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Childhood obesity is persistent as a predictor of preschoolers' parent-rated health accounting for social inequalities - Lifeways cross-generation cohort study.

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Running Title: Childhood obesity a persistent predictor of preschoolers' PRH

KEYWORDS

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ABSTRACT (Words: 244)

Objective

To examine the relationship between lifecourse factors from preschoolers' micro-ecosystem and their parent-reported (mother-reported) health (PRH), following them prospectively from preconception to age 5-years. To investigate if preschoolers' BMI and waist-circumference were associated with preschoolers' PRH when controlled for lifecourse predictors.

Design

Lifeways cross-generation cohort study

Setting

Ireland

Participants

Of 1082 families, 62% mothers responded on a health and lifestyle questionnaire at follow-up. Food frequency, BMI and waist-circumference were measured.

Main outcome measure

Mother-reported children's PRH at age-5. Associations with child's individual and familial exposures from preconception to age 5-years examined using logistic regression.

Results

In univariate analysis, relatively-positive rating of children's PRH were associated with children's lower intake of fats [OR(95%CI)=2.2(1.1-4.3)], higher intake of fruits/vegetables [OR(95%CI)=2.2(1.1-4.3)]; as well as familial socio-economic characteristics {higher household income [OR(95%CI)=3.0(1.6-5.9)], non-entitlement to means-tested healthcare [OR(95%CI)=2.1(1.0-4.3)], mothers' higher education [OR(95%CI)=1.9(1.0-3.6)]}, psycho-

social characteristics {father's participation in study [OR(95%CI)=2.1(1.0-4.3)], mothers' perceiving better support from partner [OR(95%CI)=2.3(1.2-4.3)], children [OR(95%CI)=1.9(1.0-3.7)] or relatives [OR(95%CI)=2.2(1.1-4.1)]}, parents' lifestyle {mothers' lower intake of energy [OR(95%CI)=2.2(1.1-4.3)], fathers' non-smoking status [OR(95%CI)=2.2(1.1-4.4)]}, and parents' health {mothers' self-rated health relatively-positive [OR(95%CI)=5.1(2.6-9.9)], fathers' self-rated health relatively-positive [OR(95%CI)=3.0(1.5-6.0)]}.

In multivariable analysis ($\chi 2=34.2$,df=21,N=303,$R^2=0.26$,$p<0.05$), one of the two strong predictors of children's relatively-positive PRH was child not being obese by International Obesity Task Force classification [OR(95%CI)=5.5(1.4-21.0)], observed also using BMI [OR(95%CI)=0.73(0.58-0.93)] or waist-circumference [OR(95%CI)=0.89(0.81-0.98)] as continuous variables. The other significant predictor was mothers' self-rated health relatively-positive [OR(95%CI)=4.2(1.5-12.2)].

Conclusions

Preschoolers' health is adversely associated with obesity and this is independent of lifecourse social and environmental inequalities. Findings have relevance for developmental health policies.

Strengths and limitations of this study

- Nationally representative sample of preschool-age children
- Examines the influence of lifecourse adversities, prospectively measured from preconception to age 5 on children's general health at age 5. The study analyses demographic, anthropometric, lifestyle, food and nutrients intake, psycho-social, socio-economic and health-related exposures from both children's individual as well as parental experiences.
- Demonstrates a significant and independent association between preschoolers' measured BMI as well as waist circumference and their general health status.
- The study is limited by a relatively small sample and use of parent-reported health status.

MAIN TEXT

Introduction

The development of children is critical to their adult well-being and across the lifecourse even subjective estimates may be useful to reflect objectively measured health. Bronfenbrenner[1] emphasised the importance of children's micro-ecosystem in their development. Recently, the World Health Organisation (WHO) presented a model for Early Child Development,[2] which again illustrates the importance of individual and family spheres of influence on children's health. The relevance of socio-economic, psycho-social and lifestyle environment in child development and health is widely acknowledged.[2-4]

According to the lifecourse hypothesis, risk transmission is characterised by critical periods and accumulation of risk models.[5] Based on this, Hertzman and colleagues[6] examined self-rated health in adulthood using an integrated lifecourse framework. There are a few other studies also which have examined lifecourse determinants of adult global[7,8] or specific health status.[9] On the contrary, the literature on the determinants of child global health status is sparse,[10,11] particularly for the preschool-age children.[12]. Even rarer are studies whose examination includes early lifecourse determinants of child global health status.

Thus the first objective of our analysis was to prospectively examine the relationship between demographic, anthropometric, lifestyle, nutritional, psycho-social, socio-economic and health-related lifecourse exposures taken from the children's individual and family spheres of influence starting from preconception up to age 5-years and their global health status at preschool-age.

In social epidemiology, the construct of "embodiment" refers to biological expression of individuals' materio-social world.[13,14] Similarly in lifecourse epidemiology, it is

hypothesised that early life experiences get "biologically embedded" during critical or sensitive periods of child development leading to gradients in health.[15,16]

The Foresight report identifies a large array of environmental determinants of obesity, a number of which are again related to early child development.[17] This suggests obesity as pivotal risk factor for subsequent health conditions.[18]

The negative relationship between obesity and self-rated health is now increasingly reported in adult populations,[19,20] some indicating a temporal relationship[21,22] and suggesting that obesity increases health inequalities over time.[22] However, evidence on the relationship between obesity and health is relatively limited in child population studies and those available have reported health-related-quality-of-life (HR-QoL)[23] instead of a generic measure such as global self-rated health. Moreover, this association is yet to be established for preschool-age children. To our knowledge just two population based studies have examined this association in preschool age-group children[24,25] and neither had nutritional information.

In the Longitudinal Study of Australian Children, Wake *et al*.[24] did not find a significant difference in global health status of overweight/obese and normal weight 4-5-year-old children. Skinner et al.,[25] using data on 3-5-year-olds from the US National Health and Nutrition Examination Survey, reported a poorer global health status in obese and severely obese preschoolers. Neither of these studies accounted for a number of possibly relevant confounders, including parental BMI, parental health and nutritional variables.

We thus hypothesised that similar to findings from studies on older age-groups, anthropometric markers of child obesity in our preschool-age children study would also demonstrate a negative association with their global health status. The next objective of our analysis was to examine whether anthropometric markers of child obesity would emerge as

strong predictors of global health status when accounted for other socio-economic, psycho-social, and lifestyle environmental factors in a multivariable model.

Methods

The Lifeways cross generation cohort study comprises three generations of 1082 Irish families and was established in 2001-03; the recruitment procedure of this nationally representative cohort has been described previously.[26-28] The a priori purpose was to examine familial and cross-generation influences on early childhood development over the first five years of children's lives. Briefly, would-be mothers were at random recruited from the two regional maternity hospitals in the Republic of Ireland to get a representative sample.

At this early pregnancy stage mothers completed a health and lifestyle status questionnaire adapted from a validated instrument developed for national SLÁN (Survey of Lifestyle, Attitudes and Nutrition) surveys in Republic of Ireland.[29] Mothers reported their pre-pregnancy height and weight and their smoking status during pregnancy. Mothers' and partners' socio-economic status was recorded. Subsequently at birth, the live infants were added to the cohort along-with maternity and birth related hospital information.

In 2007-08, when these children averaged five years of age, the cohort follow-up recorded a 62% response rate.[28,30] Mothers at follow-up study did not significantly differ in their baseline BMI from non-responders, suggesting no notable attrition bias.[28,30] At this 5-year follow-up, mothers repeated the health and lifestyle assessment questionnaire, with additional questions related to her family, including a five-level likert item question "In general, would you say your / your partner's / your Lifeways child's current health is Excellent, Very Good, Good, Fair or Poor". Mothers provided information on family's socio-economic, psycho-social, and lifestyle status. Mothers reported their habitual dietary intake for the previous year on a semi-quantitative food frequency (SQFFQ) instrument developed from the EPIC study

(European Prospective Investigation into Cancer and Nutrition) and validated for Irish adult population.[31] Mothers also gave details for the Lifeways child's habitual diet for the previous year using a different SQFFQ instrument adapted from the UK National Diet and Nutrition Survey of 4.5-year-old children.[32] The mothers' and children's SQFFQ were validated in the Lifeways study using a 7-day weighed food diary in a sub-sample.[30] Food items were aggregated by defined shelves of the Irish food pyramid and assessment was made for average servings per day of standard food item portions consumed from the "top" and "fruit and vegetable" shelves. The top shelf comprises of high calorie fat and sugar rich foods. Total energy (kcal) and total fats (g) intake were computed using conversion values from McCance & Widdowson's food composition tables[33] with a specially developed FFQ software version 1.0 ©.[34]

Mothers and children, and if available fathers, were offered at 5-year follow-up an anthropometric assessment at their home for height, weight and waist circumference using a standardised protocol,[28,30] with 80-85% mothers and children participating. Body mass index (BMI) was calculated from weight and height information (kg/m^2).

Thus variables from discrete stages (pre-pregnancy, early pregnancy, at birth, early infancy and 5-year follow-up) of child's early development representing lifecourse exposures from distinct domains (demographic, anthropometric, socio-economic, psycho-social, lifestyle, nutritional and health) of child's individual and family spheres of influence were considered to analyse determinants of child's health status at age-5. These lifecourse variables have been summarised as per time frame in **Table 1**. Additional details on them are provided in **eTable 1** available in the web only supplement. The independent variables have been arranged as child-related, family-related, mother-related, father-related groups for ease of presentation.

Table 1: Independent variables examined from lifecourse of 5-yr-old children

Lifecourse	Independent Variables
Pre-pregnancy	Maternal Pre-pregnancy BMI
Early pregnancy	Family stability
	Maternal smoking in pregnancy, Maternal Education level
	Paternal Education level
Birth	Child's Birth-weight, Gestational age, Gender
	Maternal Parity
Infancy	Child's breastfeeding status
When children averaged 5-yr age	Child's Age, Height, BMI, Waist circumference, Food intake: top and fruits & vegetables shelves, Nutrient intake: energy and fats intake
	Family household weekly income, Entitlement to means tested healthcare benefits scheme, Family structure (marital status), Support from partner, parents, children & relatives
	Maternal Age, Height, BMI, Waist circumference, Smoking, Employment status, Food intake: top and fruits & vegetables shelves, Nutrient intake: energy and fats intake, Self-rated health status
	Paternal Height, BMI, Waist circumference, Smoking, Employment status, Self-rated health status

Children's global health status rated in proxy by their mothers, hereafter referred to as parent-rated health (PRH), was the outcome variable of interest. The 5-graded scale response was dichotomised as relatively-positive health (excellent or very good) and relatively-negative health (poor or fair or good), based on similar dichotomisation in other studies on preschool and school children.[11,12,24] It is reasonable to take a higher cut-off when dichotomising this age dependent variable in this very young age-group as there would be very limited numbers of poor or fair health children.[11,12,35]

Initially, uni-variate associations were established between the independent predictors and children's PRH using independent t-tests or chi-square tests. Independent categorical variables were dichotomised in a manner that allowed contrasting extreme levels against the others. Thus, using International Obesity Task Force (IOTF) cut-offs, children's BMI was dichotomised as obese versus over-weight or normal-weight. Similarly nutrition variables ordered in quintiles were dichotomised as the extreme quintile (1^{st} or 5^{th}) versus the rest.

From these independent variables principally chosen on the basis of their relevance to the child's development,[2,3] all those that qualified at significance level 20% ($p<0.2$)[36] in univariate analyses were force entered into a multivariable logistic regression model. BMI and waist circumference, the anthropometric markers of obesity, were tested separately in independent multivariable models. Initially BMI was tested as a categorical variable in a model, followed by two additional models substituting it with BMI and then waist circumference as continuous variables. Other independent variables were tested as categorical variables.

Ethical approval for the Lifeways study was obtained respectively from ethical committees of participating hospitals and the University College Dublin, Ireland. Written informed consent was obtained from study participants.

Results

There were 547 family datasets available for analysis of children's PRH. **Table 2** presents the uni-variate associations between children's lifecourse variables and PRH. Within the individual-sphere of influences, children's lifestyle behaviours (lower intake of fatty/sugary foods and total fats, and higher intake of fruits/vegetables) and their anthropometric measures at age-5 (not being obese, lower BMI, and lower waist circumference) qualified as determinants of children's relatively-positive PRH for further examination in the multivariable model.

Within the family-sphere of influences, socio-economic status (higher household income, non-entitlement to subsidised healthcare, both parents' higher education status, and father's employment status), psycho-social status (father's study participation, mother's perceived social support), mother's lifestyle behaviours (lower intake of fatty/sugary foods, total energy and total fats), father's lifestyle behaviours (non-smoker), and both parents' health status

(relatively-positive self-rated health) qualified as determinants of children's relatively-positive PRH for further examination in the multivariable model.

Table 2: Uni-variate lifecourse associates of children's relatively-positive parent-rated health, PRH (N=547)

		Relatively Negative PRH (n=42)		Relatively Positive PRH (n=505)			
	N	%(n)	Mean (SD)	%(n)	Mean (SD)	OR	95% CI
Child's Individual Characteristics							
Birth-weight adjusted for gestational age (g)	487	(34)	3564.1 (616)	(453)	3548.4 (552)	1.00	(0.999-1.001)
Child's Age (Yrs)	547	(42)	5.42 (0.23)	(505)	5.46 (0.25)		
Gender	547						
Male		8.0% (22)		92.0% (242)		Ref	
Female		7.1% (21)		92.9% (262)		1.14	(0.60-2.20)
BMI (kg/m^2)	464	(35)	17.09 (2.5)	(429)	16.59 (1.6)	0.85	(0.71-1.03)^
BMI [IOTF]	464						
Obese		16.7% (5)		83.3% (25)		Ref	
Overweight / Normal		6.9% (30)		93.1% (404)		2.69	(0.96-7.54)^
Waist Circumference (cm)	462	(35)	57.01 (6.8)	(427)	55.88 (4.3)	0.95	(0.88-1.02)†
Height (cm)	464	(35)	111.6 (5.6)	(429)	112.1 (4.8)	1.02	(0.95-1.10)
Breastfeeding	528						
Not breastfed		6.5% (16)		93.5% (229)		Ref	
Breastfed		8.8% (25)		91.2% (258)		0.72	(0.38-1.38)
Energy (Kcal)	547						
Quintile 5 (>1794 kcal)		10% (11)		90.0% (99)		Ref	
Quintile 1-4		7.1% (31)		92.9% (406)		1.46	(0.71-3.00)
Fats (g)	547						
Quintile 5 (>62.9 g)		12.8% (14)		87.2% (95)		Ref	
Quintile 1-4		6.4% (28)		93.6% (410)		2.16	(1.09-4.26)*
Top shelf (servings/day)	547						
Quintile 5 (>6.47 servings)		10.9% (12)		89.1% (98)		Ref	
Quintile 1-4		6.9% (30)		93.1% (407)		1.66	(0.82-3.36)†
Fruits Veg shelf (servings/d)	547						
Quintile 1 (<2.1 servings)		12.8% (14)		87.2% (95)		Ref	
Quintile 2-5		6.4% (28)		93.6% (410)		2.16	(1.09-4.26)*
Family Characteristics							
Household Weekly Income	509						
Less than 760 Euros/wk		13.3% (26)		86.7% (170)		Ref	
More than 760 Euros/wk		4.8% (15)		95.2% (298)		3.04	(1.57-5.90)**
Entitlement to General Medical Card	532						
Entitled		13% (12)		87.0% (80)		Ref	
Not entitled		6.6% (29)		93.4% (411)		2.13	(1.04-4.34)*
Fathers' Participation	547						
Not		9.7% (31)		90.3% (290)		Ref	
Yes		4.9% (11)		95.1% (215)		2.09	(1.03-4.25)*
Marital Status	542						
Others		11.4% (5)		88.6% (39)		Ref	
Married/Cohabiting		7.2% (36)		92.8% (462)		1.65	(0.61-4.43)
Elder children in family (Parity)	535						
Nullipara		8% (18)		92.0% (207)		Ref	
Multipara		7.7% (24)		92.3% (286)		1.04	(0.55-1.96)
Support from Spouse/Partner	538						
Lesser support		12.9% (17)		87.1% (115)		Ref	
More support		6.2% (25)		93.8% (381)		2.25	(1.18-4.32)*
Support from Parents	487						
Lesser support		12.5% (12)		87.5% (84)		Ref	
More support		6.6% (26)		93.4% (365)		2.01	(0.97-4.14)^
Support from Children	532						
Lesser support		10.6% (20)		89.4% (169)		Ref	
More support		5.8% (20)		94.2% (323)		1.91	(1.00-3.65)*
Support from Close Relatives	510						
Lesser support		12.4% (19)		87.6% (134)		Ref	
More support		6.2% (22)		93.8% (335)		2.16	(1.13-4.12)*

Table 2: Uni-variate lifecourse associates of children's relatively-positive parent-rated health, PRH (continued)

	Relatively Negative PRH (n=42)			Relatively Positive PRH (n=505)			
	N	%(n)	Mean (SD)	%(n)	Mean (SD)	OR	95% CI
Maternal Characteristics							
Pre-pregnancy BMI (kg/m^2)	475	(36)	23.3 (3.3)	(439)	23.8 (3.9)	1.04	(0.94-1.14)
Pre-pregnancy BMI [WHO cut offs]							
Obese		2.6% (1)		97.4% (38)		Ref	
Overweight / Normal		8% (35)		92.0% (401)		0.30	(0.04-2.26)
Mother's Age (Yrs)	546	(42)	36.5 (6.3)	(504)	37.1 (5.3)	1.02	(0.96-1.08)
BMI at 5-yr follow-up (kg/m^2)	432		25.6 (3.9)		26.3 (5.0)	1.03	(0.95-1.12)
BMI at 5-yr follow-up [WHO cut offs]	432						
Obese		7.2% (5)		92.8% (64)		Ref	
Overweight / Normal		7.4% (27)		92.6% (336)		0.97	(0.36-2.62)
Waist Circumference (cm)	434	(31)	85.3 (10.6)	(403)	87.6 (11.9)	1.02	(0.99-1.05)
Height (cm)	454	(33)	161.9 (6.8)	(421)	162.9 (6.0)	1.03	(0.97-1.09)
Smoking in pregnancy	534						
Smoker		8.1% (8)		91.9% (91)		Ref	
Non-Smoker		7.6% (33)		92.4% (402)		1.07	(0.48-2.4)
Smoking at 5-yr follow-up	541						
Smoker		7.6% (9)		92.4% (110)		Ref	
Non-Smoker		7.6% (32)		92.4% (390)		1.0	(0.46-2.15)
Energy (Kcal)	546						
Quintile 5 (>2570.9 kcal)		13% (14)		87.0% (94)		Ref	
Quintile 1-4		6.4% (28)		93.6% (410)		2.18	(1.11-4.30)*
Fats (g)	546						
Quintile 5 (>106 g)		11% (12)		89.0% (97)		Ref	
Quintile 1-4		6.9% (30)		93.1% (407)		1.68	(0.83-3.40)†
Top shelf (servings/day)	545						
Quintile 5 (>8.35 servings)		11% (12)		89.0% (97)		Ref	
Quintile 1-4		6.9% (30)		93.1% (406)		1.67	(0.83-3.39)†
Fruits Veg shelf (servings/day)	546						
Quintile 1 (<4.5 servings)		9.1% (10)		90.9% (100)		Ref	
Quintile 2-5		7.3% (32)		92.7% (404)		1.26	(0.60-2.65)
Education level	534						
Lower		10.4% (25)		89.6% (215)		Ref	
Third Level		5.8% (17)		94.2% (277)		1.90	(1.00-3.60)*
Employment	545						
Not Earning		6.4% (15)		93.6% (221)		Ref	
Employed		9% (22)		91.0% (222)		0.69	(0.35-1.36)
Self employed		7.7% (5)		92.3% (60)		0.81	(0.29-2.33)
Self reported health	546						
Relatively Negative		17.1% (27)		82.9% (131)		Ref	
Relatively Positive		3.9% (15)		96.1% (373)		5.10	(2.64-9.93)**
Paternal Characteristics							
BMI at 5-yr follow-up (kg/m^2)	66	(4)		(62)		0.97	(0.76-1.23)
Waist Circumference (cm)	65	(3)		(62)		1.01	(0.90-1.13)
Height (cm)	66	(4)		(62)		1.01	(0.88-1.15)
Smoking at 5-yr follow-up	521						
Smoker		11.5% (16)		88.5% (123)		Ref	
Non-Smoker		5.5% (21)		94.5% (361)		2.24	(1.13-4.42)*
Education level	514						
Lower		11.1% (16)		88.9% (128)		Ref	
Third Level		6.2% (23)		93.8% (347)		1.89	(0.97-3.68)^
Employment	518						
Not Earning		9.2% (8)		90.8% (79)		Ref	
Employed		7.9% (24)		92.1% (279)		1.18	(0.51-2.72)
Self employed		3.9% (5)		96.1% (123)		2.49	(0.79-7.89)†
Self reported health	510						
Relatively Negative		12.6% (20)		87.4% (139)		Ref	
Relatively Positive		4.6% (16)		95.4% (335)		3.01	(1.52-5.99)**

**p<0.01, *p<0.05, ^p<0.1, †p<0.2; Ref=reference category (OR=1)

Table 3 presents the multivariable model for association between qualifying lifecourse variables and children's relatively-positive PRH at age-5. A significantly strong predictor of children's relatively-positive PRH was child's not being obese by IOTF classification. When BMI was tested as a continuous variable, there was 0.73 times less likelihood of the child being positively rated on health status for every 1 kg/m^2 increase in their BMI. Similarly in the waist circumference model, for every 1 cm increase there was 0.89 times less likelihood of the child getting a relatively-positive rating on health status. Another significant predictor of children's relatively-positive PRH was mother's having rated her own health as relatively-positive. These predictors maintained the highest strength of association with children's health status when independent variables were standardised (see **eTable 2** in the web only supplement). None of the other variables reached the level of statistical significance. The models explained over 25 percent of variance for children's PRH.

Table 3: Multivariable Logistic Regression model for predictors of children's relatively-positive parent-rated health, PRH (N=303)

	Relatively Positive PRH			Relatively Positive PRH			Relatively Positive PRH		
	BMI Categorical[1]			BMI Continuous[2]			WC Continuous[3]		
	OR	95% CI		OR	95% CI		OR	95% CI	
Child's Individual Characteristics									
BMI [IOTF], Obese† vs Overweight / Normal	5.48	(1.43-21.03)	*						
BMI kg/m^2 [Continuous]				0.73	(0.58-0.93)	**			
Waist Circumference cm [Continuous]							0.89	(0.81-0.98)	*
Fats gm [Quintiles], Q5† vs Q1-4	1.57	(0.42-5.79)		1.49	(0.40-5.53)		1.32	(0.36-4.80)	
Top shelf servings/d [Quintiles], Q5† vs Q1-4	1.23	(0.33-4.53)		1.30	(0.36-4.63)		1.29	(0.36-4.62)	
Fruits Veg shelf servings/d [Quintiles], Q1† vs Q2-5	2.57	(0.75-8.80)		2.86	(0.83-9.93)		2.73	(0.78-9.49)	
Family Characteristics									
Household Weekly Income, Less† vs High	1.85	(0.63-5.40)		1.76	(0.59-5.21)		1.79	(0.61-5.26)	
Entitlement to General Medical, Card Yes† vs No	0.94	(0.24-3.71)		1.03	(0.26-4.07)		1.04	(0.26-4.10)	
Fathers' Participation, No† vs Yes	1.88	(0.68-5.21)		1.86	(0.67-5.16)		2.06	(0.74-5.71)	
Support from Spouse/Partner, Less† vs More	0.70	(0.20-2.49)		0.67	(0.19-2.33)		0.74	(0.22-2.52)	
Support from Parents, Less† vs More	1.92	(0.53-6.93)		2.33	(0.64-8.42)		2.37	(0.66-8.53)	
Support from Children, Less† vs More	1.15	(0.38-3.45)		1.29	(0.42-3.91)		1.25	(0.41-3.82)	
Support from Close Relatives, Less† vs More	0.86	(0.23-3.13)		0.84	(0.24-3.02)		0.84	(0.23-3.01)	
Maternal Characteristics									
Energy Kcal [Quintiles], Q5† vs Q1-4	1.89	(0.30-11.84)		2.00	(0.31-12.86)		1.57	(0.28-8.84)	
Fats gm [Quintiles], Q5† vs Q1-4	0.72	(0.09-5.54)		0.59	(0.07-4.77)		0.92	(0.13-6.41)	
Top shelf servings/d [Quintiles], Q5† vs Q1-4	1.08	(0.29-3.94)		1.30	(0.36-4.65)		1.18	(0.32-4.34)	
Education, Lower† vs Third level	1.34	(0.47-3.78)		1.35	(0.48-3.80)		1.48	(0.53-4.13)	
Self reported health status, Rel.Negative† vs Rel.Positive	4.20	(1.45-12.20)	**	4.42	(1.53-12.79)	**	4.17	(1.47-11.87)	**
Paternal Characteristics									
Current Smoking status, Yes† vs No	1.37	(0.48-3.93)		1.31	(0.45-3.83)		1.53	(0.54-4.35)	
Education, Lower† vs Third level	0.69	(0.21-2.28)		0.79	(0.24-2.57)		0.83	(0.26-2.67)	
Employment, Non-earning † vs Self employed	1.60	(0.73-3.53)		1.52	(0.69-3.32)		1.57	(0.70-3.53)	
Self reported health status, Rel.Negative† vs Rel.Positive	1.48	(0.52-4.20)		1.54	(0.54-4.35)		1.43	(0.51-3.96)	

OR=Odds Ratio; †Reference category (OR=1); **p<0.01 (2-tailed), *p<0.05 (2-tailed)

Rel.Negative=Relatively Negative, Rel.Positive=Relatively Positive

[1]Child BMI as a categorical variable; Model Chi-sq = 34.2, df = 21, p = 0.034; -2LL = 128.6, Nagelkerke R-sq = 0.26

[2]Child BMI as a continuous variable; Model Chi-sq = 35.9, df = 21, p = 0.022; -2LL = 126.9, Nagelkerke R-sq = 0.27

[3]Child waist circumference as a continuous variable; Model Chi-sq = 33.8, df = 21, p = 0.038; -2LL = 128.9, Nagelkerke R-sq = 0.25

Discussion

This analysis showed that determinants from both child's individual and family spheres have an influence on child's health at preschool-age. The factors from all three material, psycho-social and lifestyle domains, the major explanations for child health inequalities,[4] were associated at uni-variate levels. However, in the final model this analysis clearly demonstrated a negative association between child's obesity and health status. Child's not being obese was one of the significantly strong predictors of child's relatively-positive health status, which was also observed with measured BMI and waist circumference analysed as continuous variables.

This negative relationship observed between measured obesity and PRH conforms to published literature on primary school age-group children and adolescents.[37-39] Most importantly, for the first time to our knowledge, this analysis demonstrates the association having adjusted for food and nutrient intake, along-with a wide range of other explanatory variables.

Self-rated health is a valid measure of morbidity, mortality, longevity and health status,[40] also in Irish adult[41,42] and children[10]. Use of parent proxy for child self-reported health is justified for children too young to have adequate cognitive skills.[43,44] Systematic reviews report good agreement between ratings by children and their parents on child HRQoL, particularly for physical health domain.[43,44] Parents tend to be thoughtful when responding to proxy questions and report children's usual health disposition.[45] Studies on construct validity report positively.[46-49] Maternal ratings of child's general health status were found sensitive when validated against children's illnesses and other morbidity or healthcare indicators,[35,50-52] including evidence of a gradient in strength of these associations.[35] Many national-level studies have accepted parent proxy as an appropriate measure[11,12,53,54] and successfully used it to longitudinally demonstrate risk and consequences of child health.[11,53]

Self-rated health, a composite measure, represents all domains of HR-QoL,[40] but better represents physical health than HR-QoL.[55] Studies on older age-group children have reported stronger/sole negative associations for general/physical health domain of HR-QoL and obesity,[38,56] irrespective whether children themselves or parents reported their HRQoL,[23] and also whether BMI was analysed as a categorical,[37,38] or continuous variable.[57,58]

Another relevance of this analysis is in demonstrating this association of obesity with general-health in a nationally representative sample of preschool-age children, for which literature is scant. Though, a few have shown associations with specific paediatric conditions and admission history in this age-group.[24,25,59-62] A longitudinal study speculated that pre-school obesity influences a decline in early-age health, and then both obesity and poor-health tracks into adolescence.[63] The WHO recommends high priority for determinants of health inequalities during early development.[64]

The Lifeways previously demonstrated longitudinal association between parental socio-economic and lifestyle characteristics and child's BMI and waist circumference.[30] In this analysis when same anthropometric measures are included along-with material, psycho-social, and lifestyle determinants of child obesity and health, a prominent relationship emerges between children's anthropometric measures and health status. One possible explanation is that determinants of health inequalities biologically embed[15,16] in early life and child obesity is an early phenotypic expression of this inequality; though the continued influence of environmental factors is not undermined. Adult[19,20] and adolescence studies[38,39] have also shown this association to be independent of socio-demographic, lifestyle or health-related factors.

The observed association between BMI or waist circumference and PRH in the present analysis may be temporal, as demonstrated in adults.[21,22] However, this needs careful interpretation as both anthropometric and health data were concurrently collected, and this limitation may be addressed with next sweep of cohort data collection.

This analysis demonstrated that maternal health was strongly predictive of her child's health. One concern is that mother's perception of her own health may bias her perception of her child's health. However, this intergenerational association has been previously reported,[35,50,51,65-68] and reporting mothers can effectively discriminate between their own and children's health.[35,50,51,66,67,69] Several mechanisms such as inherited susceptibility, uterine environment and shared environment have been suggested for this familial aggregation pattern.[50,66,67]

Maternal BMI may be related to both maternal self-rated health and child's BMI, so the observed associations in this analysis could possibly be a reflection of an association between maternal BMI and child's PRH. However, this was not observed in our analysis. Maternal BMI at both pre-pregnancy and 5-year follow-up were not associated with child's PRH at univariate level. Also, when maternal BMI was forcibly added into the multivariable model (not reported here), the observed associations did not attenuate.

The study has limitations in use of reported rather than measured health status and small sample size. However, it has advantages in use of lifecourse variables from pre-conception to age of 5-years, with measured BMI and waist circumference data. It also has detailed foods and nutrient data along-with other socio-economic, psycho-social and lifestyle variables for child and both parents.

In conclusion, these analyses from the Lifeways cohort show that lifecourse adversities were associated with mother-reported health for preschoolers, suggesting an early life influence. Preschoolers' BMI and waist-circumference demonstrated strong negative associations with mother-reported health independent of socio-economic, psycho-social, and lifestyle factors, suggesting early biological expression of lifecourse adversities. The findings have important implications in understanding how early life environment may create inequalities in developmental health.

Footnotes

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The Lifeways Cross-Generation Cohort Study is overseen by an interdisciplinary scientific steering group chaired by CCK, the principal investigator. The authors greatly appreciate the participation of the Lifeways cohort families.

Contributors

AS undertook all analyses reported in this manuscript, interpreted the findings and drafted the manuscript. CM contributed to data collection at five year follow-up, interpretation of the analysis and critical revision of the manuscript. CCK designed the study, supervised the analyses, interpretation of results and intellectual content of the manuscript. All three authors approved the final version.

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Competing interests

None

Ethical approvals

Ethics committees of Coombe University Hospital, Dublin, University College Hospital Galway, University College Dublin, Dublin, and the Irish College of General Practitioners, Ireland.

Data sharing statement

There are no additional data available. The data manager may be contacted at john.obrien@ucd.ie for more details on the Lifeways Cross-Generation Cohort Study.

Appendices

The web only supplement includes eTable 1 regarding details of examined variables and eTable 2 displaying standardised odds ratios for multivariable logistic regression model.

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eTable 1: Lifecourse variables examined for relationship with children's parent-rated health, PRH

Independent Variables	Time	Categories
Child's Individual characteristics		
Demographic and Anthropometric		
Birth-weight standardised for gestational age (g)	Measured at birth	continuous measure
Age at 5-year follow-up (years)	At 5-yr follow-up	continuous measure
Gender		Male, Female
Body Mass Index (BMI) kg/m^2	Measured at 5-yr follow-up	continuous measure Also as obese versus overweight or normal using IOTF definitions
Waist Circumference (cm)	Measured at 5-yr follow-up	continuous measure
Height (cm)	Measured at 5-yr follow-up	continuous measure
Lifestyle/Nutrition		
Breastfeeding	At infancy	breastfed or not
Top shelf servings per day	At 5-yr follow-up	5th Quintile (>6.47 servings) versus 1-4 Quintiles.
Fruits & Vegetables shelf servings /day	At 5-yr follow-up	1st Quintile (<2.1 servings) versus 2-5 Quintiles
Total Energy intake (kilocalories/day)	At 5-yr follow-up	5th Quintile (>1794 kcal) versus 1-4 Quintiles
Total Fats intake (grams/day)	At 5-yr follow-up	5th Quintile (>62.9g) versus 1-4 Quintiles
Family characteristics		
Socio-Economic		
Household weekly income	At 5-yr follow-up	composite family income more or less than 760 Euros a week
Entitlement to General Medical Card scheme, a means tested healthcare benefits scheme	At 5-yr follow-up	Families entitled or not to General Medical Card
Psycho-Social		
Fathers' participation (Family stability)	Early pregnancy stage	Families whose fathers participated in the study versus families whose fathers did not
Mother's marital status (Family structure)	At 5-yr follow-up	Married or cohabiting versus single, separated, divorced or widowed.
Elder children in family [Parity was a proxy measure for presence of elder siblings to the Lifeways child]	Early pregnancy stage	nullipara versus one or more para
Support from spouse or partner	At 5-yr follow-up	Mothers perceived "a lot" of support from spouse or partners versus perceived receiving "some, so-so, little" support
Support from parents	At 5-yr follow-up	Mothers perceived "a lot" of support from parents versus

		perceived receiving "some, so-so, little" support
Support from children, inclusive Lifeways child	At 5-yr follow-up	Mothers perceived "a lot" of support from children versus perceived receiving "some, so-so, little" support
Support from close relatives	At 5-yr follow-up	Mothers perceived "a lot" of support from relatives versus perceived receiving "some, so-so, little" support
Maternal characteristics		
Demographic and Anthropometric		
Age at 5-year follow-up (years)	At 5-yr follow-up	continuous measure
Pre-pregnancy BMI (kg/m^2)	Pre-pregnancy, Self-reported in early pregnancy	continuous measure Also as obese versus overweight or normal using WHO definitions
BMI at 5-year follow-up (kg/m^2)	Measured at 5-yr follow-up	continuous measure Also as obese versus overweight or normal using WHO definitions
Waist Circumference at 5-year follow-up (cm)	Measured at 5-yr follow-up	continuous measure
Height at 5-year follow-up (cm)	Measured at 5-yr follow-up	continuous measure
Lifestyle/Nutrition		
Smoking during pregnancy	Early pregnancy stage	Current smoker or not
Smoking at 5-year follow-up	At 5-yr follow-up	Current smoker or not
Top shelf servings per day	At 5-yr follow-up	5th Quintile (>8.35 servings) versus 1-4 Quintiles.
Fruits & Vegetables shelf servings /day	At 5-yr follow-up	1st Quintile (<4.5 servings) versus 2-5 Quintiles
Total Energy intake (kilocalories/day)	At 5-yr follow-up	5th Quintile (>2570.9 kcal) versus 1-4 Quintiles
Total Fats intake (grams/day)	At 5-yr follow-up	5th Quintile (>106.0 g) versus 1-4 Quintiles
Socio-Economic		
Education level	Early pregnancy stage	Third level versus lower levels of education status
Employment status	At 5-yr follow-up	Non-earning versus Employed versus Self employed
Health		
Self-rated health status of mothers	At 5-yr follow-up	Relatively Positive ("Excellent" or "Very Good") versus Relatively Negative ("Poor"/ "Fair" /"Good") responses
Paternal Characteristics		
Anthropometric		
BMI at 5-year follow-up (kg/m^2)	Measured at	continuous measure

Waist Circumference at 5-year follow-up (cm)	5-yr follow-up Measured at 5-yr follow-up	continuous measure
Height at 5-year follow-up (cm)	5-yr follow-up Measured at 5-yr follow-up	continuous measure
Lifestyle		
Smoking at 5-year follow-up	At 5-yr follow-up	Current smoker or not
Socio-Economic		
Education level	Early pregnancy stage	Third level versus lower levels of education status
Employment status	At 5-yr follow-up	Non-earning versus Employed versus Self employed
Health		
Self-rated health status of fathers (in proxy)	At 5-yr follow-up	Relatively Positive (“Excellent” or “Very Good”) versus Relatively Negative (“Poor”/ “Fair” /“Good”) responses

eTable 2: Multivariable Logistic Regression model for predictors of children's relatively positive parent-rated health, PRH (N=303)

	Relatively Positive PRH		Relatively Positive PRH		Relatively Positive PRH	
	BMI Categorical[1]		BMI Continuous[2]		WC Continuous[3]	
	Std OR	p-value	Std OR	p-value	Std OR	p-value
Child's Individual Characteristics						
BMI [IOTF], Obese† vs Overweight / Normal	1.53*	0.01				
BMI kg/m^2 [Continuous]			0.58**	0.009		
Waist Circumference cm [Continuous]					0.60*	0.02
Fats gm [Quintiles], Q5† vs Q1-4	1.20	0.50	1.18	0.55	1.12	0.68
Top shelf servings/d [Quintiles], Q5† vs Q1-4	1.09	0.76	1.11	0.69	1.11	0.70
Fruits Veg shelf servings/d [Quintiles], Q1† vs Q2-5	1.43	0.13	1.49	0.10	1.46	0.12
Family Characteristics						
Household Weekly Income, Less† vs High	1.34	0.26	1.30	0.31	1.32	0.29
Entitlement to General Medical, Card Yes† vs No	0.98	0.93	1.01	0.97	1.01	0.95
Fathers' Participation, No† vs Yes	1.37	0.23	1.36	0.23	1.43	0.17
Support from Spouse/Partner, Less† vs More	0.86	0.59	0.84	0.53	0.88	0.63
Support from Parents, Less† vs More	1.30	0.32	1.41	0.20	1.42	0.19
Support from Children, Less† vs More	1.07	0.80	1.13	0.65	1.11	0.70
Support from Close Relatives, Less† vs More	0.93	0.81	0.93	0.79	0.92	0.79
Maternal Characteristics						
Energy Kcal [Quintiles], Q5† vs Q1-4	1.28	0.50	1.31	0.47	1.19	0.61
Fats gm [Quintiles], Q5† vs Q1-4	0.88	0.76	0.82	0.62	0.97	0.93
Top shelf servings/d [Quintiles], Q5† vs Q1-4	1.03	0.91	1.11	0.69	1.07	0.80
Education, Lower† vs Third level	1.15	0.58	1.16	0.56	1.21	0.45
Self reported health status, Rel.Negative† vs Rel.Positive	1.88**	0.008	1.92**	0.006	1.88**	0.007
Paternal Characteristics						
Current Smoking status, Yes† vs No	1.15	0.55	1.13	0.62	1.21	0.42
Education, Lower† vs Third level	0.85	0.55	0.90	0.70	0.92	0.75
Employment, Non-earning † vs Self employed	1.33	0.24	1.29	0.30	1.32	0.27
Self reported health status, Rel.Negative† vs Rel.Positive	1.20	0.46	1.22	0.42	1.18	0.50

Std OR=Standardised Odds Ratio, all variables rescaled to have a mean of zero and a standard deviation of one; **p<0.01 (2-tailed), *p<0.05 (2-tailed)

†Reference category (Std OR=1); Rel.Negative=Relatively Negative, Rel.Positive=Relatively Positive

[1]Child BMI as a categorical variable

[2]Child BMI as a continuous variable

[3]Child waist circumference as a continuous variable

STROBE Statement: Childhood obesity is persistent as a predictor of preschoolers' parent-rated health accounting for social inequalities - Lifeways cross-generation cohort study

	Item No	Recommendation	Done
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	✓
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	✓
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	✓
Objectives	3	State specific objectives, including any prespecified hypotheses	✓
Methods			
Study design	4	Present key elements of study design early in the paper	✓
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	✓
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	✓
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	✓
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	✓
Bias	9	Describe any efforts to address potential sources of bias	✓
Study size	10	Explain how the study size was arrived at	✓
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	✓
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	✓
		(*b*) Describe any methods used to examine subgroups and interactions	✓
		(*c*) Explain how missing data were addressed	✓
		(*d*) If applicable, explain how loss to follow-up was addressed	✓
		(*e*) Describe any sensitivity analyses	✓
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	✓
		(b) Give reasons for non-participation at each stage	✓
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	✓
		(b) Indicate number of participants with missing data for each variable of interest	✓
		(c) Summarise follow-up time (eg, average and total amount)	✓
Outcome data	15*	Report numbers of outcome events or summary measures over time	✓
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted	✓

		estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	✓
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	✓
Discussion			
Key results	18	Summarise key results with reference to study objectives	✓
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	✓
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	✓
Generalisability	21	Discuss the generalisability (external validity) of the study results	✓
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	✓

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

Preschoolers' parent rated health disparities are strongly associated with measures of adiposity in the Lifeways cohort study children

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Title: Preschoolers' parent rated health disparities are strongly associated with measures of adiposity in the Lifeways cohort study children

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Running Title: Childhood obesity a persistent predictor of preschoolers' PRH

KEYWORDS

Lifecourse, self-rated health, obesity, BMI, waist circumference, preschool children

Word count: 3340

ABSTRACT (Words: 273)

Objective

To examine the relationship between lifecourse factors from preschoolers' micro-ecosystem and their parent-reported (mother-reported) health (PRH), following them prospectively from preconception to age 5-years. To investigate if preschoolers' BMI and waist-circumference were associated with preschoolers' PRH when controlled for lifecourse predictors.

Design

Lifeways cross-generation cohort study

Setting

Ireland

Participants

Of 1082 families, 62% mothers responded on a health and lifestyle questionnaire at follow-up. Food frequency, BMI and waist-circumference were measured.

Main outcome measure

Mother-reported children's PRH at age-5. Associations with child's individual and familial exposures from preconception to age 5-years examined using logistic regression.

Results

In univariate analysis, relatively-positive rating of children's PRH were associated with children's lower intake of fats [OR(95%CI)=2.2(1.1-4.3)], higher intake of fruits/vegetables [OR(95%CI)=2.2(1.1-4.3)]; as well as familial socio-economic characteristics {higher household income [OR(95%CI)=3.0(1.6-5.9)], non-entitlement to means-tested healthcare [OR(95%CI)=2.1(1.0-4.3)], mothers' higher education [OR(95%CI)=1.9(1.0-3.6)]}, psycho-

social characteristics {father's participation in study [OR(95%CI)=2.1(1.0-4.3)], mothers' perceiving better support from partner [OR(95%CI)=2.3(1.2-4.3)], children [OR(95%CI)=1.9(1.0-3.7)] or relatives [OR(95%CI)=2.2(1.1-4.1)]}, parents' lifestyle {mothers' lower intake of energy [OR(95%CI)=2.2(1.1-4.3)], fathers' non-smoking status [OR(95%CI)=2.2(1.1-4.4)]}, and parents' health {mothers' self-rated health relatively-positive [OR(95%CI)=5.1(2.6-9.9)], fathers' self-rated health relatively-positive [OR(95%CI)=3.0(1.5-6.0)]}.

In multivariable analysis ($\chi 2=34.2, df=21, N=303, R^2=0.26, p<0.05$), one of the two strong predictors of children's relatively-positive PRH was child not being obese by International Obesity Task Force classification [OR(95%CI)=5.5(1.4-21.0)], observed also using BMI (kg/m^2) [OR(95%CI)=0.73(0.58-0.93)] or waist-circumference (cm) [OR(95%CI)=0.89(0.81-0.98)] as continuous variables. The other significant predictor was mothers' self-rated health relatively-positive [OR(95%CI)=4.2(1.5-12.2)].

Conclusions

Preschoolers' health is adversely associated with obesity and this is independent of lifecourse social and environmental inequalities. The findings suggest that lifecourse adversities during the early developmental stage may get embedded and expressed as anthropometric measures of adiposity, suggesting that public health interventions should begin as early as possible.

Strengths and limitations of this study

- Nationally representative sample of preschool-age children
- Examines the influence of lifecourse adversities, prospectively measured from preconception to age 5 on children's general health at age 5. The study analyses demographic, anthropometric, lifestyle, food and nutrients intake, psycho-social, socio-economic and health-related exposures from both children's individual as well as parental experiences.
- Demonstrates a significant and independent association between preschoolers' measured BMI as well as waist circumference and their general health status.
- The study is limited by a relatively small sample and use of parent-reported health status.

MAIN TEXT

Introduction

The development of children is critical to their adult well-being[1,2] and across the lifecourse even subjective estimates may be useful to reflect objectively measured health[3,4]. Bronfenbrenner[5] emphasised the importance of children's micro-ecosystem in their development. Recently, the World Health Organisation's (WHO) Commission on Social Determinants of Health (CSDH) presented a Total Environment Assessment Model for Early Child Development (TEAM-ECD),[6] which again illustrates the importance of individual and family spheres of influence on children's health. The relevance of socio-economic, psycho-social and lifestyle environment in child development and health is widely acknowledged.[6-8]

According to the lifecourse hypothesis, risk transmission is characterised by critical periods and accumulation of risk models.[9] Life Course Health Development (LCHD) framework[10] suggests that health is a consequence of multiple determinants that change in context of time and circumstances as an individual develops; these experiences are programmed into bio-behavioural regulatory systems during certain critical and sensitive periods of individual's lifetime to decide their health trajectory. The lifecourse framework on childhood disadvantage and adult health[11] suggests that parental and childhood circumstances from the point of conception influences individual's health in later life, and the individual's childhood health and later life circumstances may further add to this foundation. Based on this, Hertzman and colleagues[12] examined self-rated health in adulthood using an integrated lifecourse framework. There are a few other studies also which have examined lifecourse determinants of adult global[13,14] or specific health status.[15] On the contrary, the literature on the determinants of child global health status is sparse,[16,17] particularly for the preschool-age children.[18] Even rarer are studies whose examination includes early lifecourse determinants of child global health status.

Thus the first objective of our analysis was to prospectively examine the relationship between demographic, anthropometric, lifestyle, nutritional, psycho-social, socio-economic and health-related lifecourse exposures taken from the children's individual and family spheres of influence starting from preconception up to age 5-years and their global health status at preschool-age.

In social epidemiology, the construct of "embodiment" refers to biological expression of individuals' materio-social world.[19,20] Similarly in lifecourse epidemiology, it is hypothesised that early life experiences get "biologically embedded" during critical or sensitive periods of child development leading to gradients in health.[21,22]

The Foresight report identifies a large array of environmental determinants of obesity, a number of which are again related to early child development.[23] This suggests obesity as pivotal risk factor for subsequent health conditions.[24]

The negative relationship between obesity and self-rated health is now increasingly reported in adult populations,[25,26] some indicating a temporal relationship[27,28] and suggesting that obesity increases health inequalities over time.[28] However, evidence on the relationship between obesity and health is relatively limited in child population studies and those available have reported health-related-quality-of-life (HR-QoL)[29] instead of a generic measure such as global self-rated health. Moreover, this association is yet to be established for preschool-age children. To our knowledge just two population based studies have examined this association in preschool age-group children[30,31] and neither had nutritional information.

In the Longitudinal Study of Australian Children, Wake *et al*.[30] did not find a significant difference in global health status of overweight/obese and normal weight 4-5-year-old children. Skinner et al.,[31] using data on 3-5-year-olds from the US National Health and

Nutrition Examination Survey, reported a poorer global health status in obese and severely obese preschoolers. Neither of these studies accounted for a number of possibly relevant confounders, including parental BMI, parental health and nutritional variables.

We thus hypothesised that similar to findings from studies on older age-groups, anthropometric markers of child obesity in our preschool-age children study would also demonstrate a negative association with their global health status. The next objective of our analysis was to examine whether anthropometric markers of child obesity would emerge as strong predictors of global health status when accounted for other socio-economic, psycho-social, and lifestyle environmental factors in a multivariable model.

Methods

The Lifeways cross generation cohort study comprises three generations of 1082 Irish families and was established in 2001-03; the recruitment procedure of this nationally representative cohort has been described previously.[32-34] The a priori purpose was to examine familial and cross-generation influences on early childhood development over the first five years of children's lives. Briefly, would-be mothers were at random recruited from the two regional maternity hospitals in the Republic of Ireland to get a representative sample. A comparison between the Lifeways mothers and a nationally representative sample of women of the same age group from the SLÁN (Survey of Lifestyle, Attitudes and Nutrition) surveys of Republic of Ireland[35] confirmed that the Lifeways mothers were satisfactorily representative of the Irish general women on socio-demographic characteristics.[33]

At this early pregnancy stage mothers completed a health and lifestyle status questionnaire adapted from a validated instrument developed for Irish national SLÁN surveys.[35] Mothers reported their pre-pregnancy height (cm) and weight (kg) and their smoking status during pregnancy. Mothers' and partners' socio-economic status was recorded. Subsequently at

birth, the live infants were added to the cohort along-with maternity and birth related hospital information.

In 2007-08, when these children averaged five years of age, the cohort follow-up recorded a 62% response rate.[34,36] Though mothers who responded to the follow-up were more likely to be of higher socioeconomic status, these mothers did not significantly differ in their baseline anthropometric characteristics (including BMI) from non-responders.[34,36] At this 5-year follow-up, mothers repeated the health and lifestyle assessment questionnaire, with additional questions related to her family, including a five-level likert item question "In general, would you say your / your partner's / your Lifeways child's current health is Excellent, Very Good, Good, Fair or Poor". Mothers provided information on family's socio-economic, psycho-social, and lifestyle status. Mothers reported their habitual dietary intake for the previous year on a semi-quantitative food frequency (SQFFQ) instrument developed from the EPIC study (European Prospective Investigation into Cancer and Nutrition) and validated for Irish adult population.[37] Mothers also gave details for the Lifeways child's habitual diet for the previous year using a different SQFFQ instrument adapted from the UK National Diet and Nutrition Survey of 4.5-year-old children.[38] The mothers' and children's SQFFQ were validated in the Lifeways study using a 7-day weighed food diary in a sub-sample.[36] Food items were aggregated by defined shelves (food groups) of the Irish food pyramid and assessment was made for average servings per day of standard food item portions consumed from the "top" and "fruit and vegetable" food groups (shelves of Irish food pyramid). The "top" food group comprises of high calorie fat and sugar rich foods. Total energy (kcal) and total fats (g) intake were computed using conversion values from McCance & Widdowson's food composition tables[39] with a specially developed FFQ software version 1.0 ©.[40]

Mothers and children, and if available fathers, were offered at 5-year follow-up an anthropometric assessment at their home for height (cm), weight (kg) and waist

circumference (cm) using a standardised protocol,[34,36] with 80-85% mothers and children participating. Body mass index (BMI) was calculated from weight and height information (kg/m^2).

Thus variables from discrete stages (pre-pregnancy, early pregnancy, at birth, early infancy and 5-year follow-up) of child's early development representing lifecourse exposures from distinct domains (demographic, anthropometric, socio-economic, psycho-social, lifestyle, nutritional and health) of child's individual and family spheres of influence[6-8] were considered to analyse determinants of child's health status at age-5. The selection of variables, domains and spheres of influence are based on the CSDH constructed TEAM-ECD, a model of early child development.[6-8] These lifecourse variables have been summarised as per time frame in **Table 1**. This lifecourse time frame highlights the stages and transition points relevant from perspective of child's health development.[10] Additional details on these variables are provided in **eTable 1** available in the web only supplement. The independent variables have been arranged as child-related, family-related, mother-related, father-related groups for ease of presentation.

Table 1: Independent variables examined from lifecourse of 5-yr-old children

Lifecourse	Independent Variables
Pre-pregnancy	Maternal Pre-pregnancy BMI
Early pregnancy	Family stability
	Maternal smoking in pregnancy, Maternal Education level
	Paternal Education level
Birth	Child's Birth-weight, Gestational age, Gender
	Maternal Parity
Infancy	Child's breastfeeding status
When children averaged 5-yr age	Child's Age, Height, BMI, Waist circumference, Food intake: top and fruits & vegetables food groups, Nutrient intake: energy and fats intake
	Family household weekly income, Entitlement to means tested healthcare benefits scheme, Family structure (marital status), Support from partner, parents, children & relatives
	Maternal Age, Height, BMI, Waist circumference, Smoking, Employment status, Food intake: top and fruits & vegetables food groups, Nutrient intake: energy and fats intake, Self-rated health status
	Paternal Height, BMI, Waist circumference, Smoking, Employment status, Self-rated health status

Children's global health status rated in proxy by their mothers, hereafter referred to as parent-rated health (PRH), was the outcome variable of interest. The 5-graded scale response was dichotomised as relatively-positive health (excellent or very good) and relatively-negative health (poor or fair or good), based on similar dichotomisation in other studies on preschool and school children.[17,18,30] It is reasonable to take a higher cut-off when dichotomising this age dependent variable in this very young age-group as there would be very limited numbers of poor or fair health children.[17,18,41]

Initially, uni-variate associations were established between the independent predictors and children's PRH using independent t-tests or chi-square tests. Independent categorical variables were dichotomised in a manner that allowed contrasting extreme levels against the others. Thus, using International Obesity Task Force (IOTF) cut-offs, children's BMI was dichotomised as obese versus over-weight or normal-weight. Similarly nutrition variables ordered in quintiles were dichotomised as the extreme quintile (1^{st} or 5^{th}) versus the rest.

From these independent variables principally chosen on the basis of their relevance to the child's development,[6-8] all those that qualified at significance level 20% ($p<0.2$)[42] in univariate analyses were force entered into a multivariable logistic regression model. BMI (kg/m^2) and waist circumference (cm), the anthropometric markers of obesity, were tested separately in independent multivariable models. Initially BMI was tested as a categorical variable in a model, followed by two additional models substituting it with BMI and then waist circumference as continuous variables. Other independent variables were tested as categorical variables.

Ethical approval for the Lifeways study was obtained respectively from ethical committees of participating hospitals and the University College Dublin, Ireland. Written informed consent was obtained from study participants.

Results

There were 547 family datasets available for analysis of children's PRH. **Table 2** presents the uni-variate associations between children's lifecourse variables and PRH. Within the individual-sphere of influences, children's lifestyle behaviours (lower intake of fatty/sugary foods and total fats, and higher intake of fruits/vegetables) and their anthropometric measures at age-5 (not being obese, lower BMI, and lower waist circumference) qualified as determinants of children's relatively-positive PRH for further examination in the multivariable model.

In other words, retaining $p<0.2$ as the criterion for significance, the children's healthy food and nutrient intake habits – such as decreased intake of unhealthy fat- and sugar- rich foods (servings/day) [OR(95%CI)=1.7(0.8-3.4)] or total fats (g) in their meals [OR(95%CI)=2.2(1.1-4.3)] and increased intake of healthy fruits and vegetables (servings/day) [OR(95%CI)=2.2(1.1-4.3)] were positively associated with their favourable

rating for health by their mothers. Conversely, children's increased BMI (kg/m^2) [OR(95%CI)=0.85(0.71-1.03)] and waist circumference (cm) [OR(95%CI)=0.95(0.88-1.02)] were inversely associated with a positive parental-rated health status.

Within the family-sphere of influences, socio-economic status (higher household income, non-entitlement to subsidised healthcare, both parents' higher education status, and father's employment status), psycho-social status (father's study participation, mother's perceived social support), mother's lifestyle behaviours (lower intake of fatty/sugary foods, total energy and total fats), father's lifestyle behaviours (non-smoker), and both parents' health status (relatively-positive self-rated health) qualified as determinants of children's relatively-positive PRH for further examination in the multivariable model.

In other words, by maintaining $p<0.2$ as the criterion for significance, several indicators of a family's better socio-economic status– such as increased household income (Euros/week) [OR(95%CI)=3.0(1.6-5.9)], not requiring subsidised healthcare [OR(95%CI)=2.1(1.0-4.3)], mother having a third level education [OR(95%CI)=1.9(1.0-3.6)], father having a third level education [OR(95%CI)=1.9(1.0-3.6)], father being self-employed [OR(95%CI)=2.5(0.8-7.9)]; family's better psycho-social status– such as father's involvement in family affairs [OR(95%CI)=2.1(1.0-4.3)], mother's perceiving a positive social support from spouse [OR(95%CI)=2.3(1.2-4.3)], parents [OR(95%CI)=2.0(1.0-4.1)], children [OR(95%CI)=1.9(1.0-3.7)], or relatives [OR(95%CI)=2.2(1.1-4.1)]; family's better lifestyle and food and nutrient intake habits– such as mother's decreased intake of unhealthy fat- and sugar- rich foods (servings/day) [OR(95%CI)=1.7(0.8-3.4)], total energy (kcal) [OR(95%CI)=2.2(1.1-4.3)] and total fats (g) [OR(95%CI)=1.7(0.8-3.4)] in her meals, father's not being a smoker [OR(95%CI)=2.2(1.1-4.4)]; and family's better health status– such as mother [OR(95%CI)=5.1(2.6-9.9)] and father [OR(95%CI)=3.0(1.5-6.0)] having a positively

rated health status were positively associated with children's favourable rating for health by their mothers.

Table 2: Uni-variate lifecourse associates of children's relatively-positive parent-rated health, PRH (N=547)

		Relatively Negative PRH (n=42)		Relatively Positive PRH (n=505)			
	N	%(n)	Mean (SD)	%(n)	Mean (SD)	OR	95% CI
Child's Individual Characteristics							
Birth-weight adjusted for gestational age (g)	487	(34)	3564.1 (616)	(453)	3548.4 (552)	1.00	(0.999-1.001)
Child's Age (Yrs)	547	(42)	5.42 (0.23)	(505)	5.46 (0.25)		
Gender	547						
Male		8.0% (22)		92.0% (242)		Ref	
Female		7.1% (21)		92.9% (262)		1.14	(0.60-2.20)
BMI (kg/m^2)	464	(35)	17.09 (2.5)	(429)	16.59 (1.6)	0.85	(0.71-1.03)^
BMI [IOTF]	464						
Obese		16.7% (5)		83.3% (25)		Ref	
Overweight / Normal		6.9% (30)		93.1% (404)		2.69	(0.96-7.54)^
Waist Circumference (cm)	462	(35)	57.01 (6.8)	(427)	55.88 (4.3)	0.95	(0.88-1.02)†
Height (cm)	464	(35)	111.6 (5.6)	(429)	112.1 (4.8)	1.02	(0.95-1.10)
Breastfeeding	528						
Not breastfed		6.5% (16)		93.5% (229)		Ref	
Breastfed		8.8% (25)		91.2% (258)		0.72	(0.38-1.38)
Energy (Kcal)	547						
Quintile 5 (>1794 kcal)		10% (11)		90.0% (99)		Ref	
Quintile 1-4		7.1% (31)		92.9% (406)		1.46	(0.71-3.00)
Fats (g)	547						
Quintile 5 (>62.9 g)		12.8% (14)		87.2% (95)		Ref	
Quintile 1-4		6.4% (28)		93.6% (410)		2.16	(1.09-4.26)*
Top food group (servings/day)	547						
Quintile 5 (>6.47 servings)		10.9% (12)		89.1% (98)		Ref	
Quintile 1-4		6.9% (30)		93.1% (407)		1.66	(0.82-3.36)†
Fruits Veg food group (servings/d)	547						
Quintile 1 (<2.1 servings)		12.8% (14)		87.2% (95)		Ref	
Quintile 2-5		6.4% (28)		93.6% (410)		2.16	(1.09-4.26)*
Family Characteristics							
Household Weekly Income	509						
Less than 760 Euros/wk		13.3% (26)		86.7% (170)		Ref	
More than 760 Euros/wk		4.8% (15)		95.2% (298)		3.04	(1.57-5.90)**
Entitlement to General Medical Card	532						
Entitled		13% (12)		87.0% (80)		Ref	
Not entitled		6.6% (29)		93.4% (411)		2.13	(1.04-4.34)*
Fathers' Participation	547						
Not		9.7% (31)		90.3% (290)		Ref	
Yes		4.9% (11)		95.1% (215)		2.09	(1.03-4.25)*
Marital Status	542						
Others		11.4% (5)		88.6% (39)		Ref	
Married/Cohabiting		7.2% (36)		92.8% (462)		1.65	(0.61-4.43)
Elder children in family (Parity)	535						
Nullipara		8% (18)		92.0% (207)		Ref	
Multipara		7.7% (24)		92.3% (286)		1.04	(0.55-1.96)
Support from Spouse/Partner	538						
Lesser support		12.9% (17)		87.1% (115)		Ref	
More support		6.2% (25)		93.8% (381)		2.25	(1.18-4.32)*
Support from Parents	487						
Lesser support		12.5% (12)		87.5% (84)		Ref	
More support		6.6% (26)		93.4% (365)		2.01	(0.97-4.14)^
Support from Children	532						
Lesser support		10.6% (20)		89.4% (169)		Ref	
More support		5.8% (20)		94.2% (323)		1.91	(1.00-3.65)*
Support from Close Relatives	510						
Lesser support		12.4% (19)		87.6% (134)		Ref	
More support		6.2% (22)		93.8% (335)		2.16	(1.13-4.12)*

Table 2: Uni-variate lifecourse associates of children's relatively-positive parent-rated health, PRH (continued)

	Relatively Negative PRH (n=42)			Relatively Positive PRH (n=505)			
	N	%(n)	Mean (SD)	%(n)	Mean (SD)	OR	95% CI
Maternal Characteristics							
Pre-pregnancy BMI (kg/m^2)	475	(36)	23.3 (3.3)	(439)	23.8 (3.9)	1.04	(0.94-1.14)
Pre-pregnancy BMI [WHO cut offs]							
Obese		2.6% (1)		97.4% (38)		Ref	
Overweight / Normal		8% (35)		92.0% (401)		0.30	(0.04-2.26)
Mother's Age (Yrs)	546	(42)	36.5 (6.3)	(504)	37.1 (5.3)	1.02	(0.96-1.08)
BMI at 5-yr follow-up (kg/m^2)	432		25.6 (3.9)		26.3 (5.0)	1.03	(0.95-1.12)
BMI at 5-yr follow-up [WHO cut offs]	432						
Obese		7.2% (5)		92.8% (64)		Ref	
Overweight / Normal		7.4% (27)		92.6% (336)		0.97	(0.36-2.62)
Waist Circumference (cm)	434	(31)	85.3 (10.6)	(403)	87.6 (11.9)	1.02	(0.99-1.05)
Height (cm)	454	(33)	161.9 (6.8)	(421)	162.9 (6.0)	1.03	(0.97-1.09)
Smoking in pregnancy	534						
Smoker		8.1% (8)		91.9% (91)		Ref	
Non-Smoker		7.6% (33)		92.4% (402)		1.07	(0.48-2.4)
Smoking at 5-yr follow-up	541						
Smoker		7.6% (9)		92.4% (110)		Ref	
Non-Smoker		7.6% (32)		92.4% (390)		1.0	(0.46-2.15)
Energy (Kcal)	546						
Quintile 5 (>2570.9 kcal)		13% (14)		87.0% (94)		Ref	
Quintile 1-4		6.4% (28)		93.6% (410)		2.18	(1.11-4.30)*
Fats (g)	546						
Quintile 5 (>106 g)		11% (12)		89.0% (97)		Ref	
Quintile 1-4		6.9% (30)		93.1% (407)		1.68	(0.83-3.40)†
Top food group (servings/day)	545						
Quintile 5 (>8.35 servings)		11% (12)		89.0% (97)		Ref	
Quintile 1-4		6.9% (30)		93.1% (406)		1.67	(0.83-3.39)†
Fruits Veg food group (servings/day)	546						
Quintile 1 (<4.5 servings)		9.1% (10)		90.9% (100)		Ref	
Quintile 2-5		7.3% (32)		92.7% (404)		1.26	(0.60-2.65)
Education level	534						
Lower		10.4% (25)		89.6% (215)		Ref	
Third Level		5.8% (17)		94.2% (277)		1.90	(1.00-3.60)*
Employment	545						
Not Earning		6.4% (15)		93.6% (221)		Ref	
Employed		9% (22)		91.0% (222)		0.69	(0.35-1.36)
Self employed		7.7% (5)		92.3% (60)		0.81	(0.29-2.33)
Self reported health	546						
Relatively Negative		17.1% (27)		82.9% (131)		Ref	
Relatively Positive		3.9% (15)		96.1% (373)		5.10	(2.64-9.93)**
Paternal Characteristics							
BMI at 5-yr follow-up (kg/m^2)	66	(4)		(62)		0.97	(0.76-1.23)
Waist Circumference (cm)	65	(3)		(62)		1.01	(0.90-1.13)
Height (cm)	66	(4)		(62)		1.01	(0.88-1.15)
Smoking at 5-yr follow-up	521						
Smoker		11.5% (16)		88.5% (123)		Ref	
Non-Smoker		5.5% (21)		94.5% (361)		2.24	(1.13-4.42)*
Education level	514						
Lower		11.1% (16)		88.9% (128)		Ref	
Third Level		6.2% (23)		93.8% (347)		1.89	(0.97-3.68)^
Employment	518						
Not Earning		9.2% (8)		90.8% (79)		Ref	
Employed		7.9% (24)		92.1% (279)		1.18	(0.51-2.72)
Self employed		3.9% (5)		96.1% (123)		2.49	(0.79-7.89)†
Self reported health	510						
Relatively Negative		12.6% (20)		87.4% (139)		Ref	
Relatively Positive		4.6% (16)		95.4% (335)		3.01	(1.52-5.99)**

**p<0.01, *p<0.05, ^p<0.1, †p<0.2; Ref=reference category (OR=1)

Table 3 presents the multivariable model for association between qualifying lifecourse variables and children's relatively-positive PRH at age-5. A significantly strong predictor of children's relatively-positive PRH was child's not being obese by IOTF classification [OR(95%CI)=5.5(1.4-21.0)]. When BMI was tested as a continuous variable, there was 0.73 (95%CI=0.58-0.93) times decreased odds of the child being positively rated on health status for every 1 kg/m^2 increase in their BMI. Similarly in the waist circumference model, for every 1 cm increase there was 0.89 (95%CI=0.81-0.98) times decreased odds of the child getting a relatively-positive rating on health status. Thus the association between children's BMI or waist circumference and their PRH only strengthened following adjustments in this multivariate model, irrespective of being analysed as a categorical or continuous variable. Another significant predictor of children's relatively-positive PRH was mother's having rated her own health as relatively-positive. These predictors maintained the highest strength of association with children's health status when independent variables were standardised (not reported here). None of the other variables reached the level of statistical significance. The models explained over 25 percent of variance for children's PRH.

Table 3: Multivariable Logistic Regression model for predictors of children's relatively-positive parent-rated health, PRH (N=303)

	Relatively Positive PRH			Relatively Positive PRH			Relatively Positive PRH		
	BMI Categorical[1]			BMI Continuous[2]			WC Continuous[3]		
	OR	95% CI		OR	95% CI		OR	95% CI	
Child's Individual Characteristics									
BMI [IOTF], Obese† vs Overweight / Normal	5.48	(1.43-21.03)	*						
BMI kg/m^2 [Continuous]				0.73	(0.58-0.93)	**			
Waist Circumference cm [Continuous]							0.89	(0.81-0.98)	*
Fats gm [Quintiles], Q5† vs Q1-4	1.57	(0.42-5.79)		1.49	(0.40-5.53)		1.32	(0.36-4.80)	
Top food group servings/d [Quintiles], Q5† vs Q1-4	1.23	(0.33-4.53)		1.30	(0.36-4.63)		1.29	(0.36-4.62)	
Fruits Veg food group servings/d [Quintiles], Q1† vs Q2-5	2.57	(0.75-8.80)		2.86	(0.83-9.93)		2.73	(0.78-9.49)	
Family Characteristics									
Household Weekly Income, Less† vs High	1.85	(0.63-5.40)		1.76	(0.59-5.21)		1.79	(0.61-5.26)	
Entitlement to General Medical, Card Yes† vs No	0.94	(0.24-3.71)		1.03	(0.26-4.07)		1.04	(0.26-4.10)	
Fathers' Participation, No† vs Yes	1.88	(0.68-5.21)		1.86	(0.67-5.16)		2.06	(0.74-5.71)	
Support from Spouse/Partner, Less† vs More	0.70	(0.20-2.49)		0.67	(0.19-2.33)		0.74	(0.22-2.52)	
Support from Parents, Less† vs More	1.92	(0.53-6.93)		2.33	(0.64-8.42)		2.37	(0.66-8.53)	
Support from Children, Less† vs More	1.15	(0.38-3.45)		1.29	(0.42-3.91)		1.25	(0.41-3.82)	
Support from Close Relatives, Less† vs More	0.86	(0.23-3.13)		0.84	(0.24-3.02)		0.84	(0.23-3.01)	
Maternal Characteristics									
Energy Kcal [Quintiles], Q5† vs Q1-4	1.89	(0.30-11.84)		2.00	(0.31-12.86)		1.57	(0.28-8.84)	
Fats gm [Quintiles], Q5† vs Q1-4	0.72	(0.09-5.54)		0.59	(0.07-4.77)		0.92	(0.13-6.41)	
Top food group servings/d [Quintiles], Q5† vs Q1-4	1.08	(0.29-3.94)		1.30	(0.36-4.65)		1.18	(0.32-4.34)	
Education, Lower† vs Third level	1.34	(0.47-3.78)		1.35	(0.48-3.80)		1.48	(0.53-4.13)	
Self reported health status, Rel.Negative† vs Rel.Positive	4.20	(1.45-12.20)	**	4.42	(1.53-12.79)	**	4.17	(1.47-11.87)	**
Paternal Characteristics									
Current Smoking status, Yes† vs No	1.37	(0.48-3.93)		1.31	(0.45-3.83)		1.53	(0.54-4.35)	
Education, Lower† vs Third level	0.69	(0.21-2.28)		0.79	(0.24-2.57)		0.83	(0.26-2.67)	
Employment, Non-earning † vs Self employed	1.60	(0.73-3.53)		1.52	(0.69-3.32)		1.57	(0.70-3.53)	
Self reported health status, Rel.Negative† vs Rel.Positive	1.48	(0.52-4.20)		1.54	(0.54-4.35)		1.43	(0.51-3.96)	

OR=Odds Ratio; †Reference category (OR=1); **p<0.01 (2-tailed), *p<0.05 (2-tailed)

Rel.Negative=Relatively Negative, Rel.Positive=Relatively Positive

[1]Child BMI as a categorical variable; Model Chi-sq = 34.2, df = 21, p = 0.034; -2LL = 128.6, Nagelkerke R-sq = 0.26

[2]Child BMI as a continuous variable; Model Chi-sq = 35.9, df = 21, p = 0.022; -2LL = 126.9, Nagelkerke R-sq = 0.27

[3]Child waist circumference as a continuous variable; Model Chi-sq = 33.8, df = 21, p = 0.038; -2LL = 128.9, Nagelkerke R-sq = 0.25

Discussion

This analysis showed that determinants from both child's individual and family spheres have an influence on child's health at preschool-age. The factors from all three material, psycho-social and lifestyle domains, the major explanations for child health inequalities,[8] were associated at uni-variate levels. However, in the final model this analysis clearly demonstrated a negative association between child's obesity and health status. Child's not being obese was one of the significantly strong predictors of child's relatively-positive health status, which was also observed with measured BMI and waist circumference analysed as continuous variables.

This negative relationship observed between measured obesity and PRH conforms to published literature on primary school age-group children and adolescents.[43-45] Most importantly, for the first time to our knowledge, this analysis demonstrates the association having adjusted for food and nutrient intake, along-with a wide range of other explanatory variables.

Self-rated health is an important and valid measure of morbidity, mortality, longevity and health status,[3,4] also in Irish adult[46,47] and children.[16] It is believed to be a more inclusive measure of health than the objective measurements, with a capacity to comprehensively evaluate health dynamics, behaviours and psycho-physiological states that are not otherwise easy to measure.[3] This holistic measure better accommodates the WHO defined concept of health as opposed to a diagnosed specific disease.[3] Use of parent proxy for child self-reported health is justified for children too young to have adequate cognitive skills.[48,49] Systematic reviews report good agreement between ratings by children and their parents on child HRQoL, particularly for physical health domain.[48-50] Parents tend to be thoughtful when responding to proxy questions and report children's usual health disposition.[51] Studies on construct validity report positively.[52-55] Maternal ratings of child's general health status were found sensitive when validated against children's illnesses and other morbidity or healthcare indicators,[41,56-58] including evidence of a gradient in strength of these associations.[41] Many national-level studies have accepted parent proxy as an

appropriate measure[17,18,59,60] and successfully used it to longitudinally demonstrate risk and consequences of child health.[17,59]

Self-rated health, a composite measure, represents all domains of HR-QoL,[4] but better represents physical health than HR-QoL.[61] Studies on older age-group children have reported stronger/sole negative associations for general/physical health domain of HR-QoL and obesity,[44,62] irrespective whether children themselves or parents reported their HRQoL,[29] and also whether BMI was analysed as a categorical,[43,44] or continuous variable.[63,64]

Another relevance of this analysis is in demonstrating this association of obesity with general-health in a nationally representative sample of preschool-age children, for which literature is scant. Though, a few have shown similar association of obesity with specific paediatric conditions or admission history in this age-group.[30,31,65-68] A longitudinal study speculated that pre-school obesity influences a decline in early-age health, and then both obesity and poor-health tracks into adolescence.[69] The WHO recommends high priority for determinants of health inequalities during early development.[70]

The Lifeways previously demonstrated longitudinal association between parental socio-economic and lifestyle characteristics and child's BMI and waist circumference.[36] In this analysis when same anthropometric measures are included along-with material, psycho-social, and lifestyle determinants of child obesity and health, a prominent relationship emerges between children's anthropometric measures and health status. One possible explanation is that determinants of health inequalities biologically embed[21,22] in early life and child obesity is an early phenotypic expression of this inequality; though the continued influence of environmental factors is not undermined. Adult[25,26] and adolescence studies[44,45] have also shown this association to be independent of socio-demographic, lifestyle or health-related factors.

The observed association between BMI or waist circumference and PRH in the present analysis

may be temporal, as demonstrated in adults.[27,28] Though a number of large scale cross sectional studies have shown an association between anthropometric measures of obesity and self rated health,[71] only recently a few nationally representative prospective studies have established the temporality of this association in adults.[27,28] Though this relationship maybe bi-directional to an extent,[72,73] the mounting evidence from longitudinal birth cohort studies regarding a sequential relationship between lifetime growth trajectories and adult disease, disability and deaths[2] primarily rules out reverse causality in this association and suggests that the association observed in our birth cohort is also more likely to be temporal. Moreover, the available findings from a few longitudinal studies on primary school age children suggest that at least in the childhood this inverse association found between BMI and HRQoL is predominantly in the given direction and not the reverse.[74,75] However, this needs careful interpretation as both anthropometric and health data were concurrently collected, and this limitation may be addressed with next sweep of cohort data collection.

This analysis demonstrated that maternal health was strongly predictive of her child's health. One concern is that mother's perception of her own health may bias her perception of her child's health. However, this intergenerational association has been previously reported,[41,56,57,76-79] and reporting mothers can effectively discriminate between their own and children's health.[41,56,57,77,78,80] Several mechanisms such as inherited susceptibility, uterine environment and shared environment have been suggested for this familial aggregation pattern.[56,77,78]

Maternal BMI may be related to both maternal self-rated health and child's BMI, so the observed associations in this analysis could possibly be a reflection of an association between maternal BMI and child's PRH. However, this was not observed in our analysis. Maternal BMI at both pre-pregnancy and 5-year follow-up were not associated with child's PRH at univariate level. Also, when maternal BMI was forcibly added into the multivariable model (not reported here), the observed associations did not attenuate.

The study has limitations in use of reported rather than measured health status and a relatively small sample size. Though the study was able to detect the major explanatory domains for child health inequalities documented in the literature[8], the relatively small sample size of this study may possibly have underpowered it to detect variables with lesser effect sizes. The complete case approach to analysis reduced the sample size of the final multivariate model. However, this missing data was not systematic but rather on account of accumulation of missing completely at random data across a number of variables. It may be argued that the reduced sample size possibly influenced the odds ratio estimate for the association between children's relatively-positive PRH and the child's not being obese (using a categorical IOTF classification). Nonetheless this association between children's anthropometric measures and their parent-rated health variable is likely to be coherent, because these associations remain statistically significant even when BMI and WC are analysed as continuous variables.

As in most birth cohort studies,[81,82] the Lifeways birth cohort also experienced the attrition of mothers belonging to lower socio-economic status in the early stages of the study. Though this may underestimate some socioeconomic inequalities [83], it does not negate the exposure-outcome associations detected through regression models of such longitudinal studies [84,85].

Nevertheless, this study has advantages in use of lifecourse variables from pre-conception to age of 5-years, with measured BMI and waist circumference data. It also has detailed foods and nutrient data along-with other socio-economic, psycho-social and lifestyle variables for child and both parents.

In conclusion, these analyses from the Lifeways cohort show that lifecourse adversities were associated with mother-reported health for preschoolers, suggesting an early life influence. Preschoolers' BMI and waist-circumference demonstrated strong negative associations with mother-reported health independent of socio-economic, psycho-social, and lifestyle factors, suggesting early biological expression of lifecourse adversities. The findings have important

implications in understanding how early life environment may create inequalities in developmental health.

Footnotes

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Contributors

AS undertook all analyses reported in this manuscript, interpreted the findings and drafted the manuscript. CM contributed to data collection at five year follow-up, interpretation of the analysis and critical revision of the manuscript. CCK designed the study, supervised the analyses, interpretation of results and intellectual content of the manuscript. All three authors approved the final version.

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Competing interests

None

Ethical approvals

Ethics committees of Coombe University Hospital, Dublin, University College Hospital Galway, University College Dublin, Dublin, and the Irish College of General Practitioners, Ireland.

Data sharing statement

There are no additional data available. The data manager may be contacted at john.obrien@ucd.ie for more details on the Lifeways Cross-Generation Cohort Study.

Appendices

The web only supplement includes eTable 1 regarding details of examined variables and eTable 2 displaying standardised odds ratios for multivariable logistic regression model.

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Title: Preschoolers' parent rated health disparities are strongly associated with measures of adiposity in the Lifeways cohort study children

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Running Title: Childhood obesity a persistent predictor of preschoolers' PRH

KEYWORDS

Lifecourse, self-rated health, obesity, BMI, waist circumference, preschool children

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ABSTRACT (Words: 273)

Objective

To examine the relationship between lifecourse factors from preschoolers' micro-ecosystem and their parent-reported (mother-reported) health (PRH), following them prospectively from preconception to age 5-years. To investigate if preschoolers' BMI and waist-circumference were associated with preschoolers' PRH when controlled for lifecourse predictors.

Design

Lifeways cross-generation cohort study

Setting

Ireland

Participants

Of 1082 families, 62% mothers responded on a health and lifestyle questionnaire at follow-up. Food frequency, BMI and waist-circumference were measured.

Main outcome measure

Mother-reported children's PRH at age-5. Associations with child's individual and familial exposures from preconception to age 5-years examined using logistic regression.

Results

In univariate analysis, relatively-positive rating of children's PRH were associated with children's lower intake of fats [OR(95%CI)=2.2(1.1-4.3)], higher intake of fruits/vegetables [OR(95%CI)=2.2(1.1-4.3)]; as well as familial socio-economic characteristics {higher household income [OR(95%CI)=3.0(1.6-5.9)], non-entitlement to means-tested healthcare [OR(95%CI)=2.1(1.0-4.3)], mothers' higher education [OR(95%CI)=1.9(1.0-3.6)]}, psycho-

social characteristics {father's participation in study [OR(95%CI)=2.1(1.0-4.3)], mothers' perceiving better support from partner [OR(95%CI)=2.3(1.2-4.3)], children [OR(95%CI)=1.9(1.0-3.7)] or relatives [OR(95%CI)=2.2(1.1-4.1)]}, parents' lifestyle {mothers' lower intake of energy [OR(95%CI)=2.2(1.1-4.3)], fathers' non-smoking status [OR(95%CI)=2.2(1.1-4.4)]}, and parents' health {mothers' self-rated health relatively-positive [OR(95%CI)=5.1(2.6-9.9)], fathers' self-rated health relatively-positive [OR(95%CI)=3.0(1.5-6.0)]}.

In multivariable analysis ($\chi 2=34.2, df=21, N=303, R^2=0.26, p<0.05$), one of the two strong predictors of children's relatively-positive PRH was child not being obese by International Obesity Task Force classification [OR(95%CI)=5.5(1.4-21.0)], observed also using BMI (kg/m^2) [OR(95%CI)=0.73(0.58-0.93)] or waist-circumference (cm) [OR(95%CI)=0.89(0.81-0.98)] as continuous variables. The other significant predictor was mothers' self-rated health relatively-positive [OR(95%CI)=4.2(1.5-12.2)].

Conclusions

Preschoolers' health is adversely associated with obesity and this is independent of lifecourse social and environmental inequalities. The findings suggest that lifecourse adversities during the early developmental stage may get embedded and expressed as anthropometric measures of adiposity, suggesting that public health interventions should begin as early as possible.

Strengths and limitations of this study

- Nationally representative sample of preschool-age children
- Examines the influence of lifecourse adversities, prospectively measured from preconception to age 5 on children's general health at age 5. The study analyses demographic, anthropometric, lifestyle, food and nutrients intake, psycho-social, socio-economic and health-related exposures from both children's individual as well as parental experiences.
- Demonstrates a significant and independent association between preschoolers' measured BMI as well as waist circumference and their general health status.
- The study is limited by a relatively small sample and use of parent-reported health status.

MAIN TEXT

Introduction

The development of children is critical to their adult well-being[1,2] and across the lifecourse even subjective estimates may be useful to reflect objectively measured health[3,4]. Bronfenbrenner[5] emphasised the importance of children's micro-ecosystem in their development. Recently, the World Health Organisation's (WHO) Commission on Social Determinants of Health (CSDH) presented a Total Environment Assessment Model for Early Child Development (TEAM-ECD),[6] which again illustrates the importance of individual and family spheres of influence on children's health. The relevance of socio-economic, psycho-social and lifestyle environment in child development and health is widely acknowledged.[6-8]

According to the lifecourse hypothesis, risk transmission is characterised by critical periods and accumulation of risk models.[9] Life Course Health Development (LCHD) framework[10] suggests that health is a consequence of multiple determinants that change in context of time and circumstances as an individual develops; these experiences are programmed into bio-behavioural regulatory systems during certain critical and sensitive periods of individual's lifetime to decide their health trajectory. The lifecourse framework on childhood disadvantage and adult health[11] suggests that parental and childhood circumstances from the point of conception influences individual's health in later life, and the individual's childhood health and later life circumstances may further add to this foundation. Based on this, Hertzman and colleagues[12] examined self-rated health in adulthood using an integrated lifecourse framework. There are a few other studies also which have examined lifecourse determinants of adult global[13,14] or specific health status.[15] On the contrary, the literature on the determinants of child global health status is sparse,[16,17] particularly for the preschool-age children.[18] Even rarer are studies whose examination includes early lifecourse determinants of child global health status.

Thus the first objective of our analysis was to prospectively examine the relationship between demographic, anthropometric, lifestyle, nutritional, psycho-social, socio-economic and health-related lifecourse exposures taken from the children's individual and family spheres of influence starting from preconception up to age 5-years and their global health status at preschool-age.

In social epidemiology, the construct of "embodiment" refers to biological expression of individuals' materio-social world.[19,20] Similarly in lifecourse epidemiology, it is hypothesised that early life experiences get "biologically embedded" during critical or sensitive periods of child development leading to gradients in health.[21,22]

The Foresight report identifies a large array of environmental determinants of obesity, a number of which are again related to early child development.[23] This suggests obesity as pivotal risk factor for subsequent health conditions.[24]

The negative relationship between obesity and self-rated health is now increasingly reported in adult populations,[25,26] some indicating a temporal relationship[27,28] and suggesting that obesity increases health inequalities over time.[28] However, evidence on the relationship between obesity and health is relatively limited in child population studies and those available have reported health-related-quality-of-life (HR-QoL)[29] instead of a generic measure such as global self-rated health. Moreover, this association is yet to be established for preschool-age children. To our knowledge just two population based studies have examined this association in preschool age-group children[30,31] and neither had nutritional information.

In the Longitudinal Study of Australian Children, Wake *et al*.[30] did not find a significant difference in global health status of overweight/obese and normal weight 4-5-year-old children. Skinner et al.,[31] using data on 3-5-year-olds from the US National Health and

Nutrition Examination Survey, reported a poorer global health status in obese and severely obese preschoolers. Neither of these studies accounted for a number of possibly relevant confounders, including parental BMI, parental health and nutritional variables.

We thus hypothesised that similar to findings from studies on older age-groups, anthropometric markers of child obesity in our preschool-age children study would also demonstrate a negative association with their global health status. The next objective of our analysis was to examine whether anthropometric markers of child obesity would emerge as strong predictors of global health status when accounted for other socio-economic, psycho-social, and lifestyle environmental factors in a multivariable model.

Methods

The Lifeways cross generation cohort study comprises three generations of 1082 Irish families and was established in 2001-03; the recruitment procedure of this nationally representative cohort has been described previously.[32-34] The a priori purpose was to examine familial and cross-generation influences on early childhood development over the first five years of children's lives. Briefly, would-be mothers were at random recruited from the two regional maternity hospitals in the Republic of Ireland to get a representative sample. A comparison between the Lifeways mothers and a nationally representative sample of women of the same age group from the SLÁN (Survey of Lifestyle, Attitudes and Nutrition) surveys of Republic of Ireland[35] confirmed that the Lifeways mothers were satisfactorily representative of the Irish general women on socio-demographic characteristics.[33]

At this early pregnancy stage mothers completed a health and lifestyle status questionnaire adapted from a validated instrument developed for Irish national SLÁN surveys.[35] Mothers reported their pre-pregnancy height (cm) and weight (kg) and their smoking status during pregnancy. Mothers' and partners' socio-economic status was recorded. Subsequently at

birth, the live infants were added to the cohort along-with maternity and birth related hospital information.

In 2007-08, when these children averaged five years of age, the cohort follow-up recorded a 62% response rate.[34,36] Though mothers who responded to the follow-up were more likely to be of higher socioeconomic status, these mothers did not significantly differ in their baseline anthropometric characteristics (including BMI) from non-responders.[34,36] At this 5-year follow-up, mothers repeated the health and lifestyle assessment questionnaire, with additional questions related to her family, including a five-level likert item question "In general, would you say your / your partner's / your Lifeways child's current health is Excellent, Very Good, Good, Fair or Poor". Mothers provided information on family's socio-economic, psycho-social, and lifestyle status. Mothers reported their habitual dietary intake for the previous year on a semi-quantitative food frequency (SQFFQ) instrument developed from the EPIC study (European Prospective Investigation into Cancer and Nutrition) and validated for Irish adult population.[37] Mothers also gave details for the Lifeways child's habitual diet for the previous year using a different SQFFQ instrument adapted from the UK National Diet and Nutrition Survey of 4.5-year-old children.[38] The mothers' and children's SQFFQ were validated in the Lifeways study using a 7-day weighed food diary in a sub-sample.[36] Food items were aggregated by defined shelves (food groups) of the Irish food pyramid and assessment was made for average servings per day of standard food item portions consumed from the "top" and "fruit and vegetable" food groups (shelves of Irish food pyramid). The "top" food group comprises of high calorie fat and sugar rich foods. Total energy (kcal) and total fats (g) intake were computed using conversion values from McCance & Widdowson's food composition tables[39] with a specially developed FFQ software version 1.0 ©.[40]

Mothers and children, and if available fathers, were offered at 5-year follow-up an anthropometric assessment at their home for height (cm), weight (kg) and waist

circumference (cm) using a standardised protocol,[34,36] with 80-85% mothers and children participating. Body mass index (BMI) was calculated from weight and height information (kg/m^2).

Thus variables from discrete stages (pre-pregnancy, early pregnancy, at birth, early infancy and 5-year follow-up) of child's early development representing lifecourse exposures from distinct domains (demographic, anthropometric, socio-economic, psycho-social, lifestyle, nutritional and health) of child's individual and family spheres of influence[6-8] were considered to analyse determinants of child's health status at age-5. The selection of variables, domains and spheres of influence are based on the CSDH constructed TEAM-ECD, a model of early child development.[6-8] These lifecourse variables have been summarised as per time frame in **Table 1**. This lifecourse time frame highlights the stages and transition points relevant from perspective of child's health development.[10] Additional details on these variables are provided in **eTable 1** available in the web only supplement. The independent variables have been arranged as child-related, family-related, mother-related, father-related groups for ease of presentation.

Table 1: Independent variables examined from lifecourse of 5-yr-old children

Lifecourse	Independent Variables
Pre-pregnancy	Maternal Pre-pregnancy BMI
Early pregnancy	Family stability
	Maternal smoking in pregnancy, Maternal Education level
	Paternal Education level
Birth	Child's Birth-weight, Gestational age, Gender
	Maternal Parity
Infancy	Child's breastfeeding status
When children averaged 5-yr age	Child's Age, Height, BMI, Waist circumference, Food intake: top and fruits & vegetables food groups, Nutrient intake: energy and fats intake
	Family household weekly income, Entitlement to means tested healthcare benefits scheme, Family structure (marital status), Support from partner, parents, children & relatives
	Maternal Age, Height, BMI, Waist circumference, Smoking, Employment status, Food intake: top and fruits & vegetables food groups, Nutrient intake: energy and fats intake, Self-rated health status
	Paternal Height, BMI, Waist circumference, Smoking, Employment status, Self-rated health status

Children's global health status rated in proxy by their mothers, hereafter referred to as parent-rated health (PRH), was the outcome variable of interest. The 5-graded scale response was dichotomised as relatively-positive health (excellent or very good) and relatively-negative health (poor or fair or good), based on similar dichotomisation in other studies on preschool and school children.[17,18,30] It is reasonable to take a higher cut-off when dichotomising this age dependent variable in this very young age-group as there would be very limited numbers of poor or fair health children.[17,18,41]

Initially, uni-variate associations were established between the independent predictors and children's PRH using independent t-tests or chi-square tests. Independent categorical variables were dichotomised in a manner that allowed contrasting extreme levels against the others. Thus, using International Obesity Task Force (IOTF) cut-offs, children's BMI was dichotomised as obese versus over-weight or normal-weight. Similarly nutrition variables ordered in quintiles were dichotomised as the extreme quintile (1^{st} or 5^{th}) versus the rest.

From these independent variables principally chosen on the basis of their relevance to the child's development,[6-8] all those that qualified at significance level 20% ($p<0.2$)[42] in univariate analyses were force entered into a multivariable logistic regression model. BMI (kg/m^2) and waist circumference (cm), the anthropometric markers of obesity, were tested separately in independent multivariable models. Initially BMI was tested as a categorical variable in a model, followed by two additional models substituting it with BMI and then waist circumference as continuous variables. Other independent variables were tested as categorical variables.

Ethical approval for the Lifeways study was obtained respectively from ethical committees of participating hospitals and the University College Dublin, Ireland. Written informed consent was obtained from study participants.

Results

There were 547 family datasets available for analysis of children's PRH. **Table 2** presents the uni-variate associations between children's lifecourse variables and PRH. Within the individual-sphere of influences, children's lifestyle behaviours (lower intake of fatty/sugary foods and total fats, and higher intake of fruits/vegetables) and their anthropometric measures at age-5 (not being obese, lower BMI, and lower waist circumference) qualified as determinants of children's relatively-positive PRH for further examination in the multivariable model.

In other words, retaining $p<0.2$ as the criterion for significance, the children's healthy food and nutrient intake habits – such as decreased intake of unhealthy fat- and sugar- rich foods (servings/day) [OR(95%CI)=1.7(0.8-3.4)] or total fats (g) in their meals [OR(95%CI)=2.2(1.1-4.3)] and increased intake of healthy fruits and vegetables (servings/day) [OR(95%CI)=2.2(1.1-4.3)] were positively associated with their favourable

rating for health by their mothers. Conversely, children's increased BMI (kg/m^2) [OR(95%CI)=0.85(0.71-1.03)] and waist circumference (cm) [OR(95%CI)=0.95(0.88-1.02)] were inversely associated with a positive parental-rated health status.

Within the family-sphere of influences, socio-economic status (higher household income, non-entitlement to subsidised healthcare, both parents' higher education status, and father's employment status), psycho-social status (father's study participation, mother's perceived social support), mother's lifestyle behaviours (lower intake of fatty/sugary foods, total energy and total fats), father's lifestyle behaviours (non-smoker), and both parents' health status (relatively-positive self-rated health) qualified as determinants of children's relatively-positive PRH for further examination in the multivariable model.

In other words, by maintaining $p<0.2$ as the criterion for significance, several indicators of a family's better socio-economic status– such as increased household income (Euros/week) [OR(95%CI)=3.0(1.6-5.9)], not requiring subsidised healthcare [OR(95%CI)=2.1(1.0-4.3)], mother having a third level education [OR(95%CI)=1.9(1.0-3.6)], father having a third level education [OR(95%CI)=1.9(1.0-3.6)], father being self-employed [OR(95%CI)=2.5(0.8-7.9)]; family's better psycho-social status– such as father's involvement in family affairs [OR(95%CI)=2.1(1.0-4.3)], mother's perceiving a positive social support from spouse [OR(95%CI)=2.3(1.2-4.3)], parents [OR(95%CI)=2.0(1.0-4.1)], children [OR(95%CI)=1.9(1.0-3.7)], or relatives [OR(95%CI)=2.2(1.1-4.1)]; family's better lifestyle and food and nutrient intake habits– such as mother's decreased intake of unhealthy fat- and sugar- rich foods (servings/day) [OR(95%CI)=1.7(0.8-3.4)], total energy (kcal) [OR(95%CI)=2.2(1.1-4.3)] and total fats (g) [OR(95%CI)=1.7(0.8-3.4)] in her meals, father's not being a smoker [OR(95%CI)=2.2(1.1-4.4)]; and family's better health status– such as mother [OR(95%CI)=5.1(2.6-9.9)] and father [OR(95%CI)=3.0(1.5-6.0)] having a positively

rated health status were positively associated with children's favourable rating for health by their mothers.

Table 2: Uni-variate lifecourse associates of children's relatively-positive parent-rated health, PRH (N=547)

		Relatively Negative PRH (n=42)		Relatively Positive PRH (n=505)			
	N	%(n)	Mean (SD)	%(n)	Mean (SD)	OR	95% CI
Child's Individual Characteristics							
Birth-weight adjusted for gestational age (g)	487	(34)	3564.1 (616)	(453)	3548.4 (552)	1.00	(0.999-1.001)
Child's Age (Yrs)	547	(42)	5.42 (0.23)	(505)	5.46 (0.25)		
Gender	547						
Male		8.0% (22)		92.0% (242)		Ref	
Female		7.1% (21)		92.9% (262)		1.14	(0.60-2.20)
BMI (kg/m^2)	464	(35)	17.09 (2.5)	(429)	16.59 (1.6)	0.85	(0.71-1.03)^
BMI [IOTF]	464						
Obese		16.7% (5)		83.3% (25)		Ref	
Overweight / Normal		6.9% (30)		93.1% (404)		2.69	(0.96-7.54)^
Waist Circumference (cm)	462	(35)	57.01 (6.8)	(427)	55.88 (4.3)	0.95	(0.88-1.02)†
Height (cm)	464	(35)	111.6 (5.6)	(429)	112.1 (4.8)	1.02	(0.95-1.10)
Breastfeeding	528						
Not breastfed		6.5% (16)		93.5% (229)		Ref	
Breastfed		8.8% (25)		91.2% (258)		0.72	(0.38-1.38)
Energy (Kcal)	547						
Quintile 5 (>1794 kcal)		10% (11)		90.0% (99)		Ref	
Quintile 1-4		7.1% (31)		92.9% (406)		1.46	(0.71-3.00)
Fats (g)	547						
Quintile 5 (>62.9 g)		12.8% (14)		87.2% (95)		Ref	
Quintile 1-4		6.4% (28)		93.6% (410)		2.16	(1.09-4.26)*
Top food group (servings/day)	547						
Quintile 5 (>6.47 servings)		10.9% (12)		89.1% (98)		Ref	
Quintile 1-4		6.9% (30)		93.1% (407)		1.66	(0.82-3.36)†
Fruits Veg food group (servings/d)	547						
Quintile 1 (<2.1 servings)		12.8% (14)		87.2% (95)		Ref	
Quintile 2-5		6.4% (28)		93.6% (410)		2.16	(1.09-4.26)*
Family Characteristics							
Household Weekly Income	509						
Less than 760 Euros/wk		13.3% (26)		86.7% (170)		Ref	
More than 760 Euros/wk		4.8% (15)		95.2% (298)		3.04	(1.57-5.90)**
Entitlement to General Medical Card	532						
Entitled		13% (12)		87.0% (80)		Ref	
Not entitled		6.6% (29)		93.4% (411)		2.13	(1.04-4.34)*
Fathers' Participation	547						
Not		9.7% (31)		90.3% (290)		Ref	
Yes		4.9% (11)		95.1% (215)		2.09	(1.03-4.25)*
Marital Status	542						
Others		11.4% (5)		88.6% (39)		Ref	
Married/Cohabiting		7.2% (36)		92.8% (462)		1.65	(0.61-4.43)
Elder children in family (Parity)	535						
Nullipara		8% (18)		92.0% (207)		Ref	
Multipara		7.7% (24)		92.3% (286)		1.04	(0.55-1.96)
Support from Spouse/Partner	538						
Lesser support		12.9% (17)		87.1% (115)		Ref	
More support		6.2% (25)		93.8% (381)		2.25	(1.18-4.32)*
Support from Parents	487						
Lesser support		12.5% (12)		87.5% (84)		Ref	
More support		6.6% (26)		93.4% (365)		2.01	(0.97-4.14)^
Support from Children	532						
Lesser support		10.6% (20)		89.4% (169)		Ref	
More support		5.8% (20)		94.2% (323)		1.91	(1.00-3.65)*
Support from Close Relatives	510						
Lesser support		12.4% (19)		87.6% (134)		Ref	
More support		6.2% (22)		93.8% (335)		2.16	(1.13-4.12)*

Table 2: Uni-variate lifecourse associates of children's relatively-positive parent-rated health, PRH (continued)

	Relatively Negative PRH (n=42)			Relatively Positive PRH (n=505)			
	N	%(n)	Mean (SD)	%(n)	Mean (SD)	OR	95% CI
Maternal Characteristics							
Pre-pregnancy BMI (kg/m^2)	475	(36)	23.3 (3.3)	(439)	23.8 (3.9)	1.04	(0.94-1.14)
Pre-pregnancy BMI [WHO cut offs]							
Obese		2.6% (1)		97.4% (38)		Ref	
Overweight / Normal		8% (35)		92.0% (401)		0.30	(0.04-2.26)
Mother's Age (Yrs)	546	(42)	36.5 (6.3)	(504)	37.1 (5.3)	1.02	(0.96-1.08)
BMI at 5-yr follow-up (kg/m^2)	432		25.6 (3.9)		26.3 (5.0)	1.03	(0.95-1.12)
BMI at 5-yr follow-up [WHO cut offs]	432						
Obese		7.2% (5)		92.8% (64)		Ref	
Overweight / Normal		7.4% (27)		92.6% (336)		0.97	(0.36-2.62)
Waist Circumference (cm)	434	(31)	85.3 (10.6)	(403)	87.6 (11.9)	1.02	(0.99-1.05)
Height (cm)	454	(33)	161.9 (6.8)	(421)	162.9 (6.0)	1.03	(0.97-1.09)
Smoking in pregnancy	534						
Smoker		8.1% (8)		91.9% (91)		Ref	
Non-Smoker		7.6% (33)		92.4% (402)		1.07	(0.48-2.4)
Smoking at 5-yr follow-up	541						
Smoker		7.6% (9)		92.4% (110)		Ref	
Non-Smoker		7.6% (32)		92.4% (390)		1.0	(0.46-2.15)
Energy (Kcal)	546						
Quintile 5 (>2570.9 kcal)		13% (14)		87.0% (94)		Ref	
Quintile 1-4		6.4% (28)		93.6% (410)		2.18	(1.11-4.30)*
Fats (g)	546						
Quintile 5 (>106 g)		11% (12)		89.0% (97)		Ref	
Quintile 1-4		6.9% (30)		93.1% (407)		1.68	(0.83-3.40)†
Top food group (servings/day)	545						
Quintile 5 (>8.35 servings)		11% (12)		89.0% (97)		Ref	
Quintile 1-4		6.9% (30)		93.1% (406)		1.67	(0.83-3.39)†
Fruits Veg food group (servings/day)	546						
Quintile 1 (<4.5 servings)		9.1% (10)		90.9% (100)		Ref	
Quintile 2-5		7.3% (32)		92.7% (404)		1.26	(0.60-2.65)
Education level	534						
Lower		10.4% (25)		89.6% (215)		Ref	
Third Level		5.8% (17)		94.2% (277)		1.90	(1.00-3.60)*
Employment	545						
Not Earning		6.4% (15)		93.6% (221)		Ref	
Employed		9% (22)		91.0% (222)		0.69	(0.35-1.36)
Self employed		7.7% (5)		92.3% (60)		0.81	(0.29-2.33)
Self reported health	546						
Relatively Negative		17.1% (27)		82.9% (131)		Ref	
Relatively Positive		3.9% (15)		96.1% (373)		5.10	(2.64-9.93)**
Paternal Characteristics							
BMI at 5-yr follow-up (kg/m^2)	66	(4)		(62)		0.97	(0.76-1.23)
Waist Circumference (cm)	65	(3)		(62)		1.01	(0.90-1.13)
Height (cm)	66	(4)		(62)		1.01	(0.88-1.15)
Smoking at 5-yr follow-up	521						
Smoker		11.5% (16)		88.5% (123)		Ref	
Non-Smoker		5.5% (21)		94.5% (361)		2.24	(1.13-4.42)*
Education level	514						
Lower		11.1% (16)		88.9% (128)		Ref	
Third Level		6.2% (23)		93.8% (347)		1.89	(0.97-3.68)^
Employment	518						
Not Earning		9.2% (8)		90.8% (79)		Ref	
Employed		7.9% (24)		92.1% (279)		1.18	(0.51-2.72)
Self employed		3.9% (5)		96.1% (123)		2.49	(0.79-7.89)†
Self reported health	510						
Relatively Negative		12.6% (20)		87.4% (139)		Ref	
Relatively Positive		4.6% (16)		95.4% (335)		3.01	(1.52-5.99)**

**p<0.01, *p<0.05, ^p<0.1, †p<0.2; Ref=reference category (OR=1)

Table 3 presents the multivariable model for association between qualifying lifecourse variables and children's relatively-positive PRH at age-5. A significantly strong predictor of children's relatively-positive PRH was child's not being obese by IOTF classification [OR(95%CI)=5.5(1.4-21.0)]. When BMI was tested as a continuous variable, there was 0.73 (95%CI=0.58-0.93) times decreased odds of the child being positively rated on health status for every 1 kg/m^2 increase in their BMI. Similarly in the waist circumference model, for every 1 cm increase there was 0.89 (95%CI=0.81-0.98) times decreased odds of the child getting a relatively-positive rating on health status. Thus the association between children's BMI or waist circumference and their PRH only strengthened following adjustments in this multivariate model, irrespective of being analysed as a categorical or continuous variable. Another significant predictor of children's relatively-positive PRH was mother's having rated her own health as relatively-positive. These predictors maintained the highest strength of association with children's health status when independent variables were standardised (not reported here). None of the other variables reached the level of statistical significance. The models explained over 25 percent of variance for children's PRH.

Table 3: Multivariable Logistic Regression model for predictors of children's relatively-positive parent-rated health, PRH (N=303)

	Relatively Positive PRH			Relatively Positive PRH			Relatively Positive PRH		
	BMI Categorical[1]			BMI Continuous[2]			WC Continuous[3]		
	OR	95% CI		OR	95% CI		OR	95% CI	
Child's Individual Characteristics									
BMI [IOTF], Obese† vs Overweight / Normal	5.48	(1.43-21.03)	*						
BMI kg/m^2 [Continuous]				0.73	(0.58-0.93)	**			
Waist Circumference cm [Continuous]							0.89	(0.81-0.98)	*
Fats gm [Quintiles], Q5† vs Q1-4	1.57	(0.42-5.79)		1.49	(0.40-5.53)		1.32	(0.36-4.80)	
Top food group servings/d [Quintiles], Q5† vs Q1-4	1.23	(0.33-4.53)		1.30	(0.36-4.63)		1.29	(0.36-4.62)	
Fruits Veg food group servings/d [Quintiles], Q1† vs Q2-5	2.57	(0.75-8.80)		2.86	(0.83-9.93)		2.73	(0.78-9.49)	
Family Characteristics									
Household Weekly Income, Less† vs High	1.85	(0.63-5.40)		1.76	(0.59-5.21)		1.79	(0.61-5.26)	
Entitlement to General Medical, Card Yes† vs No	0.94	(0.24-3.71)		1.03	(0.26-4.07)		1.04	(0.26-4.10)	
Fathers' Participation, No† vs Yes	1.88	(0.68-5.21)		1.86	(0.67-5.16)		2.06	(0.74-5.71)	
Support from Spouse/Partner, Less† vs More	0.70	(0.20-2.49)		0.67	(0.19-2.33)		0.74	(0.22-2.52)	
Support from Parents, Less† vs More	1.92	(0.53-6.93)		2.33	(0.64-8.42)		2.37	(0.66-8.53)	
Support from Children, Less† vs More	1.15	(0.38-3.45)		1.29	(0.42-3.91)		1.25	(0.41-3.82)	
Support from Close Relatives, Less† vs More	0.86	(0.23-3.13)		0.84	(0.24-3.02)		0.84	(0.23-3.01)	
Maternal Characteristics									
Energy Kcal [Quintiles], Q5† vs Q1-4	1.89	(0.30-11.84)		2.00	(0.31-12.86)		1.57	(0.28-8.84)	
Fats gm [Quintiles], Q5† vs Q1-4	0.72	(0.09-5.54)		0.59	(0.07-4.77)		0.92	(0.13-6.41)	
Top food group servings/d [Quintiles], Q5† vs Q1-4	1.08	(0.29-3.94)		1.30	(0.36-4.65)		1.18	(0.32-4.34)	
Education, Lower† vs Third level	1.34	(0.47-3.78)		1.35	(0.48-3.80)		1.48	(0.53-4.13)	
Self reported health status, Rel.Negative† vs Rel.Positive	4.20	(1.45-12.20)	**	4.42	(1.53-12.79)	**	4.17	(1.47-11.87)	**
Paternal Characteristics									
Current Smoking status, Yes† vs No	1.37	(0.48-3.93)		1.31	(0.45-3.83)		1.53	(0.54-4.35)	
Education, Lower† vs Third level	0.69	(0.21-2.28)		0.79	(0.24-2.57)		0.83	(0.26-2.67)	
Employment, Non-earning † vs Self employed	1.60	(0.73-3.53)		1.52	(0.69-3.32)		1.57	(0.70-3.53)	
Self reported health status, Rel.Negative† vs Rel.Positive	1.48	(0.52-4.20)		1.54	(0.54-4.35)		1.43	(0.51-3.96)	

OR=Odds Ratio; †Reference category (OR=1); **p<0.01 (2-tailed), *p<0.05 (2-tailed)

Rel.Negative=Relatively Negative, Rel.Positive=Relatively Positive

[1]Child BMI as a categorical variable; Model Chi-sq = 34.2, df = 21, p = 0.034; -2LL = 128.6, Nagelkerke R-sq = 0.26

[2]Child BMI as a continuous variable; Model Chi-sq = 35.9, df = 21, p = 0.022; -2LL = 126.9, Nagelkerke R-sq = 0.27

[3]Child waist circumference as a continuous variable; Model Chi-sq = 33.8, df = 21, p = 0.038; -2LL = 128.9, Nagelkerke R-sq = 0.25

Discussion

This analysis showed that determinants from both child's individual and family spheres have an influence on child's health at preschool-age. The factors from all three material, psycho-social and lifestyle domains, the major explanations for child health inequalities,[8] were associated at uni-variate levels. However, in the final model this analysis clearly demonstrated a negative association between child's obesity and health status. Child's not being obese was one of the significantly strong predictors of child's relatively-positive health status, which was also observed with measured BMI and waist circumference analysed as continuous variables.

This negative relationship observed between measured obesity and PRH conforms to published literature on primary school age-group children and adolescents.[43-45] Most importantly, for the first time to our knowledge, this analysis demonstrates the association having adjusted for food and nutrient intake, along-with a wide range of other explanatory variables.

Self-rated health is an important and valid measure of morbidity, mortality, longevity and health status,[3,4] also in Irish adult[46,47] and children.[16] It is believed to be a more inclusive measure of health than the objective measurements, with a capacity to comprehensively evaluate health dynamics, behaviours and psycho-physiological states that are not otherwise easy to measure.[3] This holistic measure better accommodates the WHO defined concept of health as opposed to a diagnosed specific disease.[3] Use of parent proxy for child self-reported health is justified for children too young to have adequate cognitive skills.[48,49] Systematic reviews report good agreement between ratings by children and their parents on child HRQoL, particularly for physical health domain.[48-50] Parents tend to be thoughtful when responding to proxy questions and report children's usual health disposition.[51] Studies on construct validity report positively.[52-55] Maternal ratings of child's general health status were found sensitive when validated against children's illnesses and other morbidity or healthcare indicators,[41,56-58] including evidence of a gradient in strength of these associations.[41] Many national-level studies have accepted parent proxy as an

appropriate measure[17,18,59,60] and successfully used it to longitudinally demonstrate risk and consequences of child health.[17,59]

Self-rated health, a composite measure, represents all domains of HR-QoL,[4] but better represents physical health than HR-QoL.[61] Studies on older age-group children have reported stronger/sole negative associations for general/physical health domain of HR-QoL and obesity,[44,62] irrespective whether children themselves or parents reported their HRQoL,[29] and also whether BMI was analysed as a categorical,[43,44] or continuous variable.[63,64]

Another relevance of this analysis is in demonstrating this association of obesity with general-health in a nationally representative sample of preschool-age children, for which literature is scant. Though, a few have shown similar association of obesity with specific paediatric conditions or admission history in this age-group.[30,31,65-68] A longitudinal study speculated that pre-school obesity influences a decline in early-age health, and then both obesity and poor-health tracks into adolescence.[69] The WHO recommends high priority for determinants of health inequalities during early development.[70]

The Lifeways previously demonstrated longitudinal association between parental socio-economic and lifestyle characteristics and child's BMI and waist circumference.[36] In this analysis when same anthropometric measures are included along-with material, psycho-social, and lifestyle determinants of child obesity and health, a prominent relationship emerges between children's anthropometric measures and health status. One possible explanation is that determinants of health inequalities biologically embed[21,22] in early life and child obesity is an early phenotypic expression of this inequality; though the continued influence of environmental factors is not undermined. Adult[25,26] and adolescence studies[44,45] have also shown this association to be independent of socio-demographic, lifestyle or health-related factors.

The observed association between BMI or waist circumference and PRH in the present analysis

may be temporal, as demonstrated in adults.[27,28] Though a number of large scale cross sectional studies have shown an association between anthropometric measures of obesity and self rated health,[71] only recently a few nationally representative prospective studies have established the temporality of this association in adults.[27,28] Though this relationship maybe bi-directional to an extent,[72,73] the mounting evidence from longitudinal birth cohort studies regarding a sequential relationship between lifetime growth trajectories and adult disease, disability and deaths[2] primarily rules out reverse causality in this association and suggests that the association observed in our birth cohort is also more likely to be temporal. Moreover, the available findings from a few longitudinal studies on primary school age children suggest that at least in the childhood this inverse association found between BMI and HRQoL is predominantly in the given direction and not the reverse.[74,75] However, this needs careful interpretation as both anthropometric and health data were concurrently collected, and this limitation may be addressed with next sweep of cohort data collection.

This analysis demonstrated that maternal health was strongly predictive of her child's health. One concern is that mother's perception of her own health may bias her perception of her child's health. However, this intergenerational association has been previously reported,[41,56,57,76-79] and reporting mothers can effectively discriminate between their own and children's health.[41,56,57,77,78,80] Several mechanisms such as inherited susceptibility, uterine environment and shared environment have been suggested for this familial aggregation pattern.[56,77,78]

Maternal BMI may be related to both maternal self-rated health and child's BMI, so the observed associations in this analysis could possibly be a reflection of an association between maternal BMI and child's PRH. However, this was not observed in our analysis. Maternal BMI at both pre-pregnancy and 5-year follow-up were not associated with child's PRH at univariate level. Also, when maternal BMI was forcibly added into the multivariable model (not reported here), the observed associations did not attenuate.

The study has limitations in use of reported rather than measured health status and a relatively small sample size. Though the study was able to detect the major explanatory domains for child health inequalities documented in the literature[8], the relatively small sample size of this study may possibly have underpowered it to detect variables with lesser effect sizes. The complete case approach to analysis reduced the sample size of the final multivariate model. However, this missing data was not systematic but rather on account of accumulation of missing completely at random data across a number of variables. It may be argued that the reduced sample size possibly influenced the odds ratio estimate for the association between children's relatively-positive PRH and the child's not being obese (using a categorical IOTF classification). Nonetheless this association between children's anthropometric measures and their parent-rated health variable is likely to be coherent, because these associations remain statistically significant even when BMI and WC are analysed as continuous variables.

As in most birth cohort studies,[81,82] the Lifeways birth cohort also experienced the attrition of mothers belonging to lower socio-economic status in the early stages of the study. Though this may underestimate some socioeconomic inequalities [83], it does not negate the exposure-outcome associations detected through regression models of such longitudinal studies [84,85].

Nevertheless, this study has advantages in use of lifecourse variables from pre-conception to age of 5-years, with measured BMI and waist circumference data. It also has detailed foods and nutrient data along-with other socio-economic, psycho-social and lifestyle variables for child and both parents.

In conclusion, these analyses from the Lifeways cohort show that lifecourse adversities were associated with mother-reported health for preschoolers, suggesting an early life influence. Preschoolers' BMI and waist-circumference demonstrated strong negative associations with mother-reported health independent of socio-economic, psycho-social, and lifestyle factors, suggesting early biological expression of lifecourse adversities. The findings have important

implications in understanding how early life environment may create inequalities in developmental health.

Footnotes

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Contributors

AS undertook all analyses reported in this manuscript, interpreted the findings and drafted the manuscript. CM contributed to data collection at five year follow-up, interpretation of the analysis and critical revision of the manuscript. CCK designed the study, supervised the analyses, interpretation of results and intellectual content of the manuscript. All three authors approved the final version.

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Competing interests

None

Ethical approvals

Ethics committees of Coombe University Hospital, Dublin, University College Hospital Galway, University College Dublin, Dublin, and the Irish College of General Practitioners, Ireland.

Data sharing statement

There are no additional data available. The data manager may be contacted at john.obrien@ucd.ie for more details on the Lifeways Cross-Generation Cohort Study.

Appendices

The web only supplement includes eTable 1 regarding details of examined variables and eTable 2 displaying standardised odds ratios for multivariable logistic regression model.

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eTable 1: Lifecourse variables examined for relationship with children's parent-rated health, PRH

Independent Variables	Time	Categories
Child's Individual characteristics		
Demographic and Anthropometric		
Birth-weight standardised for gestational age (g)	Measured at birth	continuous measure
Age at 5-year follow-up (years)	At 5-yr follow-up	continuous measure
Gender		Male, Female
Body Mass Index (BMI) kg/m^2	Measured at 5-yr follow-up	continuous measure Also as obese versus overweight or normal using IOTF definitions
Waist Circumference (cm)	Measured at 5-yr follow-up	continuous measure
Height (cm)	Measured at 5-yr follow-up	continuous measure
Lifestyle/Nutrition		
Breastfeeding	At infancy	breastfed or not
Top food group servings per day	At 5-yr follow-up	5th Quintile (>6.47 servings) versus 1-4 Quintiles.
Fruits & Vegetables food group servings /day	At 5-yr follow-up	1st Quintile (<2.1 servings) versus 2-5 Quintiles
Total Energy intake (kilocalories/day)	At 5-yr follow-up	5th Quintile (>1794 kcal) versus 1-4 Quintiles
Total Fats intake (grams/day)	At 5-yr follow-up	5th Quintile (>62.9g) versus 1-4 Quintiles
Family characteristics		
Socio-Economic		
Household weekly income	At 5-yr follow-up	composite family income more or less than 760 Euros a week
Entitlement to General Medical Card scheme, a means tested healthcare benefits scheme	At 5-yr follow-up	Families entitled or not to General Medical Card
Psycho-Social		
Fathers' participation (Family stability)	Early pregnancy stage	Families whose fathers participated in the study versus families whose fathers did not
Mother's marital status (Family structure)	At 5-yr follow-up	Married or cohabiting versus single, separated, divorced or widowed.
Elder children in family [Parity was a proxy measure for presence of elder siblings to the Lifeways child]	Early pregnancy stage	nullipara versus one or more para
Support from spouse or partner	At 5-yr follow-up	Mothers perceived "a lot" of support from spouse or partners versus perceived receiving "some, so-so, little" support
Support from parents	At 5-yr follow-up	Mothers perceived "a lot" of support from parents versus

		perceived receiving "some, so-so, little" support
Support from children, inclusive Lifeways child	At 5-yr follow-up	Mothers perceived "a lot" of support from children versus perceived receiving "some, so-so, little" support
Support from close relatives	At 5-yr follow-up	Mothers perceived "a lot" of support from relatives versus perceived receiving "some, so-so, little" support
Maternal characteristics		
Demographic and Anthropometric		
Age at 5-year follow-up (years)	At 5-yr follow-up	continuous measure
Pre-pregnancy BMI (kg/m^2)	Pre-pregnancy, Self-reported in early pregnancy	continuous measure Also as obese versus overweight or normal using WHO definitions
BMI at 5-year follow-up (kg/m^2)	Measured at 5-yr follow-up	continuous measure Also as obese versus overweight or normal using WHO definitions
Waist Circumference at 5-year follow-up (cm)	Measured at 5-yr follow-up	continuous measure
Height at 5-year follow-up (cm)	Measured at 5-yr follow-up	continuous measure
Lifestyle/Nutrition		
Smoking during pregnancy	Early pregnancy stage	Current smoker or not
Smoking at 5-year follow-up	At 5-yr follow-up	Current smoker or not
Top food group servings per day	At 5-yr follow-up	5th Quintile (>8.35 servings) versus 1-4 Quintiles.
Fruits & Vegetables food group servings /day	At 5-yr follow-up	1st Quintile (<4.5 servings) versus 2-5 Quintiles
Total Energy intake (kilocalories/day)	At 5-yr follow-up	5th Quintile (>2570.9 kcal) versus 1-4 Quintiles
Total Fats intake (grams/day)	At 5-yr follow-up	5th Quintile (>106.0 g) versus 1-4 Quintiles
Socio-Economic		
Education level	Early pregnancy stage	Third level versus lower levels of education status
Employment status	At 5-yr follow-up	Non-earning versus Employed versus Self employed
Health		
Self-rated health status of mothers	At 5-yr follow-up	Relatively Positive ("Excellent" or "Very Good") versus Relatively Negative ("Poor"/ "Fair" /"Good") responses
Paternal Characteristics		
Anthropometric		
BMI at 5-year follow-up (kg/m^2)	Measured at	continuous measure

Waist Circumference at 5-year follow-up (cm)	5-yr follow-up Measured at 5-yr follow-up	continuous measure
Height at 5-year follow-up (cm)	Measured at 5-yr follow-up	continuous measure
Lifestyle		
Smoking at 5-year follow-up	At 5-yr follow-up	Current smoker or not
Socio-Economic		
Education level	Early pregnancy stage	Third level versus lower levels of education status
Employment status	At 5-yr follow-up	Non-earning versus Employed versus Self employed
Health		
Self-rated health status of fathers (in proxy)	At 5-yr follow-up	Relatively Positive (“Excellent” or “Very Good”) versus Relatively Negative (“Poor”/ “Fair” /“Good”) responses

eTable 2: Multivariable Logistic Regression model for predictors of children's relatively positive parent-rated health, PRH (N=303)

	Relatively Positive PRH		Relatively Positive PRH		Relatively Positive PRH	
	BMI Categorical[1]		BMI Continuous[2]		WC Continuous[3]	
	Std OR	p-value	Std OR	p-value	Std OR	p-value
Child's Individual Characteristics						
BMI [IOTF], Obese† vs Overweight / Normal	1.53*	0.01				
BMI kg/m^2 [Continuous]			0.58**	0.009		
Waist Circumference cm [Continuous]					0.60*	0.02
Fats gm [Quintiles], Q5† vs Q1-4	1.20	0.50	1.18	0.55	1.12	0.68
Top shelf servings/d [Quintiles], Q5† vs Q1-4	1.09	0.76	1.11	0.69	1.11	0.70
Fruits Veg shelf servings/d [Quintiles], Q1† vs Q2-5	1.43	0.13	1.49	0.10	1.46	0.12
Family Characteristics						
Household Weekly Income, Less† vs High	1.34	0.26	1.30	0.31	1.32	0.29
Entitlement to General Medical, Card Yes† vs No	0.98	0.93	1.01	0.97	1.01	0.95
Fathers' Participation, No† vs Yes	1.37	0.23	1.36	0.23	1.43	0.17
Support from Spouse/Partner, Less† vs More	0.86	0.59	0.84	0.53	0.88	0.63
Support from Parents, Less† vs More	1.30	0.32	1.41	0.20	1.42	0.19
Support from Children, Less† vs More	1.07	0.80	1.13	0.65	1.11	0.70
Support from Close Relatives, Less† vs More	0.93	0.81	0.93	0.79	0.92	0.79
Maternal Characteristics						
Energy Kcal [Quintiles], Q5† vs Q1-4	1.28	0.50	1.31	0.47	1.19	0.61
Fats gm [Quintiles], Q5† vs Q1-4	0.88	0.76	0.82	0.62	0.97	0.93
Top shelf servings/d [Quintiles], Q5† vs Q1-4	1.03	0.91	1.11	0.69	1.07	0.80
Education, Lower† vs Third level	1.15	0.58	1.16	0.56	1.21	0.45
Self reported health status, Rel.Negative† vs Rel.Positive	1.88**	0.008	1.92**	0.006	1.88**	0.007
Paternal Characteristics						
Current Smoking status, Yes† vs No	1.15	0.55	1.13	0.62	1.21	0.42
Education, Lower† vs Third level	0.85	0.55	0.90	0.70	0.92	0.75
Employment, Non-earning † vs Self employed	1.33	0.24	1.29	0.30	1.32	0.27
Self reported health status, Rel.Negative† vs Rel.Positive	1.20	0.46	1.22	0.42	1.18	0.50

Std OR=Standardised Odds Ratio, all variables rescaled to have a mean of zero and a standard deviation of one; **p<0.01 (2-tailed), *p<0.05 (2-tailed)

†Reference category (Std OR=1); Rel.Negative=Relatively Negative, Rel.Positive=Relatively Positive

[1]Child BMI as a categorical variable

[2]Child BMI as a continuous variable

[3]Child waist circumference as a continuous variable

STROBE Statement: Preschoolers' parent rated health disparities are strongly associated with measures of adiposity in the Lifeways cohort study children

	Item No	Recommendation	Done
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	✓
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	✓
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	✓
Objectives	3	State specific objectives, including any prespecified hypotheses	✓
Methods			
Study design	4	Present key elements of study design early in the paper	✓
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	✓
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	✓
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	✓
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	✓
Bias	9	Describe any efforts to address potential sources of bias	✓
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	✓
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	✓
		(*b*) Describe any methods used to examine subgroups and interactions	✓
		(*c*) Explain how missing data were addressed	✓
		(*d*) If applicable, explain how loss to follow-up was addressed	✓
		(*e*) Describe any sensitivity analyses	✓
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	✓
		(b) Give reasons for non-participation at each stage	✓
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	✓
		(b) Indicate number of participants with missing data for each variable of interest	✓
		(c) Summarise follow-up time (eg, average and total amount)	✓
Outcome data	15*	Report numbers of outcome events or summary measures over time	✓
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted	✓

		estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	✓
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	✓
Discussion			
Key results	18	Summarise key results with reference to study objectives	✓
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	✓
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	✓
Generalisability	21	Discuss the generalisability (external validity) of the study results	✓
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	✓

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

Preschoolers' parent rated health disparities are strongly associated with measures of adiposity in the Lifeways cohort study children

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Running Title: Childhood obesity a persistent predictor of preschoolers' PRH

KEYWORDS

Lifecourse, self-rated health, obesity, BMI, waist circumference, preschool children

Word count: 3439

ABSTRACT (Words: 272)

Objective

To examine the relationship between lifecourse factors from preschoolers' micro-ecosystem and their parent-reported (mother-reported) health (PRH), following them prospectively from preconception to age 5-years. To investigate if preschoolers' BMI and waist-circumference were associated with preschoolers' PRH when controlled for lifecourse predictors.

Design

Lifeways cross-generation cohort study

Setting

Ireland

Participants

Of 1082 families, 62% mothers responded on a health and lifestyle questionnaire at follow-up. Food frequency, BMI and waist-circumference were measured. There were 547 family datasets available for analysis of children's PRH.

Main outcome measure

Mother-reported children's PRH at age-5. Associations with child's individual and familial exposures from preconception to age 5-years examined using logistic regression.

Results

In univariate analysis, relatively-positive rating of children's PRH were associated with children's lower intake of fats [OR(95%CI)=2.2(1.1-4.3)], higher intake of fruits/vegetables [OR(95%CI)=2.2(1.1-4.3)]; as well as familial socio-economic characteristics {higher household income [OR(95%CI)=3.0(1.6-5.9)], non-entitlement to means-tested healthcare

[OR(95%CI)=2.1(1.0-4.3)], mothers' higher education [OR(95%CI)=1.9(1.0-3.6)]}, psycho-social characteristics {father's participation in study [OR(95%CI)=2.1(1.0-4.3)], mothers' perceiving better support from partner [OR(95%CI)=2.3(1.2-4.3)], children [OR(95%CI)=1.9(1.0-3.7)] or relatives [OR(95%CI)=2.2(1.1-4.1)]}, parents' lifestyle {mothers' lower intake of energy [OR(95%CI)=2.2(1.1-4.3)], fathers' non-smoking status [OR(95%CI)=2.2(1.1-4.4)]}, and parents' health {mothers' self-rated health relatively-positive [OR(95%CI)=5.1(2.6-9.9)], fathers' self-rated health relatively-positive [OR(95%CI)=3.0(1.5-6.0)]}.

In multivariable analysis ($\chi 2=34.2, df=21, N=303, R^2=0.26, p<0.05$), one of the two strong predictors of children's relatively-positive PRH was child not being obese by International Obesity Task Force classification [OR(95%CI)=5.5(1.4-21.0)], observed also using BMI (kg/m^2) [OR(95%CI)=0.73(0.58-0.93)] or waist-circumference (cm) [OR(95%CI)=0.89(0.81-0.98)] as continuous variables. The other significant predictor was mothers' self-rated health relatively-positive [OR(95%CI)=4.2(1.5-12.2)].

Conclusions

Preschoolers' health is adversely associated with obesity and this is independent of lifecourse social and environmental inequalities. The findings suggest that reducing childhood obesity and improving maternal health may be useful ways to improve child's global health.

Strengths and limitations of this study

- Nationally representative sample of preschool-age children
- Examines the influence of lifecourse adversities, prospectively measured from preconception to age 5 on children's general health at age 5. The study analyses demographic, anthropometric, lifestyle, food and nutrients intake, psycho-social, socio-economic and health-related exposures from both children's individual as well as parental experiences.
- Demonstrates a significant and independent association between preschoolers' measured BMI as well as waist circumference and their general health status.
- The study is limited by a relatively small sample and use of parent-reported health status.

MAIN TEXT

Introduction

The development of children is critical to their adult well-being[1,2] and across the lifecourse even subjective estimates may be useful to reflect objectively measured health[3,4]. Bronfenbrenner[5] emphasised the importance of children's micro-ecosystem in their development. Recently, the World Health Organisation's (WHO) Commission on Social Determinants of Health (CSDH) presented a Total Environment Assessment Model for Early Child Development (TEAM-ECD),[6] which again illustrates the importance of individual and family spheres of influence on children's health. The relevance of socio-economic, psycho-social and lifestyle environment in child development and health is widely acknowledged.[6-8]

According to the lifecourse hypothesis, risk transmission is characterised by critical periods and accumulation of risk models.[9] Life Course Health Development (LCHD) framework[10] suggests that health is a consequence of multiple determinants that change in context of time and circumstances as an individual develops; these experiences are programmed into bio-behavioural regulatory systems during certain critical and sensitive periods of individual's lifetime to decide their health trajectory. The lifecourse framework on childhood disadvantage and adult health[11] suggests that parental and childhood circumstances from the point of conception influences individual's health in later life, and the individual's childhood health and later life circumstances may further add to this foundation. Based on this, Hertzman and colleagues[12] examined self-rated health in adulthood using an integrated lifecourse framework. There are a few other studies also which have examined lifecourse determinants of adult global[13,14] or specific health status.[15] On the contrary, the literature on the determinants of child global health status is sparse,[16,17] particularly for the preschool-age children.[18] Even rarer are studies whose examination includes early lifecourse determinants of child global health status.

Thus the first objective of our analysis was to prospectively examine the relationship between demographic, anthropometric, lifestyle, nutritional, psycho-social, socio-economic and health-related lifecourse exposures taken from the children's individual and family spheres of influence starting from preconception up to age 5-years and their global health status at preschool-age.

In social epidemiology, the construct of "embodiment" refers to biological expression of individuals' materio-social world.[19,20] Similarly in lifecourse epidemiology, it is hypothesised that early life experiences get "biologically embedded" during critical or sensitive periods of child development leading to gradients in health.[21,22]

The Foresight report identifies a large array of environmental determinants of obesity, a number of which are again related to early child development.[23] This suggests obesity as pivotal risk factor for subsequent health conditions.[24]

The negative relationship between obesity and self-rated health is now increasingly reported in adult populations,[25,26] some indicating a temporal relationship[27,28] and suggesting that obesity increases health inequalities over time.[28] However, evidence on the relationship between obesity and health is relatively limited in child population studies and those available have reported health-related-quality-of-life (HR-QoL)[29] instead of a generic measure such as global self-rated health. Moreover, this association is yet to be established for preschool-age children. To our knowledge just two population based studies have examined this association in preschool age-group children[30,31] and neither had nutritional information.

In the Longitudinal Study of Australian Children, Wake *et al*.[30] did not find a significant difference in global health status of overweight/obese and normal weight 4-5-year-old children. Skinner et al.,[31] using data on 3-5-year-olds from the US National Health and

Nutrition Examination Survey, reported a poorer global health status in obese and severely obese preschoolers. Neither of these studies accounted for a number of possibly relevant confounders, including parental BMI, parental health and nutritional variables.

We thus hypothesised that similar to findings from studies on older age-groups, anthropometric markers of child obesity in our preschool-age children study would also demonstrate a negative association with their global health status. The next objective of our analysis was to examine whether anthropometric markers of child obesity would emerge as strong predictors of global health status when accounted for other socio-economic, psycho-social, and lifestyle environmental factors in a multivariable model.

Methods

The Lifeways cross generation cohort study comprises three generations of 1082 Irish families and was established in 2001-03; the recruitment procedure of this nationally representative cohort has been described previously.[32-34] The a priori purpose was to examine familial and cross-generation influences on early childhood development over the first five years of children's lives. Briefly, would-be mothers were at random recruited from the two regional maternity hospitals in the Republic of Ireland to get a representative sample. A comparison between the Lifeways mothers and a nationally representative sample of women of the same age group from the SLÁN (Survey of Lifestyle, Attitudes and Nutrition) surveys of Republic of Ireland[35] confirmed that the Lifeways mothers were satisfactorily representative of the Irish general women on socio-demographic characteristics.[33]

At this early pregnancy stage mothers completed a health and lifestyle status questionnaire adapted from a validated instrument developed for Irish national SLÁN surveys.[35] Mothers reported their pre-pregnancy height (cm) and weight (kg) and their smoking status during pregnancy. Mothers' and partners' socio-economic status was recorded. Subsequently at

birth, the live infants were added to the cohort along-with maternity and birth related hospital information.

In 2007-08, when these children averaged five years of age, the cohort follow-up recorded a 62% response rate.[34,36] Though mothers who responded to the follow-up were more likely to be of higher socioeconomic status, these mothers did not significantly differ in their baseline anthropometric characteristics (including BMI) from non-responders.[34,36] At this 5-year follow-up, mothers repeated the health and lifestyle assessment questionnaire, with additional questions related to her family, including a five-level likert item question "In general, would you say your / your partner's / your Lifeways child's current health is Excellent, Very Good, Good, Fair or Poor". Mothers provided information on family's socio-economic, psycho-social, and lifestyle status. Mothers reported their habitual dietary intake for the previous year on a semi-quantitative food frequency (SQFFQ) instrument developed from the EPIC study (European Prospective Investigation into Cancer and Nutrition) and validated for Irish adult population.[37] Mothers also gave details for the Lifeways child's habitual diet for the previous year using a different SQFFQ instrument adapted from the UK National Diet and Nutrition Survey of 4.5-year-old children.[38] The mothers' and children's SQFFQ were validated in the Lifeways study using a 7-day weighed food diary in a sub-sample.[36] Food items were aggregated by defined shelves (food groups) of the Irish food pyramid and assessment was made for average servings per day of standard food item portions consumed from the "top" and "fruit and vegetable" food groups (shelves of Irish food pyramid). The "top" food group comprises of high calorie fat and sugar rich foods. Total energy (kcal) and total fats (g) intake were computed using conversion values from McCance & Widdowson's food composition tables[39] with a specially developed FFQ software version 1.0 ©.[40]

Mothers and children, and if available fathers, were offered at 5-year follow-up an anthropometric assessment at their home for height (cm), weight (kg) and waist

circumference (cm) using a standardised protocol,[34,36] with 80-85% mothers and children participating. Body mass index (BMI) was calculated from weight and height information (kg/m^2).

Thus variables from discrete stages (pre-pregnancy, early pregnancy, at birth, early infancy and 5-year follow-up) of child's early development representing lifecourse exposures from distinct domains (demographic, anthropometric, socio-economic, psycho-social, lifestyle, nutritional and health) of child's individual and family spheres of influence[6-8] were considered to analyse determinants of child's health status at age-5. The selection of variables, domains and spheres of influence are based on the CSDH constructed TEAM-ECD, a model of early child development.[6-8] These lifecourse variables have been summarised as per time frame in **Table 1**. This lifecourse time frame highlights the stages and transition points relevant from perspective of child's health development.[10] Additional details on these variables are provided in **eTable 1** available in the web only supplement. The independent variables have been arranged as child-related, family-related, mother-related, father-related groups for ease of presentation.

Table 1: Independent variables examined from lifecourse of 5-yr-old children

Lifecourse	Independent Variables
Pre-pregnancy	Maternal Pre-pregnancy BMI
Early pregnancy	Family stability
	Maternal smoking in pregnancy, Maternal Education level
	Paternal Education level
Birth	Child's Birth-weight, Gestational age, Gender
	Maternal Parity
Infancy	Child's breastfeeding status
When children averaged 5-yr age	Child's Age, Height, BMI, Waist circumference, Food intake: top and fruits & vegetables food groups, Nutrient intake: energy and fats intake
	Family household weekly income, Entitlement to means tested healthcare benefits scheme, Family structure (marital status), Support from partner, parents, children & relatives
	Maternal Age, Height, BMI, Waist circumference, Smoking, Employment status, Food intake: top and fruits & vegetables food groups, Nutrient intake: energy and fats intake, Self-rated health status
	Paternal Height, BMI, Waist circumference, Smoking, Employment status, Self-rated health status

Children's global health status rated in proxy by their mothers, hereafter referred to as parent-rated health (PRH), was the outcome variable of interest. The 5-graded scale response was dichotomised as relatively-positive health (excellent or very good) and relatively-negative health (poor or fair or good), based on similar dichotomisation in other studies on preschool and school children.[17,18,30] It is reasonable to take a higher cut-off when dichotomising this age dependent variable in this very young age-group as there would be very limited numbers of poor or fair health children.[17,18,41]

Initially, uni-variate associations were established between the independent predictors and children's PRH using independent t-tests or chi-square tests. Independent categorical variables were dichotomised in a manner that allowed contrasting extreme levels against the others. Thus, using International Obesity Task Force (IOTF) cut-offs, children's BMI was dichotomised as obese versus over-weight or normal-weight. Similarly nutrition variables ordered in quintiles were dichotomised as the extreme quintile (1^{st} or 5^{th}) versus the rest.

From these independent variables principally chosen on the basis of their relevance to the child's development,[6-8] all those that qualified at significance level 20% ($p<0.2$)[42] in univariate analyses were force entered into a multivariable logistic regression model. BMI (kg/m^2) and waist circumference (cm), the anthropometric markers of obesity, were tested separately in independent multivariable models. They were not analysed together within a model as results of possible interactions among body composition variables would have been difficult to interpret [43,44]. Initially BMI was tested as a categorical variable in a model, followed by two additional models substituting it with BMI and then waist circumference as continuous variables. Other independent variables were tested as categorical variables.

Ethical approval for the Lifeways study was obtained respectively from ethical committees of participating hospitals and the University College Dublin, Ireland. Written informed consent was obtained from study participants.

Results

There were 547 family datasets available for analysis of children's PRH. **Table 2** presents the uni-variate associations between children's lifecourse variables and PRH. Within the individual-sphere of influences, children's lifestyle behaviours (lower intake of fatty/sugary foods and total fats, and higher intake of fruits/vegetables) and their anthropometric measures at age-5 (not being obese, lower BMI, and lower waist circumference) qualified as determinants of children's relatively-positive PRH for further examination in the multivariable model.

In other words, retaining $p<0.2$ as the criterion for significance, the children's healthy food and nutrient intake habits – such as lower intake of unhealthy fat- and sugar- rich foods (servings/day) [OR(95%CI)=1.7(0.8-3.4)] or total fats (g) in their meals [OR(95%CI)=2.2(1.1-4.3)] and higher intake of healthy fruits and vegetables (servings/day)

[OR(95%CI)=2.2(1.1-4.3)] were positively associated with their favourable rating for health by their mothers. Conversely, children's higher BMI (kg/m^2) [OR(95%CI)=0.85(0.71-1.03)] and waist circumference (cm) [OR(95%CI)=0.95(0.88-1.02)] were inversely associated with a positive parental-rated health status.

Within the family-sphere of influences, socio-economic status (higher household income, non-entitlement to subsidised healthcare, both parents' higher education status, and father's employment status), psycho-social status (father's study participation, mother's perceived social support), mother's lifestyle behaviours (lower intake of fatty/sugary foods, total energy and total fats), father's lifestyle behaviours (non-smoker), and both parents' health status (relatively-positive self-rated health) qualified as determinants of children's relatively-positive PRH for further examination in the multivariable model.

In other words, by maintaining $p<0.2$ as the criterion for significance, several indicators of a family's better socio-economic status– such as higher household income (Euros/week) [OR(95%CI)=3.0(1.6-5.9)], not requiring subsidised healthcare [OR(95%CI)=2.1(1.0-4.3)], mother having a third level education [OR(95%CI)=1.9(1.0-3.6)], father having a third level education [OR(95%CI)=1.9(1.0-3.6)], father being self-employed [OR(95%CI)=2.5(0.8-7.9)]; family's better psycho-social status– such as father's involvement in family affairs [OR(95%CI)=2.1(1.0-4.3)], mother's perceiving a positive social support from spouse [OR(95%CI)=2.3(1.2-4.3)], parents [OR(95%CI)=2.0(1.0-4.1)], children [OR(95%CI)=1.9(1.0-3.7)], or relatives [OR(95%CI)=2.2(1.1-4.1)]; family's better lifestyle and food and nutrient intake habits– such as mother's lower intake of unhealthy fat- and sugar- rich foods (servings/day) [OR(95%CI)=1.7(0.8-3.4)], total energy (kcal) [OR(95%CI)=2.2(1.1-4.3)] and total fats (g) [OR(95%CI)=1.7(0.8-3.4)] in her meals, father's not being a smoker [OR(95%CI)=2.2(1.1-4.4)]; and family's better health status– such as mother [OR(95%CI)=5.1(2.6-9.9)] and father [OR(95%CI)=3.0(1.5-6.0)] having a positively

rated health status were positively associated with children's favourable rating for health by their mothers.

Table 2: Uni-variate lifecourse associates of children's relatively-positive parent-rated health, PRH (N=547)

		Relatively Negative PRH (n=42)		Relatively Positive PRH (n=505)			
	N	%(n)	Mean (SD)	%(n)	Mean (SD)	OR	95% CI
Child's Individual Characteristics							
Birth-weight adjusted for gestational age (g)	487	(34)	3564.1 (616)	(453)	3548.4 (552)	1.00	(0.999-1.001)
Child's Age (Yrs)	547	(42)	5.42 (0.23)	(505)	5.46 (0.25)		
Gender	547						
Male		8.0% (22)		92.0% (242)		Ref	
Female		7.1% (21)		92.9% (262)		1.14	(0.60-2.20)
BMI (kg/m^2)	464	(35)	17.09 (2.5)	(429)	16.59 (1.6)	0.85	(0.71-1.03)^
BMI [IOTF]	464						
Obese		16.7% (5)		83.3% (25)		Ref	
Overweight / Normal		6.9% (30)		93.1% (404)		2.69	(0.96-7.54)^
Waist Circumference (cm)	462	(35)	57.01 (6.8)	(427)	55.88 (4.3)	0.95	(0.88-1.02)†
Height (cm)	464	(35)	111.6 (5.6)	(429)	112.1 (4.8)	1.02	(0.95-1.10)
Breastfeeding	528						
Not breastfed		6.5% (16)		93.5% (229)		Ref	
Breastfed		8.8% (25)		91.2% (258)		0.72	(0.38-1.38)
Energy (Kcal)	547						
Quintile 5 (>1794 kcal)		10% (11)		90.0% (99)		Ref	
Quintile 1-4		7.1% (31)		92.9% (406)		1.46	(0.71-3.00)
Fats (g)	547						
Quintile 5 (>62.9 g)		12.8% (14)		87.2% (95)		Ref	
Quintile 1-4		6.4% (28)		93.6% (410)		2.16	(1.09-4.26)*
Top food group (servings/day)	547						
Quintile 5 (>6.47 servings)		10.9% (12)		89.1% (98)		Ref	
Quintile 1-4		6.9% (30)		93.1% (407)		1.66	(0.82-3.36)†
Fruits Veg food group (servings/d)	547						
Quintile 1 (<2.1 servings)		12.8% (14)		87.2% (95)		Ref	
Quintile 2-5		6.4% (28)		93.6% (410)		2.16	(1.09-4.26)*
Family Characteristics							
Household Weekly Income	509						
Less than 760 Euros/wk		13.3% (26)		86.7% (170)		Ref	
More than 760 Euros/wk		4.8% (15)		95.2% (298)		3.04	(1.57-5.90)**
Entitlement to General Medical Card	532						
Entitled		13% (12)		87.0% (80)		Ref	
Not entitled		6.6% (29)		93.4% (411)		2.13	(1.04-4.34)*
Fathers' Participation	547						
Not		9.7% (31)		90.3% (290)		Ref	
Yes		4.9% (11)		95.1% (215)		2.09	(1.03-4.25)*
Marital Status	542						
Others		11.4% (5)		88.6% (39)		Ref	
Married/Cohabiting		7.2% (36)		92.8% (462)		1.65	(0.61-4.43)
Elder children in family (Parity)	535						
Nullipara		8% (18)		92.0% (207)		Ref	
Multipara		7.7% (24)		92.3% (286)		1.04	(0.55-1.96)
Support from Spouse/Partner	538						
Lesser support		12.9% (17)		87.1% (115)		Ref	
More support		6.2% (25)		93.8% (381)		2.25	(1.18-4.32)*
Support from Parents	487						
Lesser support		12.5% (12)		87.5% (84)		Ref	
More support		6.6% (26)		93.4% (365)		2.01	(0.97-4.14)^
Support from Children	532						
Lesser support		10.6% (20)		89.4% (169)		Ref	
More support		5.8% (20)		94.2% (323)		1.91	(1.00-3.65)*
Support from Close Relatives	510						
Lesser support		12.4% (19)		87.6% (134)		Ref	
More support		6.2% (22)		93.8% (335)		2.16	(1.13-4.12)*

Table 2: Uni-variate lifecourse associates of children's relatively-positive parent-rated health, PRH (continued)

	Relatively Negative PRH (n=42)			Relatively Positive PRH (n=505)			
	N	%(n)	Mean (SD)	%(n)	Mean (SD)	OR	95% CI
Maternal Characteristics							
Pre-pregnancy BMI (kg/m^2)	475	(36)	23.3 (3.3)	(439)	23.8 (3.9)	1.04	(0.94-1.14)
Pre-pregnancy BMI [WHO cut offs]							
Obese		2.6% (1)		97.4% (38)		Ref	
Overweight / Normal		8% (35)		92.0% (401)		0.30	(0.04-2.26)
Mother's Age (Yrs)	546	(42)	36.5 (6.3)	(504)	37.1 (5.3)	1.02	(0.96-1.08)
BMI at 5-yr follow-up (kg/m^2)	432		25.6 (3.9)		26.3 (5.0)	1.03	(0.95-1.12)
BMI at 5-yr follow-up [WHO cut offs]	432						
Obese		7.2% (5)		92.8% (64)		Ref	
Overweight / Normal		7.4% (27)		92.6% (336)		0.97	(0.36-2.62)
Waist Circumference (cm)	434	(31)	85.3 (10.6)	(403)	87.6 (11.9)	1.02	(0.99-1.05)
Height (cm)	454	(33)	161.9 (6.8)	(421)	162.9 (6.0)	1.03	(0.97-1.09)
Smoking in pregnancy	534						
Smoker		8.1% (8)		91.9% (91)		Ref	
Non-Smoker		7.6% (33)		92.4% (402)		1.07	(0.48-2.4)
Smoking at 5-yr follow-up	541						
Smoker		7.6% (9)		92.4% (110)		Ref	
Non-Smoker		7.6% (32)		92.4% (390)		1.0	(0.46-2.15)
Energy (Kcal)	546						
Quintile 5 (>2570.9 kcal)		13% (14)		87.0% (94)		Ref	
Quintile 1-4		6.4% (28)		93.6% (410)		2.18	(1.11-4.30)*
Fats (g)	546						
Quintile 5 (>106 g)		11% (12)		89.0% (97)		Ref	
Quintile 1-4		6.9% (30)		93.1% (407)		1.68	(0.83-3.40)†
Top food group (servings/day)	545						
Quintile 5 (>8.35 servings)		11% (12)		89.0% (97)		Ref	
Quintile 1-4		6.9% (30)		93.1% (406)		1.67	(0.83-3.39)†
Fruits Veg food group (servings/day)	546						
Quintile 1 (<4.5 servings)		9.1% (10)		90.9% (100)		Ref	
Quintile 2-5		7.3% (32)		92.7% (404)		1.26	(0.60-2.65)
Education level	534						
Lower		10.4% (25)		89.6% (215)		Ref	
Third Level		5.8% (17)		94.2% (277)		1.90	(1.00-3.60)*
Employment	545						
Not Earning		6.4% (15)		93.6% (221)		Ref	
Employed		9% (22)		91.0% (222)		0.69	(0.35-1.36)
Self employed		7.7% (5)		92.3% (60)		0.81	(0.29-2.33)
Self reported health	546						
Relatively Negative		17.1% (27)		82.9% (131)		Ref	
Relatively Positive		3.9% (15)		96.1% (373)		5.10	(2.64-9.93)**
Paternal Characteristics							
BMI at 5-yr follow-up (kg/m^2)	66	(4)		(62)		0.97	(0.76-1.23)
Waist Circumference (cm)	65	(3)		(62)		1.01	(0.90-1.13)
Height (cm)	66	(4)		(62)		1.01	(0.88-1.15)
Smoking at 5-yr follow-up	521						
Smoker		11.5% (16)		88.5% (123)		Ref	
Non-Smoker		5.5% (21)		94.5% (361)		2.24	(1.13-4.42)*
Education level	514						
Lower		11.1% (16)		88.9% (128)		Ref	
Third Level		6.2% (23)		93.8% (347)		1.89	(0.97-3.68)^
Employment	518						
Not Earning		9.2% (8)		90.8% (79)		Ref	
Employed		7.9% (24)		92.1% (279)		1.18	(0.51-2.72)
Self employed		3.9% (5)		96.1% (123)		2.49	(0.79-7.89)†
Self reported health	510						
Relatively Negative		12.6% (20)		87.4% (139)		Ref	
Relatively Positive		4.6% (16)		95.4% (335)		3.01	(1.52-5.99)**

**p<0.01, *p<0.05, ^p<0.1, †p<0.2; Ref=reference category (OR=1)

Table 3 presents the multivariable model for association between qualifying lifecourse variables and children's relatively-positive PRH at age-5. A significantly strong predictor of children's relatively-positive PRH was child's not being obese by IOTF classification [OR(95%CI)=5.5(1.4-21.0)]. When BMI was tested as a continuous variable, there was 0.73 (95%CI=0.58-0.93) times lower odds of the child being positively rated on health status for every 1 kg/m^2 increase in their BMI. Similarly in the waist circumference model, for every 1 cm increase there was 0.89 (95%CI=0.81-0.98) times lower odds of the child getting a relatively-positive rating on health status. Thus the association between children's BMI or waist circumference and their PRH only strengthened following adjustments in this multivariate model, irrespective of being analysed as a categorical or continuous variable. Another significant predictor of children's relatively-positive PRH was mother's having rated her own health as relatively-positive. These predictors maintained the highest strength of association with children's health status when independent variables were standardised (not reported here). None of the other variables reached the level of statistical significance. The models explained over 25 percent of variance for children's PRH.

Table 3: Multivariable Logistic Regression model for predictors of children's relatively-positive parent-rated health, PRH (N=303)

	Relatively Positive PRH			Relatively Positive PRH			Relatively Positive PRH		
	BMI Categorical[1]			BMI Continuous[2]			WC Continuous[3]		
	OR	95% CI		OR	95% CI		OR	95% CI	
Child's Individual Characteristics									
BMI [IOTF], Obese† vs Overweight / Normal	5.48	(1.43-21.03)	*						
BMI kg/m^2 [Continuous]				0.73	(0.58-0.93)	**			
Waist Circumference cm [Continuous]							0.89	(0.81-0.98)	*
Fats gm [Quintiles], Q5† vs Q1-4	1.57	(0.42-5.79)		1.49	(0.40-5.53)		1.32	(0.36-4.80)	
Top food group servings/d [Quintiles], Q5† vs Q1-4	1.23	(0.33-4.53)		1.30	(0.36-4.63)		1.29	(0.36-4.62)	
Fruits Veg food group servings/d [Quintiles], Q1† vs Q2-5	2.57	(0.75-8.80)		2.86	(0.83-9.93)		2.73	(0.78-9.49)	
Family Characteristics									
Household Weekly Income, Less† vs High	1.85	(0.63-5.40)		1.76	(0.59-5.21)		1.79	(0.61-5.26)	
Entitlement to General Medical, Card Yes† vs No	0.94	(0.24-3.71)		1.03	(0.26-4.07)		1.04	(0.26-4.10)	
Fathers' Participation, No† vs Yes	1.88	(0.68-5.21)		1.86	(0.67-5.16)		2.06	(0.74-5.71)	
Support from Spouse/Partner, Less† vs More	0.70	(0.20-2.49)		0.67	(0.19-2.33)		0.74	(0.22-2.52)	
Support from Parents, Less† vs More	1.92	(0.53-6.93)		2.33	(0.64-8.42)		2.37	(0.66-8.53)	
Support from Children, Less† vs More	1.15	(0.38-3.45)		1.29	(0.42-3.91)		1.25	(0.41-3.82)	
Support from Close Relatives, Less† vs More	0.86	(0.23-3.13)		0.84	(0.24-3.02)		0.84	(0.23-3.01)	
Maternal Characteristics									
Energy Kcal [Quintiles], Q5† vs Q1-4	1.89	(0.30-11.84)		2.00	(0.31-12.86)		1.57	(0.28-8.84)	
Fats gm [Quintiles], Q5† vs Q1-4	0.72	(0.09-5.54)		0.59	(0.07-4.77)		0.92	(0.13-6.41)	
Top food group servings/d [Quintiles], Q5† vs Q1-4	1.08	(0.29-3.94)		1.30	(0.36-4.65)		1.18	(0.32-4.34)	
Education, Lower† vs Third level	1.34	(0.47-3.78)		1.35	(0.48-3.80)		1.48	(0.53-4.13)	
Self reported health status, Rel.Negative† vs Rel.Positive	4.20	(1.45-12.20)	**	4.42	(1.53-12.79)	**	4.17	(1.47-11.87)	**
Paternal Characteristics									
Current Smoking status, Yes† vs No	1.37	(0.48-3.93)		1.31	(0.45-3.83)		1.53	(0.54-4.35)	
Education, Lower† vs Third level	0.69	(0.21-2.28)		0.79	(0.24-2.57)		0.83	(0.26-2.67)	
Employment, Non-earning † vs Self employed	1.60	(0.73-3.53)		1.52	(0.69-3.32)		1.57	(0.70-3.53)	
Self reported health status, Rel.Negative† vs Rel.Positive	1.48	(0.52-4.20)		1.54	(0.54-4.35)		1.43	(0.51-3.96)	

OR=Odds Ratio; †Reference category (OR=1); **p<0.01 (2-tailed), *p<0.05 (2-tailed)

Rel.Negative=Relatively Negative, Rel.Positive=Relatively Positive

[1]Child BMI as a categorical variable; Model Chi-sq = 34.2, df = 21, p = 0.034; -2LL = 128.6, Nagelkerke R-sq = 0.26

[2]Child BMI as a continuous variable; Model Chi-sq = 35.9, df = 21, p = 0.022; -2LL = 126.9, Nagelkerke R-sq = 0.27

[3]Child waist circumference as a continuous variable; Model Chi-sq = 33.8, df = 21, p = 0.038; -2LL = 128.9, Nagelkerke R-sq = 0.25

Discussion

This analysis showed that determinants from both child's individual and family spheres have an influence on child's health at preschool-age. The factors from all three material, psycho-social and lifestyle domains, the major explanations for child health inequalities,[8] were associated at uni-variate levels. However, in the final model this analysis clearly demonstrated a negative association between child's obesity and health status. Child's not being obese was one of the significantly strong predictors of child's relatively-positive health status, which was also observed with measured BMI and waist circumference analysed as continuous variables.

This negative relationship observed between measured obesity and PRH conforms to published literature on primary school age-group children and adolescents.[45-47] Most importantly, for the first time to our knowledge, this analysis demonstrates the association having adjusted for food and nutrient intake, along-with a wide range of other explanatory variables.

Self-rated health is an important and valid measure of morbidity, mortality, longevity and health status,[3,4] also in Irish adult[48,49] and children.[16] It is believed to be a more inclusive measure of health than the objective measurements, with a capacity to comprehensively evaluate health dynamics, behaviours and psycho-physiological states that are not otherwise easy to measure.[3] This holistic measure better accommodates the WHO defined concept of health as opposed to a diagnosed specific disease.[3] Use of parent proxy for child self-reported health is justified for children too young to have adequate cognitive skills.[50,51] Systematic reviews report good agreement between ratings by children and their parents on child HRQoL, particularly for physical health domain.[50-52] Parents tend to be thoughtful when responding to proxy questions and report children's usual health disposition.[53] Studies on construct validity report positively.[54-57] Maternal ratings of child's general health status were found sensitive when validated against children's illnesses and other morbidity or healthcare indicators,[41,58-60] including evidence of a gradient in strength of these associations.[41] Many national-level studies have accepted parent proxy as an

appropriate measure[17,18,61,62] and successfully used it to longitudinally demonstrate risk and consequences of child health.[17,61]

Self-rated health, a composite measure, represents all domains of HR-QoL,[4] but better represents physical health than HR-QoL.[63] Studies on older age-group children have reported stronger/sole negative associations for general/physical health domain of HR-QoL and obesity,[46,64] irrespective whether children themselves or parents reported their HRQoL,[29] and also whether BMI was analysed as a categorical,[45,46] or continuous variable.[65,66]

Another relevance of this analysis is in demonstrating this association of obesity with general-health in a nationally representative sample of preschool-age children, for which literature is scant. Though, a few have shown similar association of obesity with specific paediatric conditions or admission history in this age-group.[30,31,67-70] A longitudinal study speculated that pre-school obesity influences a decline in early-age health, and then both obesity and poor-health tracks into adolescence.[71] The WHO recommends high priority for determinants of health inequalities during early development.[72]

The Lifeways previously demonstrated longitudinal association between parental socio-economic and lifestyle characteristics and child's BMI and waist circumference.[36] In this analysis when same anthropometric measures are included along-with material, psycho-social, and lifestyle determinants of child obesity and health, a prominent relationship emerges between children's anthropometric measures and health status. One possible explanation is that determinants of health inequalities biologically embed[21,22] in early life and child obesity is an early phenotypic expression of this inequality; though the continued influence of environmental factors is not undermined. Adult[25,26] and adolescence studies[46,47] have also shown this association to be independent of socio-demographic, lifestyle or health-related factors.

The observed association between BMI or waist circumference and PRH in the present analysis

may be temporal, as demonstrated in adults.[27,28] Though a number of large scale cross sectional studies have shown an association between anthropometric measures of obesity and self rated health,[73] only recently a few nationally representative prospective studies have established the temporality of this association in adults.[27,28] Though this relationship maybe bi-directional to an extent,[74,75] the mounting evidence from longitudinal birth cohort studies regarding a sequential relationship between lifetime growth trajectories and adult disease, disability and deaths[2] primarily rules out reverse causality in this association and suggests that the association observed in our birth cohort is also more likely to be temporal. Moreover, the available findings from a few longitudinal studies on primary school age children suggest that at least in the childhood this inverse association found between BMI and HRQoL is predominantly in the given direction and not the reverse.[76,77] However, this needs careful interpretation as both anthropometric and health data were concurrently collected, and this limitation may be addressed with next sweep of cohort data collection.

This analysis demonstrated that maternal health was strongly predictive of her child's health. One concern is that mother's perception of her own health may bias her perception of her child's health. However, this intergenerational association has been previously reported,[41,58,59,78-81] and reporting mothers can effectively discriminate between their own and children's health.[41,58,59,79,80,82] Several mechanisms such as inherited susceptibility, uterine environment and shared environment have been suggested for this familial aggregation pattern.[58,79,80]

Maternal BMI may be related to both maternal self-rated health and child's BMI, so the observed associations in this analysis could possibly be a reflection of an association between maternal BMI and child's PRH. However, this was not observed in our analysis. Maternal BMI at both pre-pregnancy and 5-year follow-up were not associated with child's PRH at univariate level. Also, when maternal BMI was forcibly added into the multivariable model (not reported here), the observed associations did not attenuate.

The study has limitations in use of reported rather than measured health status and a relatively small sample size. Though the study was able to detect the major explanatory domains for child health inequalities documented in the literature[8], the relatively small sample size of this study may possibly have underpowered it to detect variables with lesser effect sizes. The complete case approach to analysis reduced the sample size of the final multivariate model, which may have power implications. However, this missing data was on account of an accumulation across a number of variables. On analysis, there was no evidence of selectivity in the participants for whom there were missing data (**eTable 2**). **eTable 2,** available in the web only supplement, compares children included and not included in the final model for variables belonging to explanatory domains. It suggests that there were no significant differences in the characteristics of children included and not included (due to missing data) for analysis, suggesting that the children in the final model are representative of the study participants as a whole. It may be argued that the reduced sample size possibly influenced the odds ratio estimate for the association between children's relatively-positive PRH and the child's not being obese (using a categorical IOTF classification). Nonetheless this association between children's anthropometric measures and their parent-rated health variable is likely to be coherent, because these associations remain statistically significant even when BMI and WC are analysed as continuous variables.

As in most birth cohort studies,[83,84] the Lifeways birth cohort also experienced the attrition of mothers belonging to lower socio-economic status in the early stages of the study. Though this may underestimate some socioeconomic inequalities [85], it does not negate the exposure-outcome associations detected through regression models of such longitudinal studies [86,87].

Nevertheless, this study has advantages in use of lifecourse variables from pre-conception to age of 5-years, with measured BMI and waist circumference data. It also has detailed foods and nutrient data along-with other socio-economic, psycho-social and lifestyle variables for child and both parents.

In conclusion, these analyses from the Lifeways cohort show that lifecourse adversities were associated with mother-reported health for preschoolers, suggesting an early life influence. Preschoolers' BMI and waist-circumference demonstrated strong negative associations with mother-reported health independent of socio-economic, psycho-social, and lifestyle factors, suggesting early biological expression of lifecourse adversities. The findings have important implications in understanding how early life environment may create inequalities in developmental health.

Footnotes

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Contributors

AS undertook all analyses reported in this manuscript, interpreted the findings and drafted the manuscript. CM contributed to data collection at five year follow-up, interpretation of the analysis and critical revision of the manuscript. CCK designed the study, supervised the analyses, interpretation of results and intellectual content of the manuscript. All three authors approved the final version.

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Competing interests

None of the authors have any conflict of interest, including financial interests relevant to this article to disclose.

Ethical approvals

Ethics committees of Coombe University Hospital, Dublin, University College Hospital Galway, University College Dublin, Dublin, and the Irish College of General Practitioners, Ireland.

Data sharing statement

No additional data available. The data manager may be contacted at john.obrien@ucd.ie for more details on the Lifeways Cross-Generation Cohort Study.

Appendices

The supplement includes eTable 1 displaying details of examined variables and eTable 2 which compares children included and not included (due to missing data) in the final model for variables belonging to explanatory domains.

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Title: Preschoolers' parent rated health disparities are strongly associated with measures of adiposity in the Lifeways cohort study children

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Running Title: Childhood obesity a persistent predictor of preschoolers' PRH

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Lifecourse, self-rated health, obesity, BMI, waist circumference, preschool children

Word count: 3439

ABSTRACT (Words: 272)

Objective

To examine the relationship between lifecourse factors from preschoolers' micro-ecosystem and their parent-reported (mother-reported) health (PRH), following them prospectively from preconception to age 5-years. To investigate if preschoolers' BMI and waist-circumference were associated with preschoolers' PRH when controlled for lifecourse predictors.

Design

Lifeways cross-generation cohort study

Setting

Ireland

Participants

Of 1082 families, 62% mothers responded on a health and lifestyle questionnaire at follow-up. Food frequency, BMI and waist-circumference were measured. There were 547 family datasets available for analysis of children's PRH.

Main outcome measure

Mother-reported children's PRH at age-5. Associations with child's individual and familial exposures from preconception to age 5-years examined using logistic regression.

Results

In univariate analysis, relatively-positive rating of children's PRH were associated with children's lower intake of fats [OR(95%CI)=2.2(1.1-4.3)], higher intake of fruits/vegetables [OR(95%CI)=2.2(1.1-4.3)]; as well as familial socio-economic characteristics {higher household income [OR(95%CI)=3.0(1.6-5.9)], non-entitlement to means-tested healthcare

[OR(95%CI)=2.1(1.0-4.3)], mothers' higher education [OR(95%CI)=1.9(1.0-3.6)]}, psycho-social characteristics {father's participation in study [OR(95%CI)=2.1(1.0-4.3)], mothers' perceiving better support from partner [OR(95%CI)=2.3(1.2-4.3)], children [OR(95%CI)=1.9(1.0-3.7)] or relatives [OR(95%CI)=2.2(1.1-4.1)]}, parents' lifestyle {mothers' lower intake of energy [OR(95%CI)=2.2(1.1-4.3)], fathers' non-smoking status [OR(95%CI)=2.2(1.1-4.4)]}, and parents' health {mothers' self-rated health relatively-positive [OR(95%CI)=5.1(2.6-9.9)], fathers' self-rated health relatively-positive [OR(95%CI)=3.0(1.5-6.0)]}.

In multivariable analysis ($\chi 2$=34.2,df=21,N=303,R^2=0.26,p<0.05), one of the two strong predictors of children's relatively-positive PRH was child not being obese by International Obesity Task Force classification [OR(95%CI)=5.5(1.4-21.0)], observed also using BMI (kg/m^2) [OR(95%CI)=0.73(0.58-0.93)] or waist-circumference (cm) [OR(95%CI)=0.89(0.81-0.98)] as continuous variables. The other significant predictor was mothers' self-rated health relatively-positive [OR(95%CI)=4.2(1.5-12.2)].

Conclusions

Preschoolers' health is adversely associated with obesity and this is independent of lifecourse social and environmental inequalities. The findings suggest that reducing childhood obesity and improving maternal health may be useful ways to improve child's global health.

Strengths and limitations of this study

- Nationally representative sample of preschool-age children
- Examines the influence of lifecourse adversities, prospectively measured from preconception to age 5 on children's general health at age 5. The study analyses demographic, anthropometric, lifestyle, food and nutrients intake, psycho-social, socio-economic and health-related exposures from both children's individual as well as parental experiences.
- Demonstrates a significant and independent association between preschoolers' measured BMI as well as waist circumference and their general health status.
- The study is limited by a relatively small sample and use of parent-reported health status.

MAIN TEXT

Introduction

The development of children is critical to their adult well-being[1,2] and across the lifecourse even subjective estimates may be useful to reflect objectively measured health[3,4]. Bronfenbrenner[5] emphasised the importance of children's micro-ecosystem in their development. Recently, the World Health Organisation's (WHO) Commission on Social Determinants of Health (CSDH) presented a Total Environment Assessment Model for Early Child Development (TEAM-ECD),[6] which again illustrates the importance of individual and family spheres of influence on children's health. The relevance of socio-economic, psycho-social and lifestyle environment in child development and health is widely acknowledged.[6-8]

According to the lifecourse hypothesis, risk transmission is characterised by critical periods and accumulation of risk models.[9] Life Course Health Development (LCHD) framework[10] suggests that health is a consequence of multiple determinants that change in context of time and circumstances as an individual develops; these experiences are programmed into bio-behavioural regulatory systems during certain critical and sensitive periods of individual's lifetime to decide their health trajectory. The lifecourse framework on childhood disadvantage and adult health[11] suggests that parental and childhood circumstances from the point of conception influences individual's health in later life, and the individual's childhood health and later life circumstances may further add to this foundation. Based on this, Hertzman and colleagues[12] examined self-rated health in adulthood using an integrated lifecourse framework. There are a few other studies also which have examined lifecourse determinants of adult global[13,14] or specific health status.[15] On the contrary, the literature on the determinants of child global health status is sparse,[16,17] particularly for the preschool-age children.[18] Even rarer are studies whose examination includes early lifecourse determinants of child global health status.

Thus the first objective of our analysis was to prospectively examine the relationship between demographic, anthropometric, lifestyle, nutritional, psycho-social, socio-economic and health-related lifecourse exposures taken from the children's individual and family spheres of influence starting from preconception up to age 5-years and their global health status at preschool-age.

In social epidemiology, the construct of "embodiment" refers to biological expression of individuals' materio-social world.[19,20] Similarly in lifecourse epidemiology, it is hypothesised that early life experiences get "biologically embedded" during critical or sensitive periods of child development leading to gradients in health.[21,22]

The Foresight report identifies a large array of environmental determinants of obesity, a number of which are again related to early child development.[23] This suggests obesity as pivotal risk factor for subsequent health conditions.[24]

The negative relationship between obesity and self-rated health is now increasingly reported in adult populations,[25,26] some indicating a temporal relationship[27,28] and suggesting that obesity increases health inequalities over time.[28] However, evidence on the relationship between obesity and health is relatively limited in child population studies and those available have reported health-related-quality-of-life (HR-QoL)[29] instead of a generic measure such as global self-rated health. Moreover, this association is yet to be established for preschool-age children. To our knowledge just two population based studies have examined this association in preschool age-group children[30,31] and neither had nutritional information.

In the Longitudinal Study of Australian Children, Wake *et al*.[30] did not find a significant difference in global health status of overweight/obese and normal weight 4-5-year-old children. Skinner et al.,[31] using data on 3-5-year-olds from the US National Health and

Nutrition Examination Survey, reported a poorer global health status in obese and severely obese preschoolers. Neither of these studies accounted for a number of possibly relevant confounders, including parental BMI, parental health and nutritional variables.

We thus hypothesised that similar to findings from studies on older age-groups, anthropometric markers of child obesity in our preschool-age children study would also demonstrate a negative association with their global health status. The next objective of our analysis was to examine whether anthropometric markers of child obesity would emerge as strong predictors of global health status when accounted for other socio-economic, psycho-social, and lifestyle environmental factors in a multivariable model.

Methods

The Lifeways cross generation cohort study comprises three generations of 1082 Irish families and was established in 2001-03; the recruitment procedure of this nationally representative cohort has been described previously.[32-34] The a priori purpose was to examine familial and cross-generation influences on early childhood development over the first five years of children's lives. Briefly, would-be mothers were at random recruited from the two regional maternity hospitals in the Republic of Ireland to get a representative sample. A comparison between the Lifeways mothers and a nationally representative sample of women of the same age group from the SLÁN (Survey of Lifestyle, Attitudes and Nutrition) surveys of Republic of Ireland[35] confirmed that the Lifeways mothers were satisfactorily representative of the Irish general women on socio-demographic characteristics.[33]

At this early pregnancy stage mothers completed a health and lifestyle status questionnaire adapted from a validated instrument developed for Irish national SLÁN surveys.[35] Mothers reported their pre-pregnancy height (cm) and weight (kg) and their smoking status during pregnancy. Mothers' and partners' socio-economic status was recorded. Subsequently at

birth, the live infants were added to the cohort along-with maternity and birth related hospital information.

In 2007-08, when these children averaged five years of age, the cohort follow-up recorded a 62% response rate.[34,36] Though mothers who responded to the follow-up were more likely to be of higher socioeconomic status, these mothers did not significantly differ in their baseline anthropometric characteristics (including BMI) from non-responders.[34,36] At this 5-year follow-up, mothers repeated the health and lifestyle assessment questionnaire, with additional questions related to her family, including a five-level likert item question "In general, would you say your / your partner's / your Lifeways child's current health is Excellent, Very Good, Good, Fair or Poor". Mothers provided information on family's socio-economic, psycho-social, and lifestyle status. Mothers reported their habitual dietary intake for the previous year on a semi-quantitative food frequency (SQFFQ) instrument developed from the EPIC study (European Prospective Investigation into Cancer and Nutrition) and validated for Irish adult population.[37] Mothers also gave details for the Lifeways child's habitual diet for the previous year using a different SQFFQ instrument adapted from the UK National Diet and Nutrition Survey of 4.5-year-old children.[38] The mothers' and children's SQFFQ were validated in the Lifeways study using a 7-day weighed food diary in a sub-sample.[36] Food items were aggregated by defined shelves (food groups) of the Irish food pyramid and assessment was made for average servings per day of standard food item portions consumed from the "top" and "fruit and vegetable" food groups (shelves of Irish food pyramid). The "top" food group comprises of high calorie fat and sugar rich foods. Total energy (kcal) and total fats (g) intake were computed using conversion values from McCance & Widdowson's food composition tables[39] with a specially developed FFQ software version 1.0 ©.[40]

Mothers and children, and if available fathers, were offered at 5-year follow-up an anthropometric assessment at their home for height (cm), weight (kg) and waist

circumference (cm) using a standardised protocol,[34,36] with 80-85% mothers and children participating. Body mass index (BMI) was calculated from weight and height information (kg/m^2).

Thus variables from discrete stages (pre-pregnancy, early pregnancy, at birth, early infancy and 5-year follow-up) of child's early development representing lifecourse exposures from distinct domains (demographic, anthropometric, socio-economic, psycho-social, lifestyle, nutritional and health) of child's individual and family spheres of influence[6-8] were considered to analyse determinants of child's health status at age-5. The selection of variables, domains and spheres of influence are based on the CSDH constructed TEAM-ECD, a model of early child development.[6-8] These lifecourse variables have been summarised as per time frame in **Table 1**. This lifecourse time frame highlights the stages and transition points relevant from perspective of child's health development.[10] Additional details on these variables are provided in **eTable 1** available in the web only supplement. The independent variables have been arranged as child-related, family-related, mother-related, father-related groups for ease of presentation.

Table 1: Independent variables examined from lifecourse of 5-yr-old children

Lifecourse	Independent Variables
Pre-pregnancy	Maternal Pre-pregnancy BMI
Early pregnancy	Family stability
	Maternal smoking in pregnancy, Maternal Education level
	Paternal Education level
Birth	Child's Birth-weight, Gestational age, Gender
	Maternal Parity
Infancy	Child's breastfeeding status
When children averaged 5-yr age	Child's Age, Height, BMI, Waist circumference, Food intake: top and fruits & vegetables food groups, Nutrient intake: energy and fats intake
	Family household weekly income, Entitlement to means tested healthcare benefits scheme, Family structure (marital status), Support from partner, parents, children & relatives
	Maternal Age, Height, BMI, Waist circumference, Smoking, Employment status, Food intake: top and fruits & vegetables food groups, Nutrient intake: energy and fats intake, Self-rated health status
	Paternal Height, BMI, Waist circumference, Smoking, Employment status, Self-rated health status

Children's global health status rated in proxy by their mothers, hereafter referred to as parent-rated health (PRH), was the outcome variable of interest. The 5-graded scale response was dichotomised as relatively-positive health (excellent or very good) and relatively-negative health (poor or fair or good), based on similar dichotomisation in other studies on preschool and school children.[17,18,30] It is reasonable to take a higher cut-off when dichotomising this age dependent variable in this very young age-group as there would be very limited numbers of poor or fair health children.[17,18,41]

Initially, uni-variate associations were established between the independent predictors and children's PRH using independent t-tests or chi-square tests. Independent categorical variables were dichotomised in a manner that allowed contrasting extreme levels against the others. Thus, using International Obesity Task Force (IOTF) cut-offs, children's BMI was dichotomised as obese versus over-weight or normal-weight. Similarly nutrition variables ordered in quintiles were dichotomised as the extreme quintile (1^{st} or 5^{th}) versus the rest.

From these independent variables principally chosen on the basis of their relevance to the child's development,[6-8] all those that qualified at significance level 20% ($p<0.2$)[42] in univariate analyses were force entered into a multivariable logistic regression model. BMI (kg/m^2) and waist circumference (cm), the anthropometric markers of obesity, were tested separately in independent multivariable models. They were not analysed together within a model as results of possible interactions among body composition variables would have been difficult to interpret [43,44]. Initially BMI was tested as a categorical variable in a model, followed by two additional models substituting it with BMI and then waist circumference as continuous variables. Other independent variables were tested as categorical variables.

Ethical approval for the Lifeways study was obtained respectively from ethical committees of participating hospitals and the University College Dublin, Ireland. Written informed consent was obtained from study participants.

Results

There were 547 family datasets available for analysis of children's PRH. **Table 2** presents the uni-variate associations between children's lifecourse variables and PRH. Within the individual-sphere of influences, children's lifestyle behaviours (lower intake of fatty/sugary foods and total fats, and higher intake of fruits/vegetables) and their anthropometric measures at age-5 (not being obese, lower BMI, and lower waist circumference) qualified as determinants of children's relatively-positive PRH for further examination in the multivariable model.

In other words, retaining $p<0.2$ as the criterion for significance, the children's healthy food and nutrient intake habits – such as lower intake of unhealthy fat- and sugar- rich foods (servings/day) [OR(95%CI)=1.7(0.8-3.4)] or total fats (g) in their meals [OR(95%CI)=2.2(1.1-4.3)] and higher intake of healthy fruits and vegetables (servings/day)

[OR(95%CI)=2.2(1.1-4.3)] were positively associated with their favourable rating for health by their mothers. Conversely, children's higher BMI (kg/m^2) [OR(95%CI)=0.85(0.71-1.03)] and waist circumference (cm) [OR(95%CI)=0.95(0.88-1.02)] were inversely associated with a positive parental-rated health status.

Within the family-sphere of influences, socio-economic status (higher household income, non-entitlement to subsidised healthcare, both parents' higher education status, and father's employment status), psycho-social status (father's study participation, mother's perceived social support), mother's lifestyle behaviours (lower intake of fatty/sugary foods, total energy and total fats), father's lifestyle behaviours (non-smoker), and both parents' health status (relatively-positive self-rated health) qualified as determinants of children's relatively-positive PRH for further examination in the multivariable model.

In other words, by maintaining p<0.2 as the criterion for significance, several indicators of a family's better socio-economic status– such as higher household income (Euros/week) [OR(95%CI)=3.0(1.6-5.9)], not requiring subsidised healthcare [OR(95%CI)=2.1(1.0-4.3)], mother having a third level education [OR(95%CI)=1.9(1.0-3.6)], father having a third level education [OR(95%CI)=1.9(1.0-3.6)], father being self-employed [OR(95%CI)=2.5(0.8-7.9)]; family's better psycho-social status– such as father's involvement in family affairs [OR(95%CI)=2.1(1.0-4.3)], mother's perceiving a positive social support from spouse [OR(95%CI)=2.3(1.2-4.3)], parents [OR(95%CI)=2.0(1.0-4.1)], children [OR(95%CI)=1.9(1.0-3.7)], or relatives [OR(95%CI)=2.2(1.1-4.1)]; family's better lifestyle and food and nutrient intake habits– such as mother's lower intake of unhealthy fat- and sugar- rich foods (servings/day) [OR(95%CI)=1.7(0.8-3.4)], total energy (kcal) [OR(95%CI)=2.2(1.1-4.3)] and total fats (g) [OR(95%CI)=1.7(0.8-3.4)] in her meals, father's not being a smoker [OR(95%CI)=2.2(1.1-4.4)]; and family's better health status– such as mother [OR(95%CI)=5.1(2.6-9.9)] and father [OR(95%CI)=3.0(1.5-6.0)] having a positively

rated health status were positively associated with children's favourable rating for health by their mothers.

Table 2: Uni-variate lifecourse associates of children's relatively-positive parent-rated health, PRH (N=547)

		Relatively Negative PRH (n=42)		Relatively Positive PRH (n=505)			
	N	%(n)	Mean (SD)	%(n)	Mean (SD)	OR	95% CI
Child's Individual Characteristics							
Birth-weight adjusted for gestational age (g)	487	(34)	3564.1 (616)	(453)	3548.4 (552)	1.00	(0.999-1.001)
Child's Age (Yrs)	547	(42)	5.42 (0.23)	(505)	5.46 (0.25)		
Gender	547						
Male		8.0% (22)		92.0% (242)		Ref	
Female		7.1% (21)		92.9% (262)		1.14	(0.60-2.20)
BMI (kg/m^2)	464	(35)	17.09 (2.5)	(429)	16.59 (1.6)	0.85	(0.71-1.03)^
BMI [IOTF]	464						
Obese		16.7% (5)		83.3% (25)		Ref	
Overweight / Normal		6.9% (30)		93.1% (404)		2.69	(0.96-7.54)^
Waist Circumference (cm)	462	(35)	57.01 (6.8)	(427)	55.88 (4.3)	0.95	(0.88-1.02)†
Height (cm)	464	(35)	111.6 (5.6)	(429)	112.1 (4.8)	1.02	(0.95-1.10)
Breastfeeding	528						
Not breastfed		6.5% (16)		93.5% (229)		Ref	
Breastfed		8.8% (25)		91.2% (258)		0.72	(0.38-1.38)
Energy (Kcal)	547						
Quintile 5 (>1794 kcal)		10% (11)		90.0% (99)		Ref	
Quintile 1-4		7.1% (31)		92.9% (406)		1.46	(0.71-3.00)
Fats (g)	547						
Quintile 5 (>62.9 g)		12.8% (14)		87.2% (95)		Ref	
Quintile 1-4		6.4% (28)		93.6% (410)		2.16	(1.09-4.26)*
Top food group (servings/day)	547						
Quintile 5 (>6.47 servings)		10.9% (12)		89.1% (98)		Ref	
Quintile 1-4		6.9% (30)		93.1% (407)		1.66	(0.82-3.36)†
Fruits Veg food group (servings/d)	547						
Quintile 1 (<2.1 servings)		12.8% (14)		87.2% (95)		Ref	
Quintile 2-5		6.4% (28)		93.6% (410)		2.16	(1.09-4.26)*
Family Characteristics							
Household Weekly Income	509						
Less than 760 Euros/wk		13.3% (26)		86.7% (170)		Ref	
More than 760 Euros/wk		4.8% (15)		95.2% (298)		3.04	(1.57-5.90)**
Entitlement to General Medical Card	532						
Entitled		13% (12)		87.0% (80)		Ref	
Not entitled		6.6% (29)		93.4% (411)		2.13	(1.04-4.34)*
Fathers' Participation	547						
Not		9.7% (31)		90.3% (290)		Ref	
Yes		4.9% (11)		95.1% (215)		2.09	(1.03-4.25)*
Marital Status	542						
Others		11.4% (5)		88.6% (39)		Ref	
Married/Cohabiting		7.2% (36)		92.8% (462)		1.65	(0.61-4.43)
Elder children in family (Parity)	535						
Nullipara		8% (18)		92.0% (207)		Ref	
Multipara		7.7% (24)		92.3% (286)		1.04	(0.55-1.96)
Support from Spouse/Partner	538						
Lesser support		12.9% (17)		87.1% (115)		Ref	
More support		6.2% (25)		93.8% (381)		2.25	(1.18-4.32)*
Support from Parents	487						
Lesser support		12.5% (12)		87.5% (84)		Ref	
More support		6.6% (26)		93.4% (365)		2.01	(0.97-4.14)^
Support from Children	532						
Lesser support		10.6% (20)		89.4% (169)		Ref	
More support		5.8% (20)		94.2% (323)		1.91	(1.00-3.65)*
Support from Close Relatives	510						
Lesser support		12.4% (19)		87.6% (134)		Ref	
More support		6.2% (22)		93.8% (335)		2.16	(1.13-4.12)*

Table 2: Uni-variate lifecourse associates of children's relatively-positive parent-rated health, PRH (continued)

	Relatively Negative PRH (n=42)			Relatively Positive PRH (n=505)			
	N	%(n)	Mean (SD)	%(n)	Mean (SD)	OR	95% CI
Maternal Characteristics							
Pre-pregnancy BMI (kg/m^2)	475	(36)	23.3 (3.3)	(439)	23.8 (3.9)	1.04	(0.94-1.14)
Pre-pregnancy BMI [WHO cut offs]							
Obese		2.6% (1)		97.4% (38)		Ref	
Overweight / Normal		8% (35)		92.0% (401)		0.30	(0.04-2.26)
Mother's Age (Yrs)	546	(42)	36.5 (6.3)	(504)	37.1 (5.3)	1.02	(0.96-1.08)
BMI at 5-yr follow-up (kg/m^2)	432		25.6 (3.9)		26.3 (5.0)	1.03	(0.95-1.12)
BMI at 5-yr follow-up [WHO cut offs]	432						
Obese		7.2% (5)		92.8% (64)		Ref	
Overweight / Normal		7.4% (27)		92.6% (336)		0.97	(0.36-2.62)
Waist Circumference (cm)	434	(31)	85.3 (10.6)	(403)	87.6 (11.9)	1.02	(0.99-1.05)
Height (cm)	454	(33)	161.9 (6.8)	(421)	162.9 (6.0)	1.03	(0.97-1.09)
Smoking in pregnancy	534						
Smoker		8.1% (8)		91.9% (91)		Ref	
Non-Smoker		7.6% (33)		92.4% (402)		1.07	(0.48-2.4)
Smoking at 5-yr follow-up	541						
Smoker		7.6% (9)		92.4% (110)		Ref	
Non-Smoker		7.6% (32)		92.4% (390)		1.0	(0.46-2.15)
Energy (Kcal)	546						
Quintile 5 (>2570.9 kcal)		13% (14)		87.0% (94)		Ref	
Quintile 1-4		6.4% (28)		93.6% (410)		2.18	(1.11-4.30)*
Fats (g)	546						
Quintile 5 (>106 g)		11% (12)		89.0% (97)		Ref	
Quintile 1-4		6.9% (30)		93.1% (407)		1.68	(0.83-3.40)†
Top food group (servings/day)	545						
Quintile 5 (>8.35 servings)		11% (12)		89.0% (97)		Ref	
Quintile 1-4		6.9% (30)		93.1% (406)		1.67	(0.83-3.39)†
Fruits Veg food group (servings/day)	546						
Quintile 1 (<4.5 servings)		9.1% (10)		90.9% (100)		Ref	
Quintile 2-5		7.3% (32)		92.7% (404)		1.26	(0.60-2.65)
Education level	534						
Lower		10.4% (25)		89.6% (215)		Ref	
Third Level		5.8% (17)		94.2% (277)		1.90	(1.00-3.60)*
Employment	545						
Not Earning		6.4% (15)		93.6% (221)		Ref	
Employed		9% (22)		91.0% (222)		0.69	(0.35-1.36)
Self employed		7.7% (5)		92.3% (60)		0.81	(0.29-2.33)
Self reported health	546						
Relatively Negative		17.1% (27)		82.9% (131)		Ref	
Relatively Positive		3.9% (15)		96.1% (373)		5.10	(2.64-9.93)**
Paternal Characteristics							
BMI at 5-yr follow-up (kg/m^2)	66	(4)		(62)		0.97	(0.76-1.23)
Waist Circumference (cm)	65	(3)		(62)		1.01	(0.90-1.13)
Height (cm)	66	(4)		(62)		1.01	(0.88-1.15)
Smoking at 5-yr follow-up	521						
Smoker		11.5% (16)		88.5% (123)		Ref	
Non-Smoker		5.5% (21)		94.5% (361)		2.24	(1.13-4.42)*
Education level	514						
Lower		11.1% (16)		88.9% (128)		Ref	
Third Level		6.2% (23)		93.8% (347)		1.89	(0.97-3.68)^
Employment	518						
Not Earning		9.2% (8)		90.8% (79)		Ref	
Employed		7.9% (24)		92.1% (279)		1.18	(0.51-2.72)
Self employed		3.9% (5)		96.1% (123)		2.49	(0.79-7.89)†
Self reported health	510						
Relatively Negative		12.6% (20)		87.4% (139)		Ref	
Relatively Positive		4.6% (16)		95.4% (335)		3.01	(1.52-5.99)**

**p<0.01, *p<0.05, ^p<0.1, †p<0.2; Ref=reference category (OR=1)

Table 3 presents the multivariable model for association between qualifying lifecourse variables and children's relatively-positive PRH at age-5. A significantly strong predictor of children's relatively-positive PRH was child's not being obese by IOTF classification [OR(95%CI)=5.5(1.4-21.0)]. When BMI was tested as a continuous variable, there was 0.73 (95%CI=0.58-0.93) times lower odds of the child being positively rated on health status for every 1 kg/m^2 increase in their BMI. Similarly in the waist circumference model, for every 1 cm increase there was 0.89 (95%CI=0.81-0.98) times lower odds of the child getting a relatively-positive rating on health status. Thus the association between children's BMI or waist circumference and their PRH only strengthened following adjustments in this multivariate model, irrespective of being analysed as a categorical or continuous variable. Another significant predictor of children's relatively-positive PRH was mother's having rated her own health as relatively-positive. These predictors maintained the highest strength of association with children's health status when independent variables were standardised (not reported here). None of the other variables reached the level of statistical significance. The models explained over 25 percent of variance for children's PRH.

Table 3: Multivariable Logistic Regression model for predictors of children's relatively-positive parent-rated health, PRH (N=303)

	Relatively Positive PRH			Relatively Positive PRH			Relatively Positive PRH		
	BMI Categorical[1]			BMI Continuous[2]			WC Continuous[3]		
	OR	95% CI		OR	95% CI		OR	95% CI	
Child's Individual Characteristics									
BMI [IOTF], Obese† vs Overweight / Normal	5.48	(1.43-21.03)	*						
BMI kg/m^2 [Continuous]				0.73	(0.58-0.93)	**			
Waist Circumference cm [Continuous]							0.89	(0.81-0.98)	*
Fats gm [Quintiles], Q5† vs Q1-4	1.57	(0.42-5.79)		1.49	(0.40-5.53)		1.32	(0.36-4.80)	
Top food group servings/d [Quintiles], Q5† vs Q1-4	1.23	(0.33-4.53)		1.30	(0.36-4.63)		1.29	(0.36-4.62)	
Fruits Veg food group servings/d [Quintiles], Q1† vs Q2-5	2.57	(0.75-8.80)		2.86	(0.83-9.93)		2.73	(0.78-9.49)	
Family Characteristics									
Household Weekly Income, Less† vs High	1.85	(0.63-5.40)		1.76	(0.59-5.21)		1.79	(0.61-5.26)	
Entitlement to General Medical, Card Yes† vs No	0.94	(0.24-3.71)		1.03	(0.26-4.07)		1.04	(0.26-4.10)	
Fathers' Participation, No† vs Yes	1.88	(0.68-5.21)		1.86	(0.67-5.16)		2.06	(0.74-5.71)	
Support from Spouse/Partner, Less† vs More	0.70	(0.20-2.49)		0.67	(0.19-2.33)		0.74	(0.22-2.52)	
Support from Parents, Less† vs More	1.92	(0.53-6.93)		2.33	(0.64-8.42)		2.37	(0.66-8.53)	
Support from Children, Less† vs More	1.15	(0.38-3.45)		1.29	(0.42-3.91)		1.25	(0.41-3.82)	
Support from Close Relatives, Less† vs More	0.86	(0.23-3.13)		0.84	(0.24-3.02)		0.84	(0.23-3.01)	
Maternal Characteristics									
Energy Kcal [Quintiles], Q5† vs Q1-4	1.89	(0.30-11.84)		2.00	(0.31-12.86)		1.57	(0.28-8.84)	
Fats gm [Quintiles], Q5† vs Q1-4	0.72	(0.09-5.54)		0.59	(0.07-4.77)		0.92	(0.13-6.41)	
Top food group servings/d [Quintiles], Q5† vs Q1-4	1.08	(0.29-3.94)		1.30	(0.36-4.65)		1.18	(0.32-4.34)	
Education, Lower† vs Third level	1.34	(0.47-3.78)		1.35	(0.48-3.80)		1.48	(0.53-4.13)	
Self reported health status, Rel.Negative† vs Rel.Positive	4.20	(1.45-12.20)	**	4.42	(1.53-12.79)	**	4.17	(1.47-11.87)	**
Paternal Characteristics									
Current Smoking status, Yes† vs No	1.37	(0.48-3.93)		1.31	(0.45-3.83)		1.53	(0.54-4.35)	
Education, Lower† vs Third level	0.69	(0.21-2.28)		0.79	(0.24-2.57)		0.83	(0.26-2.67)	
Employment, Non-earning † vs Self employed	1.60	(0.73-3.53)		1.52	(0.69-3.32)		1.57	(0.70-3.53)	
Self reported health status, Rel.Negative† vs Rel.Positive	1.48	(0.52-4.20)		1.54	(0.54-4.35)		1.43	(0.51-3.96)	

OR=Odds Ratio; †Reference category (OR=1); **p<0.01 (2-tailed), *p<0.05 (2-tailed)

Rel.Negative=Relatively Negative, Rel.Positive=Relatively Positive

[1]Child BMI as a categorical variable; Model Chi-sq = 34.2, df = 21, p = 0.034; -2LL = 128.6, Nagelkerke R-sq = 0.26

[2]Child BMI as a continuous variable; Model Chi-sq = 35.9, df = 21, p = 0.022; -2LL = 126.9, Nagelkerke R-sq = 0.27

[3]Child waist circumference as a continuous variable; Model Chi-sq = 33.8, df = 21, p = 0.038; -2LL = 128.9, Nagelkerke R-sq = 0.25

Discussion

This analysis showed that determinants from both child's individual and family spheres have an influence on child's health at preschool-age. The factors from all three material, psycho-social and lifestyle domains, the major explanations for child health inequalities,[8] were associated at uni-variate levels. However, in the final model this analysis clearly demonstrated a negative association between child's obesity and health status. Child's not being obese was one of the significantly strong predictors of child's relatively-positive health status, which was also observed with measured BMI and waist circumference analysed as continuous variables.

This negative relationship observed between measured obesity and PRH conforms to published literature on primary school age-group children and adolescents.[45-47] Most importantly, for the first time to our knowledge, this analysis demonstrates the association having adjusted for food and nutrient intake, along-with a wide range of other explanatory variables.

Self-rated health is an important and valid measure of morbidity, mortality, longevity and health status,[3,4] also in Irish adult[48,49] and children.[16] It is believed to be a more inclusive measure of health than the objective measurements, with a capacity to comprehensively evaluate health dynamics, behaviours and psycho-physiological states that are not otherwise easy to measure.[3] This holistic measure better accommodates the WHO defined concept of health as opposed to a diagnosed specific disease.[3] Use of parent proxy for child self-reported health is justified for children too young to have adequate cognitive skills.[50,51] Systematic reviews report good agreement between ratings by children and their parents on child HRQoL, particularly for physical health domain.[50-52] Parents tend to be thoughtful when responding to proxy questions and report children's usual health disposition.[53] Studies on construct validity report positively.[54-57] Maternal ratings of child's general health status were found sensitive when validated against children's illnesses and other morbidity or healthcare indicators,[41,58-60] including evidence of a gradient in strength of these associations.[41] Many national-level studies have accepted parent proxy as an

appropriate measure[17,18,61,62] and successfully used it to longitudinally demonstrate risk and consequences of child health.[17,61]

Self-rated health, a composite measure, represents all domains of HR-QoL,[4] but better represents physical health than HR-QoL.[63] Studies on older age-group children have reported stronger/sole negative associations for general/physical health domain of HR-QoL and obesity,[46,64] irrespective whether children themselves or parents reported their HRQoL,[29] and also whether BMI was analysed as a categorical,[45,46] or continuous variable.[65,66]

Another relevance of this analysis is in demonstrating this association of obesity with general-health in a nationally representative sample of preschool-age children, for which literature is scant. Though, a few have shown similar association of obesity with specific paediatric conditions or admission history in this age-group.[30,31,67-70] A longitudinal study speculated that pre-school obesity influences a decline in early-age health, and then both obesity and poor-health tracks into adolescence.[71] The WHO recommends high priority for determinants of health inequalities during early development.[72]

The Lifeways previously demonstrated longitudinal association between parental socio-economic and lifestyle characteristics and child's BMI and waist circumference.[36] In this analysis when same anthropometric measures are included along-with material, psycho-social, and lifestyle determinants of child obesity and health, a prominent relationship emerges between children's anthropometric measures and health status. One possible explanation is that determinants of health inequalities biologically embed[21,22] in early life and child obesity is an early phenotypic expression of this inequality; though the continued influence of environmental factors is not undermined. Adult[25,26] and adolescence studies[46,47] have also shown this association to be independent of socio-demographic, lifestyle or health-related factors.

The observed association between BMI or waist circumference and PRH in the present analysis

may be temporal, as demonstrated in adults.[27,28] Though a number of large scale cross sectional studies have shown an association between anthropometric measures of obesity and self rated health,[73] only recently a few nationally representative prospective studies have established the temporality of this association in adults.[27,28] Though this relationship maybe bi-directional to an extent,[74,75] the mounting evidence from longitudinal birth cohort studies regarding a sequential relationship between lifetime growth trajectories and adult disease, disability and deaths[2] primarily rules out reverse causality in this association and suggests that the association observed in our birth cohort is also more likely to be temporal. Moreover, the available findings from a few longitudinal studies on primary school age children suggest that at least in the childhood this inverse association found between BMI and HRQoL is predominantly in the given direction and not the reverse.[76,77] However, this needs careful interpretation as both anthropometric and health data were concurrently collected, and this limitation may be addressed with next sweep of cohort data collection.

This analysis demonstrated that maternal health was strongly predictive of her child's health. One concern is that mother's perception of her own health may bias her perception of her child's health. However, this intergenerational association has been previously reported,[41,58,59,78-81] and reporting mothers can effectively discriminate between their own and children's health.[41,58,59,79,80,82] Several mechanisms such as inherited susceptibility, uterine environment and shared environment have been suggested for this familial aggregation pattern.[58,79,80]

Maternal BMI may be related to both maternal self-rated health and child's BMI, so the observed associations in this analysis could possibly be a reflection of an association between maternal BMI and child's PRH. However, this was not observed in our analysis. Maternal BMI at both pre-pregnancy and 5-year follow-up were not associated with child's PRH at univariate level. Also, when maternal BMI was forcibly added into the multivariable model (not reported here), the observed associations did not attenuate.

The study has limitations in use of reported rather than measured health status and a relatively small sample size. Though the study was able to detect the major explanatory domains for child health inequalities documented in the literature[8], the relatively small sample size of this study may possibly have underpowered it to detect variables with lesser effect sizes. The complete case approach to analysis reduced the sample size of the final multivariate model, which may have power implications. However, this missing data was on account of an accumulation across a number of variables. On analysis, there was no evidence of selectivity in the participants for whom there were missing data (**eTable 2**). **eTable 2,** available in the web only supplement, compares children included and not included in the final model for variables belonging to explanatory domains. It suggests that there were no significant differences in the characteristics of children included and not included (due to missing data) for analysis, suggesting that the children in the final model are representative of the study participants as a whole. It may be argued that the reduced sample size possibly influenced the odds ratio estimate for the association between children's relatively-positive PRH and the child's not being obese (using a categorical IOTF classification). Nonetheless this association between children's anthropometric measures and their parent-rated health variable is likely to be coherent, because these associations remain statistically significant even when BMI and WC are analysed as continuous variables.

As in most birth cohort studies,[83,84] the Lifeways birth cohort also experienced the attrition of mothers belonging to lower socio-economic status in the early stages of the study. Though this may underestimate some socioeconomic inequalities [85], it does not negate the exposure-outcome associations detected through regression models of such longitudinal studies [86,87].

Nevertheless, this study has advantages in use of lifecourse variables from pre-conception to age of 5-years, with measured BMI and waist circumference data. It also has detailed foods and nutrient data along-with other socio-economic, psycho-social and lifestyle variables for child and both parents.

In conclusion, these analyses from the Lifeways cohort show that lifecourse adversities were associated with mother-reported health for preschoolers, suggesting an early life influence. Preschoolers' BMI and waist-circumference demonstrated strong negative associations with mother-reported health independent of socio-economic, psycho-social, and lifestyle factors, suggesting early biological expression of lifecourse adversities. The findings have important implications in understanding how early life environment may create inequalities in developmental health.

Footnotes

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Contributors

AS undertook all analyses reported in this manuscript, interpreted the findings and drafted the manuscript. CM contributed to data collection at five year follow-up, interpretation of the analysis and critical revision of the manuscript. CCK designed the study, supervised the analyses, interpretation of results and intellectual content of the manuscript. All three authors approved the final version.

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Competing interests

None

Ethical approvals

Ethics committees of Coombe University Hospital, Dublin, University College Hospital Galway, University College Dublin, Dublin, and the Irish College of General Practitioners, Ireland.

Data sharing statement

There are no additional data available. The data manager may be contacted at john.obrien@ucd.ie for more details on the Lifeways Cross-Generation Cohort Study.

Appendices

The supplement includes eTable 1 displaying details of examined variables and eTable 2 which compares children included and not included (due to missing data) in the final model for variables belonging to explanatory domains.

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eTable 1: Lifecourse variables examined for relationship with children's parent-rated health, PRH

Independent Variables	Time	Categories
Child's Individual characteristics		
Demographic and Anthropometric		
Birth-weight standardised for gestational age (g)	Measured at birth	continuous measure
Age at 5-year follow-up (years)	At 5-yr follow-up	continuous measure
Gender		Male, Female
Body Mass Index (BMI) kg/m^2	Measured at 5-yr follow-up	continuous measure Also as obese versus overweight or normal using IOTF definitions
Waist Circumference (cm)	Measured at 5-yr follow-up	continuous measure
Height (cm)	Measured at 5-yr follow-up	continuous measure
Lifestyle/Nutrition		
Breastfeeding	At infancy	breastfed or not
Top food group servings per day	At 5-yr follow-up	5th Quintile (>6.47 servings) versus 1-4 Quintiles.
Fruits & Vegetables food group servings /day	At 5-yr follow-up	1st Quintile (<2.1 servings) versus 2-5 Quintiles
Total Energy intake (kilocalories/day)	At 5-yr follow-up	5th Quintile (>1794 kcal) versus 1-4 Quintiles
Total Fats intake (grams/day)	At 5-yr follow-up	5th Quintile (>62.9g) versus 1-4 Quintiles
Family characteristics		
Socio-Economic		
Household weekly income	At 5-yr follow-up	composite family income more or less than 760 Euros a week
Entitlement to General Medical Card scheme, a means tested healthcare benefits scheme	At 5-yr follow-up	Families entitled or not to General Medical Card
Psycho-Social		
Fathers' participation (Family stability)	Early pregnancy stage	Families whose fathers participated in the study versus families whose fathers did not
Mother's marital status (Family structure)	At 5-yr follow-up	Married or cohabiting versus single, separated, divorced or widowed.
Elder children in family [Parity was a proxy measure for presence of elder siblings to the Lifeways child]	Early pregnancy stage	nullipara versus one or more para
Support from spouse or partner	At 5-yr follow-up	Mothers perceived "a lot" of support from spouse or partners versus perceived receiving "some, so-so, little" support
Support from parents	At 5-yr follow-up	Mothers perceived "a lot" of support from parents versus perceived receiving "some, so-so, little" support

Support from children, inclusive Lifeways child	At 5-yr follow-up	Mothers perceived “a lot” of support from children versus perceived receiving “some, so-so, little” support
Support from close relatives	At 5-yr follow-up	Mothers perceived “a lot” of support from relatives versus perceived receiving “some, so-so, little” support
Maternal characteristics		
Demographic and Anthropometric		
Age at 5-year follow-up (years)	At 5-yr follow-up	continuous measure
Pre-pregnancy BMI (kg/m^2)	Pre-pregnancy, Self-reported in early pregnancy	continuous measure Also as obese versus overweight or normal using WHO definitions
BMI at 5-year follow-up (kg/m^2)	Measured at 5-yr follow-up	continuous measure Also as obese versus overweight or normal using WHO definitions
Waist Circumference at 5-year follow-up (cm)	Measured at 5-yr follow-up	continuous measure
Height at 5-year follow-up (cm)	Measured at 5-yr follow-up	continuous measure
Lifestyle/Nutrition		
Smoking during pregnancy	Early pregnancy stage	Current smoker or not
Smoking at 5-year follow-up	At 5-yr follow-up	Current smoker or not
Top food group servings per day	At 5-yr follow-up	5th Quintile (>8.35 servings) versus 1-4 Quintiles.
Fruits & Vegetables food group servings /day	At 5-yr follow-up	1st Quintile (<4.5 servings) versus 2-5 Quintiles
Total Energy intake (kilocalories/day)	At 5-yr follow-up	5th Quintile (>2570.9 kcal) versus 1-4 Quintiles
Total Fats intake (grams/day)	At 5-yr follow-up	5th Quintile (>106.0 g) versus 1-4 Quintiles
Socio-Economic		
Education level	Early pregnancy stage	Third level versus lower levels of education status
Employment status	At 5-yr follow-up	Non-earning versus Employed versus Self employed
Health		
Self-rated health status of mothers	At 5-yr follow-up	Relatively Positive (“Excellent” or “Very Good”) versus Relatively Negative (“Poor”/ “Fair” /“Good”) responses
Paternal Characteristics		
Anthropometric		
BMI at 5-year follow-up (kg/m^2)	Measured at 5-yr follow-up	continuous measure
Waist Circumference at 5-year follow-up (cm)	Measured at 5-yr follow-up	continuous measure
Height at 5-year follow-up (cm)	Measured at	continuous measure

	5-yr follow-up	
Lifestyle		
Smoking at 5-year follow-up	At 5-yr follow-up	Current smoker or not
Socio-Economic		
Education level	Early pregnancy stage	Third level versus lower levels of education status
Employment status	At 5-yr follow-up	Non-earning versus Employed versus Self employed
Health		
Self-rated health status of fathers (in proxy)	At 5-yr follow-up	Relatively Positive (“Excellent” or “Very Good”) versus Relatively Negative (“Poor”/ “Fair” /“Good”) responses

eTable 2: Comparative characteristics of children included and not included in the final model (with and without missing data) for selective variables from each of the explanatory domains -

S.No.	Variables		Children NOT in the final model – with missing data (n=244)	Children IN the final model – without missing data (n=303)	Statistic - chi-square or t-test	p-value
	OUTCOME VARIABLE	**sub-categories**	**n (%)**	**n (%)**		
1	Parent rated health status of the child	Good+Fair+Poor	19 (7.8%)	23 (7.6%)		
		Excellent+Very Good	225 (92.2%)	280 (92.4%)	0.01	0.93
	INDEPENDENT VARIABLES					
Anthropometric Variables						
2	Child BMI categorised by IOTF classification	Obese	10 (6.2%)	20 (6.6%)		
		Overweight plus Normal	151 (93.8%)	283 (93.4%)	0.03	0.87
3	Child BMI (continuous) kg/m^2	Mean (Std Dev)	16.73 (1.53)	16.57 (1.74)	0.96	0.34
4	Child waist circumference (continuous) cm		55.95 (4.49)	55.97 (4.54)	0.06	0.95
Nutrition Variables						
5	Top food group consumed by Child (servings/day)	Quintile 5	46 (18.9%)	64 (21.1%)		
		Quintiles1-4	198 (81.1%)	239 (78.9%)	0.43	0.51
6	Top food group consumed by Mothers (servings/day)	Quintile 5	46 (19.0%)	63 (20.8%)		
		Quintiles1-4	196 (81.0%)	240 (79.2%)	0.27	0.61
Behaviour Variables						
7	Father's smoking	Smoker	58 (26.6%)	81 (26.7%)		
		Non-Smoker	160 (73.4%)	222 (73.3%)	0.01	0.97
Health Variables						
8	Father's health status rating	Good+Fair+Poor	69 (33.3%)	90 (29.7%)		
		Excellent+Very Good	138 (66.7%)	213 (70.3%)	0.76	0.39
9	Mother's health status rating	Good+Fair+Poor	79 (32.5%)	79 (26.1%)		
		Excellent+Very Good	164 (67.5%)	224 (73.9%)	2.72	0.10
Socio Economic Variables						
10	Father's Education	Lower	64 (30.3%)	80 (26.4%)		
		Third level	147 (69.7%)	223 (73.6%)	0.95	0.33
11	Father's employment status	Not Earning	44 (20.5%)	43 (14.2%)		
		Employed	117 (54.4%)	186 (61.4%)		
		Self employed	54 (25.1%)	74 (24.4%)	4.02	0.13
Psycho-Social Variables						
12	Support from Parents	Lesser support	33 (17.9%)	63 (20.8%)		
		More support	151 (82.1%)	240 (79.2%)	0.59	0.44

STROBE Statement: Preschoolers' parent rated health disparities are strongly associated with measures of adiposity in the Lifeways cohort study children

	Item No	Recommendation	Done
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	✓
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	✓
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	✓
Objectives	3	State specific objectives, including any prespecified hypotheses	✓
Methods			
Study design	4	Present key elements of study design early in the paper	✓
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	✓
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	✓
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	✓
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	✓
Bias	9	Describe any efforts to address potential sources of bias	✓
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	✓
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	✓
		(*b*) Describe any methods used to examine subgroups and interactions	✓
		(*c*) Explain how missing data were addressed	✓
		(*d*) If applicable, explain how loss to follow-up was addressed	✓
		(*e*) Describe any sensitivity analyses	✓
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	✓
		(b) Give reasons for non-participation at each stage	✓
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	✓
		(b) Indicate number of participants with missing data for each variable of interest	✓
		(c) Summarise follow-up time (eg, average and total amount)	✓
Outcome data	15*	Report numbers of outcome events or summary measures over time	✓
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted	✓

		estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	✓
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	✓
Discussion			
Key results	18	Summarise key results with reference to study objectives	✓
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	✓
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	✓
Generalisability	21	Discuss the generalisability (external validity) of the study results	✓
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	✓

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.