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JACC FOCUS SEMINAR: FUTURES OF CARDIOLOGY

JACC REVIEW TOPIC OF THE WEEK

Children Present a Window of Opportunity for Promoting Health

JACC Review Topic of the Week

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ABSTRACT

Cardiovascular disease is the leading cause of death and disability in the world, largely because of risk factors modifiable by changes in behavior. There is evolving evidence that our behavior as adults has its roots in the environment that we live in from early childhood. Early sustained multicomponent educational programs focused on health promotion in children may represent a window of opportunity to potentially prevent disease in adulthood. The integration of school-based, family-based, and community-based strategies, along with the support of public policies, are likely necessary for the success of these programs. In this review, the authors describe the future of promoting health. Specifically: 1) reasons why children should be a focus for health promotion (alarming trends of risk factors, association between unhealthy factors and subclinical disease, and cost-effectiveness); 2) strategies for health promotion in children (school-based, family-based, and community-based approaches) along with legislative efforts; and 3) research gaps are discussed. (J Am Coll Cardiol 2018;72:3310–9) © 2018 Published by Elsevier on behalf of the American College of Cardiology Foundation.

Cardiovascular (CV) disease is the leading cause of death and disability in the world largely because of risk factors modifiable by changes in behavior (1). Observational studies suggest that positive changes in health behaviors and factors at a young age are associated with lower burden of subclinical disease (2). Because of the unique plasticity of the human brain during childhood (3), this period represents a window of opportunity to instill life-long lasting healthy habits, therefore preventing future development of CV disease (4). By educating on health promotion early in life, we may also have the potential to reduce the burden of other diseases such as dementia (5) or cancer (6). Thus, investing in children's health and promoting CV health are considered main priorities from a public health perspective (7). In this review, we describe the future of promoting health. Specifically, we discuss: 1) reasons why children should be a focus for health promotion (alarming trends of risk factors, the association between unhealthy behaviors and subclinical disease, and cost-effectiveness); 2) strategies for health promotion in children (school-based, family-based, and community-based approaches) along with legislative efforts; and 3) research gaps.

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REASONS WHY CHILDREN SHOULD BE A PRIORITY FOCUS OF HEALTH PROMOTION

ALARMING PREVALENCE AND TRENDS OF UNHEALTHY FACTORS AND BEHAVIORS IN CHILDREN. Modifiable CV risk factors in children and adolescents include smoking, obesity, physical inactivity, unhealthy diet, abnormal cholesterol, elevated blood pressure, and elevated blood glucose (8). In the United States, <1% of children have ideal dietary habits (1,9), and only ~50% of adolescents follow the recommended amount of daily physical activity (**Figure 1**) (10). Up to ~8% of children have high total cholesterol levels (11). Furthermore, around 20% of high school students report current use of some type of tobacco product (12). These factors, such as unhealthy diet, show alarming trends in children and adolescents (**Figure 2**) (1). Similar data has been reported worldwide (13–15). Unhealthy habits contribute significantly to the growing problem of obesity in the United States (**Figure 3**), which is more prevalent among children from disadvantaged backgrounds (16,17). Overall, the prevalence of childhood obesity has doubled in >70 countries over the last decades, and affects approximately 108 million children (18).

LINK BETWEEN UNHEALTHY BEHAVIORS IN CHILDHOOD AND DISEASE IN ADULTHOOD. Evidence suggests that the cumulative exposure to risk behaviors and factors from childhood is a major contributor to adverse outcomes later in life (19,20). Added sugars are associated with increased adiposity and dyslipidemia, which might be particularly harmful if they are introduced during infancy (21). Young smokers tend to continue smoking through adulthood, which has long-term health consequences (22). Remarkably, the pervasive effect of exposure to parental smoking is independent of CV risk factors (23). Adverse childhood experiences such as child abuse and neglect, parental conflict, substance abuse, or mental illness are also major risk factors for many health conditions throughout life (24). Negative consequences may extend to the cognitive function (25). Even at very early stages, there are relationships between the quality of the child's diet and subsequent neurocognitive development (26). Later in life, there is substantial evidence linking vascular risk factors to dementia (27). On the other hand, physical activity is associated with numerous long-term health benefits in children, which might be especially relevant in those individuals who already have risk factors (28).

These studies are especially relevant because the process of subclinical atherosclerosis disease may begin in the youth (29). Prospective cohort studies have confirmed that unhealthy lifestyle and risk factors, as identified in childhood, may initiate changes in the arterial wall that could eventually lead to stiffening and potential atherosclerotic plaque formation (30). The adverse influence of unhealthy factors is not restricted to vascular damage, but also contributes to adverse long-term heart remodeling (31). This highlights the importance of a healthy lifestyle maintenance across the lifespan, starting in childhood.

TRANSITION TO ADOLESCENCE AND ADULTHOOD: POTENTIAL TO REVERSE ADVERSE OUTCOMES. Adverse outcomes among unhealthy children who became healthier by adulthood could be similar to those among individuals who were never unhealthy (32). Childhood overweight status associates with increased risk of diabetes in adulthood only if they continue to be overweight until puberty or later; those children able to normalize their weight before the age of 13 show a risk of future diabetes similar to children who were never overweight (33). Conversely, those individuals who exhibit a progressive increase in weight during childhood seem to be at especially elevated risk. Similarly, persistent elevated blood pressure from childhood to adulthood increases the risk of surrogate markers of atherosclerosis; however, this risk is reduced if elevated blood pressure is resolved by adulthood (34). On the other hand, CV risk prevention might benefit growing children by modifying the children's dietary fat quality (35). Overall, associations of cumulative risk factor exposures with subclinical atherosclerosis in adulthood have been shown even in the presence of elevated levels of risk factors in adolescence independently of the change of risk factor profile from adolescence to adulthood (36). Observational studies have shown that, even in cases of high genetic risk, a favorable lifestyle is associated with a substantially lower risk of coronary events (37). However, behavioral interventions in adults using counseling and education strategies may be more effective in high-risk individuals than the general population (38).

COST-EFFECTIVENESS IMPLICATIONS. In the United States, the estimated expenditures on CV disease are expected to exceed $1 trillion a year by 2030 (39). For example, smoking costs the U.S. economy >$301 billion/year, so the implementation of preventative programs targeting smoking holds the

ABBREVIATIONS AND ACRONYMS

BMI = body mass index

CV = cardiovascular

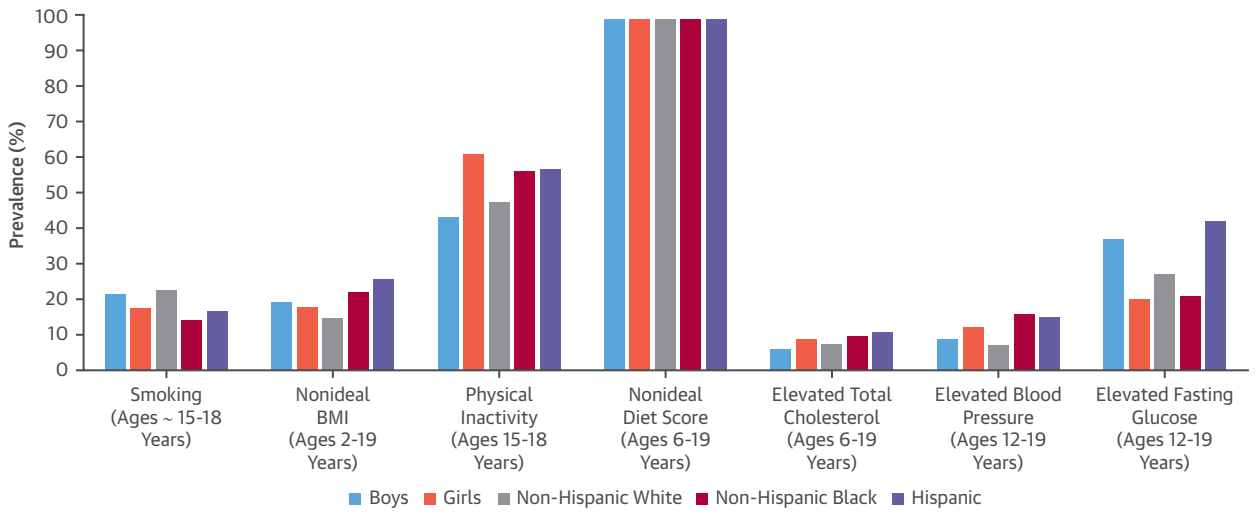
KAH = Knowledge to Attitudes to Habits

QALY = quality-adjusted life years

SES = socioeconomic status

SI! = Salud Integral (Comprehensive Health)

FIGURE 1 Prevalence of Modifiable Risk Factors for Cardiovascular Disease in Children and Adolescents in the United States, by Sex and Race



Smoking is defined as current use of any tobacco product, as analyzed from the 2011–2017 National Youth Tobacco Surveys (12). Nonideal body mass index (BMI) is defined as BMI ≥85th percentile, as analyzed from the 2015–2016 National Health and Nutrition Examination Survey (NHANES) (17). Physical inactivity is defined as less than the recommended physical activity of 60 min/day on ≥5 days/week, as analyzed from the 2015 Youth Risk Behavior Surveillance System (10). Nonideal diet score is defined as adherence to ≤3 of the following dietary recommendations (fruits and vegetables, ≥4.5 cups/day; fish, 2 or more 3.5-ounce servings/week; sodium, ≤1,500 mg/day; sugar-sweetened beverages, ≤450 kcal (36 ounces)/week; and whole grains, ≥3 servings/day), as analyzed from the 2007–2008 and 2011–2012 NHANES (1). Elevated total cholesterol is defined as ≥200 mg/dl, as analyzed from 2011–2014 NHANES (11). Elevated blood pressure and fasting glucose is defined as ≥90th percentile and ≥100 mg/dl, respectively, as analyzed from 2007–2008 NAHNES (8).

potential for saving about $275 billion/year (40). Another example is the costs associated with obese patients, which are 36% higher in comparison to nonobese patients (39). This highlights the need to develop more cost-effective strategies for preventing disease (41). However, cost-effectiveness evaluation of health promotion programs is difficult from technical and practical standpoints (39).

Few studies have evaluated the economic implications of educational programs in children. In Canada, APPLE (Alberta Project Promoting active Living and healthy Eating in Schools) was launched in 2008 as a 3-year intervention in 10 elementary schools. It was cost-effective >64% of the time per quality-adjusted life years (QALY) gained, and >93% of the time when using a higher threshold for incremental cost-effectiveness ratio (42,43). Also, in New York City, the *Food, Health, & Choices* intervention is a 24-lesson education curriculum that was initially evaluated in fifth-grade students at 20 schools during 2012 to 2013. It was found to be cost-effective $275/QALY with estimates up to $6,029/QALY in sensitivity analysis, confirming the feasibility of using public funds for supporting such programs (44). Other comprehensive school-based initiatives to promote healthy eating and physical activity showed cost saving results of $900 to $4,305/QALY (45–48). Similar findings were shown in elementary school-based physical education programs as a potential way of reducing health expenditures over 10 years (49,50). Promising results were shown also in smoking-cessation programs targeting adolescents such as ASSIST (A Stop Smoking In Schools Trial) (51).

In conclusion, evidence highlight the importance of early primordial prevention in children, defined as preventing the adoption of risk factors in the first place, and primary prevention, defined as interventions aimed at modifying adverse levels of risk factors once present to prevent an initial CV event (**Figure 4**) (8).

PROMOTING HEALTH IN CHILDREN: A WINDOW OF OPPORTUNITY

According to the Human Capital Theory, social and economic success for individuals and for countries relies on the knowledge, skills, competences, and attributes that allow people to contribute to their personal and social well-being (52). This concept

implies that education improves health because individuals gain the ability to be effective agents in their own lives by enhancing the sense of personal control that encourages and enables a healthy lifestyle (53). Meta-analyses evaluating the effect of behavioral interventions on children and adolescents show conflicting results but suggest that effective health promotion interventions should use a multicomponent educational approach (54,55) with involvement of their immediate environment, that is, their family (56) and their teachers (55). Some strategies for health promotion in children are outlined in the following text.

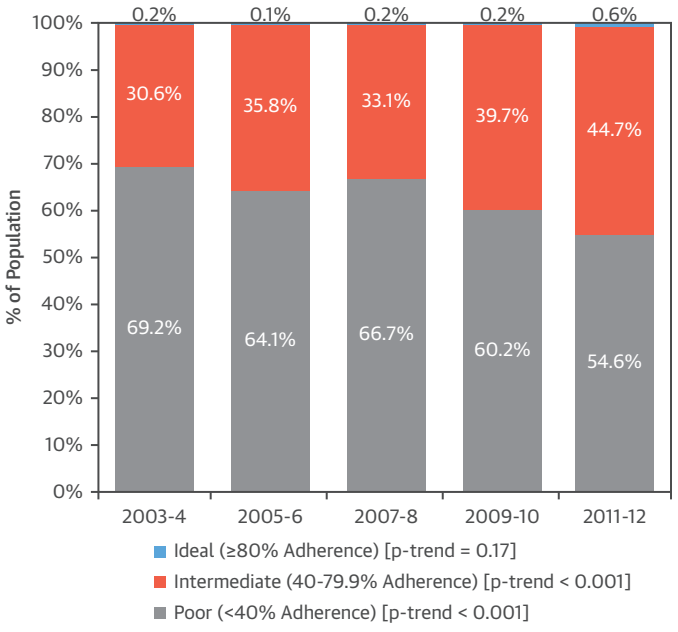
SCHOOL-BASED INITIATIVES. Through education, schools may play a major role in promoting long-lasting healthy habits in children, because these individuals spend the majority of their day there (57). Evidence suggests that when healthy habits are adopted early in life, they are more likely to be retained in adulthood (58); therefore, school-based interventions are considered a promising approach to shape healthy behaviors from early childhood (59). Moreover, these interventions could benefit executive functions and general school achievement in children (60).

Many school-based intervention studies have been conducted in the preschool setting; however, few have been tested in randomized trials (61). Most studies focused mainly on preventing weight gain by addressing only 1 component of lifestyle, such as diet or physical activity, with overall small intervention effect sizes. Similar issues and overall modest effect sizes have been reported in meta-analyses conducted in older children (62,63).

Effective interventions should use a multilevel multicomponent educational approach. One example is the SI! Program (*Salud Integral*, or Comprehensive Health) (64). It aims to progressively empower the individual toward healthy living through the implementation of a multilevel (child, teacher, family, and school) and multicomponent (diet, physical activity, body and heart awareness, and emotion management) approach (**Table 1**). The curriculum is adapted to each educational stage following the model of sequential behavior change: Knowledge to Attitudes to Habits (KAH) toward a healthy lifestyle (65).

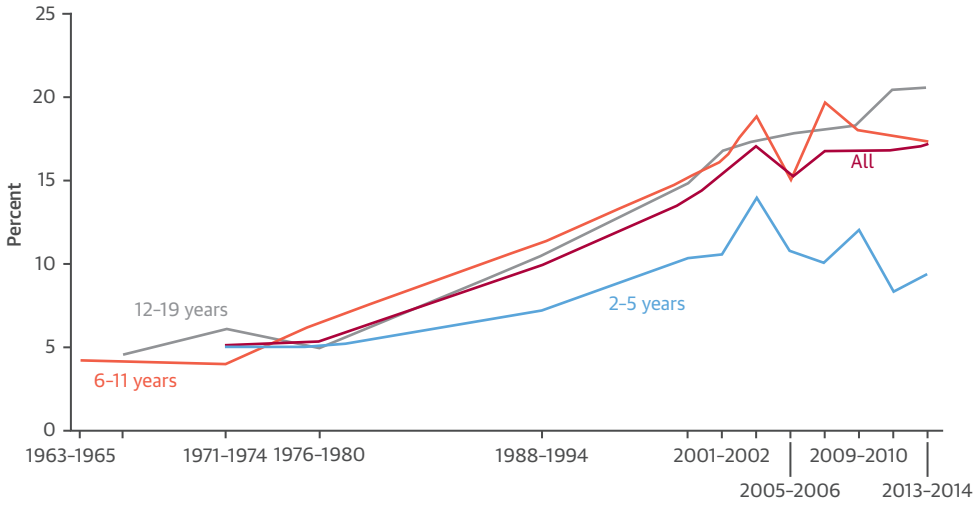
This strategy showed improvement in KAH scores in different settings. It was first tested in a low-income area in Colombia (66). In this study, ~1,200 preschoolers and their parents/teachers were randomized to receive the educational program or control. In comparison to control subjects, children in the intervention group showed a larger increase (10.9% vs. 5.3%) in KAH toward a healthy lifestyle at 6 months (post-intervention) (66). The control group then crossed over and showed a positive trend in KAH that was maintained after 36-month follow-up (67) (**Figure 5**). Similar findings were found in a middle-income setting in Madrid (Spain) involving >2,000 children. After 3 years of follow-up, the KAH score was 4.9% higher in children in the intervention group compared with the control group (68). By using the same methodology, the SI! Program for elementary students age 6 to 11 years (NCT02428634) and for adolescents aged 12 to 16 years (NCT03504059) are being investigated. Similarly, the FAMILIA (Family-Based Approach in a Minority Community Integrating Systems-Biology for Promotion of Health) study seeks to promote health throughout life in a disadvantaged community, while understanding the biological basis of CV disease (69). Some limitations with regards to the SI! Program should be acknowledged. First, the underpinning of the sequential behavioral change

FIGURE 2 Trends of Healthy Diet Targets in Children (Age 5 to 19 Years) in the United States: NHANES 2003 to 2004, 2005 to 2006, 2007 to 2008, 2009 to 2010, and 2011 to 2012



The Healthy Diet Score is based on adherence to the following dietary recommendations: fruits and vegetables, ≥4.5 cups/day; fish, 2 or more 3.5-ounce servings/week; sodium, ≤1,500 mg/day; sugar-sweetened beverages, ≤450 kcal (36 ounces)/week; and whole grains, ≥3 servings/day. Poor, intermediate, and ideal diet is defined as adherence to 0 to 1, 2 to 3, and 4 to 5 components of the recommendations, respectively. Reproduced with permission from the original publisher (1). All requests to use this information must come through the AHA.

FIGURE 3 Alarming Trends of Obesity in the United States Among Children and Adolescents, 1963 to 2014

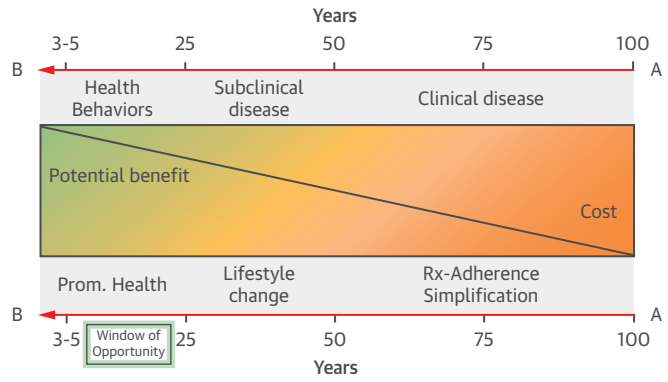


Obesity is body mass index (BMI) at or above the sex-specific and age-specific 95th percentile BMI cut-off points from the 2000 Centers for Disease Control and Prevention growth charts. Reproduced with permission from the original publisher (1). All requests to use this information must come through the AHA.

theory does not fully addressed the complexity of behavior, and it is more likely to induced short-term changes in motivation and other potential mediators of change rather than in actual habits (70). Second, the improvement in KAH does not necessarily translate into a reduction in CV risk factors or other harder endpoints. Third, the long-term sustainability of the intervention effects remain to be studied.

Available published data supports that interventions should have a follow-up for at least 1 to 2 years to sufficiently evaluate their sustainability or identify a delayed effect (61). Two recent trials, WAVES (West Midlands ActiVe lifestyle and healthy Eating in School children) (71) and AFLY5 (Active for Life Year 5) (72), were conducted in approximately 3,600 children at >100 primary schools combined. They included long-term follow-up and have failed to prevent obesity and promote healthy habits in children. These results highlight the need of integration of additional strategies for child health promotion including family-based and community-based approaches, and a wide support across multiple sectors through the implementation of public policies.

FIGURE 4 The Future of Promoting Health



The adoption of unhealthy behaviors begins in early childhood, introducing the first stage of development of cardiovascular (CV) disease. Health promotion programs represent a cost-effective window of opportunity to potentially prevent the development of disease. Adapted from Fuster (100). A = aging; B = birth; Prom. = promoting; Rx = treatment.

FAMILY-BASED AND COMMUNITY-BASED INTERVENTIONS. Family cohesion and communication may play a vital role in the development and maintenance of healthy behaviors in children (56). Several studies have shown better outcomes for family-based program targeting childhood obesity than control subjects (73). Moreover, community-based programs to improve physical activity and nutrition, and to prevent smoking, have the potential of great return of investment (74). However, the evidence is conflicting. The recent GROW (Growing Right Onto

Wellness) trial was conducted between 2012 and 2017 and included 610 parent-child pairs (children were between ages 3 and 5 years). It did not show a significant change in body mass index (BMI) after a 36-month, multicomponent, family-based, community-centered behavioral intervention (75). This is consistent with meta-analyses suggesting that diet, physical activity, and behavioral interventions for the treatment of overweight and obesity in children and adolescents may be beneficial only in achieving small, short-term reduction in BMI with unclear long-term effects (76-78). These meta-analyses also suggest that these interventions are more effective the earlier they are started. In fact, approaches focusing on very early stages in life have shown that children's lifestyle choices might be influenced by their mothers to a significant extent (79). Promising results from the INSIGHT (Intervention Nurses Start Infants Growing on Health Trajectories) trial, including 279 mother-child dyads, have demonstrated a modest long-term reduction in BMI z score after a parenting curriculum focused on feeding, sleep, interactive play, and emotion regulation starting at the age of 3 to 4 weeks (80). Providing ongoing implementation support may help sustain intervention effect (81).

LEGISLATION AND PUBLIC POLICIES. Health promotion programs focused on individuals are important; however, they do not address other important contributors to unhealthy behaviors including social, environmental, and economic determinants (**Central Illustration**) (82). This requires comprehensive legislations and the implementation of practical public policies (83). As an example, legislation supporting accessibility to healthy choices, including subsidies to low-income people, has been shown to increase sales and consumption of healthy foods (84). Moreover, financial strategies like taxation can be a powerful tool to promote health and nutrition. Mexico's tax on sugar-sweetened beverages was associated with an average reduction of almost 8% in the sale of these products, with a more pronounced effect in lower-income households (85). Comparable taxation strategies have been passed in >25 countries including 7 cities in the United States, such as Philadelphia, Seattle, and San Francisco (86). Similarly, tobacco taxation and smoking bans in public areas have been shown as a very effective way to reduce tobacco use and prevent secondhand smoking (87,88). These tax revenues could be reinvested for other health promotion programs, making it a win-win strategy (83,87).

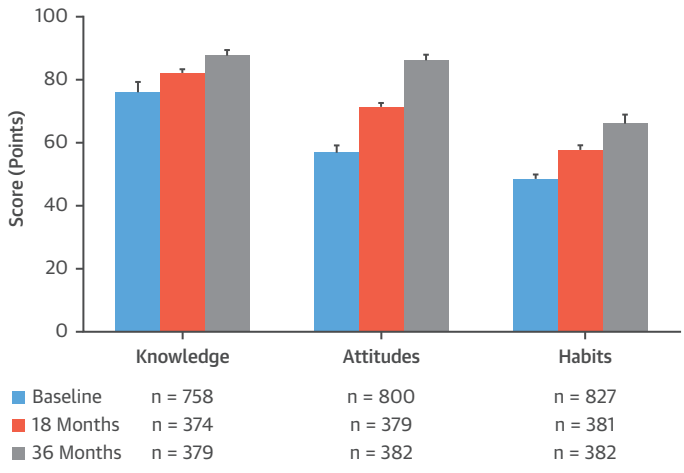
Legislation can also help schools provide an environment supportive of healthy diet and physical activity given that schools are natural and complementary settings for effective policies in children. In a recent meta-analysis, the implementation of school food environment policies resulted in a modest increased in combined fruits and vegetables by ~0.3 servings/day, and reduced sugar-sweetened beverage intake and unhealthy snacks by ~0.2 servings/day (89). It has been estimated that the national implementation of these policies in the United States would avert ~22,000 deaths/year related to cardiometabolic diseases (90). Another focus of public

TABLE 1 Curricular Objectives of the SI! Program for Health Promotion in Preschool Children

Component	Goals
Diet	• Understanding and learning to value a healthy balanced diet • Awakening the curiosity about characteristics of foods and their origins • Developing healthy attitudes toward family cuisine and natural surroundings
Physical activity	• Understanding the relationship between movement and health • Developing coordination through dance and play • Acquiring healthy attitudes and routines in relation to physical activity
Body and heart awareness	• Knowing the external and internal body parts, with special emphasis in the heart function and its relation to other organs • Understanding and valuing health issues in the care of the human body and welfare according to one's own possibilities and limitations • Developing a positive self-image and learning to value difference
Emotion management	• Understanding facial expressions and body language in relation to basic emotions • Developing self-reliance, self-knowledge, and self-esteem • Forming relationships to other people and gradually developing ways of peacefully resolving conflict

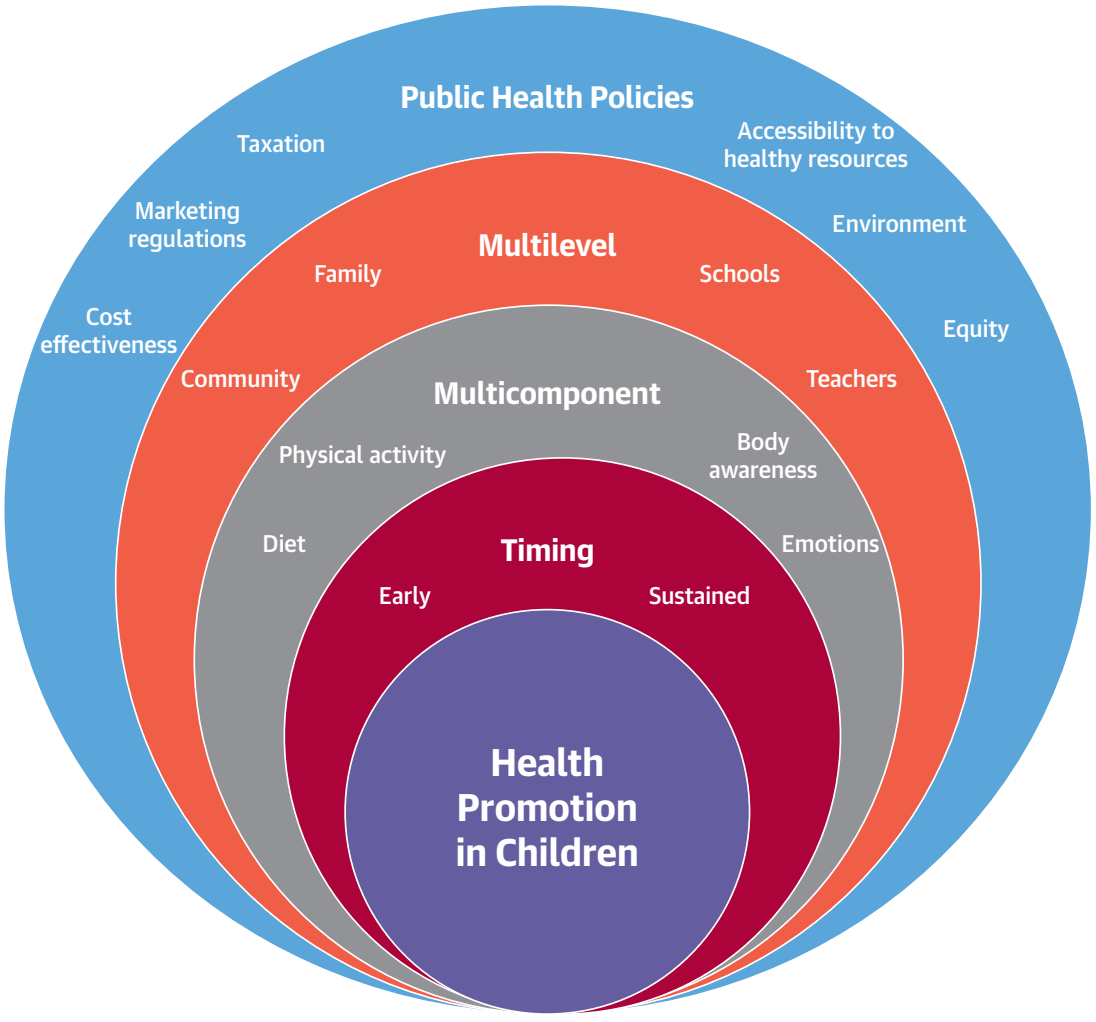
Adapted from Bansilal et al. (69).

FIGURE 5 Long-Term Results of the SI! Program in Colombia for Health Promotion in Children



Mean scores for knowledge, attitudes, and habits in children toward a healthy lifestyle over time. **Bars** represent mean and standard error of the mean. n = sample size.

CENTRAL ILLUSTRATION **Promoting Health in Children: Factors and Components of Effective Interventions**



Fernandez-Jimenez, R. et al. J Am Coll Cardiol. 2018;72(25):3310–9.

Successful health promotion initiatives should use a multilevel multicomponent educational approach that starts early and is maintained throughout the development of the child. These strategies should be supported by legislation and public health policies that target socioeconomic and environmental factors.

policies is to limit marketing to children of foods and beverages that do not meet nutrition standards, while promoting healthy choices instead. This should include social media and web-based advertisement, in addition to traditional forms of media. In addition, restructuring nutritional labels to make them simpler and easier to interpret might contribute to healthier choices (91).

RESEARCH GAPS

Health promotion programs in children offer promise; however, there are some pitfalls that need to be addressed. To be more effective, interventions should start early in life and be maintained during childhood using an intensive multicomponent multilevel approach supported by the community and legislative body (19).

Additional factors might influence the success of health promotion interventions in children. Adverse socioeconomic status (SES) may be associated with family strain and emotional issues in children, which can lead to unhealthy habits (92). Consequently, underserved children are alarmingly predisposed to high rates of disease (93). Furthermore, children from low SES are generally less well-reached through lifestyle interventions (94), and SES may affect the efficacy of health promoting programs (95). Nevertheless, few intervention studies have targeted both low-income and wealthier populations to examine the feasibility of reducing or eliminating CV disease disparities (74).

Differences and diversity in the school environments may play a relevant role in the successful implementation of school-based interventions and policies (96). Schools vary greatly in content, community involvement, financial support, and delivery of interventions, which could affect the efficacy of childhood educational programs (97). In addition, teachers' characteristics may be important given that they are one of the cornerstones in children's development and are instrumental for the successful implementation of school-based health promotion programs (98).

Finally, there is need for more data on long-term outcomes and large-scale implementations of such programs. Longitudinal data directly linking unhealthy behaviors in children and CV outcomes in adults is scarce, and needs more investigation. Collaborative efforts are likely to yield unique insights into the independent effects of childhood levels of CV risk factors on subsequent disease occurrence (99).

CONCLUSIONS

CV disease is the leading cause of death and disability in the world, largely because of risk factors modifiable by changes in behavior. Notably, behavioral risk factors start in early childhood. This will manifest as an increased disease risk decades later. Early and maintained multicomponent educational interventions focused on health promotion in children represent a promising approach to prevent disease in adulthood. The integration of school-based, family-based, and community-based approaches, along with a wide support across multiple sectors through the implementation of public policies, are likely necessary for the success of health promotion programs in children. However, long-term and large-scale research studies need to establish their effectiveness in reducing CV risk factors and disease later in life.

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REFERENCES

1. Benjamin EJ, Virani SS, Callaway CW, et al. Heart disease and stroke statistics-2018 update: a report from the American Heart Association. Circulation 2018;137:e67–492.

2. Laitinen TT, Pahkala K, Magnussen CG, et al. Lifetime measures of ideal cardiovascular health and their association with subclinical atherosclerosis: The Cardiovascular Risk in Young Finns Study. Int J Cardiol 2015;185:186–91.

3. Shonkoff JP. Capitalizing on advances in science to reduce the health consequences of early childhood adversity. JAMA Pediatr 2016;170:1003–7.

4. Fuster V, Frazer J, Snair M, et al. The future role of the United States in global health: emphasis on cardiovascular disease. J Am Coll Cardiol 2017;70:3140–56.

5. Shah H, Albanese E, Duggan C, et al. Research priorities to reduce the global burden of dementia by 2025. Lancet Neurol 2016;15:1285–94.

6. Fitzmaurice C, Allen C, Barber RM, et al., for the Global Burden of Disease Cancer Collaboration. Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: a systematic analysis for the Global Burden of Disease Study. JAMA Oncol 2017;3:524–48.

7. Dzau V, Fuster V, Frazer J, Snair M. Investing in global health for our future. N Engl J Med 2017;377:1292–6.

8. Steinberger J, Daniels SR, Hagberg N, et al. Cardiovascular health promotion in children: challenges and opportunities for 2020 and beyond: a scientific statement from the American Heart Association. Circulation 2016;134:e236–55.

9. Ning H, Labarthe DR, Shay CM, et al. Status of cardiovascular health in US children up to 11 years of age: the National Health and Nutrition Examination Surveys 2003–2010. Circ Cardiovasc Qual Outcomes 2015;8:164–71.

10. National Physical Activity Plan Alliance. 2016 United States Report Card on Physical Activity for Children and Youth. Columbia, SC: National Physical Activity Plan Alliance, 2016.

11. Nguyen D, Kit B, Carroll M. Abnormal cholesterol among children and adolescents in the United States, 2011–2014. NCHS data brief, no 228. Hyattsville, MD: National Center for Health Statistics, 2015.

12. Wang TW, Gentzke A, Sharapova S, Cullen KA, Ambrose BK, Jamal A. Tobacco product use among middle and high school students-United States, 2011–2017. MMWR Morb Mortal Wkly Rep 2018;67:629–33.

13. Benziger CP, Zavala-Loayza JA, Bernabe-Ortiz A, et al. Low prevalence of ideal cardiovascular health in Peru. Heart 2018;104:1251–6.

14. Dong H, Yan Y, Liu J, et al. Alarming trends in ideal cardiovascular health among children and adolescents in Beijing, China, 2004 to 2014. Int J Cardiol 2017;231:264–70.

15. Henriksson P, Henriksson H, Gracia-Marco L, et al. Prevalence of ideal cardiovascular health in European adolescents: the HELENA study. Int J Cardiol 2017;240:428–32.

16. Ogden CL, Fryar CD, Hales CM, Carroll MD, Aoki Y, Freedman DS. Differences in Obesity Prevalence by Demographics and Urbanization in US Children and Adolescents, 2013-2016. JAMA 2018;319:2410–8.

17. Hales C, Carroll M, Fryar C, Ogden C. Prevalence of obesity among adults and youth: United States, 2015–2016. NCHS data brief, no 288. Hyattsville, MD: National Center for Health Statistics, 2017.

18. Afshin A, Forouzanfar MH, Reitsma MB, et al., for the GBD 2015 Obesity Collaborators. Health Effects of Overweight and Obesity in 195 Countries over 25 Years. N Engl J Med 2017;377:13–27.

19. O'Connor EA, Evans CV, Burda BU, Walsh ES, Eder M, Lozano P. Screening for obesity and intervention for weight management in children and adolescents: evidence report and systematic review for the US Preventive Services Task Force. JAMA 2017;317:2427–44.

20. Song M, Hu FB, Wu K, et al. Trajectory of body shape in early and middle life and all cause and cause specific mortality: results from two prospective US cohort studies. BMJ 2016;353:i2195.

21. Vos MB, Kaar JL, Welsh JA, et al. Added sugars and cardiovascular disease risk in children: a scientific statement from the American Heart Association. Circulation 2017;135:e1017–34.

22. Fanshawe TR, Halliwell W, Lindson N, Aveyard P, Livingstone-Banks J, Hartmann-Boyce J. Tobacco cessation interventions for young people. Cochrane Database Syst Rev 2017;11:CD003289.

23. Raghuveer G, White DA, Hayman LL, et al. Cardiovascular consequences of childhood secondhand tobacco smoke exposure: prevailing evidence, burden, and racial and socioeconomic disparities: a scientific statement from the American Heart Association. Circulation 2016;134:e336–59.

24. Hughes K, Bellis MA, Hardcastle KA, et al. The effect of multiple adverse childhood experiences on health: a systematic review and meta-analysis. Lancet Public Health 2017;2:e356–66.

25. Rovio SP, Pahkala K, Nevalainen J, et al. Cardiovascular risk factors from childhood and midlife cognitive performance: the Young Finns Study. J Am Coll Cardiol 2017;69:2279–89.

26. Leventakou V, Roumeliotaki T, Sarri K, et al. Dietary patterns in early childhood and child cognitive and psychomotor development: the Rhea mother-child cohort study in Crete. Br J Nutr 2016;115:1431–7.

27. van der Flier WM, Skoog I, Schneider JA, et al. Vascular cognitive impairment. Nat Rev Dis Primers 2018;4:18003.

28. Poitras VJ, Gray CE, Borghese MM, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. Appl Physiol Nutr Metab 2016;41:S197–239.

29. Berenson GS, Srinivasan SR, Bao W, Newman WP 3rd, Tracy RE, Wattigney WA. Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. The Bogalusa Heart Study. N Engl J Med 1998;338:1650–6.

30. Pahkala K, Hietalampi H, Laitinen TT, et al. Ideal cardiovascular health in adolescence: effect of lifestyle intervention and association with vascular intima-media thickness and elasticity (the Special Turku Coronary Risk Factor Intervention Project for Children [STRIP] study). Circulation 2013;127:2088–96.

31. Laitinen TT, Ruohonen S, Juonala M, et al. Ideal cardiovascular health in childhood-Longitudinal associations with cardiac structure and function: The Special Turku Coronary Risk Factor Intervention Project (STRIP) and the Cardiovascular Risk in Young Finns Study (YFS). Int J Cardiol 2017;230:304–9.

32. Juonala M, Magnussen CG, Berenson GS, et al. Childhood adiposity, adult adiposity, and cardiovascular risk factors. N Engl J Med 2011;365:1876–85.

33. Bjerregaard LG, Jensen BW, Angquist L, Osler M, Sorensen TIA, Baker JL. Change in Overweight from Childhood to Early Adulthood and Risk of Type 2 Diabetes. N Engl J Med 2018;378:1302–12.

34. Juhola J, Magnussen CG, Berenson GS, et al. Combined effects of child and adult elevated blood pressure on subclinical atherosclerosis: the International Childhood Cardiovascular Cohort Consortium. Circulation 2013;128:217–24.

35. Nupponen M, Pahkala K, Juonala M, et al. 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 2015;131:605–13.

36. Hartiala O, Kajander S, Knuuti J, et al. Life-course risk factor levels and coronary artery calcification. The Cardiovascular Risk in Young Finns Study. Int J Cardiol 2016;225:23–9.

37. Khera AV, Emdin CA, Drake I, et al. Genetic risk, adherence to a healthy lifestyle, and coronary disease. N Engl J Med 2016;375:2349–58.

38. Ebrahim S, Taylor F, Ward K, Beswick A, Burke M, Davey Smith G. Multiple risk factor interventions for primary prevention of coronary heart disease. Cochrane Database Syst Rev 2011:CD001561.

39. Weintraub WS, Daniels SR, Burke LE, et al. Value of primordial and primary prevention for cardiovascular disease: a policy statement from the American Heart Association. Circulation 2011;124:967–90.

40. American Lung Association. Smoking cessation: the economic benefits. . Available at: https://www.lung.org/our-initiatives/tobacco/cessation-and-prevention/smoking-cessation-economic-benefits.html. Accessed October 25, 2018.

41. Shaw LJ, Goyal A, Mehta C, et al. 10-Year Resource Utilization and Costs for Cardiovascular Care. J Am Coll Cardiol 2018;71:1078–89.

42. Ekwaru JP, Ohinmaa A, Tran BX, Setayeshgar S, Johnson JA, Veugelers PJ. Cost-effectiveness of a school-based health promotion program in Canada: A life-course modeling approach. PLoS One 2017;12:e0177848.

43. Korber K. Quality assessment of economic evaluations of health promotion programs for children and adolescents-a systematic review using the example of physical activity. Health Econ Rev 2015;5:35.

44. Graziose MM, Koch PA, Wang YC, Lee Gray H, Contento IR. Cost-effectiveness of a Nutrition Education Curriculum Intervention in Elementary Schools. J Nutr Educ Behav 2017;49:684–91.e1.

45. Wang LY, Yang Q, Lowry R, Wechsler H. Economic analysis of a school-based obesity prevention program. Obes Res 2003;11:1313–24.

46. Brown HS 3rd, Perez A, Li YP, Hoelscher DM, Kelder SH, Rivera R. The cost-effectiveness of a school-based overweight program. Int J Behav Nutr Phys Act 2007;4:47.

47. Gomez-Pardo E, Fernandez-Alvira JM, Vilanova M, et al. A Comprehensive lifestyle peer group-based intervention on cardiovascular risk factors: the randomized controlled Fifty-Fifty Program. J Am Coll Cardiol 2016;67:476–85.

48. Oosterhoff M, Bosma H, van Schayck OCP, Evers S, Dirksen CD, Joore MA. A systematic review on economic evaluations of school-based lifestyle interventions targeting weight-related behaviours among 4-12 year olds: Issues and ways forward. Prev Med 2018;114:115–22.

49. Barrett JL, Gortmaker SL, Long MW, et al. Cost effectiveness of an elementary school active physical education policy. Am J Prev Med 2015;49:148–59.

50. Cradock AL, Barrett JL, Kenney EL, et al. Using cost-effectiveness analysis to prioritize policy and programmatic approaches to physical activity promotion and obesity prevention in childhood. Prev Med 2017;95 Suppl:S17–27.

51. Leao T, Kunst AE, Perelman J. Cost-effectiveness of tobacco control policies and programmes targeting adolescents: a systematic review. Eur J Public Health 2018;28:39–43.

52. Keeley B. Human Capital: How what you know shapes your life. Available at: https://doi.org/10.1787/9789264029095-en. Accessed November 12, 2018.

53. Mirowsky J, Ross CE. Education, personal control, lifestyle and health—a human capital hypothesis. Research on Aging 1998;20:415–49.

54. Bleich SN, Vercammen KA, Zatz LY, Frelier JM, Ebbeling CB, Peeters A. Interventions to prevent global childhood overweight and obesity: a systematic review. Lancet Diabetes Endocrinol 2018;6:332–46.

55. Waters E, de Silva-Sanigorski A, Hall BJ, et al. Interventions for preventing obesity in children. Cochrane Database Syst Rev 2011:CD001871.

56. Vedanthan R, Bansilal S, Soto AV, et al. Family-based approaches to cardiovascular health promotion. J Am Coll Cardiol 2016;67:1725–37.

57. Fuster VKB, editor. Promoting Cardiovascular Health in the Developing World: A Critical Challenge to Achieve Global Health. Washington (DC): Institute of Medicine (US) Committee on Preventing the Global Epidemic of Cardiovascular Disease: Meeting the Challenges in Developing Countries, 2010.

58. Telama R, Yang X, Viikari J, Valimaki I, Wanne O, Raitakari O. Physical activity from childhood to adulthood: a 21-year tracking study. Am J Prev Med 2005;28:267–73.

59. Katz DL. School-based interventions for health promotion and weight control: not just waiting on the world to change. Annu Rev Public Health 2009;30:253–72.

60. Martin A, Booth JN, Laird Y, Sproule J, Reilly JJ, Saunders DH. Physical activity, diet and other behavioural interventions for improving cognition and school achievement in children and adolescents with obesity or overweight. Cochrane Database Syst Rev 2018;3:CD009728.

61. Ling J, Robbins LB, Wen F, Zhang N. Lifestyle Interventions in Preschool Children: A Meta-analysis of Effectiveness. Am J Prev Med 2017;53:102–12.

62. Cai L, Wu Y, Wilson RF, Segal JB, Kim MT, Wang Y. Effect of childhood obesity prevention programs on blood pressure: a systematic review and meta-analysis. Circulation 2014;129:1832–9.

63. Dobbins M, Husson H, DeCorby K, LaRocca RL. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. Cochrane Database Syst Rev 2013:CD007651.

64. SHE Foundation. The SI! Programme. Available at: http://www.programasi.org/en/. Accessed July 8, 2018.

65. Di Noia J, Prochaska JO. Dietary stages of change and decisional balance: a meta-analytic review. Am J Health Behav 2010;34:618–32.

66. Cespedes J, Briceno G, Farkouh ME, et al. Targeting preschool children to promote cardiovascular health: cluster randomized trial. Am J Med 2013;126:27–35.e3.

67. Cespedes J, Briceno G, Farkouh ME, et al. Promotion of cardiovascular health in preschool children: 36-month cohort follow-up. Am J Med 2013;126:1122–6.

68. Penalvo JL, Santos-Beneit G, Sotos-Prieto M, et al. The SI! Program for Cardiovascular Health Promotion in Early Childhood: A Cluster-Randomized Trial. J Am Coll Cardiol 2015;66:1525–34.

69. Bansilal S, Vedanthan R, Kovacic JC, et al. Rationale and design of family-based approach in a minority community integrating systems-biology for promotion of health (FAMILIA). Am Heart J 2017;187:170–81.

70. Adams J, White M. Why don't stage-based activity promotion interventions work? Health education research 2005;20:237–43.

71. Adab P, Pallan MJ, Lancashire ER, et al. Effectiveness of a childhood obesity prevention programme delivered through schools, targeting 6 and 7 year olds: cluster randomised controlled trial (WAVES study). BMJ 2018;360:k211.

72. Anderson EL, Howe LD, Kipping RR, et al. Long-term effects of the Active for Life Year 5 (AFLY5) school-based cluster-randomised controlled trial. BMJ open 2016;6:e010957.

73. Wilfley DE, Saelens BE, Stein RI, et al. Dose, content, and mediators of family-based treatment for childhood obesity: a multisite randomized clinical trial. JAMA Pediatr 2017;171:1151–9.

74. Mensah GA, Cooper RS, Siega-Riz AM, et al. Reducing cardiovascular disparities through community-engaged implementation research: A National Heart, Lung, and Blood Institute workshop report. Circ Res 2018;122:213–30.

75. Barkin SL, Heerman WJ, Sommer EC, et al. Effect of a behavioral intervention for underserved preschool-age children on change in body mass index: a randomized clinical trial. JAMA 2018;320:450–60.

76. Al-Khudairy L, Loveman E, Colquitt JL, et al. Diet, physical activity and behavioural interventions for the treatment of overweight or obese adolescents aged 12 to 17 years. Cochrane Database Syst Rev 2017;6:CD012691.

77. Colquitt JL, Loveman E, O'Malley C, et al. Diet, physical activity, and behavioural interventions for the treatment of overweight or obesity in preschool children up to the age of 6 years. Cochrane Database Syst Rev 2016;3:CD012105.

78. Mead E, Brown T, Rees K, et al. Diet, physical activity and behavioural interventions for the treatment of overweight or obese children from the age of 6 to 11 years. Cochrane Database Syst Rev 2017;6:CD012651.

79. Dhana K, Haines J, Liu G, et al. Association between maternal adherence to healthy lifestyle practices and risk of obesity in offspring: results from two prospective cohort studies of mother-child pairs in the United States. BMJ 2018;362:k2486.

80. Paul IM, Savage JS, Anzman-Frasca S, et al. Effect of a responsive parenting educational intervention on childhood weight outcomes at 3 years of age: the INSIGHT Randomized Clinical Trial. JAMA 2018;320:461–8.

81. Wen LM, Baur LA, Simpson JM, et al. Sustainability of effects of an early childhood obesity prevention trial over time: a further 3-year follow-up of the Healthy Beginnings Trial. JAMA Pediatr 2015;169:543–51.

82. Novak NL, Brownell KD. Role of policy and government in the obesity epidemic. Circulation 2012;126:2345–52.

83. Mozaffarian D, Angell SY, Lang T, Rivera JA. Role of government policy in nutrition-barriers to and opportunities for healthier eating. BMJ 2018;361:k2426.

84. Sassi F, Belloni A, Mirelman AJ, et al. Equity impacts of price policies to promote healthy behaviours. Lancet 2018;391:2059–70.

85. Colchero MA, Rivera-Dommarco J, Popkin BM, Ng SW. In Mexico, evidence of sustained consumer response two years after implementing a sugar-sweetened beverage tax. Health Aff (Millwood) 2017;36:564–71.

86. Jacobson MF, Krieger J, Brownell KD. Potential policy approaches to address diet-related diseases. JAMA 2018;320:341–2.

87. Sugar, Tobacco, and Alcohol Taxes (STAX) Group. Sugar, tobacco, and alcohol taxes to achieve the SDGs. Lancet 2018;391:2400–1.

88. GBD 2015 Tobacco Collaborators. Smoking prevalence and attributable disease burden in 195 countries and territories, 1990-2015: a systematic analysis from the Global Burden of Disease Study 2015. Lancet 2017;389:1885–906.

89. Micha R, Karageorgou D, Bakogianni I, et al. Effectiveness of school food environment policies on children's dietary behaviors: a systematic review and meta-analysis. PLoS One 2018;13:e0194555.

90. Rosettie KL, Micha R, Cudhea F, et al. Comparative risk assessment of school food environment policies and childhood diets, childhood obesity, and future cardiometabolic mortality in the United States. PLoS One 2018;13:e0200378.

91. Crockett RA, King SE, Marteau TM, et al. Nutritional labelling for healthier food or non-alcoholic drink purchasing and consumption. Cochrane Database Syst Rev 2018;2:CD009315.

92. Hemmingsson E. Early childhood obesity risk factors: socioeconomic adversity, family dysfunction, offspring distress, and junk food self-medication. Curr Obes Rep 2018;7:204–9.

93. Pulkki-Raback L, Elovainio M, Hakulinen C, et al. Cumulative effect of psychosocial factors in youth on ideal cardiovascular health in adulthood: the Cardiovascular Risk in Young Finns Study. Circulation 2015;131:245–53.

94. Bukman AJ, Teuscher D, Feskens EJ, van Baak MA, Meershoek A, Renes RJ. Perceptions on healthy eating, physical activity and lifestyle advice: opportunities for adapting lifestyle interventions to individuals with low socioeconomic status. BMC Public Health 2014;14:1036.

95. van Sluijs EM, McMinn AM, Griffin SJ. Effectiveness of interventions to promote physical activity in children and adolescents: systematic review of controlled trials. BMJ 2007;335:703.

96. Centers for Disease Control and Prevention. School health guidelines to promote healthy eating and physical activity. MMWR Recomm Rep 2011;60:1–76.

97. McSweeney L, Araujo-Soares V, Rapley T, Adamson A. A feasibility study with process evaluation of a preschool intervention to improve child and family lifestyle behaviours. BMC Public Health 2017;17:248.

98. Esquivel MK, Nigg CR, Fialkowski MK, Braun KL, Li F, Novotny R. Influence of teachers' personal health behaviors on operationalizing obesity prevention policy in head start preschools: a project of the Children's Healthy Living Program (CHL). J Nutr Educ Behav 2016;48:318–25.e1.

99. Sinaiko AR, Jacobs DR Jr., Woo JG, et al. The International Childhood Cardiovascular Cohort (i3C) consortium outcomes study of childhood cardiovascular risk factors and adult cardiovascular morbidity and mortality: design and recruitment. Contemp Clin Trials 2018;69:55–64.

100. Fuster V. Stratified approach to health: integration of science and education at the right time for each individual. J Am Coll Cardiol 2015;66:1627–9.

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