CHAPTER 14.

Which new data are needed to explore the relationships of diet and dietary patterns to obesity and weight gain?

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There is an abundance of evidence that obesity and/or weight gain are related to a variety of types of cancer [1], for several of which the incidence is rising in low- and middle-income countries (LMICs) [2]. Obesity-related cancers of particular concern in LMICs include colorectal and oesophageal cancers [1] and breast cancer, which is related to weight gain in postmenopausal women [3]. Convincing evidence is available that other cancers are associated with obesity, including pancreatic, endometrial, and kidney cancers, and possibly gallbladder cancer [4].

Although weight gain and obesity may have been studied extensively in high-income countries (HICs), the cofactors and etiologies may be slightly different in LMICs. An example is oesophageal cancer, a serious malignancy in terms of prognosis and mortality, for which the incidence is expected to increase over the next 10 years [5]. The most common histological type of oesophageal cancer worldwide is squamous cell carcinoma, which has a higher incidence in developing countries than in developed countries [5]. Identified risk factors for oesophageal squamous cell carcinoma include smoking, alcohol consumption, drinking hot tea, consumption of red meat, poor oral health, low intake of fresh fruits and vegetables, and low socioeconomic status [6, 7], whereas risk factors for oesophageal adenocarcinomas include chronic heartburn, tobacco use, white race, and obesity [8]. If the rise in the prevalence of obesity continues in LMICs, there may be an increase in the incidence of oesophageal adenocarcinoma, colorectal cancer, and other cancers, as well as a continued high incidence of stomach cancer, liver cancer, and oesophageal squamous cell carcinoma. It will be important to monitor trends in the incidence and the epidemiology of these cancers in LMICs in the coming years.

Cultural diversity

Most research on obesity and cancer has focused on Caucasians in HICs. Although many of the identified risk factors in HICs will have the same physiological effects in LMICs, the determinants may be different, in addition to other environmental and genetic differences across populations. Novel risk factors may be identified in newly studied populations and regions.

Diet is shaped by many factors, such as knowledge about diet, food availability, budgetary constraints, and health conditions. Similarly, a

variety of factors influence daily physical activity, including dwellings, urbanization, employment constraints, and health conditions. A broad review of cultural determinants of obesity in LMICs is presented in Chapter 2. To the extent possible, evaluation of these factors that influence weight gain and obesity will inform efforts to mitigate the rising prevalence of obesity in the study populations.

Reporting and analyses of dietary intakes

Evaluation of biases in reported intake of macronutrients in HICs has shown underreporting of intake of carbohydrates and fat, but less underreporting of protein intake [9]. However, obese subjects are more likely to underreport intake of all macronutrients [9], and the lack of accuracy is dependent on the specific dietary assessment instrument used [10]. Such associations may be similar in research conducted in LMICs [11].

Whereas lack of food composition tables may be a current limitation in many regions, use of food patterns may be helpful, and may be more pertinent and more applicable for comparing results across populations in LMICs. If nutrient data are preferred, regional food composition tables from neighbouring countries could be used, or Food and Agriculture Organization of the United Nations (FAO) food composition data by continent (http://www.fao.org/infoods/en/) could be used. Significant efforts and funding are needed to develop country-specific and continent-specific food composition tables.

Foods and nutrients are eaten in a variety of combinations and can have interactive or cumulative effects when consumed together. Dietary patterns are defined as the quantities, proportions, variety, and combinations of different foods, drinks, and nutrients, and the frequency with which they are routinely consumed [12]. It will be important to identify dietary patterns related to weight gain and obesity in a variety of settings to evaluate the major lifestyle, behavioural, and policy influences, in an effort to plan public health interventions appropriately.

Recent research exploring the effect of dietary patterns on mortality suggests that overall nutritional quality may be more predictive than individual dietary components. Defining dietary quality usually involves comparison of the dietary intakes with guidance provided for that region.

In 2014, the United States Department of Agriculture (USDA) Nutrition Evidence Library summarized the literature on dietary patterns and obesity as part of a larger review of dietary patterns and several outcomes [12]. Dietary patterns can be assessed in various ways, including numerical indices designed to gauge adherence to a particular recommended pattern (e.g. the Healthy Eating Index in the USA) or data-driven approaches that use mathematics to empirically derive food intake patterns inherent in a study population.

The USDA review concluded that "there is moderate evidence that, in adults, increased adherence to dietary patterns scoring high in fruits, vegetables, whole grains, legumes, unsaturated oils, and fish; low in total meat, saturated fat, cholesterol, sugar-sweetened foods and beverages, and sodium; and moderate in dairy products and alcohol is associated with more favorable outcomes related to body weight or risk of obesity", with some variation by sex, race, or body weight status [12]. Adherence to a Mediterranean diet score or a dietary guidelines-related score was associated with decreased risk of obesity and with decreased body weight, body mass index (BMI), waist circumference, or body fat percentage. Mediterranean or dietary guidelines-related dietary patterns generally reflect a plant-based, minimally processed, nutrient-dense diet.

A variety of scores were included in the USDA review, including the Mediterranean Diet Score (MDS), the relative Mediterranean Diet Score (rMED), the Healthy Eating Index (HEI-1995 and HEI-2005), the Diet Quality Index-International (DQI-I), the Dietary Guidelines Adherence Index (DGAI), and the French Programme National Nutrition Santé Guideline Score (PNNS-GS). Overall, common dietary components related to decreased risk of obesity were fruits, vegetables, whole grains, legumes, and fish. Sugar-sweetened food and drink components were included and scored negatively in most of the dietary guidelines indices. Data-driven studies that used factor or cluster analyses or reduced rank regression provided limited or insufficient evidence for the association of dietary patterns with favourable body weight status [12].

Future efforts in LMICs should have regional similarities in the approaches and methods used, and use of guidance-based indices may prove more effective. Once dietary patterns in various countries/cultures are identified, a culturally appropriate set of dietary guidance recommendations may be used to calculate indices of nutritional quality for analyses in relation to outcomes, such as obesity.

Much attention has been focused on the association of childhood and adolescent obesity with higher risk of obesity in adulthood [13]. A systematic review on childhood nutrition and obesity later in life showed that diets high in energy-dense, high-fat, low-dietary-fibre foods were associated with later obesity [14]. This review of the evidence highlighted that food patterns better explained the link with later obesity than individual foods or nutrients.

Given that metabolic syndrome is likely to be a comorbid condition with the rising prevalence of obesity in LMICs, an evaluation of dietary patterns related to ameliorating the components of metabolic syndrome shows promise. Three dietary patterns were shown to improve components of metabolic syndrome (a Mediterranean dietary pattern, the Dietary Approaches to Stop Hypertension [DASH] diet, and the Nordic diet), and they were characterized by increases in intake of fruits, vegetables, whole grains, dairy products, whey protein, calcium, vitamin D, monounsaturated fatty acids, and omega-3 fatty acids [15]. Future studies in LMICs may benefit from a similar approach evaluating dietary patterns associated with components of metabolic syndrome.

There have been many intervention studies in children to prevent obesity later in life. A particularly interesting recent study in Finland shows promise. This longitudinal trial provided repeated dietary counselling aimed at reducing saturated fat intake beginning in infancy. The long-term risk, up to age 20 years, of metabolic syndrome was 40% lower in the intervention group [16]. Knowing the variety of region-specific dietary patterns and their associations with obesity and other morbidities will enable the implementation of interventions to improve nutritional status and general health.

Although they are not included in specific dietary pattern analyses, sugar-sweetened beverages have been shown to increase the risk of a variety of conditions in HICs. Literature reviews have found a strong association of high intakes of sugar-sweetened beverages with weight gain [17, 18], and evidence exists that decreasing the intake of sugar-sweetened beverages reduces the prevalence of obesity and obesity-related diseases [19]. New efforts in LMICs should monitor the intakes of sugar-sweetened beverages as part of dietary surveillance programmes in the diverse regions.

Surveillance to assess current intakes and trends

Surveillance efforts provide information on the population's weight and nutritional status as well as on food system variables at one time point and across time points. A food system encompasses foods, nutrition, health, community economic development, agriculture, and the social, political, economic, and environmental contexts of these processes.

For assessing baseline nutritional status and dietary changes over time, it will be important that suitable methods for measuring diet and nutrition-related behaviours are used in various LMICs. There is a need to evaluate the use of available methods in LMICs, their potential for standardization, and the capacity to develop new methods to enhance assessment, comparisons, and pooling of data.

For surveillance, it is desirable to use 24-hour recalls with standardized methodologies that will permit comparisons across populations at both the food and nutrient levels. Repeated surveys of diet, anthropometric measures, and physical activity will generate baseline information and enable assessment of changes over time at the population level. Such data are needed in low-resource countries to evaluate the current status of the population and to address adverse trends with a variety of prevention and control programmes.

Intervention studies in countries/regions are needed to learn about physiological changes and the sustainability of the changes. For example, a 2-year worksite intervention study in Israel showed favourable effects in weight loss and lipid profiles, with the largest effects in the Mediterranean-diet and low-carbohydrate-diet groups compared with the low-fat-diet group [20]. There was high compliance during the study (85%), and a 6-year follow-up showed long-lasting post-intervention effects on dietary intakes, weight, and lipid parameters [21]. The participants were invited to the clinic for a regular check-up, anthropometry, and a blood sample once a year during the follow-up period. Although the special labels were not available in the cafeteria after the intervention study ended, most participants continued to consume their specific dishes from the intervention study. At 6 years, 67% of the participants were complying with the original diet, demonstrating that appropriate, sustainable diets and intervention methods hold promise for future intervention research.

Short-term intervention studies can also be revealing. In a 2-week food exchange programme, African Americans were fed a high-fibre, low-fat African diet and rural Africans were fed a high-fat, low-fibre diet typical of high-income countries [22]. The food interventions resulted in the acquisition of microbiota and other biological parameters consistent with those found in the original diet group. There were changes in colonic mucosal proliferation rates and inflammation, and in characteristics of the microbiota and the metabolome that are associated with cancer risk. Given that the microbiota and inflammation have been related to obesity [23–25], further work in this area is worthwhile. Similar targeted intervention studies in LMICs may reveal dramatic effects from changes in dietary composition, with implications for improved health.

Influence of early life and life-cycle

Increasing attention is being paid to the role of factors across the life-course in relation to weight and

health outcomes in adulthood. More specifically, the role of nutrition in early development has been suggested to influence metabolic parameters and disease outcomes later in life [26]. It has been shown that a mother's own birth weight influenced her adult BMI, and that the risk of large-for-gestational-age offspring was increased among women with a high adult BMI who also had a high birth weight [27]. A variety of studies have shown independent effects of maternal BMI and offspring BMI, adiposity, abdominal obesity, and insulin resistance [28, 29]. Such observations suggest a vicious cycle of overweight across generations.

In 2011, the United Kingdom Scientific Advisory Committee on Nutrition (https://www.gov.uk/government/groups/scientific-advisory-committee-on-nutrition) published a review entitled "The influence of maternal, fetal and child nutrition on development of chronic disease in later life" [30]. The review warned against the later health consequences of excessive nutrient supply during early fetal and infant life, and emphasized that current dietary patterns of girls and women of reproductive age are a particular concern. The review suggested that improving the nutritional status of these women and of infants and young children has the potential to improve the health of future generations.

Further work on birth cohorts or other prospective studies in LMICs is likely to provide additional insights into developmental causes of obesity and noncommunicable diseases. Early-life factors operate together with exposures that accumulate over the life-course [31], but fundamental information on key time periods is still lacking. Although prospective studies are an important area of research, as are surveillance, intervention, and implementation research, resources and expanded research capacity are of the highest priority.

Discussion

Diet and physical activity are shaped by many physical, social, and cultural determinants, which need to be investigated in each population. New efforts should take into account factors that may modify energy requirements and response to dietary intakes, such as ageing, sex, body composition, activity level, environmental exposures, smoking, genetics, and disease status. The prevalence and etiologies of obesity in different populations need to be evaluated, addressing many of these factors and with culturally adapted methods.

To effectively advance the role of nutrition in improving and maintaining optimal weight status in populations, efforts need to be made to develop capacity and coordinate training efforts to support nutrition research. A key priority is nutrition surveillance; intervention research and implementation sciences are also important. Efforts should begin with evaluation of the available dietary methods in LMICs, their potential for standardization, and the capacity to develop new methods to enhance assessment, comparisons, and pooling of data. The potential of using 24-hour recalls with standardized methods should be evaluated, because they have been used successfully in many populations.

Given the evidence suggesting that physical activity and nutrition may interact in their influence on metabolic programming, research should include examination of the role of physical activity and its interaction with nutrition. These observations are of paramount importance in some LMIC settings, where emerging evidence suggests that physical activity patterns are changing and that nutrient supply early in life may vary with time and often moves towards food patterns that are less nutrient-rich. The prime importance of addressing physical activity in energy balance is discussed in Chapter 6, and these efforts could incorporate parallel capacity-building approaches to those for dietary assessment.

Further research focused on food patterns in LMICs may be beneficial in identifying helpful interventions for specific populations and subgroups. In some regions, lack of food composition tables may be a current limitation. It may be useful to conduct evaluations at the food level now, which may be followed by nutrient-level evaluations when food composition tables become available. Food pattern analyses in populations have many advantages. They can be used to develop dietary guidance, evaluate the nutritional quality of diets, evaluate associations with weight gain and obesity, and enable informed interventions to improve nutritional status. It will be important to identify dietary patterns related to weight gain and obesity in a variety of settings to evaluate the major lifestyle, behavioural, and policy influences, in an effort to plan public health interventions and research efforts appropriately. In addition, given the evidence from other countries, new efforts in LMICs should monitor the intake of sugar-sweetened beverages as part of dietary surveillance programmes.

Conclusions

There is clearly a need for capacity-building and resources devoted to nutrition research in LMICs. The first step would be a comprehensive assessment of resources already in place, and the identification of gaps and priorities for moving forward. Repeated surveillance surveys are essential in LMICs, to evaluate the current and future status of the population and to address undesirable

trends with prevention and control programmes. It is recognized that few prospective studies are currently under way in LMICs, and resources will be needed to pursue this important area of research. Input from local research communities, health ministries, and policy-makers is critical for the success of new efforts in LMICs.

Key points

- The prevalence of obesity is increasing in LMICs.
- Cultural and environmental aspects of the context are drivers of the obesity epidemic and require evaluation in each setting.
- Dietary quality is a main driver of weight gain and maintenance of optimal body weight.
- Evaluation of dietary patterns may be helpful in identifying region-specific patterns related to weight gain and obesity.
- Evaluation of dietary patterns will inform intervention strategies.
- Physical activity influences body weight, and the interaction of physical activity with dietary intakes affects weight status.
- Surveillance efforts provide information on current status and trends over time, and enable pooling of data across regions.
- Early-life time periods are important, and childhood obesity is particularly problematic.

Research needs

The following are needed in LMICs.

- Develop capacity and coordinate training efforts for nutrition research.
- Evaluate current methods and plan for standardized methods within and across regions.
- Build capacity to monitor and conduct research on physical activity.
- Develop methods to evaluate dietary patterns related to body weight status.
- Develop interventions related to foods and dietary patterns to improve nutritional status and modify negative trends in weight status in the populations.
- Prospective studies are needed to evaluate influences over the life-course, and resources are needed to support such studies.

References

1. Renehan AG, Tyson M, Egger M, Heller RF, Zwahlen M (2008). Body-mass index and incidence of cancer: a systematic review and meta-analysis of prospective observational studies. Lancet. 371(9612):569–78. http://dx.doi.org/10.1016/S0140-6736(08)60269-X PMID:18280327

2. Ferlay J, Soerjomataram I, Dikshit R, Eser S, Mathers C, Rebelo M, et al. (2015). Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012. Int J Cancer. 136(5):E359–86. http://dx.doi.org/10.1002/ijc.29210 PMID:25220842

3. Keum N, Greenwood DC, Lee DH, Kim R, Aune D, Ju W, et al. (2015). Adult weight gain and adiposity-related cancers: a dose-response meta-analysis of prospective observational studies. J Natl Cancer Inst. 107(2):djv088. http://dx.doi.org/10.1093/jnci/djv088 PMID:25757865

4. WCRF/AICR (2007). Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Washington (DC), USA: World Cancer Research Fund/American Institute for Cancer Research. Available from: www.aicr.org/assets/docs/pdf/reports/Second_Expert_Report.pdf.

5. Napier KJ, Scheerer M, Misra S (2014). Esophageal cancer: a review of epidemiology, pathogenesis, staging workup and treatment modalities. World J Gastrointest Oncol. 6(5):112–20. http://dx.doi.org/10.4251/wjgo.v6.i5.112 PMID:24834141

6. Prabhu A, Obi KO, Rubenstein JH (2014). The synergistic effects of alcohol and tobacco consumption on the risk of esophageal squamous cell carcinoma: a meta-analysis. Am J Gastroenterol. 109(6):822–7. http://dx.doi.org/10.1038/ajg.2014.71 PMID:24751582

7. Zhang Y (2013). Epidemiology of esophageal cancer. World J Gastroenterol. 19(34):5598–606. http://dx.doi.org/10.3748/wjg.v19.i34.5598 PMID:24039351

8. Runge TM, Abrams JA, Shaheen NJ (2015). Epidemiology of Barrett's esophagus and esophageal adenocarcinoma. Gastroenterol Clin North Am. 44(2):203–31. http://dx.doi.org/10.1016/j.gtc.2015.02.001 PMID:26021191

9. Lissner L, Heitmann BL, Bengtsson C (2000). Population studies of diet and obesity. Br J Nutr. 83(Suppl 1):S21–4. http://dx.doi.org/10.1017/S000711450000091X PMID:10889788

10. Lissner L, Troiano RP, Midthune D, Heitmann BL, Kipnis V, Subar AF, et al. (2007). OPEN about obesity: recovery biomarkers, dietary reporting errors and BMI. Int J Obes. 31(6):956–61. http://dx.doi.org/10.1038/sj.ijo.0803527 PMID:17299385

11. Scagliusi FB, Ferriolli E, Pfrimer K, Laureano C, Cunha CS, Gualano B, et al. (2008). Underreporting of energy intake in Brazilian women varies according to dietary assessment: a cross-sectional study using doubly labeled water. J Am Diet Assoc. 108(12):2031–40. http://dx.doi.org/10.1016/j.jada.2008.09.012 PMID:19027406

12. USDA Nutrition Evidence Library (2014). A series of systematic reviews on the relationship between dietary patterns and health outcomes. Alexandria (VA), USA: United States Department of Agriculture. Available from: https://www.cnpp.usda.gov/sites/default/files/usda_nutrition_evidence_flbrary/DietaryPatternsReport-FullFinal.pdf.

13. Simmonds M, Burch J, Llewellyn A, Griffiths C, Yang H, Owen C, et al. (2015). The use of measures of obesity in childhood for predicting obesity and the development of obesity-related diseases in adulthood: a systematic review and meta-analysis. Health Technol Assess. 19(43):1–336. http://dx.doi.org/10.3310/hta19430 PMID:26108433

14. Ambrosini GL (2014). Childhood dietary patterns and later obesity: a review of the evidence. Proc Nutr Soc. 73(1):137–46. http://dx.doi.org/10.1017/S0029665113003765 PMID:24280165

15. Calton EK, James AP, Pannu PK, Soares MJ (2014). Certain dietary patterns are beneficial for the metabolic syndrome: reviewing the evidence. Nutr Res. 34(7):559–68. http://dx.doi.org/10.1016/j.nutres.2014.06.012 PMID:25150114

16. Nupponen M, Pahkala K, Juonala M, Magnussen CG, Niinikoski H, Rönnemaa T, et al. (2015). Metabolic syndrome from adolescence to early adulthood: effect of infancy-onset dietary counseling of low saturated fat: the Special Turku Coronary Risk Factor Intervention Project (STRIP). Circulation. 131(7):605–13. http://dx.doi.org/10.1161/CIRCULATIONAHA.114.010532 PMID:25605660

17. Malik VS, Schulze MB, Hu FB (2006). Intake of sugar-sweetened beverages and weight gain: a systematic review. Am J Clin Nutr. 84(2):274–88. PMID:16895873

18. Te Morenga L, Mallard S, Mann J (2012). Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. BMJ. 346:e7492. http://dx.doi.org/10.1136/bmj.e7492 PMID:23321486

19. Hu FB (2013). Resolved: there is sufficient scientific evidence that decreasing sugar-sweetened beverage consumption will reduce the prevalence of obesity and obesity-related diseases. Obes Rev. 14(8):606–19. http://dx.doi.org/10.1111/obr.12040 PMID:23763695

20. Shai I, Schwarzfuchs D, Henkin Y, Shahar DR, Witkow S, Greenberg I, et al.; Dietary Intervention Randomized Controlled Trial (DIRECT) Group (2008). Weight loss with a low-carbohydrate, Mediterranean, or low-fat diet. N Engl J Med. 359(3):229–41. PMID:18635428

21. Schwarzfuchs D, Golan R, Shai I (2012). Four-year follow-up after two-year dietary interventions. N Engl J Med. 367(14):1373–4. PMID:23034044

22. O'Keefe SJD, Li JV, Lahti L, Ou J, Carbonero F, Mohammed K, et al. (2015). Fat, fibre and cancer risk in African Americans and rural Africans. Nat Commun. 6:6342. http://dx.doi.org/10.1038/ncomms7342 PMID:25919227

23. Barlow GM, Yu A, Mathur R (2015). Role of the gut microbiome in obesity and diabetes mellitus. Nutr Clin Pract. 30(6):787–97. http://dx.doi.org/10.1177/0884533615609896 PMID:26452391

24. Ojeda P, Bobe A, Dolan K, Leone V, Martinez K (2016). Nutritional modulation of gut microbiota – the impact on metabolic disease pathophysiology. J Nutr Biochem. 28:191–200. http://dx.doi.org/10.1016/j.jnutbio.2015.08.013 PMID:26372091

25. Apostolopoulos V, de Courten MP, Stojanovska L, Blatch GL, Tangalakis K, de Courten B (2016). The complex immunological and inflammatory network of adipose tissue in obesity. Mol Nutr Food Res. 60(1):43–57. http://dx.doi.org/10.1002/mnfr.201500272 PMID:26331761

26. Gluckman PD, Hanson MA, Buklijas T (2010). A conceptual framework for the developmental origins of health and disease. J Dev Orig Health Dis. 1(1):6–18. http://dx.doi.org/10.1017/S2040174409990171 PMID:25142928

27. Cnattingius S, Villamor E, Lagerros YT, Wikström A-K, Granath F (2012). High birth weight and obesity – a vicious circle across generations. Int J Obes (Lond). 36(10):1320–4. http://dx.doi.org/10.1038/ijo.2011.248 PMID:22158263

28. Pirkola J, Pouta A, Bloigu A, Hartikainen AL, Laitinen J, Järvelin MR, et al. (2010). Risks of overweight and abdominal obesity at age 16 years associated with prenatal exposures to maternal prepregnancy overweight and gestational diabetes mellitus. Diabetes Care. 33(5):1115–21. http://dx.doi.org/10.2337/dc09-1871 PMID:20427685

29. Benyshek DC (2013). The "early life" origins of obesity-related health disorders: new discoveries regarding the intergenerational transmission of developmentally programmed traits in the global cardiometabolic health crisis. Am J Phys Anthropol. 152(Suppl 57):79–93. http://dx.doi.org/10.1002/ajpa.22393 PMID:24249592

30. United Kingdom Scientific Advisory Committee on Nutrition (2011). The influence of maternal, fetal and child nutrition on development of chronic disease in later life. London, UK: The Stationery Office. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/339325/SACN_Early_Life_Nutrition_Report.pdf.

31. Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al.; Maternal and Child Undernutrition Study Group (2008). Maternal and child undernutrition: consequences for adult health and human capital. Lancet. 371(9609):340–57. http://dx.doi.org/10.1016/S0140-6736(07)61692-4 PMID:18206223