults of the 1982 birth cohort, Pelotas, Southern Brazil. *Rev Saude Publica* 2008;**42(Suppl. 2):** 93–100.

[30] Kumar G, Sng BL, Kumar S. Correlation of capillary and venous glucometry with laboratory determination. *Prehosp Emerg Care* 2004;**8:**378–83.

[31] Petersen JR, Graves DF, Tacker DH, Okurodudu AO, Mohammad AA, Cardenas VJ. Comparison of POCT and central laboratory blood glucose results using arterial, capillary, and venous samples from MICU patients on tight glycaemic control. *Clin Chim Acta* 2008;**396:**10–13.

[32] World Health Organisation. Definition, diagnosis and classification of diabetes mellitus and its complications. *Report of a WHO consultation. Part 1: Diagnosis and Classification of Diabetes Mellitus*. Geneva: WHO, 1999.

[33] Physical status: the use and interpretation of anthropometry. *WHO Technical Report Series No 854*. Geneva: WHO, 1995.

[34] Wells JCK, Gigante D, Wright A, Hallal PC, Victora CG. Validation of leg-to-leg impedance for body composition assessment in male Brazilians aged 16–19 years. *Int J Body Composition Res* 2003;**1:**69–75.

[35] Ramirez-Zea M, Torun B, Martorell R, Stein AD. Anthropometric predictors of body fat as measured by hydrostatic weighing in Guatemalan adults. *Am J Clin Nutr* 2006;**83:**795–802.

[36] Durnin JV, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *Br J Nutr* 1974;**32:**77–97.

[37] Deurenberg P, Deurenberg-Yap M. Validation of skinfold thickness and hand-held impedance measurements for estimation of body fat percentage among Singaporean Chinese, Malay and Indian subjects. *Asia Pac J Clin Nutr* 2002;**11:**1–7.

[38] Araujo CL, Victora CG, Hallal PC, Gigante DP. Breastfeeding and overweight in childhood, evidence from the Pelotas 1993 birth cohort study. *Int J Obesity* 2006;**30:** 500–6.

[39] Sellen DW, Thompson AL, Hruschka DJ, Stein AD, Martorell R. Early determinants of non-exclusive breastfeeding among Guatemalan infants. *Adv Exp Med Biol* 2004;**554:**299–301.

[40] Ghosh S, Gidwani S, Mittal SK, Verma RK. Socio-cultural factors affecting breastfeeding and other infant feeding practices in an urban community. *Indian Pediatr* 1976; **13:**827–32.

[41] Daniels MC, Adair L. Breastfeeding influences cognitive development in Filipino children. *J Nutr* 2005;**135:**2589–95.

[42] Ellison GT, Wagstaff L, Cameron N, de Wet T. Geographical differences in infant feeding patterns in disadvantaged communities. *S African Med J* 1997;**87:** 1025–26.

[43] Adair L, Dahly D. Quantifying the urban environment; a scale measure of urbanicity outperforms the rural-urban dichotomy. *Soc Sci Med* 2007;**64:**1407–19.

[44] Ma Y, Temprosa M, Fowler S *et al*. Evaluating the accuracy of an aneroid sphygmomanometer in a clinical trial setting. *Am J Hypertens* 2009;**22:**263–66.

[45] Rogoza AN, Pavlova TS, Sergeeva MV. Validation of A&D UA-767 device for the self-measurement of blood pressure. *Blood Press Monit* 2000;**5:**227–31.

[46] Grim CE, Grim CM. Omron HEM-711 DLX home blood pressure monitor passes the European Society of Hypertension International Validation Protocol. *Blood Press Monit* 2008;**13:**225–26.

[47] Altunkan S, Ilman N, Kayaturk N, Altunkan E. Validation of the Omron M6 (HEM-7001-E) upper-arm blood pressure measuring device according to the International Protocol in adults and obese adults. *Blood Press Monit* 2007;**12:**219–25.

[48] World Health Organisation. Definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia. *Report of a WHO/IDF Consultation*. Geneva: WHO, 2006.

[49] Burdette HL, Whitaker RC, Hall WC, Daniels ST. Breastfeeding, introduction of complementary foods, and adiposity at 5 y of age. *Am J Clin Nutr* 2006;**83:**550–58.

[50] Zive MM, McKay H, Frank-Spohrer GC, Broyles SL, Nelson JA, Nader PR. Infant-feeding practices and adiposity in 4-y-old Anglo- and Mexican-Americans. *Am J Clin Nutr* 1992;**55:**1104–8.

[51] Agras WS, Kraemer HC, Berkowitz RI, Hammer LD. Influence of early feeding style on adiposity at 6 years of age. *J Pediatr* 1990;**116:**805–9.

[52] Baker JL, Michaelsen KF, Rasmussen KM, Sorenson TI. Maternal prepregnant body mass index, duration of breastfeeding, and timing of complementary food introduction are associated with infant weight gain. *Am J Clin Nutr* 2004;**80:**1579–88.

[53] Martin RM, Ness AR, Gunnell D, Emmett P, Davey Smith G and the ALSPAC study team. Does breast-feeding in infancy lower blood pressure in childhood? the Avon Longitudinal Study of Parents and Children (ALSPAC). *Circulation* 2004;**109:**1259–66.

[54] Mayer-Davis EJ, Dabelea D, Lamichhane AP *et al*. Breastfeeding and type 2 diabetes in the youth of three ethnic groups: the SEARCH for diabetes in youth case-control study. *Diabetes Care* 2008;**31:**470–75.

[55] Davis JN, Weigensberg MJ, Shaibi GQ *et al*. Influence of breastfeeding on obesity and type 2 diabetes risk factors in Latino youth with a family history of type 2 diabetes. *Diabetes Care* 2007;**30:**784–89.

[56] Wadsworth M, Marshall S, Hardy R, Paul A. Breastfeeding and obesity; relation may be accounted for by social factors. *BMJ* 1999;**319:**1576.

[57] Kramer MS, Matush L, Vanilovich I *et al*. Effects of prolonged and exclusive breastfeeding on child height, weight, adiposity, and blood pressure at age 6.5 years: evidence from a large randomised trial. *Am J Clin Nutr* 2007;**86:**1717–21.

[58] Lucas A, Morley R. Does early nutrition in infants born before term programme later blood pressure? *BMJ* 1994; **309:**304–8.

[59] Singhal A, Cole TJ, Lucas A. Early nutrition in preterm infants and later blood pressure: two cohorts after randomised trials. *Lancet* 2001;**357:**413–19.

Published by Oxford University Press on behalf of the International Epidemiological Association
International Journal of Epidemiology 2011;**40**:62–64

doi:10.1093/ije/dyq194

Commentary: Effect of initial breastfeeding on cardiovascular risk in later life—a perspective from lower-middle-income countries

Christopher G Owen

Division of Population Health Sciences and Education, St George's University of London, Cranmer Terrace, London SW17 ORE, UK. E-mail: cowen@sgul.ac.uk

Accepted 18 September 2010

Breastmilk is the preferred form of nourishment for an infant, although it may not always be feasible to provide. The immediate health benefits of breastfeeding are well established, especially in a developing world context, providing protection against infectious disease morbidity and mortality in early life. Breastfeeding has been associated with improved neural, cognitive and psychosocial development; it has also been suggested that it may program disease risk in the longer term. Largely observational evidence from the developed world suggests that breastfeeding is associated with lower cardiometabolic risk and cardiovascular outcome in adulthood. However, not all studies have been equally supportive, and