How Nutrition and Health Change over the Life Course: The Role of Longitudinal Studies

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DEPARTMENT OF POPULATION MEDICINE
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PROJECT Viva
A STUDY OF HEALTH FOR THE NEXT GENERATIO
CORAL
DIVISION OF
CHRONIC DISEASE RESEARCH ACROSS THE LIFECOURSE

Why a longitudinal cohort?

Benefits of Studying Diet Longitudinally

- Identify life stages when diet changes – opportunities for targeted intervention
- Understand the relationship between diet at different life stages and health status/chronic disease
- Characterize the relationship between dietary shifts and transitions in life circumstances/other behaviors
- Reduces risk of bias, which can result when single measurements of diet are applied in different life stages without considering factors that contribute to differential shifts in dietary quality

Mid to older adulthood

- Increasing risk of malnutrition with aging
- Generally lower energy requirements
- Development of chronic diseases that affect nutritional status

PMID: 29704915

Selected Cohort Studies on Diet Trajectories: Mid-Older Adulthood

Cohort	Location (N)	Life Stage or age	Diet Characterization	Findings
Baltimore Longitudinal Study of Aging[1]	US N=851 mostly men	Mid-adulthood (~30-59y)	3-day diet records; Adherence to the AHEI	Two trajectories characterized, both indicating improvements in diet quality over time. Less dietary improvement predicted poorer physical function (SPPB) at older age
Australian Longitudinal Study on Women's Health[2]	Australia n=2381 women	Mid-adulthood (45-49 at baseline 2001, followed 9y)	FFQ validated in Australia used to develop overall diet quality score aligned with Australian guidelines	Women with the greatest improvement in diet quality over 9 years gained significantly (1.2kg) less weight, compared to those with worsening diet quality over time
Framingham Offspring Cohort[3]	Framingham, MA n=2187 men and women	Mean age 52 at baseline 1991, median 13 years follow-up	DASH diet concordance	Every increase in DASH score associated with modest increase in SBP; no associations with DBP or incident HTN

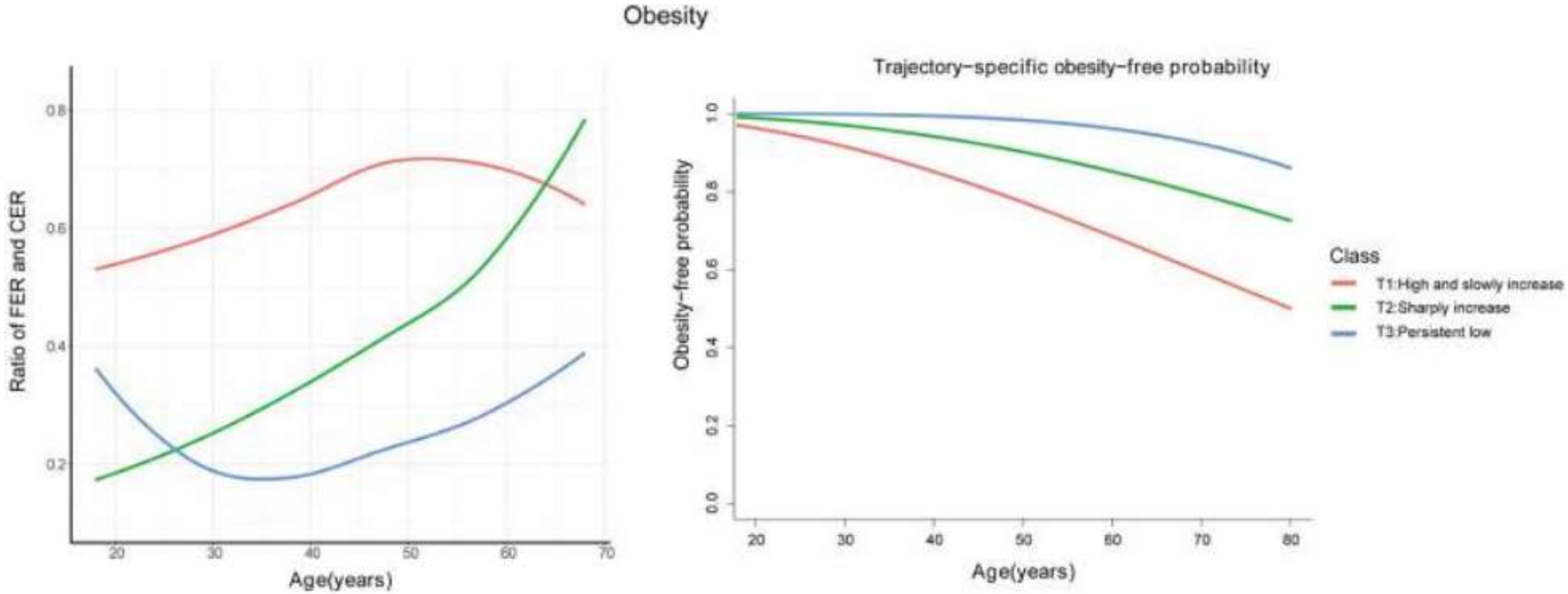
1. PMID: 33216872; 2. PMID: 31767421; 3 PMID: 26259122

China Health and Nutrition Study

- ~30,000 adults aged 18-60
- 8 surveys across 20 years, 1991 to 2011
- 3 consecutive days of 24-hour recalls by trained interviewers
- Several analyses suggesting that diet trajectories important above and beyond diet at one period in time

China Health and Nutrition Study

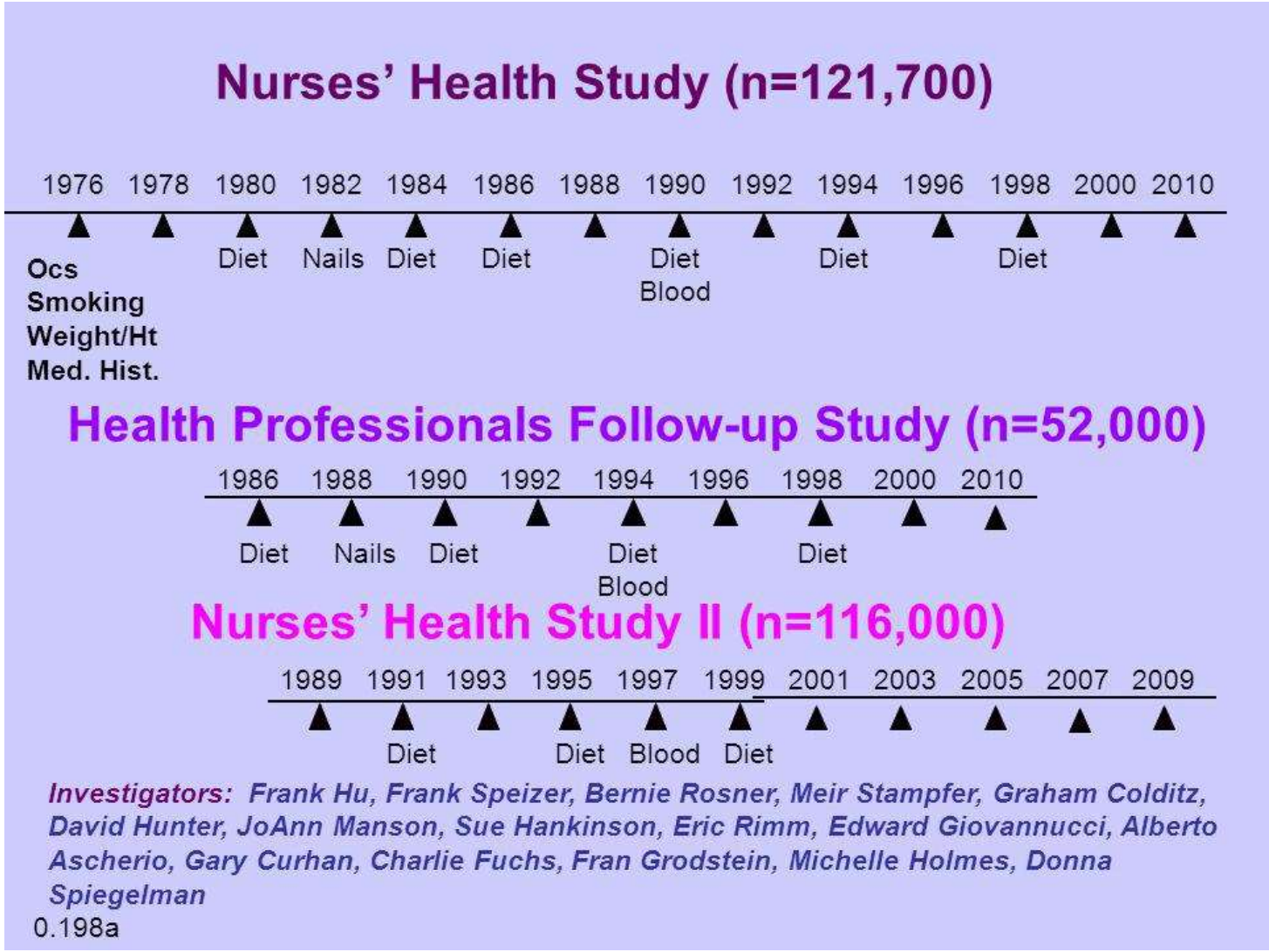
Ratio of fat to carbohydrate intake over time: Both where you start and where you end up matter; similar associations for diabetes, hypertension, all cause mortality (PMID: 34552952)



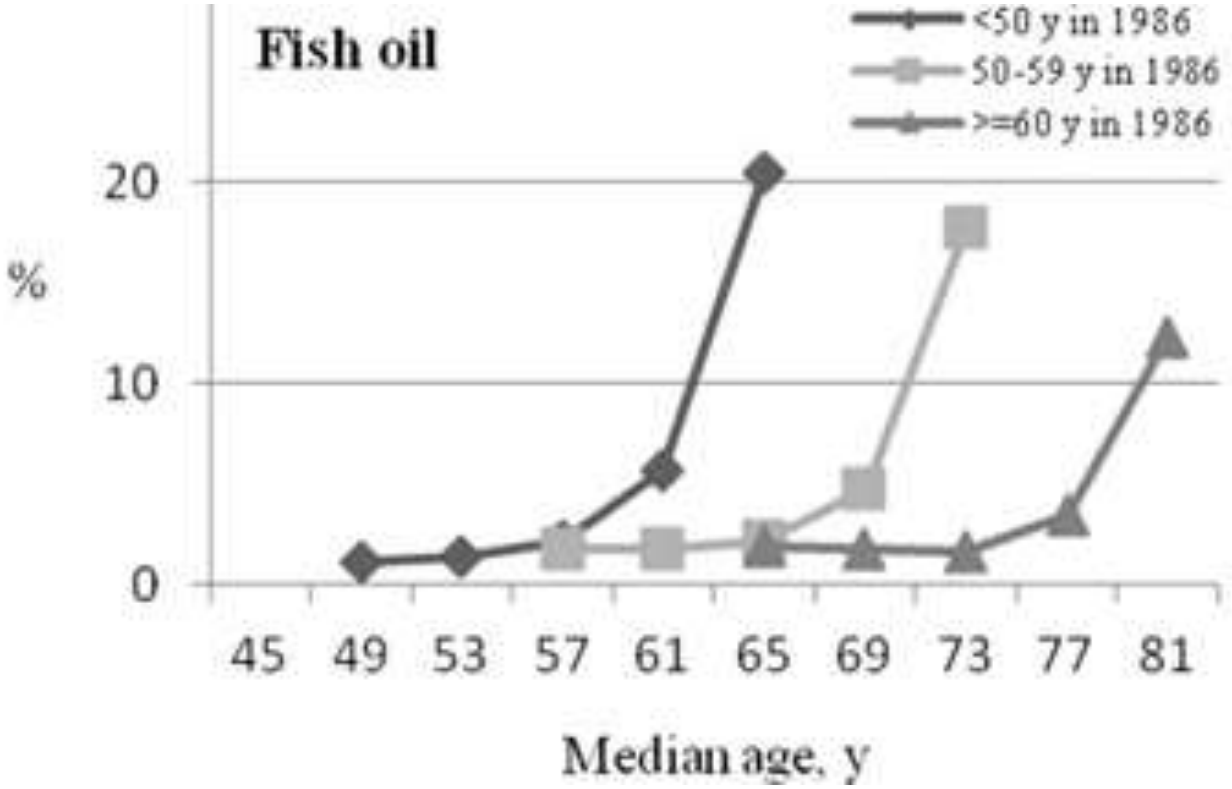
Xiaoyu Guo [1], Xiaoqing Xu [1], Jian Gao [1], Weiqi Wang [1], Wanying Hou [1], Xiaoyan Wu [1], Changhao Sun [1], Ying Li [1], Tianshu Han [1]Twenty-Year Trajectory-Patterns of Percentage Energy From Dietary Fat vs. Carbohydrate Throughout Adult Life and Associations With Cardio-Metabolic Disease and All-Cause Mortality. 2021 Sep 6;8:701188. doi: 10.3389/fnut.2021.701188. eCollection 2021.

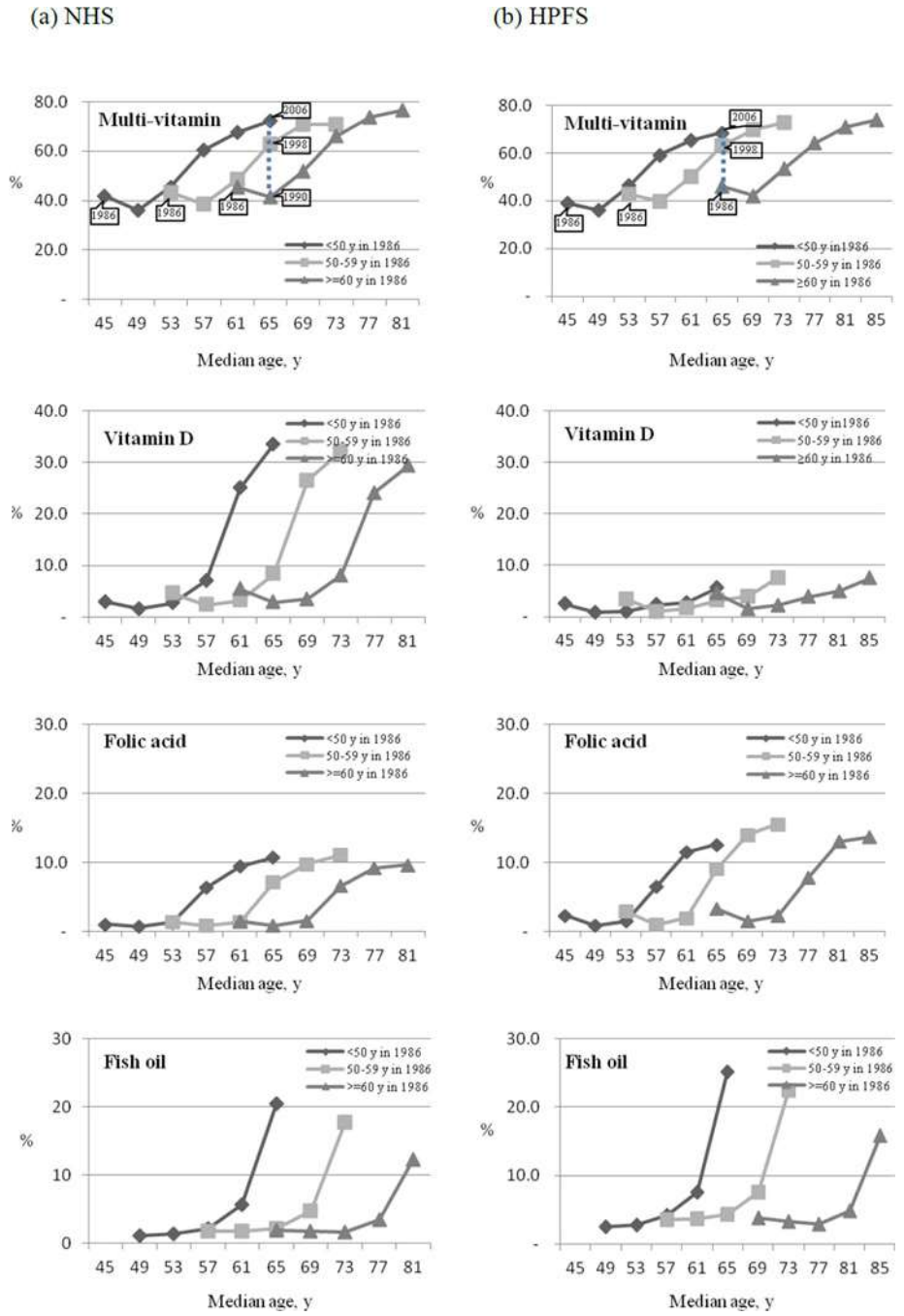
“Harvard cohorts”

- Nurses Health Study, NHSII, and Health Professionals Follow-Up Study
- Semiquantitative food frequency questionnaire administered every 4 years
- Many dozens of health and disease outcomes studied



Secular trends in supplement use – NHS and HPFS





PMID: 24119503

Adolescence and Young Adulthood

Tracking of Diet Quality and its Determinants

- Diet quality typically declines during the transition from childhood to adolescence, along with behavioral changes such as higher consumption of SSBs and energy-dense snacks, eating more foods away from home and more autonomy over food selection, skipping breakfast, and a decline in family dinners[1]
- Adolescents generally have a poor-quality diet that does not align with recommendations[1, 2]
  - Many health behaviors established during adolescence, including those related to diet, track into adulthood.[2, 3]
  - One nationally representative study found strong tracking of eating behaviors across late adolescence into young adulthood (16-20yrs), suggesting that this may be a key window for intervention on eating behaviors [2]
  - Key inflection points at which dietary quality is most likely to change occur at ~3 years, 7-9 years, adolescence, early adulthood[4]

1. PMID: 19430591; 2. PMID: 26537771; 3. PMID: 28446498; 4. PMID: 35475441

Selected Cohort Studies on Diet Trajectories: AYA

Cohort	Location	Life Stages	Diet Characterization	Findings
MATCH[1]	Canada N=744	11y-18y	Eating behaviors related to amount of food intake, breakfast consumption, and intake of fruits and vegetables, SSB, fast food	Heterogeneity in eating behaviors with sex-specific differences. No group with consistently healthy eating behaviors.
Norwegian Longitudinal Health Behaviour Study[2]	Norway N=1100	14y-30y	Self-reported intake of fruit, vegetables, confectionary, and SSB	Fruit and vegetable intakes declined from early adolescence to young adulthood, then increased. Intake of sweets (including SSBs) increased during adolescence (to 18 years), then decreased. Leaving education and parent's home -> higher SSB and sweets
Norwegian HEalth In Adolescents (HEIA) cohort study[3]	Norway N=885	11y with follow-up over 20 months	Internet-based questionnaire	Both boys and girls maintained their relative position in rank of dietary intake over time, when grouped by baseline consumption.

1. PMID: 33923453; 2. PMID: 30200990; 3. PMID: 22874120

Selected Cohort Studies on Diet Trajectories: AYA

Cohort	Location	Life Stages	Diet Characterization	Findings
CARDIA[4]	US (N~2500)	18-30y at baseline 1985-6, diet Y0-Y20 and outcomes Y20-30)	A Priori Diet Quality Score (APDQS), a marker of plant-rich foods	Those with largest increase in APDQS over 20 years had 48% lower risk of diabetes in the next 10 years, lower gain in BMI, lower gain in weight
Western Australian Pregnancy Cohort (Raine Study) [5]	Australia N=1414	14y, 17y, 20y, 22y	FFQs; Sex-specific diet trajectories	Most common trajectory (>70%) was a stable, low-quality diet. One trajectory with modest declining quality after late adolescence (females); one with steady decrease in diet quality after mid-adolescence (males). Lower maternal SES, higher BMI predicted poorer offspring diet quality
GINIplus birth cohort study[6]	Germany N=1232	10y, 15y	FFQ (parent report at 10y, self-report at 15y)	Average dietary intakes changed significantly, despite fair tracking levels, suggesting the presence of trends in dietary behaviour during puberty. Family income and parental education predominantly influenced intake changes

4. PMID: 32847828; 5. PMID: 33181820; 6. PMID: 26329931

Adolescence to Young Adulthood

- Life stage with biggest jump in overweight/obesity prevalence
- Fast food intake common and maybe a contributor
  - In Project EAT (follow-up ~15-31y), mean fast food intake followed an underlying quadratic trajectory, increasing through adolescence to a maximum of 1.88 (SE 0.94) times/week and then decreasing again through early adulthood to 0.76 (SE 2.06) times/week at wave 4. (PMID: 33036629)
    - Higher fast food with beginning full time employment and becoming a parent
    - Lower fast food with leaving parental home and beginning cohabitation

FREE THEMES • Ciênc. saúde colet. 24 (6) • June 2019 • https://doi.org/10.1590/1413-81232018246.11562017 COPY

Effect of implementation of a University Restaurant on the diet of students in a Brazilian public university

Efeito da implementação do Restaurante Universitário na alimentação de estudantes de uma universidade pública brasileira

Patrícia Maria Périco Perez Inês Rugani Ribeiro de Castro Daniela Silva Canella Amanda da Silva Franco

- Evaluation of natural experiment at Brazilian University, comparing change in student diet over time before vs. after the University established a “restaurant” that provided lost-cost lunch and dinner for students.
- The restaurant-exposed group had higher chance of positive diet trajectory - higher frequency of regular consumption of beans, vegetables, raw vegetables, cooked vegetables and fruit and lower frequency of regular consumption of French fries and/or fried snacks (PMID: 35730847, PMID: 31269191)

Winpenny *et al. International Journal of Behavioral Nutrition and Physical Activity* (2017) 14:60
DOI 10.1186/s12966-017-0518-7

International Journal of Behavioral Nutrition and Physical Activity

REVIEW

Open Access

Change in diet in the period from adolescence to early adulthood: a systematic scoping review of longitudinal studies

Eleanor M. Winpenny*, Tarra L. Penney, Kirsten Corder, Martin White and Esther M. F. van Sluijs

Winpenny et al. Conclusions

- Limited longitudinal data available on diet across adolescence and young adulthood
- Some data available across macronutrients and key food groups
- Data availability varies significantly by country
- Varied methods of diet data collection used may have implications for data quality and potential for future evidence synthesis.
- Little repeated longitudinal data across the adolescence to adult transition; very little data beyond the early twenties.

Childhood

Tracking of Diet Quality and its Determinants

- Food/flavor preferences are a major determinant of dietary intake, are established early in life, and track into later childhood and adulthood[1, 2]
  - Innate preferences for sweet and salty flavors and aversions to bitter flavors can be modified by early experiences
- Early, repeated exposure to certain foods and flavors, including those present in healthy yet commonly disliked foods such as vegetables, can increase later acceptance of these foods.[3, 4, 5]
  - Early exposure includes detection of flavors from the mother's diet prenatally in the amniotic fluid and postnatally in breast milk.
- Conversely, early, repeated exposure to sweet flavors, such as in sugar-sweetened complementary foods and beverages, may enhance the innate preference for sweetness in both infants and children.[6]
- Intake of sweetened snacks and beverages has been shown to track from infancy into toddlerhood and early childhood[7]

1. PMID: 31290381; 2. PMID:PMID: 10608944; 3. PMID: 30982867; 4. PMID: 11389286;
5. PMID: 28515063; 6. PMID: 27079145; 7. PMID: 25183757

Selected Cohort Studies on Diet Trajectories: Childhood

Cohort	Location	Life Stages	Diet Characterization	Findings
Longitudinal Study of Australian Children - Baby Cohort and Kindergarten Cohort[1]	Australia Baby: N=4504 Kindergarten: N=4640	B: 2-3y to 10-11y K: 4-5y to 14-15y	24h recall of 12 to 16 healthy or less healthy foods and beverages; Dietary scores/patterns based on Australian guidelines	4 distinct trajectories, 3 stable ("never healthy," "moderately healthy" and "always healthy" 1 not stable: "becoming less healthy;" change occurred at ~7 years.
Healthy Smiles, Healthy Kids (HSHK)[2]	Australia N=934 kids	4m, 8m, 1y, 2y, 3y	FFQs; Dietary scores capturing core and discretionary foods	Increase in discretionary food intake over time; Different trajectories of core food intake, with general decline after 2 years. SES and breastfeeding predicted trajectories
Epidemiology of BMI Rebound Study[3]	US N=349 kids	Up to 12 study visits between ages 3y and 7y	3-day diaries; Diet quality trajectories (HEI)	5 distinct trajectories – 1 declining, 1 improving, 3 stable. More differences in HEI components than total score. Diet quality generally low and stable over time, predicted by breastfeeding and SSB intake before age 3.

1. PMID: 28478764; ; 2. PMID: 34493286; 3. PMID: 33109501

Selected Cohort Studies on Diet Trajectories: Childhood

Cohort	Location (N)	Life Stage or age	Diet Characterization	Findings
GUSTO[4] (Growing up in Singapore Towards healthy Outcomes)	Singapore (n=486)	6m, 9m, 12m	24h recalls and food diaries	Little change in patterns from 6 to 12 m; diet trajectory strongly influenced by maternal demographics
Generation R[5]	Netherlands (n=3991)	1y, 8y	FFQ used to create diet quality score (0-10 points)	Higher diet quality at 1y, higher height, weight BMI and fat-free mass; no diff in fat mass or fat%, through age 10. Similar associations with 8y diet
Norwegian Mother and Child Cohort Study (MoBa)[6]	Norway (N=9025)	18m, 36m, 7y	Questionnaires (different at each timepoint)	F&V intake tracked moderately. Children of mothers with more education ate more F&V, less SSB at 18m

4. PMID: 27314387; 5. PMID: 30967308; 6. PMID: 24103398

Diet trajectories and CV functional phenotypes

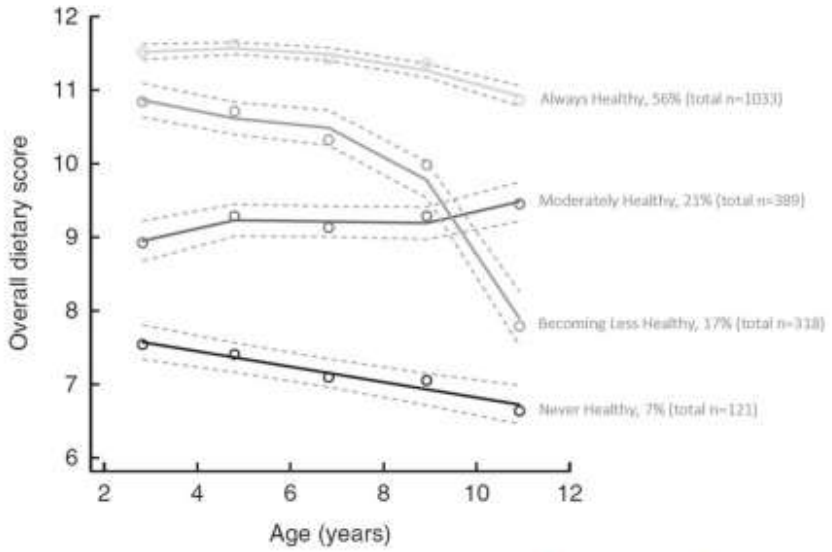


Fig. 1 Diet trajectories for LSAC's B-Cohort, age 2–11 years. Reprinted with permission from Cambridge University Press (originally printed as Fig. 2a [22]). Proportions of children in each trajectory differ from previous publication because we use only the CheckPoint subsample of the full LSAC B-Cohort. Key: dotted line = 95% confidence interval.

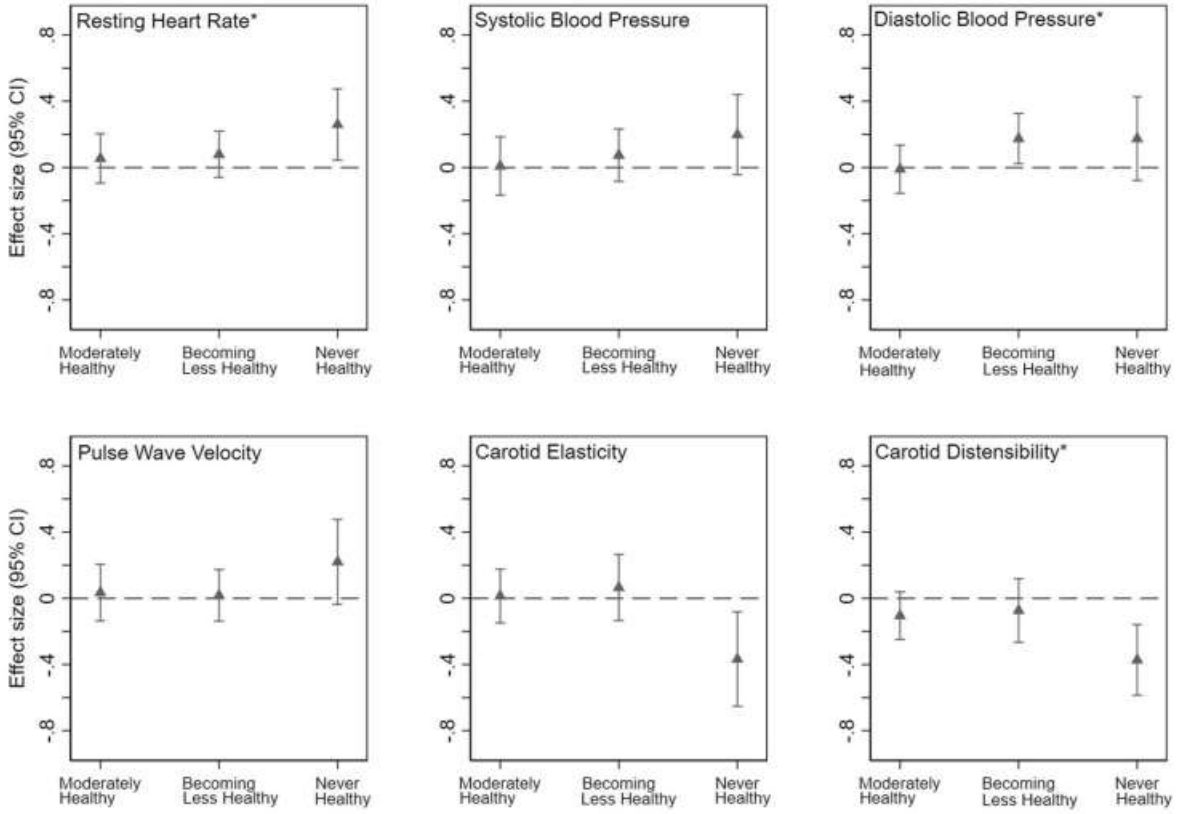


Fig. 2 Standardised mean differences (i.e. effect size) for preclinical cardiovascular functional phenotypes by diet trajectory. Effects sizes from Table 2, reference group 'Always Healthy' (dotted line), *linear trend $p < 0.05$.

Diet quality **trajectories** and cardiovascular phenotypes/metabolic syndrome risk by 11-12 years.Kerr JA, Liu RS, Gasser CE, Mensah FK, Burgner D, Lycett K, Gillespie AN, Juonala M, Clifford SA, Olds T, Saffery R, Gold L, Liu M, Azzopardi P, Edwards B, Dwyer T, Wake M.Int J Obes (Lond). 2021 Jul;45(7):1392-1403. doi: 10.1038/s41366-021-00800-x. Epub 2021 Apr 6.PMID: 33824404

Pregnancy and Infancy

- Developmental Origins of Health and Disease (DoHAD)
- Importance of sensitive windows for exposure – timing matters!

Cohort Study Research on Diet Trajectories: Pregnancy and Postpartum

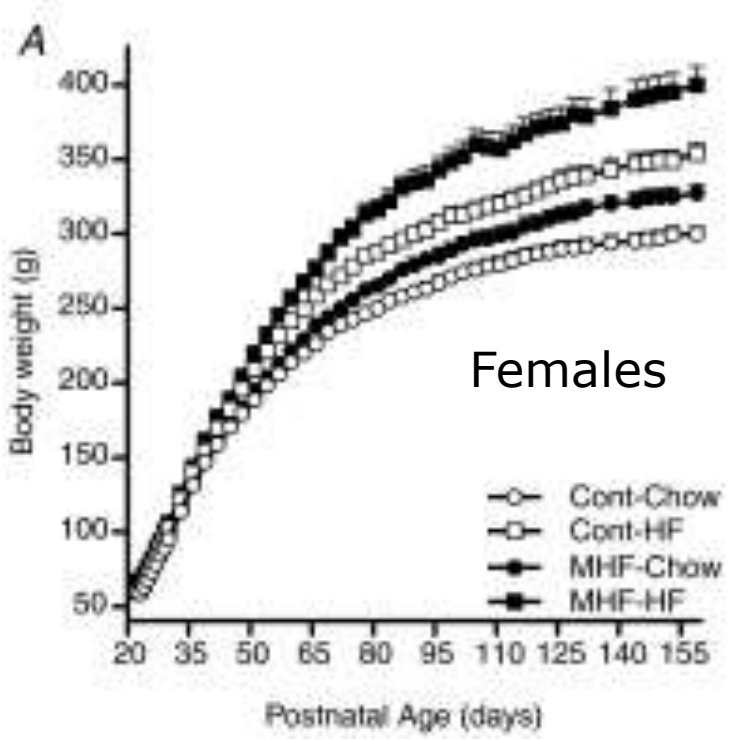
Cohort	Location	Life Stages	Diet Characterization	Findings
Southampton Women's Survey[1]	UK N=2963 pairs	M: Pre-pregnancy, 11w and 34w gest; C: 6m, 12m, 3y, 6-7y, 8-9y	Interviewer- administered FFQs; latent classes of mother-offspring diet quality	5 trajectories with different levels of diet quality, all stable horizontal lines over time; maternal obesity, sociodemographics predicted poorer diet group which predicted higher child adiposity
LIFE Child Study[2]	Germany (n=110)	24w gestation, 3m postpartum (during lactation), 12m postpartum (weaning)	Nutritional Health Score (NHS) from "CoCu", a short nutritional questionnaire that assesses diet composition and culture of eating	NHS highly correlated over time, on average lower at 3m than pregnancy and higher again at 12m. Sociodemographics predicted nutritional health.

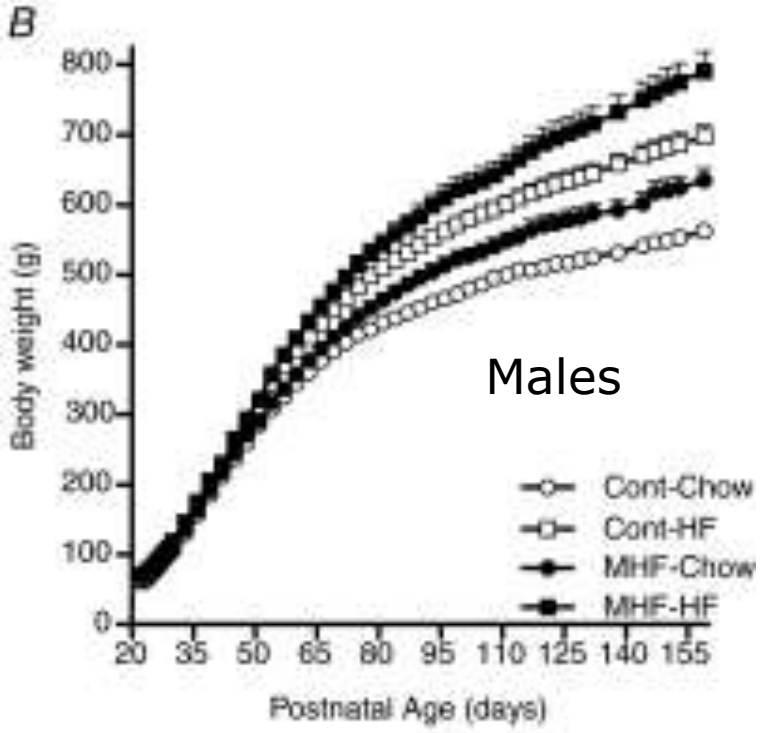
1. PMID: 34916617 2. PMID: 34481457

Rat studies show importance of exposure timing

High fat feeding before and during pregnancy (MHF) leads to higher offspring body weight and %fat, than offspring HF diet; combination of the two has strongest effect

Similar effects if maternal exposure limited to pregnancy and lactation only





Maternal nutritional history predicts obesity in adult offspring independent of postnatal diet.
Howie GJ, Sloboda DM, Kamal T, **Vickers** MH. J Physiol. 2009 Feb 15;587(Pt 4):905-15.

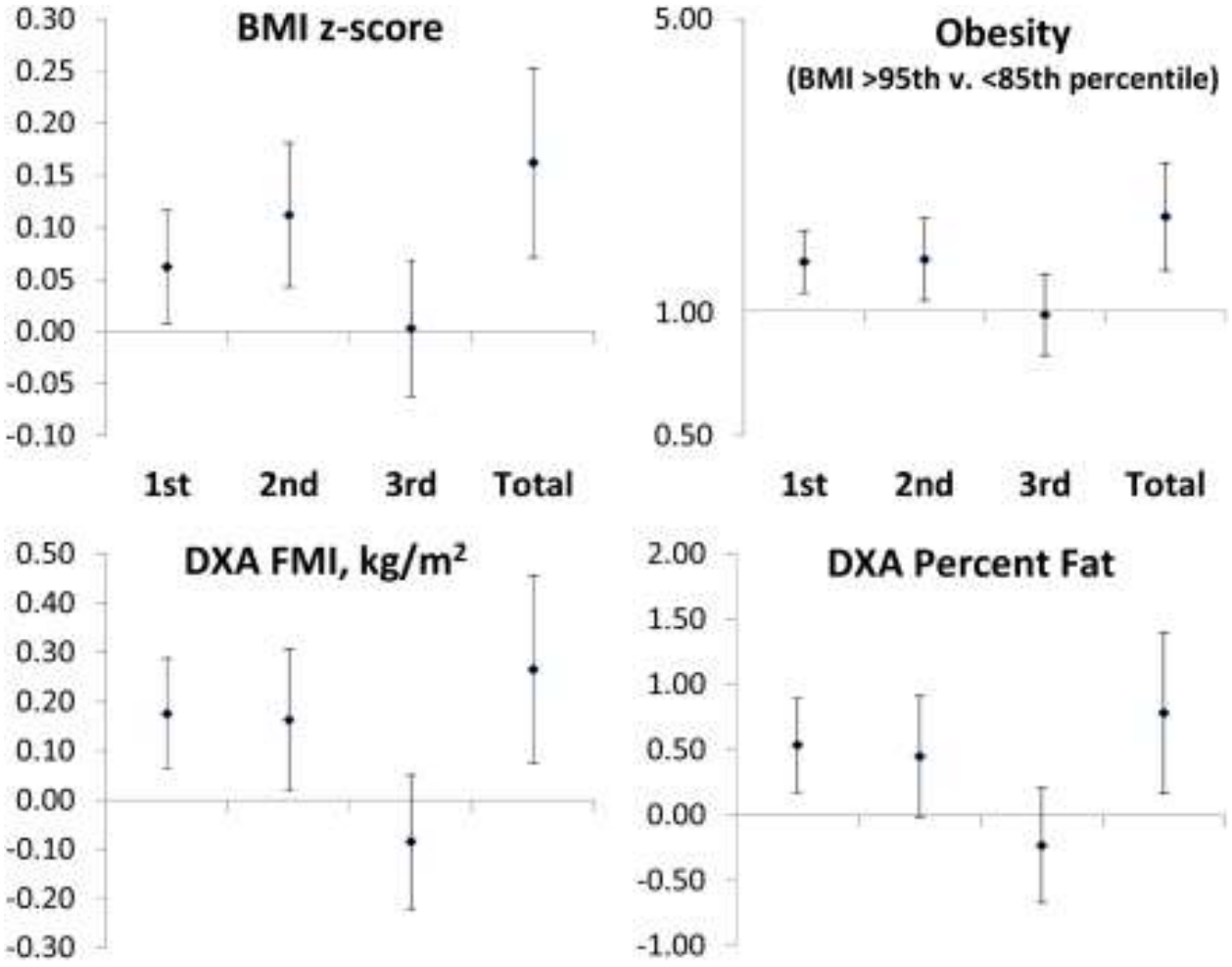
Timing of diet matters– historic experiments

21 days: Weights 14g, 60g

75 days: Weights 86g, 230g

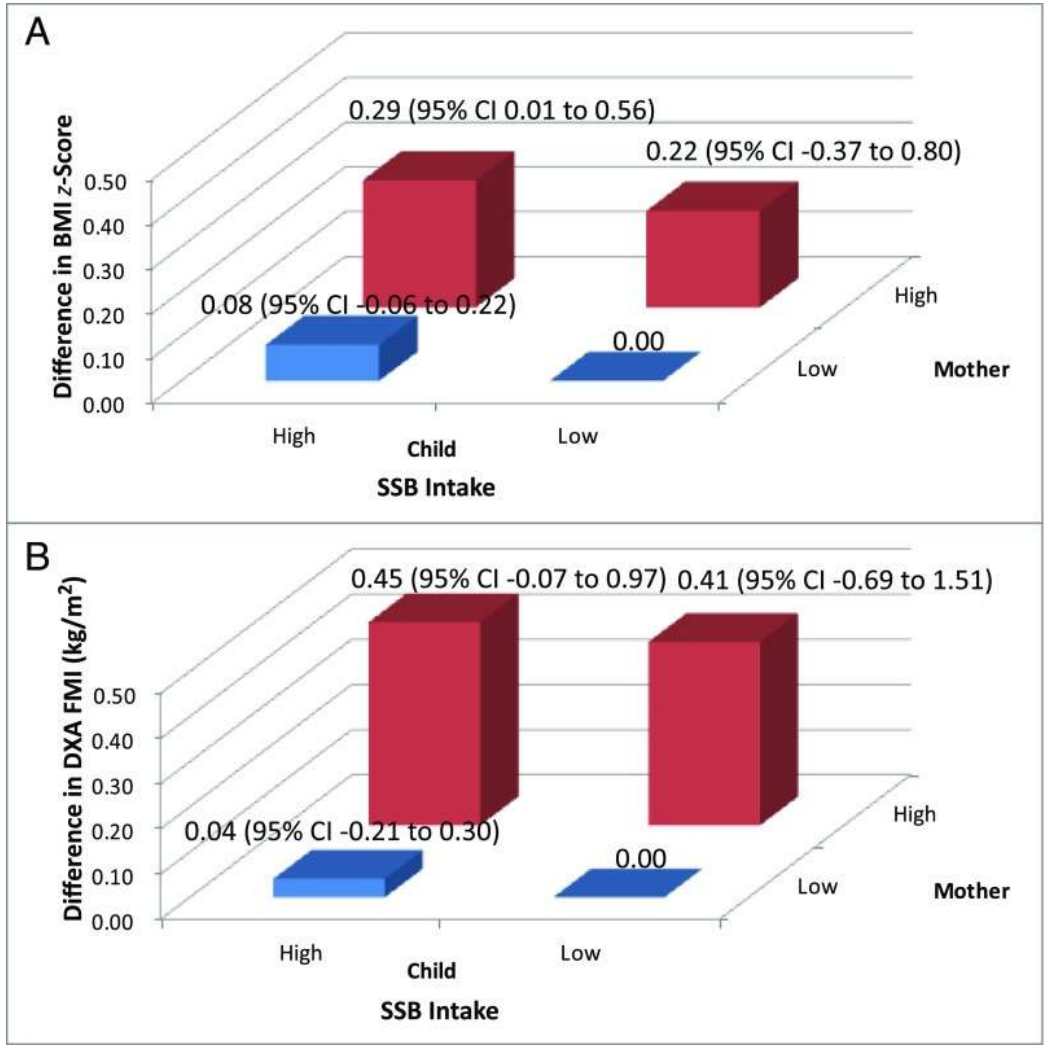
Widdowson and McCance, 1960

Greater early and mid-pregnancy (but not late pregnancy) gestational weight gains are associated with excess offspring adiposity in mid-childhood



Greater early and mid-pregnancy **gestational weight** gains are associated with excess adiposity in mid-childhood.
Hivert MF, Rifas-Shiman SL, Gillman MW, **Oken** E. Obesity (Silver Spring). 2016 Jul;24(7):1546-53. PMID: 27345963

Higher SSB intake in pregnancy leads to higher offspring weight and fat, with no additional effect of child SSB intake



Beverage Intake During Pregnancy and Childhood Adiposity. Gillman MW, Rifas-Shiman SL, Fernandez-Barres S, Kleinman K, Taveras EM, **Oken** E. Pediatrics. 2017 Aug;140(2). PMID: 28689188

Paediatric and Perinatal Epidemiology

Volume 20, Issue 1
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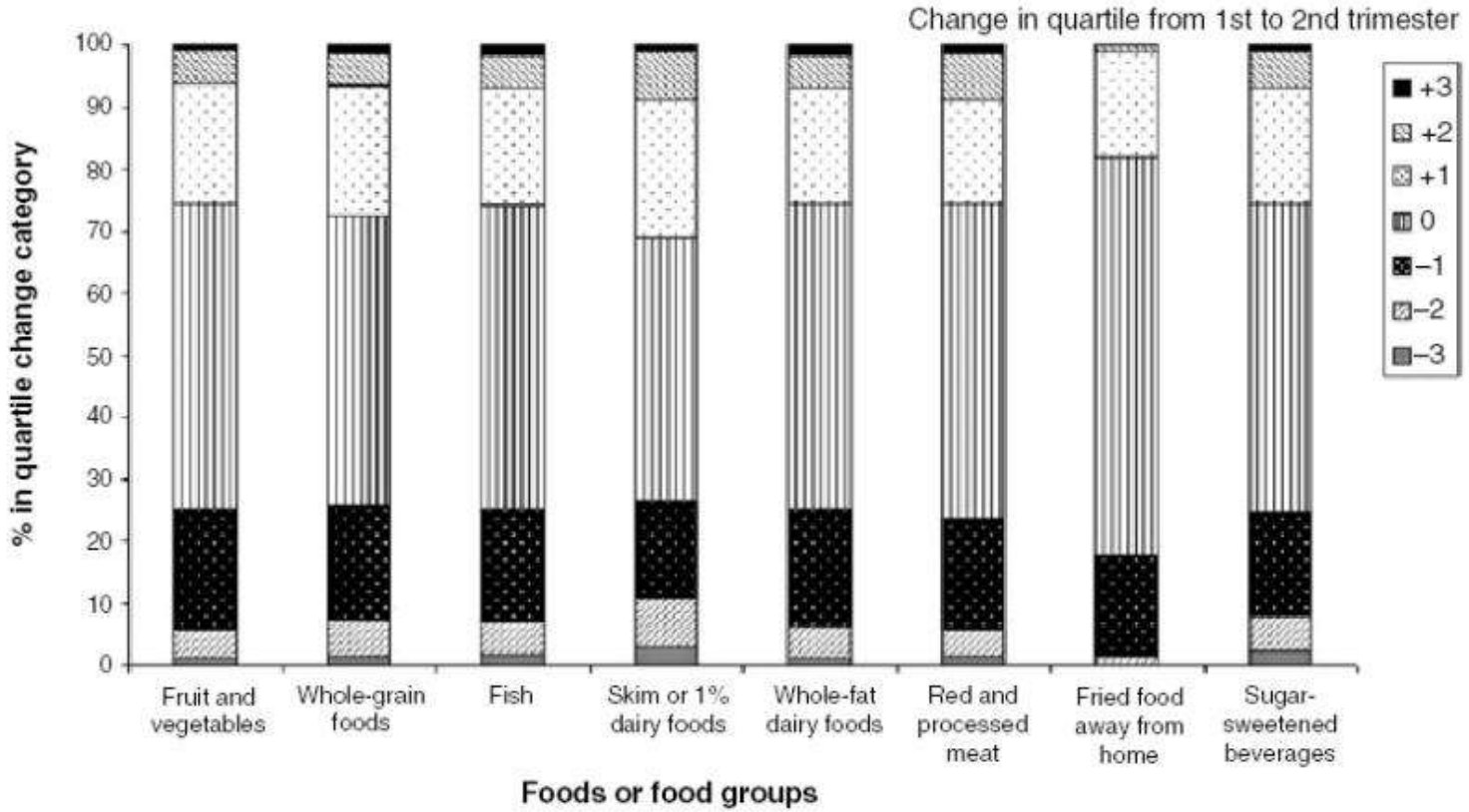
Changes in dietary intake from the first to the second trimester of pregnancy

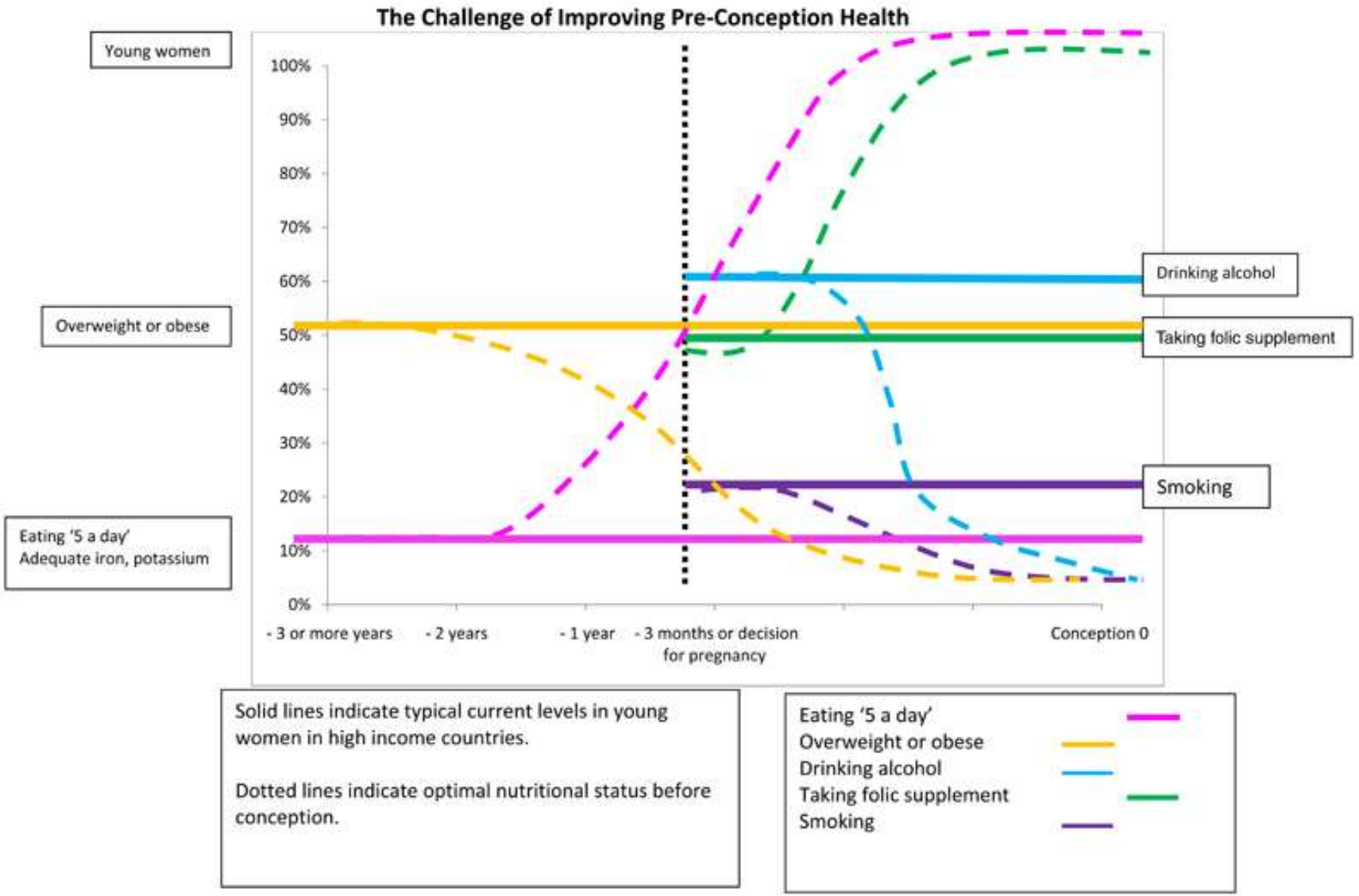
Sheryl L. Rifas-Shiman, Janet W. Rich-Edwards, Walter C. Willett, Ken P. Kleinman, Emily Oken, Matthew W. Gillman

- Overall mean intakes of foods and nutrient intakes from foods did not change appreciably from the 1st to 2nd trimester
- Only 50% of individuals stayed in the same quartile of intake



Individual changes in quartiles of intakes of foods and food groups from the 1st to 2nd trimester of pregnancy. Data from 1543 women participating in Project Viva

Preconception nutrition: Also important
Timing of assessment also key, varies by exposure



PMID: 29673873

Challenges and Considerations for Longitudinal Dietary Assessment in Cohort Studies

- Diet should ideally be assessed in the same way over time, but not all tools are validated or appropriate for all life stages
  - And that does not reflect the current reality
- Diet assessment is associated with high staff and participant burden and it may be difficult to maintain engagement with repeated assessment at multiple life stages
- Diet is strongly related to sociodemographic and other lifestyle factors, and studies examining diet in relation to health outcomes should carefully consider and measure potential confounders

Summary

- Diet not static and tends to change at predicable transition periods in the lifecourse
- Looking at repeat cross sections may be misleading
- Repeated measures important for identifying sensitive exposure windows; Relevant exposure windows vary by lifecourse period (weeks, months, years)

Recommendations for funders

- Many cohorts already exist with repeated measures of diet, but these have not been fully leveraged
  - Funding opportunities targeted at these existing cohorts would likely result in large contributions in the near term
- We need methods to reconcile diet across different assessment tools
- We also need summary measures of diet quality that can leverage the multiple different types of dietary assessments

Funding and Support

ECHO

Environmental influences
on Child Health Outcomes

A program supported by the NIH

National **Heart**
Lung and Blood Institute

National Institute
of Allergy and
Infectious Diseases

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