

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

Rodrigo Fernandez-Jimenez, MD, PhD,^{a,b,c,*} Mohamed Al-Kazaz, MD,^{a,*} Risa Jaslow, MS, RDN,^a Isabel Carvajal, MS,^d Valentin Fuster, MD, PhD^{a,b}

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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From ^aThe Zena and Michael A. Wiener Cardiovascular Institute, Icahn School of Medicine at Mount Sinai, New York, New York; ^bCentro Nacional de Investigaciones Cardiovasculares Carlos III (CNIC), Madrid, Spain; ^cCIBER de Enfermedades Cardiovasculares (CIBERCV), Madrid, Spain; and the ^dFoundation for Science, Health and Education (Fundación SHE), Barcelona, Spain. *Drs. Fernandez-Jimenez and Al-Kazaz contributed equally to this work. The FAMILIA (Family-Based Approach in a Minority Community Integrating Systems-Biology for Promotion of Health) study is funded by the American Heart Association under grant No 14SFRN20490315. The CNIC is supported by the Ministerio de Ciencia, Innovación y Universidades, and the Pro CNIC Foundation, and is a Severo Ochoa Center of Excellence (SEV-2015-0505). Dr. Fernandez-Jimenez has received funding from the European Union Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 707642. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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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.

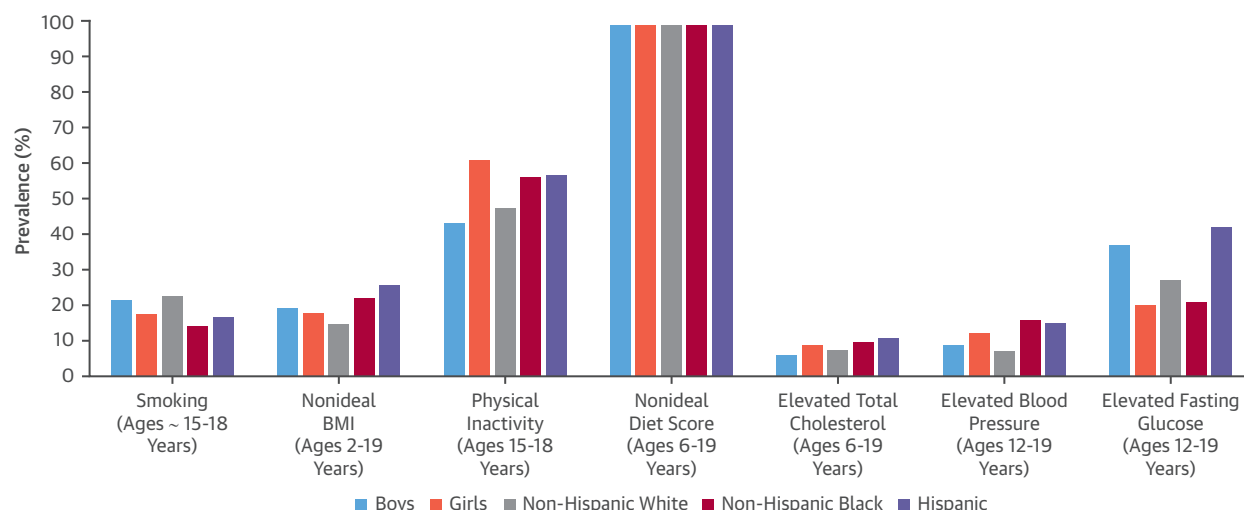
Adverse outcomes among unhealthy children who became healthier by adulthood could be similar to those among individuals who were never unhealthy (32). Childhood overweight status associates with increased risk of diabetes in adulthood only if they continue to be overweight until puberty or later; those 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
SH = 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 \geq 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 \geq 5 days/week, as analyzed from the 2015 Youth Risk Behavior Surveillance System (10). Nonideal diet score is defined as adherence to \leq 3 of the following dietary recommendations (fruits and vegetables, \geq 4.5 cups/day; fish, 2 or more 3.5-ounce servings/week; sodium, \leq 1,500 mg/day; sugar-sweetened beverages, \leq 450 kcal (36 ounces)/week; and whole grains, \geq 3 servings/day), as analyzed from the 2007–2008 and 2011–2012 NHANES (1). Elevated total cholesterol is defined as \geq 200 mg/dl, as analyzed from 2011–2014 NHANES (11). Elevated blood pressure and fasting glucose is defined as \geq 90th percentile and \geq 100 mg/dl, respectively, as analyzed from 2007–2008 NHANES (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 multi-component 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.

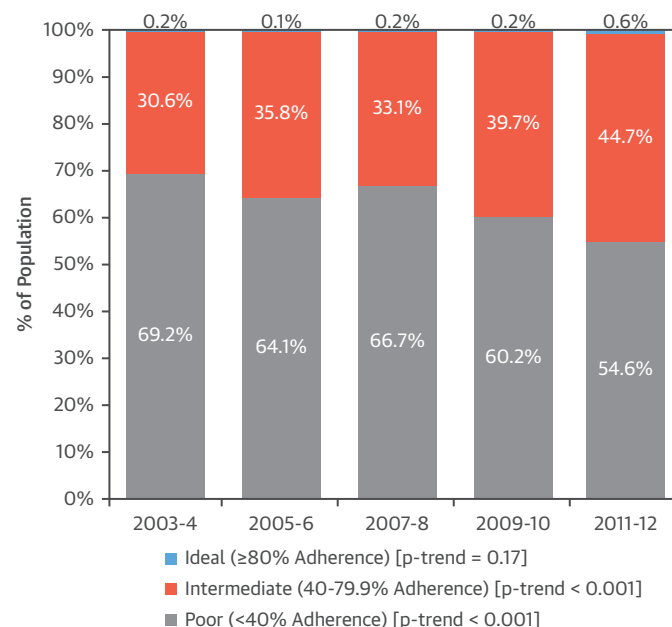
SCHOOL-BASED INITIATIVES. Through education, schools may play a major role in promoting long-lasting healthy habits in children, because these individuals spend the majority of their day there (57). Evidence suggests that when healthy habits are adopted early in life, they are more likely to be retained 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).

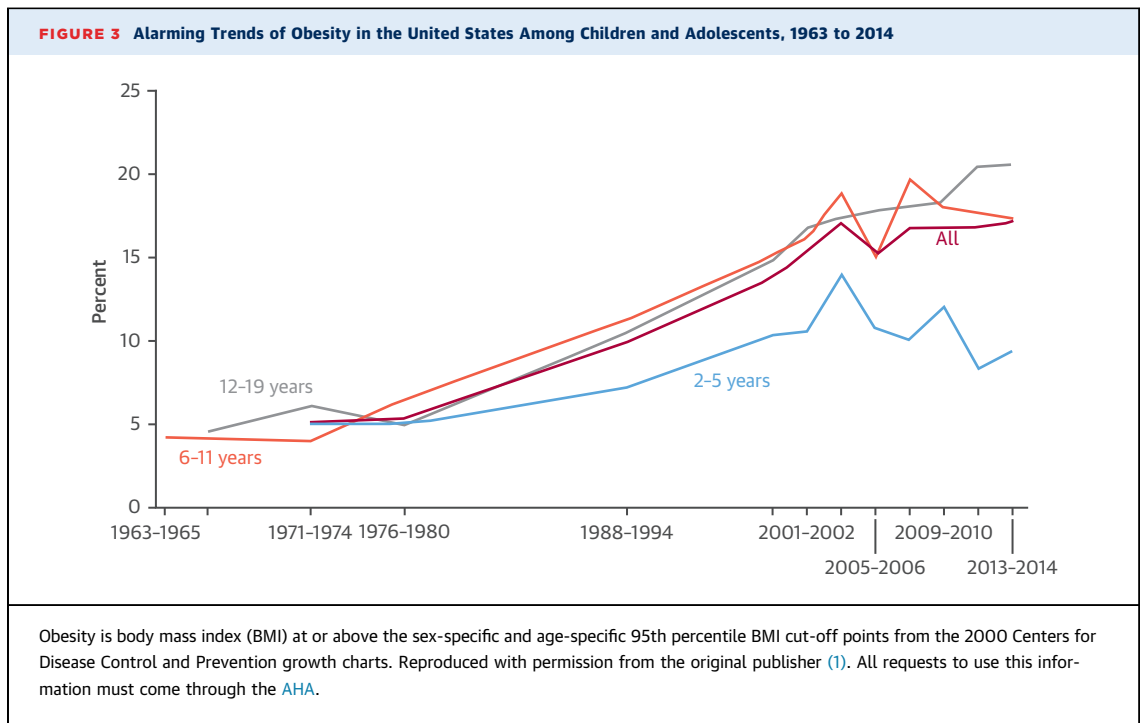
This strategy showed improvement in KAH scores in different settings. It was first tested in a low-income area in Colombia (66). In this study, ~1,200 preschoolers and their parents/teachers were randomized to receive the educational program or control. In comparison to control subjects, children in the intervention group showed a larger increase (10.9%

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.

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

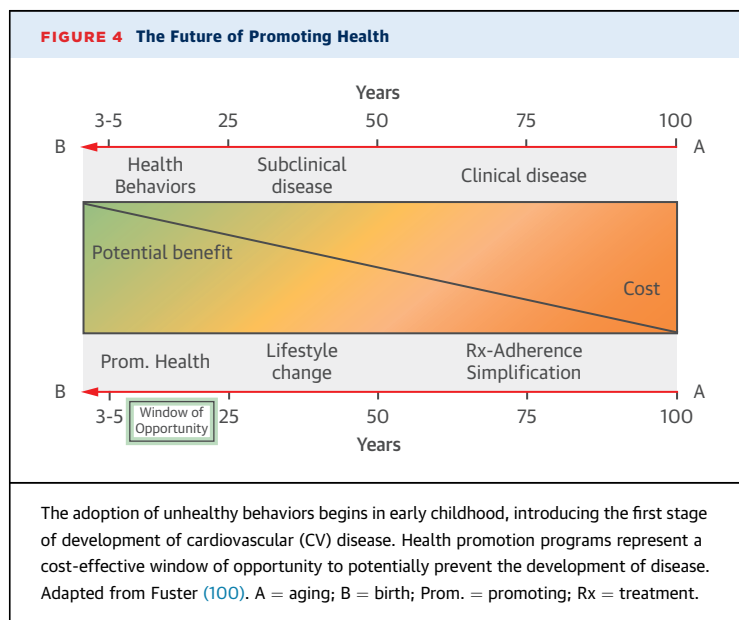


theory does not fully address the complexity of behavior, and it is more likely to induce short-term changes in motivation and other potential mediators of change rather than in actual habits (70). Second, the improvement in KAH does not necessarily translate into a reduction in CV risk factors or other 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.

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

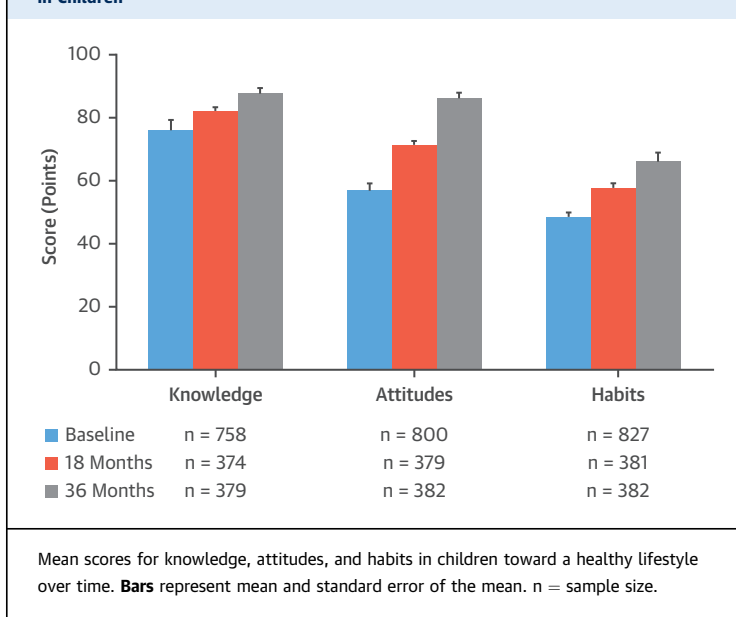
TABLE 1 Curricular Objectives of the SI! Program for Health Promotion in Preschool Children

| Component | Goals |
|--------------------------|---|
| Diet | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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 |

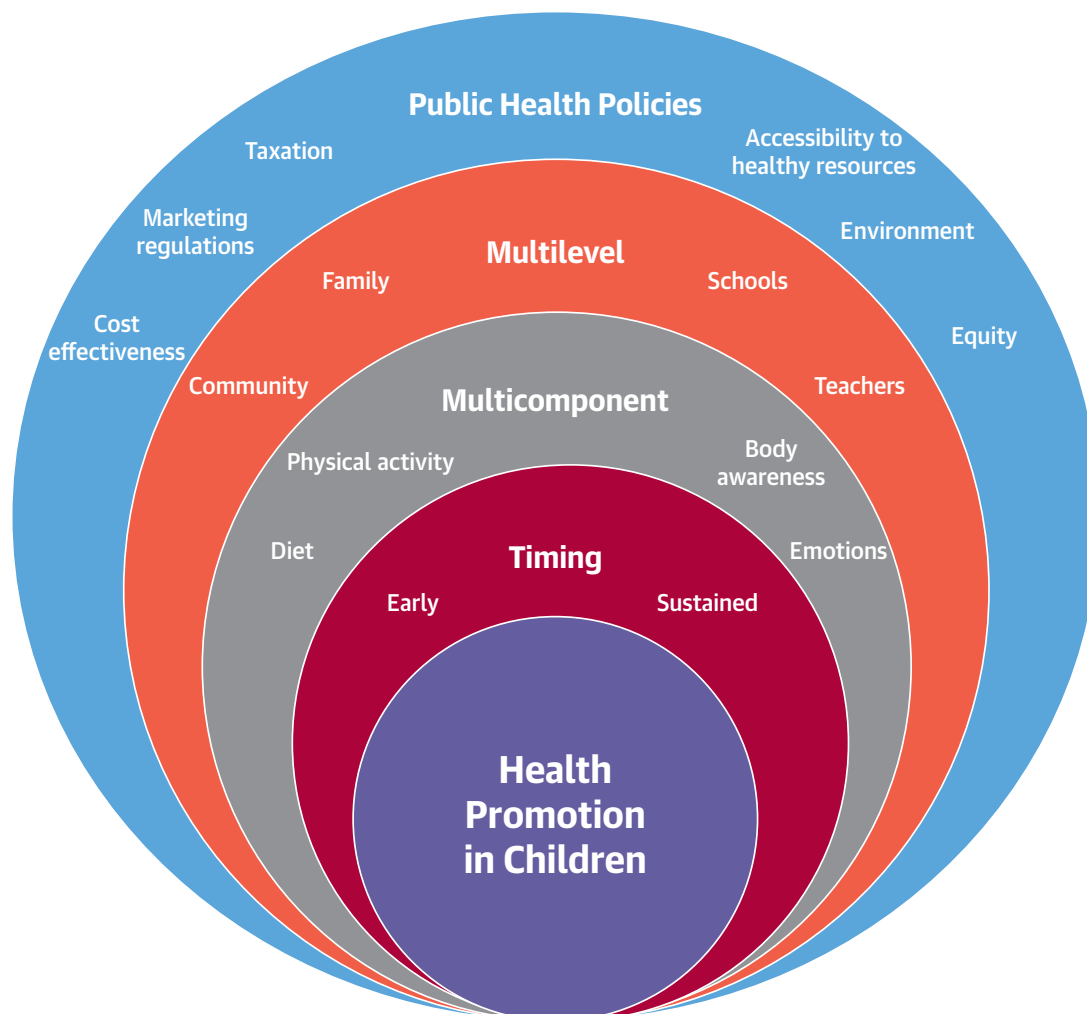
Adapted from Bansilal *et al.* (69).

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

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



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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ADDRESS FOR CORRESPONDENCE: Dr. Valentin Fuster, The Zena and Michael A. Wiener Cardiovascular Institute, Icahn School of Medicine at Mount Sinai, 1 Gustave L. Levy Place, New York, New York 10029. E-mail: valentin.fuster@mountsinai.org. Twitter: [@IcahnMountSinai](https://twitter.com/IcahnMountSinai), [@CNIC_CARDIO](https://twitter.com/CNIC_CARDIO).

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