PARTICIPATORY RESEARCH AS A NEW APPROACH TO MAKING DECISIONS AND INCREASING ACTIVE ENGAGEMENT IN HEALTH INTERVENTIONS FOR EFFECTIVELY IMPROVING HEALTHY LIFESTYLES BEHAVIOURS

Judit Queral Añó

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UNIVERSITAT ROVIRA i VIRGILI

Participatory Research as a new approach to making decisions and increasing active engagement in health interventions for effectively improving healthy lifestyle behaviours

Judit Queral Añó

DOCTORAL THESIS

2023

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DOCTORAL THESIS

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I STATE that the present study, entitled **"Participatory research as a new approach to take decisions and increase active engagement in health interventions for effectively improving healthy lifestyle behaviours"**, presented by **Judit Queral Añó** for the award of the degree of Doctor, has been carried out under my supervision at the Department of Medicine and Surgery of this university.

Reus, 29 November 2023

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A la família i al millor company de vida,

pel seu suport incondicional.

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ABBREVIATIONS

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ABBREVIATIONS

Citizen Science (CS)

Cluster Randomised Controlled Trial (c-RCT)

Community-based participatory research (CBPR)

Control group (CG)

Health and well-being for all (E4A)

Health Behaviour in School-age Children (HBSC)

Healthy lifestyle behaviours (HLBs)

High-income countries (HIC)

Intervention group (IG)

Mediterranean diet (MD)

Moderate to vigorous Physical Activity (MVPA)

Noncommunicable diseases (NCDs)

Obesity (OB)

Organisation for Economic Co-operation and Development (OECD)

Overweight (OW)

Participatory Action Research (PAR)

Participatory research (PR)

Physical activity (PA)

Programme for International Student Assessment (PISA)

Science Engagement to Empower aDoleScent (SEEDS)

Science, Technology, Engineering and Mathematics (STEM)

Socioeconomic status (SES)

Sustainable Development Goal (SDG)

Theory of Planned Behaviour (TPB)

Vigorous-intensity Physical Activity (VPA)

World Health Organization (WHO)

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ABSTRACT

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ABSTRACT

European populations continue to engage in unhealthy lifestyle behaviours. The participatory research (PR) approach, which is based on the identification of intrinsic and extrinsic factors that act as barriers and facilitators of Healthy Lifestyle Behaviours (HLBs) in order to adapt interventions for the target population, could represent a key strategy considering the poor active engagement of individuals in HLBs. The general aim of the thesis is to provide evidence about PR as a potential new approach to making decisions based on intrinsic and extrinsic factors, such as barriers and facilitators among the target population, and to increasing active engagement via PR in health interventions in order to effectively improve HLBs. The specific aims are twofold: 1) to identify the HLBs and to elucidate the intrinsic/extrinsic factors that act as barriers to and facilitators of HLBs among the target population, in order to adapt strategies for improving HLBs (Studies 1, 2 and 3) and 2) to identify effective approaches to actively engaging adolescents in improving their HLBs through PR interventions published in the literature. (Study 4). Four studies were conducted and methodology and findings were as follows: 1) Regarding European HLBs, the changes in time study from 2013/14 to 2017/18 in European adolescents, based on the Health Behaviour in School-aged Children (HBSC) data, resulted in an improvement in daily fruit consumption in 10 of the 36 countries and daily vegetable consumption in 12 of the36 countries. In general, intrinsic factors, such as age and sex, and extrinsic factors, such as SES are assessed. Older (13 to 15 years), boys and low SES adolescents showed poor dietary behaviours compared to younger (11 years), girls and medium/high SES adolescents. Conversely, girls consumed more sweets daily than boys. 2) A cross-sectional study determined the changes in intrinsic and extrinsic factors, such as needs, barriers, interests, and food choice in restaurants and in customers before and during the COVID-19 pandemic in the Tarragona Region (Spain). The first COVID-19 lockdown increased takeaway orders, sanitation, and digital communication in restaurants. Moreover, the barriers, needs, interests, and food choices of restaurants customers have changed during the COVID-19 pandemic. 3) A comparative study of the Science Engagement to Empower aDoleScent (SEEDS) project indicated that interventions co-created in four European countries (Spain, the Netherlands, the United Kingdom, and Greece) have some common

aspects and addressed the barriers identified in focus groups. However, the facilitators were not sufficiently addressed. 4) The systematic review and metanalysis included cluster Randomised Control Trials (RCTs) and non-RCTs that aimed to effectively improve HLB by using PR approach, showing that PR interventions may have positive effects on increasing fruit consumption. However, the fact that few studies have been published and those that exist are heterogeneous makes its elucidation difficult. In conclusion, the present thesis provides evidence about PR, considered as a strategy by and for populations, as a potential new approach to making decisions to improve HLBs, based on intrinsic and extrinsic factors such as the barriers and facilitators of the target population. However, high-quality evidence about PR interventions is needed to confirm its effectiveness in improving HLBs.

Funding Sources:

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The SEEDS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 101006251.

JUSTIFICATION

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JUSTIFICATION

Nowadays, the European populations continue to engage in unhealthy lifestyle behaviours, such as a low daily intake of fruit and vegetables (1), excessive sugar intake (2), and low levels of physical activity (PA) (3). Additionally, unhealthy lifestyle behaviours worsened during the COVID-19 pandemic in some European countries. The social isolation, restrictions on movement, and restricted access to food provisions triggered decreases in PA, an increase in unhealthy dietary behaviours such as the consumption of ultra-processed food, and an increase in health risk behaviours, such as alcohol and tobacco consumption (4,5). Surprisingly, some evidence showed an increase in adherence to the Mediterranean diet (MD) especially in countries with the highest level of restriction measures due to the COVID-19 pandemic; these included Bosnia and Herzegovina, Croatia, Denmark, Germany, Greece, Ireland, Italy, Lithuania, Montenegro, North Macedonia, Poland, Portugal, Serbia, Slovenia, Spain, and Turkey (6).

Unhealthy behaviours increase the risk of a person suffering from noncommunicable diseases (NCDs) such as cardiovascular diseases, chronic respiratory diseases, diabetes, and cancer, as well as other risks such as overweight and obesity (7).

Lifestyle behaviours change depending on a person's age and life stage, as a consequence, the recommendations are specific to each stage (8,9). Adolescence is a crucial stage of life in terms of promoting lifestyle behaviours because is when behaviour patterns, such as diet and PA, are established, and these patterns are closely directed to the behaviour patterns that characterise the rest of person's life (10,11).

A population's healthy lifestyle behaviours (HLBs) of the population can be influenced by different key factors. This influence can be explained by the key factors referred to as intrinsic and extrinsic factors, which act as barriers or facilitators (12). The intrinsic factors are related to an individual (age, gender, genetics, disease states, attitudes and beliefs, knowledge and literacy, ethnic perspectives, etc.). For example, age can act as a barrier because HLBs decrease linearly from early adolescence to older adolescence or young adulthood (13,14).

The extrinsic factors are related to the influence on the environment of the individuals (peer and family influence, the community environment, socioeconomic status (SES), demographic characteristics, etc.) (15–17).

The demand for Science, Technology, Engineering, and Mathematics (STEM) professionals is expected to grow more in the coming years than that for other occupations (18). However, the choice of STEM career paths among students is declining (19). Additionally, in STEM careers, there exists a significant gender and socioeconomic inequality. The gender ratio shows that three times more European boys than girls are interested in STEM careers (20), and low-income families have less access to science education and feel less confident in supporting their children to learn science (21). Furthermore, financial deprivation and low levels of education have been associated with poorer health literacy, which is also associated with a poor health status (22). One way to improve health literacy is through the development of scientific literacy (23), because health literacy is closely linked to one's knowledge of the scientific principles of human biology, critical thinking, and the ability to make informed decisions about science-related issues (24).

Therefore, changes in HLBs may arise, in part, due to science literacy or health literacy (25). Health literacy interventions can lead to changes in behaviours patterns such as diet and PA (26).

The literature presents a great deal of evidence about health promotion and education interventions aimed at improving HLBs in different settings, including communities and schools (27–29). However, to improve and enhance the benefits of this type of traditional research, it is necessary to eliminate or avoid some of its main limitations. One important limitation relates to the minimal interaction between the target population and the researchers, even though the positive effects of health promotion are particularly dependent on collaboration and public participation (30,31). Additionally, other limitations arise during the design stages, when community priorities and insights are not considered. These include the following: 1) dissemination (directed only to academic audiences without considering the target groups), 2) applicability of the results (the research ends with the publication of the

results with little impact in terms of society changes), and 3) sustainability (the researchers do not continue the partnership after the project when the grant ends) (31).

In order to account for community priorities and insights, the World Health Organization (WHO) recommends engaging the population to improve health and well-being outcomes and change behaviours, environments, and policies (32). One way to actively engage the population is the participatory research (PR) approach, defined as "the co-construction of research between researchers and people affected by the issues under study, supporting health by improving research quality, empowerment, capacity building, sustainability, program extension, and unanticipated new activities" (33).

Given the high prevalence of unhealthy lifestyle behaviours, low levels of interest in science and heat, and the lack of active engagement of the population in interventions, the literature gaps identified are as follows (*Figure 1*):

1. The **need to detect HLBs in order to determine how intrinsic** (age, gender, beliefs, and knowledge of the target population) and **extrinsic factors** (community, environment characteristics, socioeconomic status (SES), and peer and family influence of the target population) **act as barriers and facilitators among the target population, and how they can influence and help to adapt strategies for improving HLBs** (Study 1, Study 2, and Study 3)**.**

The intrinsic and extrinsic factors are related to the Theory of Planned Behaviour (TPB) (34), which is used to predict and explain human behaviour in specific contexts (35). The use of TPB is growing in the research areas of health sciences, environmental science, and education (36). Additionally, an awareness of these aspects can be useful when identifying the barriers and facilitators of the target population related to the intention to improve specific behaviours (37,38); as a consequence, this knowledge may improve the population's adherence to a specific intervention (39,40).

2. The **scarce evidence identified regarding the most effective PR approaches for improving HLBs in adolescents** (Study 4).

A combination of methods and approaches for implementing PR are identified (41,42) and some guidelines about how to implement the PR approach have been described (43,44).

Nevertheless, there is **scarce evidence in terms of an overview of the PR approach that can most effectively improve HBLs.**

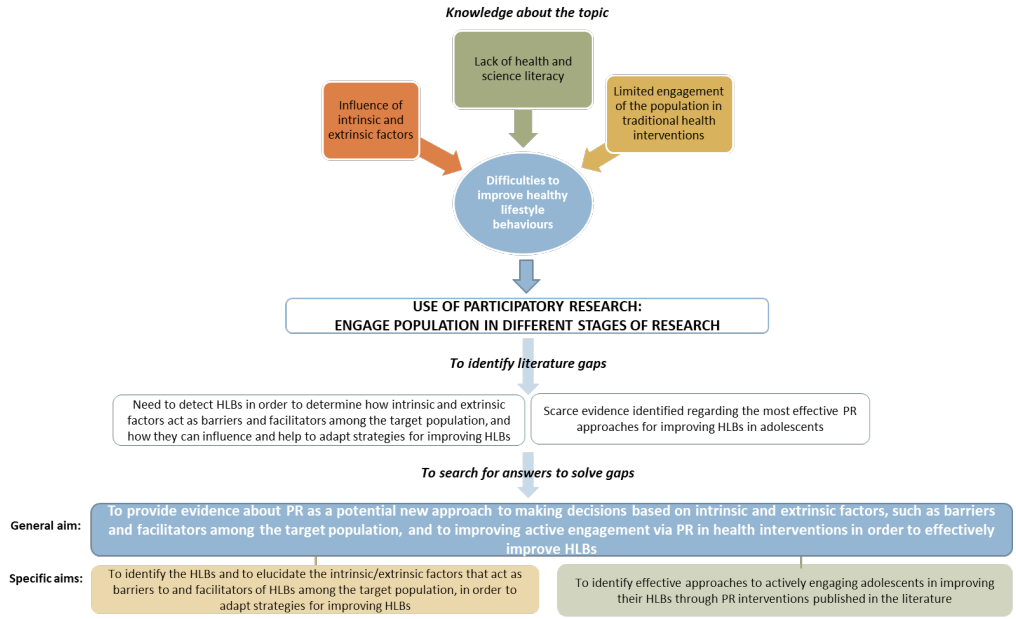
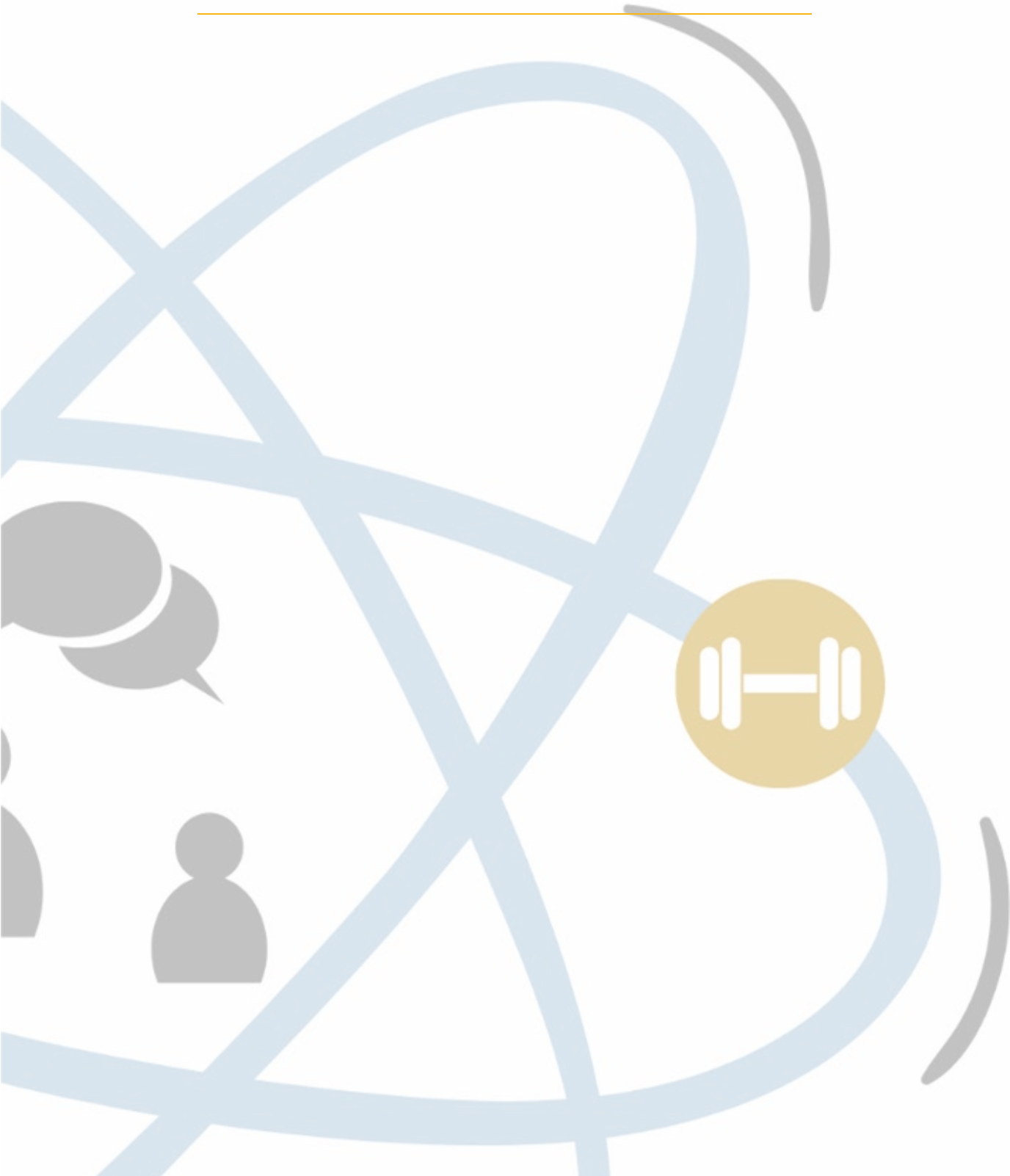


Figure 1. Diagram of the thesis design process elucidating the gaps found and the general and specific aims proposed to solve. Abbreviations: HLBs, Healthy Lifestyle Behaviours; PR, participatory research. Source: designed by the author.

INTRODUCTION



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INTRODUCTION

1. Health status of adults and adolescents

1.1. Lifestyles

Lifestyle refers to the characteristics of the inhabitants of a region at a specific time and in a specific place, that involve day-to-day behaviours and functions related to different areas including the workplace, leisure, diet, and physical activity (45).

The WHO provided 20 health tips for leading healthier lifestyles; some of them related to healthy diet (including fruit, vegetables, legumes, nuts, and whole grains), a reduced intake of harmful fat (saturated fats and trans-fats), reduced sugar and salt intake, and being active (46).

1.1.1. Food habits

Following a healthy diet helps to prevent malnutrition in all its forms (undernutrition, inadequate vitamins or minerals, and overweight and obesity) (47), as well as protecting against NCDs such as diabetes, heart disease, stroke, and cancer (8).

One of the most widely recognized healthy diets is the MD, which is characterised by a high intake of fruit, vegetables, olive oil, unrefined cereals, legumes, and nuts; moderate amounts of fish, eggs, poultry, and dairy products; and low quantities of red meat and processed meat (48,49). Adherence to the MD has health benefits including the prevention of cardiovascular diseases (50), reducing overall cancer risk and specific types of cancer, especially colorectal cancer (51), and helping the overall management of type 2 diabetes (52). In addition, the MD proves an optimal dietary pattern to tackling obesity, which is a risk factor for the NCDs mentioned above (53).

Nowadays, the WHO recommends consuming at least 400 g per day or five portions of fruit and vegetables; this reduces the risk of NCDs due to the protective effect of their components (e.g., dietary fibre, vitamins, and minerals) and the associated physiological mechanisms (8,54).

In 2018, the Health Behaviour in School-aged Children (HBSC) survey reported that 48% of European 11-15 years old adolescents did not eat fruit or vegetables daily (55). Additionally, in 2019, only 12% of the population aged 15 years or older in Europe consumed five portions or more of fruit and vegetables every day (*Figure 2*) (56).

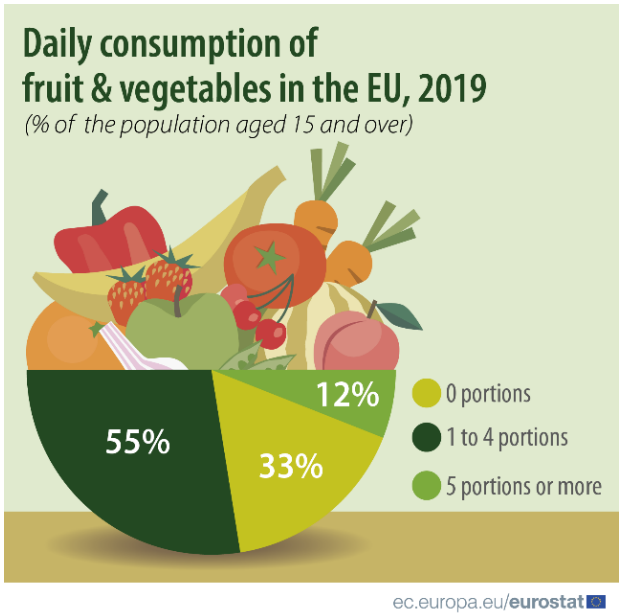

Figure 2. Daily fruit and vegetable consumption in the European Union in 2019. Source: Dataset from Eurostat (56).

The consumption of sweets and soft drinks in adolescents and adults decreased in the last years (57–59). Conversely, 25% and 16% of adolescents consumed sweets and soft drinks every day, respectively (55).

Adults (>18 years old) consumed a lower percentage of added sugar than children and adolescents (from 3 to 18 years old); thus, adults consumed between 7 and 11% of their total energy intake, and adolescents between 11 and 17% of their total energy intake (60).

As a consequence, the percentage of added sugar in the total energy intake among both populations exceeds the WHO recommendations, which stated that this should be less than 10% of the total energy intake (61); additionally, the European Society for Paediatric Gastroenterology, Hepatology and the Committee on Nutrition recommended that added

sugar constitute less than 5% of the energy intake of children and adolescents (aged 2–18 years) (62). The excessive intake of free sugar has a significant and serious impact on health conditions such as type 2 diabetes, cardiovascular diseases, overweight and obesity, dental caries, and gastrointestinal complaints, among others (62).

1.1.2. Physical Activity

PA is defined as "any bodily movement produced by skeletal muscles that requires energy expenditure, which refers to all movement including during leisure time, for transport to places, or as part of a person's job" (9).

The WHO recommendations for PA differ between children, adolescents, and adults; they are shown in *Figure 3* (63).

Children and adolescents between 5 and 17 years old should, on average, undertake at least 60 minutes per day of moderate to vigorous PA (MVPA) and at least three days a week of aerobic vigorous-intensity physical activity (VPA), as well as those that strengthen muscles and bones (63).

Adults aged 18–64 should engage in at least 150– 300 minutes of aerobic MVPA; or at least 75–150 minutes of aerobic VPA; or an equivalent combination of MVPA and VPA throughout the week. However, to obtain additional the health benefits, one may increase the aforementioned durations and should engage in muscle-strengthening activities at a moderate or higher intensity on two or more days a week; these activities should involve all major muscle groups (63).

Figure 3. Physical activity recommendations in children and adolescents (from 5 to 17 years old), and adults (≥18 years old) by World Health Organization. Source: WHO guidelines on PA, and sedentary behaviours, 2020 (63).

Following the PA recommendations results in many health benefits in children, adolescents and the adult population (*Table 1*) (64).

Table 1. Physical activity health benefits.

In children and adolescents:	In adults:
- Improved bone health - Improved weight status - Improved cardiorespiratory and muscular fitness - Improved cardiometabolic health - Improved cognition - Reduced risk of depression	- Lower risk of all-cause mortality - Lower risk of cardiovascular disease mortality - Lower risk of cardiovascular disease (including heart disease and stroke) - Lower risk of hypertension - Lower risk of type 2 diabetes - Lower risk of adverse blood lipid profile - Lower risk of cancers - Improved cognition - Improved quality of life - Reduced anxiety and risk of depression - Reduces risk of weight gain - Improved sleep - Improved bone health - Improved physical function

Source: Designed by the author, adapted from the Physical Activity Guidelines for Americans 2nd edition, 2018 (64).

Despite these benefits, one in four adults and three in four adolescents do not meet the global WHO recommendations for PA worldwide (65).

At the European level, only 19% of adolescents meet the 60 minutes of MVPA every day and the level of accomplishment is higher in boys (23%) than in girls (16%) (55). Additionally, 49% of boys and 35% of girls accomplished the recommendation of engaging in VPA four or more times a week (55).

1.1.3. Sedentary behaviour

Sedentary behaviour is defined as "any waking behaviour characterised by an energy expenditure ≤ 1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (66). Some examples of sedentary behaviour activities are the use of electronic devices (e.g., television, computer, tablet, phone) while sitting, reclining, or lying; reading/writing/drawing/painting while sitting; sitting in a bus, car, or train (67).

A commonly assessed behaviour in children and adolescents is screen time; this refers to the time spent on screen-based behaviours such as TV viewing, video game playing, and computer use (65,67). This behaviour can be sedentary or physically active; the difference arises when using a screen-based device while being sedentary in any context or, on the other hand, not being stationary (67).

Regarding sedentary behaviours, in 2017, EU adolescents showed a prevalence of sedentary behaviours (>4h30mins of sitting time/day) of 76.8%, with no significant differences between boys and girls. This behaviour exhibited no differences among genders, nor did it change over time (from 2002 to 2017) (68). The prevalence of sedentary behaviour in adults is still increasing, although its prevalence (55.8% in men and 53.1% in women) is lower than during childhood (69).

The Australian and Canadian 24-Hour Movement Guidelines for Children and Youth (5 to 17 years) recommended that children and young people should have no more than two hours of sedentary recreational screen time per day, not including screen time needed for schoolwork (70,71). However, the evidence showed that, overall, 50% or more of EU adolescents (11 to 15 years old) spend more than two hours on screen time per day (72).
For this reason, some guidelines provide tips for how to reduce sedentary behaviour among children and the youth population (*Figures 4 and 5*) (70,73).

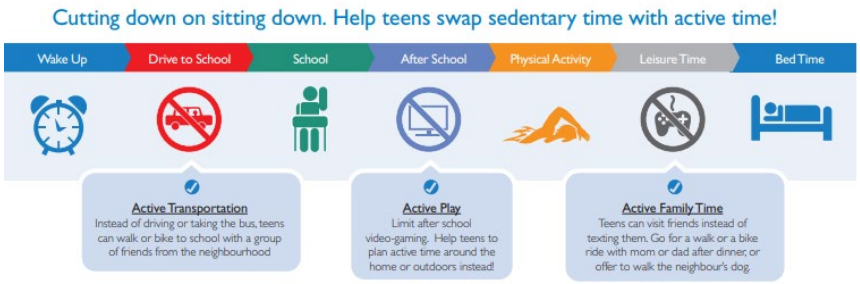

Figure 4. Tips to reduce sedentary behaviours in youth (12-17 years old) during the day. Source: Canadian sedentary behaviour guidelines for children and youth, 2011 (73).

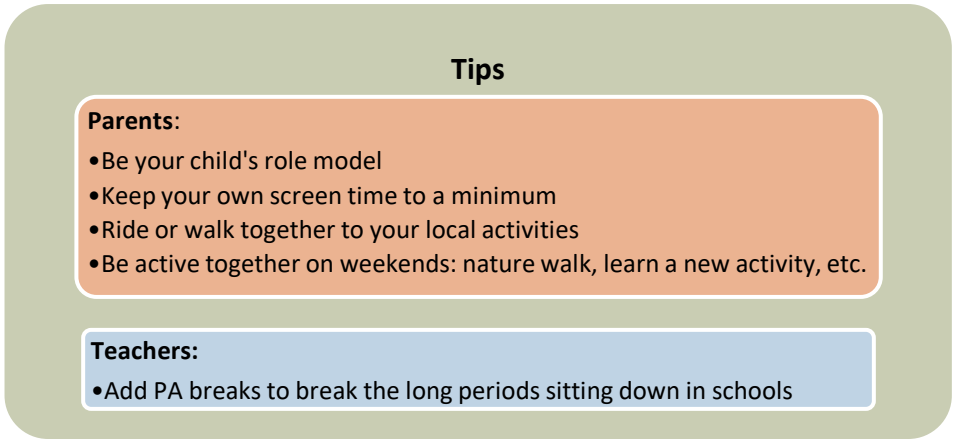

Figure 5. Tips for parents and teachers to reduce sedentary behaviours in children and youth. Source: Adapted from Australian 24-Hour Movement Guidelines for Children and Young People (5 to 17 years), 2019 (70).

1.2. Overweight and obesity

Overweight (OW) and obesity (OB) are defined as excessive fat accumulation that may impair health (74). OB is a complex multifactorial disease linked to an increased risk of many NCDs, such as cardiovascular diseases, certain types of cancer, type 2 diabetes, and pulmonary diseases, including sleep apnoea (75). OB is caused by multiple factors such as human physiology (metabolic, genetic, epigenetic, endocrinal, and neurological variables), PA patterns (individual and environmental factors), human psychology (individual and social factors), and the food environment (food production and consumption) (76).

Nowadays, OB is recognised as a serious public health and a major determinant of disability and death in Europe (77). The WHO European Obesity Report from 2022 highlighted that OW and OB affect almost 60% of adults. Additionally, over 7.1% of adolescents from 10 to 19 years lived with obesity and 24.9% with overweight (including obesity) (77).

For this reason, in 2022, the WHO designed the Acceleration Plan to Stop Obesity, which raises the possibility of a step change in delivery and impact in the effort to tackle the growing crisis of obesity (78). Tackle the growing OB epidemic is one of the 2025 Global Nutrition Targets (for children under five) and represents two of the Sustainable Development Goals (SDG) by 2030: Goal 2.2., to end all forms of malnutrition, and Goal 3.4., to reduce by one-third premature mortality from NCDs (79,80).

2. Science literacy and health literacy

2.1. Science literacy

The concept of science literacy appeared at the end of the 1950s in the United States; it aimed to emphasise the importance of science education to prepare students to cope with science and technological developments during future generations (81).

Then, in 1989, the American Association for the Advancement of Science created *Project 2061: Science for All Americans* and defined science literacy as knowing and being familiar with the concepts and principles of science and their strengths and limitations; knowing the relationship between mathematics, technology, and sciences; having a capacity for scientific ways of thinking; and being able to use scientific knowledge and ways of thinking for personal and social purposes (82).

As the literature shows, the concept of science literacy has a wide range of meanings. However, a more recent definition is stated, in the 2018 Programme for International Student Assessment (PISA), which defined scientific literacy as "the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen" (83).

2.1.1. Interest in STEM

The demand for STEM skills in the EU is growing because, from 2013 to 2025, the demand for STEM professionals is expected to grow by around 8%, a much higher rate than the 3% average growth for all other occupations (18). Additionally, a 2023 report from the United States highlighted that STEM jobs will rise by 10.5% in 2030, compared to non-STEM jobs, with a growth of 7.5% (84).

To meet the expected increased occupation demand, adolescents should increase their interest in STEM careers, particularly, given the low number of women in the labour market nowadays.

In 2015, only 25% 15-year-old boys and 24% of 15-year-old girls from countries in the Organisation for Economic Co-operation and Development (OECD) reported that they expected to work in science-related occupations (85), and their lack of interest in pursuing STEM careers was elucidated (86–88). Moreover, in 2018, only 1% of girls and 8% of boys of

15 years of age reported an interest in working in occupations related to Information and Communication Technology (89).

Moreover, the female gender and a low socioeconomic status act as important barriers to engaging in STEM. Regarding the gender gap, the evidence showed that only 29.3% of women work in this research area (90). Additionally, in Europe, only 10 out of 100 females are interested in pursuing STEM careers, while the number of boys is almost three times higher (20).

Regarding, socioeconomics, low-income families have less access to science education and feel less confident in supporting their children to learn science (21).

In fact, in 2015, a smaller percentage of disadvantaged students (18.9%) than advantaged ones (31.5%) expected to work in an occupation that requires further scientific training beyond compulsory education (91).

2.2. Health literacy

In 1998, health literacy was defined by the WHO as "the achievement of a level of knowledge, personal skills and confidence to take action to improve personal and community health by changing personal lifestyles and living conditions" (92).

The National Institutes of Health uses the definition of health literacy advanced by the Healthy People 2030 objectives, aimed to increase the health literacy of the population (93); here, it was defined as "the degree to which individuals have the ability to find, understand, and use information and services to inform health-related decisions and actions for themselves and others" (94).

Additionally, in 2020, systematic review identified the key themes that involved health literacy (95):

1) Knowledge of health, healthcare, and health systems,
2) Processing and using information about health and healthcare, and
3) An ability to maintain health through self-management and working in partnerships with health providers.

In addition, the proposed definition of health literacy is "the ability of an individual to obtain and translate knowledge and information to maintain and improve health in a way that is appropriate to the individual and system contexts" (95).

Based on all the concepts discussed here, science literacy aims to allow the population to achieve skills and knowledge of science that they can apply in everyday decision making, as well as engaging with science-related issues. Science literacy differs from health literacy terms of its application. Health literacy aims to help the population to achieve skills, knowledge, and confidence about health, allowing them to make health-related decisions in order to maintain and improve health at the individual level and system context.

2.3. The relationship between science literacy, health literacy, and health behaviours

The evidence indicates that a change in behaviours may be partially influenced by science literacy or health literacy because other multiple factors can affect these changes in health behaviour (25).

The TPB indicates that the intention to change a behaviour is influenced by the attitude toward the behaviour, the subjective norms, and perceived behavioural control. (25,36) Additionally, these factors are affected by background factors such as individual factors (age, gender, knowledge, education, income, etc.) and social factors (ethnicity, culture, economy, geography, media, etc.) (96). The evidence shows that people with limited health literacy have low SES and lower levels of education and are older, which indicates rising health inequalities in European society (22). In addition, people who report having a poor health status presented limited health literacy (22). One way to improve health literacy is through the development of scientific literacy (23) because health literacy is closely linked with the knowledge of the scientific principles of human biology, critical thinking, and the ability to make informed decisions about science-related issues (24).

The literature indicates a positive relationship between health literacy and health-related behaviours, including nutrition and PA behaviours (26,97,98). Nevertheless, some researchers suggest undertaking further longitudinal research to strengthen the evidence (99,100)

3. Innovative approaches: Participatory Research

3.1. Health Promotion and Health Education

3.1.1. Principles of Health Promotion

In 1998, health was defined as "a state of complete physical, social, and mental well-being, and not merely the absence of disease or infirmity" and Health Promotion was defined as "the process of enabling people to increase control over and to improve their health" (92).

In the first International Conference on Health Promotion (Ottawa on the 21st day of November 1986), three basic strategies for health promotion were identified (101):

1) Advocate: this relates to the political, economic, social, cultural, environmental, behavioural, and biological factors can favour or compromise health. Health promotion aims to make these conditions favourable through advocacy for health.
2) Enable: focus on achieving equity in health for all.
3) Mediate: mediate between differing interests in society for the pursuit of health.

These three basic strategies for health promotion should be implemented in the five key action areas: 1) building healthy public policy, 2) creating supportive environments for health, 3) strengthening community action for health, 4) developing personal skills, and 5) re-orienting health services (101).

3.1.2. Health Promotion across the Sustainable Development Goals

In 2015, the 194 countries of the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development. The 2030 agenda identifies 17 SDGs; they are a universal call to action to end poverty, protect the planet, and improve the lives and prospects of everyone, everywhere (102). SDG 3 is focused on ensuring healthy lives and promoting well-being for all people of all ages.

The 9th Global Conference on Health Promotion, titled "Promoting Health in the Sustainable Development Goals: Health for All and All for Health", was held in Shanghai in 2016. It highlighted the critical links between promoting health and the 2030 Agenda for SDGs (*Figure*

6) and inspiring national governments, municipal leaders, and other stakeholders to leverage the significant potential of promoting health across all sectors of society (103).

Figure 6. Health promotion across the SDGs. The figure highlights that the 9th Global Conference on Health Promotion placed at the centre of the 2030 Agenda for Sustainable Development the promotion of health and shows the link between the 17 SDGs and the action to promote health to achieve the goals because health and well-being are recognized as essential to achieving sustainable development. Source: WHO, 2017 (103).

In 2020, the WHO developed an approach to policy development and implementation that was designed to support policymakers, public health institutions, and professionals in accelerating progress to achieve the health-related SDGs in countries in the WHO European Region; this approach is known as Health and Well-being for all (E4A) (104).

The E4A approach consists of five building blocks to take into account when developing and implementing policies: 1) Engage: engagement with health-related stakeholders across all sectors and levels; 2) Assess: assessing how far we are from achieving the health-related SDG

targets, and the context, opportunities and challenges to achieving them; 3) Align: the harmonization of policies and interventions for the achievement of the health-related SDG targets within and between sectors and levels; 4) Accelerate: select policy and/or program areas that can increase the pace and support uptake of innovation in reaching the health-related SDGs; and 5) Account: share responsibility for implementing the 2030 Agenda and achieving its health-related SDG targets (104).

Therefore, this approach provides some key points for policymakers, public health institutions and professionals, enabling them to develop and implement policies related to health promotion, among other topics, and achieve the health-related SDGs (104).

3.1.3. Principles of Health Education

Health education is defined as "any combination of learning experiences designed to help individuals and communities improve their health by increasing knowledge, influencing motivation, and improving health literacy" (105).

Moreover, health education is involved in one of the key action areas of health promotion, the Develop Personal Skills, which supports personal and social development by providing information, education for health, and enhancing life skills (101,106). The four settings where health education is implemented are scholar setting (schools, high schools, university campuses), workplaces, health care (primary and specialized care, mental health, and others), and community (community organizations and government agencies) (107–109).

The present thesis focused on the two most relevant settings: the scholar and community settings.

According to the setting, health education has the following characteristics:

- **Scholar setting:**

School-based health education helps adolescents to acquire health-related knowledge, strengthen their attitudes and beliefs, and practice skills to adopt and maintain healthy behaviours throughout their lives. The Centers for Disease Control and Prevention defined the health education curriculum for scholar setting as follows (110):

1) A set of intended learning outcomes or objectives that directly relate to students' acquisition of health-related knowledge, attitudes, and skills.

2) A planned progression of developmentally appropriate lessons or learning experiences that lead to the achievement of health objectives.
3) Continuity between lessons or learning experiences that reinforce the adoption and maintenance of specific health-enhancing behaviours.
4) Content or materials that correspond with the sequence of learning events and help teachers and students meet the learning objectives.
5) Assessment strategies to determine whether students have achieved the desired learning objectives.

- **Community setting:**

The key components to achieving effectiveness in community-based health education are as follows (106,111):

- **Participant involvement**: Community members should be involved in all phases of a programme's development (identifying community needs, organizations, planning and implementing programme activities, and evaluating results) to empower the population and enhance the programme's impact.
- **Planning:** identifying the health problems present in the community, formulating goals, identifying the target behaviour and environmental characteristics that will be the focus of the intervention, and deciding how stakeholders will be involved.
- **Acceptance:** the relevant organizations and political and opinion leaders must be recruited into a coalition to ensure full acceptance of and cooperation in health education programmes.
- **Comprehensive:** health education programmes must be designed to change not only risky behaviours but also the factors and conditions that sustain these behaviours. In addition, they must also go well beyond the individual level, involving the community level (e.g. community organizations to change the social environment and regulations that promote access to the facilities and resources needed for healthy practices), familiar level, social networks, etc.
- **Variety, Integration, and Timing:** there must be an appropriate mix and sequence of programs delivered via varied channels and physically integrated into the settings where people live their lives.

- **Message design:** The message must be tailored for each subgroup of community needs and preferences, recognizing cultural differences, learning styles, and preferred learning sites.
- **Effective message:** 'Learning by doing' is more effective than 'learning from Observing'; that is, guided practice can lead to increased self-efficacy and more significant behavioural change.
- **Intervention duration (dose):** The dose duration should be adapted to the size population and for the behaviours to be changed. However, programmes should also be designed to produce stable and lasting changes in health behaviour.
- **Activism and Advocacy:** Successful community-based health education requires effective leaders such as community activists with the courage to advocate for health innovations.
- **Role of Policy, Laws, and Regulations:** National, state, or provincial actions can magnify local policy, laws, regulations, and education efforts on given topics.
- **Research and evaluation:** A comprehensive evaluation and research process is necessary to document programme outcomes and effects, to describe the formation and process, and the cost-effectiveness and benefits.

The community setting involves health promotion and education in restaurants because, over the last decade, the total household expenditure on catering services such as restaurants, cafes, canteens, etc., increased in most European Union Member States, with Spain being the country with the second largest expenditure (13%) (112). Eating out is associated with a higher energy, fat, and sugar intake and a lower fibre and micronutrient intake (113–116). As mentioned above, the MD is healthy diet with health benefits that are globally recognised; for this reason, the Public Health Agency of Catalonia (Spain) created the AMed criteria certification to be provided to restaurants and food service establishments to guarantee the offer of an MD based menu, with three mandatory criteria not related to diet, nine mandatory diet-related criteria and eight optional criteria (117).

3.2. History of Participatory Research

3.2.1. Beginnings of Participatory Research

Before the professionalization of science, in the late 19th century, non-scientist members of the public society conducted scientific research and investigated topics such as natural history observations. These "early scientists" recruited non-experts who contributed to the data collection and/or analysis of information and data (118).

PR originated between 1940 and 1970 based on two concepts (119): 1) social action research conducted by Lewins (120), who promoted the empowerment of minority groups to help them seek "independence, equality, and cooperation" through action research. That is, used social science as a means of solving social conflicts. 2) Emancipatory philosophy regarding social justice; this was advanced by Paulo Freire, who, in 1970, defined participants as full participants who were able to determine their own needs to improve their own lives (121,122).

3.2.2. Emergence of Participatory Research in in Public Health and Health Promotion

In 1980, PR emerged in public health and health promotion when the Centers for Disease Control and Prevention provided programs with community collaboration to prevent and control disease in underserved communities (119). This was when the concept of community-based participatory research (CBPR) emerged.

In addition, in 1995, guidelines for assessing PR projects were detailed. These contained questions about the following areas (123):

1) Participants and their involvement
2) The purpose and scope of the research
3) Research implementation and context
4) Research outcomes

Then, in 1998, the key principles of CBPR for improving Public Health and Health Promotion were stated (124):

1) Recognizes community as a unit of identity
2) Builds on strengths and resources within the community
3) Facilitates collaborative partnerships in all phases of the research

4) Integrates knowledge and action for the mutual benefit of all partners
5) Promotes a co-learning and empowering process that attends to social inequalities
6) Involves a cyclical and iterative process
7) Addresses health from both positive and ecological perspectives
8) Disseminates the findings and knowledge gained to all partners

3.2.3. Emergence of participatory research in primary health care

In 1990, PR emerged in the field of public healthcare, especially in family medicine among the indigenous population (119).

In 1998, the North American Primary Care Research Group developed a policy statement for primary health care professionals called *Responsible Research with Communities: Participatory Research in Primary Care,* which addressed the need for, benefits of, and ethics of using PR for primary care research. In 2017 an amendment was published and some future directions were added, with the aim of strengthening PR in primary care (125):

- Improving the assessment of PR processes to better delineate the links between how PR teams work together and diverse PR outcomes (individuals, community level, and policy changes)
- Improving our understanding of best practices for applying PR processes to clinical settings; patient–provider and provider–provider relationships; and changes in practice to increase the utilization of PR approaches in patient-engaged research.
- Applying innovative participatory models that link the community with clinical practice and policy.
- Looking beyond traditional randomised controlled trials towards innovative methodologies that acknowledge and incorporate community complexity.
- Increasing support for PR through funding opportunities, ethical reviews, and the co-creation of presentations and publications.

3.3. Approaches to and methods of Participatory Research

The literature shows a wide range of PR approaches and methods (41,42). Additionally, there is no definitive consent about classifying something as a PR approach or method because the evidence shows some contradictory opinions (41,42).

For this reason, a classification of PR approaches and methods is proposed by the author; this classification is related to more common evidence (41,42).

3.3.1. Approaches of Participatory Research

Table 2 summarises the most common PA approaches in the literature and their definitions.

Table 2. Participatory Research approaches and definitions.

PR approaches	***Definitions***	***Sources***
Action Research	Action research is an umbrella term that involves PR approaches where the focus is "action". It consists of an active collaboration between the researcher and members of the system and a cycle process of ideation, planning, action, reflection, and evaluation.	(42,126)
Citizen Science (CS)	CS actively involves citizens as contributors, collaborators, or leaders in some stages of the scientific process to generate new knowledge.	(127)
Co-design/co-production/ co-creation (Figure 7)	- Co-design consists of an active collaboration of participants in in the design of solutions related to a problem. - Co-production engages participants in the implementation of a solution to a problem and the assessment of solutions. - Co-creation consists of the active involvement of participants, from the exploration of the problems or needs to the implementation and assessment of solutions.	(128)
Community-based participatory research (CBPR)	CBPR involves community members, researchers, and other stakeholders in the research process (from the formulation of the research question to the dissemination of the findings) to improving health and reducing health disparities.	(129–131)

Design Thinking	Design thinking is a human-centred innovative approach to problem solving that considers the insights of the end-users regarding new products, services, and experiences in order to develop adapted solutions for rapidly creating prototypes that can be deployed quickly and cost-effectively.	(132)
Participatory Action Research (PAR)	PAR involves the participation of people experiencing issues in a cycle process (define a problem, design an action, observe the results, analyse the results, reflect on the action and its impact, and redefine the problem) to solve social systemic problems through the implementation of alternatives.	(133)
Participatory Rural Appraisal (PRA)	PRA is used in developing countries as a reaction against unethical development practices, with techniques including participatory diagramming, interviews, or observations of the population.	(134)
Peer-led	Peer-led approach is defined as an educational strategy that involves the effective transmission of information and behaviours between peer leaders (members of a similar age or status group to their peers) and their peers.	(135,136)
User-Centered Design Research	User-centered design research is based on considering the user's needs; it emphasizes empathy toward their goals and aspirations in each design stage in order to fit the program or intervention to them.	(137)

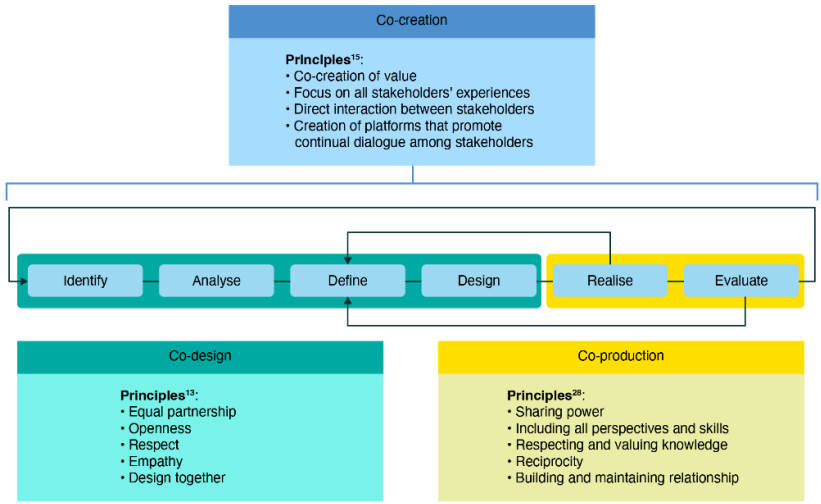

Figure 7. The model of co-creation. The figure shows the principles of co-creation and the different parts of the process that are divided into two principal steps, the co-design and the co-production process. Source: Vargas et al., 2022 (128).

3.3.2. Methods of Participatory Research

The evidence shows some common methods that are used to carry out PR approaches, as detailed in *Table* 3 (41,138,139).

Table 3. Participatory Research methods and definitions.

PR Methods	***Definitions***	***Sources***
Focus groups	A focus group is a qualitative research method in which the interviewer asks research participants specific questions about a topic or an issue in a group discussion. It aims to obtain in-depth knowledge about the attitudes, perceptions, beliefs, and opinions of participants regarding a specific health topic or issue. Between 4 and 14 participants should be involved and the focus group should last one or two hours.	(140,141)

Concept mapping	The concept mapping methodology is a mixed-methods (qualitative and quantitative) data collection method, which includes techniques like brainstorming and card sorting to create a visual representation of the thoughts or ideas of a group	(138)
Interviews	Interviews consist of asking individuals or small groups some questions about a topic but without discussion between the members of the group.	(142)
Makeathon	*A makeathon* consists of involving "makers" at an event that lasts from a few hours to several days; the "makers" work on solving a problem by collaboratively creating tangible and creative things.	(143)
Photovoice/ Videovoice	Photovoice and videovoice are methods by which people can identify, reflect, and represent their community and life using photo or video techniques.	(144,145)

Regarding the focus groups, obtaining in-depth knowledge about the attitudes, perceptions, beliefs, and opinions of participants can be a useful means of identifying the barriers and facilitators of the target population regarding their intention to improve specific behaviours (37,38); as a consequence, they may improve a population's adherence to a specific intervention (39,40). Additionally, barriers and facilitators are used to make decisions related to the design of an intervention (146,147).

3.4. Levels of participation

In 1969, Arnstein described the citizens' levels of participation in citizen power when making political and economic decisions *(Figure 8)* (148).

At lower levels or non-participation levels, manipulation and therapy are used, the real objective is not for people participate in planning or conducting programs but to "educate" or "cure" the participants. The middle level of participation involves informing and

consultation, where citizens may indeed hear and be heard but without having any effect on the program. The highest levels of participation are as follows(148):

- Partnership (enabling citizens to negotiate and engage in trade-offs)
- Delegated Power and Citizen Control (citizens obtain most decision-making seats or full managerial power)

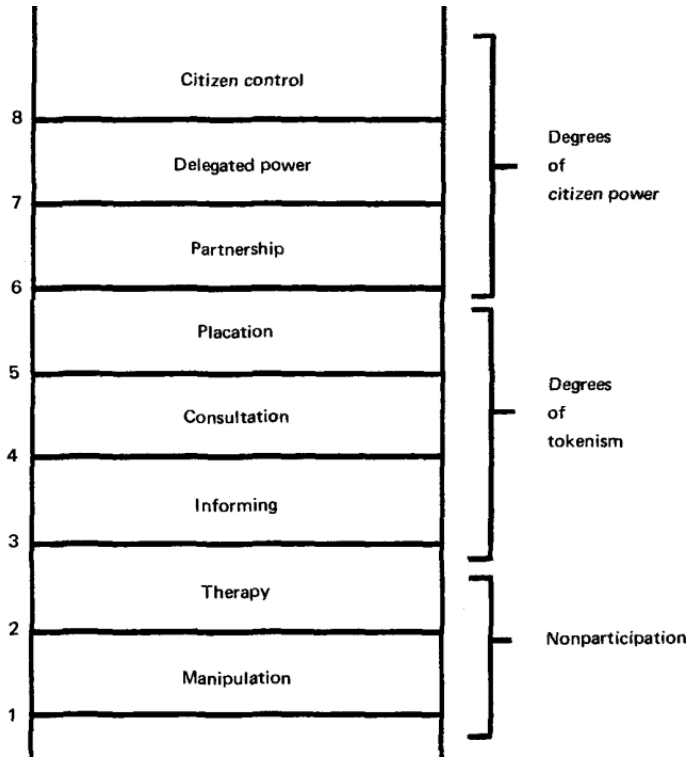

Figure 8. Citizen levels of participation in citizen power to making political and economic decisions. The figure shows the eight levels of participation with each rung corresponding to the extent of citizens' power in determining a plan and/or program. Source: Arnstein, 1969 (148).

Nowadays, two classifications of levels of participation in PR approaches are used. One of them is a more general classification and the other focused on the CS approach (42).

The first general classification, based on the participation choices, is focused on the research process. The levels are as follows (42):

1) Inform: this level is associated with traditional research, but participants are asked to be informed about a particular topic.
2) Consult: participants provide feedback that researchers consider when making their research decisions.
3) Involve: community members provide feedback throughout the research process.
4) Collaborate: community members are trained to be co-researchers in a project that benefits the local community.
5) Empower: the community members choose the research methods, tools, and processes; that is, this level prioritizes shared decision making and co-leadership.

The second classification is related to the CS approach, leading to four levels of participation (*Figure 9*) (149):

1) Crowdsourcing: this is limited to the provision of resources, and cognitive engagement is minimal.
2) Distributed intelligence: participants are asked to take some basic training and then collect data or carry out a simple interpretative activity.
3) Participatory science: participants are involved in defining the problem and in data collection but require the assistance of the experts when analysing and interpreting the results.
4) Extreme CS: participants are involved in defining the problem, conducting data collection, analysing the results, and publication or utilising of results.

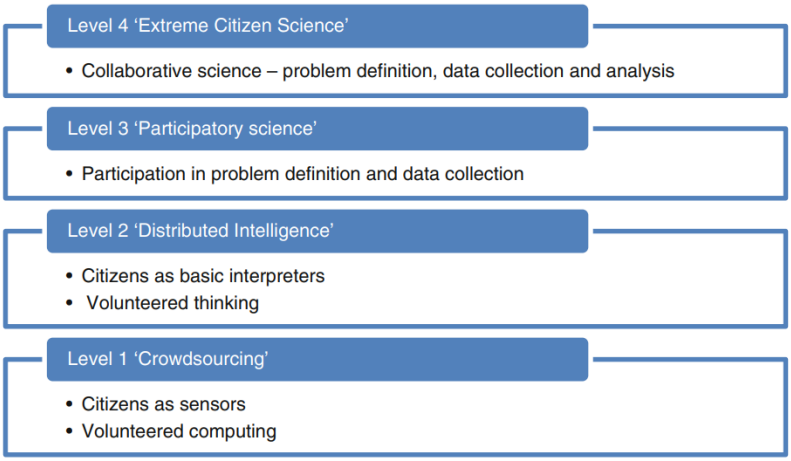

Figure 9. Levels of participation and engagement in Citizen Science projects**.** Source: Haklay, 2013 (149).

3.5. The adherence, impact, and sustainability of Participatory Research

In 2000, PR was recognised for strengthening academic–community relationships, showing the relevance of research questions, increasing the capacity of data collection/analysis/interpretation, and improving program recruitment, sustainability, and extension (119).

Over the last decade, the evidence has shown that the use of PR approaches has multiple advantages (131,150):

- The relevance and impact of research
- Enhanced recruitment capacity
- Increasing the quality of outputs and outcomes over time
- The sustainability of project goals

4. Science Engagement to Empower aDoleScent project

4.1. Study design

The Science Engagement to Empower aDoleScent (SEEDS) project is a multi-country cluster Randomised Controlled Trial (c-RCT) undertaken in four European countries: Greece, the Netherlands, Spain, and the United Kingdom. The project aimed to use the CS approach to engage and empower adolescents (boys and girls) from deprived areas by co-creating interventions through a *makeathon* (co-creation process) to promote healthy lifestyles and to seed interest in STEM (151).

4.2. Recruitment of participants and sample size

High schools were recruited from low-income areas or deprived neighbourhood and randomised in the intervention (IG) or control groups (CG) at a ratio of 1:1 within each country. The target population was adolescents of 13–15 years old and the different groups of participants of the SEEDS project were: 1) ambassadors: ambassadors from different intervention high schools per country were selected by teachers based on their leadership skills; 2) all participating adolescents from the high schools in the intervention and control groups; 3) stakeholders: important members of the Quadruple Helix (government, community, business and academia) who are relevant to the outcomes.

The sample size should constitute 12 clusters in the intervention group and 720 subjects (360 in each group) (151).

4.3. Phases of the project

The SEEDS project lasted two years (2021-2022) and was divided into five phases: 1) recruitment of high schools (adolescents and ambassadors) from deprived areas and stakeholders; 2) Focus groups with ambassadors and stakeholders; 3) assessment: baseline and a final questionnaire with questions about snacking behaviours, PA and sedentary behaviour, and STEM interest among adolescent participants; 4) intervention: a *makeathon* and the implementation, of the intervention and 5) dissemination of the project.

In each country, focus groups with ambassadors and stakeholders were held on the subjects of PA, snacking behaviour, and STEM. The focus groups with ambassadors aimed to gain insights into the barriers and facilitators of healthy and active living behaviours and input on

how science and technology help to change these behaviours, as well as how to actively engage adolescents in all phases of the project. The focus groups with stakeholders aimed to reflect on the barriers and facilitators identified in the focus groups with ambassadors, indicate the feasibility of changing behaviours during the six-month intervention, and identify the support that stakeholders can give to adolescents to overcome those barriers.

The input from focus groups was used to shape the *makeathon* event, and guide the formulation of the questions for the *makeathon*, in each country where ambassadors and adolescents co-created, developed, and tested the interventions with the support of the facilitator's agents and stakeholders. The phases of the *makeathon* were as follows: 1) empathise (general introduction to the process of the *makeathon* and SEEDS project), 2) define (presented topics via questions to discuss during the *makeathon* and the challenge of the day), 3) ideate (adolescents generated ideas in smaller groups and discussed ideas among themselves with the help of facilitators agents and stakeholders), 4) prototype and test (the most feasible ideas were developed and practically tested with a guide provided by researchers), 5) pitch (each group presented their ideas to all of the participants and, between them, they determined the pros and, cons and the solutions to the cons), 6) summary (all the ideas were summarised), 6) evaluation (each participant assessed their experiences in *makeathon* with different evaluation questions) (*Figure 10).*

Figure 10. Ideate and Prototype/Test phase. Source: designed by the author.

After the *makeathon,* the researchers worked with ambassadors to design the final intervention. The resultant was implemented in the intervention high schools of each country for six months. The interventions are detailed in depth in **Study 3** in this thesis.

4.4. Statistical analysis

The effectiveness of the intervention was evaluated using a multilevel mixed model controlling for sociodemographic characteristics (age, gender, country) and taking clustering at the school level into account. A two-sided p-value <0.05 was be considered statistically significant.

4.5. Next steps in the project

The complete and final analysis currently in progress, with a comparison between gender and countries. The findings of the SEEDS project will provide more evidence about the effectiveness of participatory-approach-based interventions to improve lifestyles and interest in STEM among disadvantaged adolescents.

HYPOTHESIS AND OBJECTIVES

UNIVERSITAT ROVIRA I VIRGILI
PARTICIPATORY RESEARCH AS A NEW APPROACH TO MAKING DECISIONS AND INCREASING ACTIVE ENGAGEMENT IN HEALTH INTERVENTIONS FOR EFFECTIVELY IMPROVING HEALTHY LIFESTYLES BEHAVIOURS
Judit Queral Añó

HYPOTHESIS

The total involvement of the target population in the interventions by Participatory Research (PR), based on the identification of intrinsic and extrinsic factors that act as barriers to and facilitators of healthy lifestyle behaviours (HLBs), is essential for designing tailored specific interventions and it can have a positive impact on HLBs.

OBJECTIVES

The general aim of the thesis is to provide evidence about PR as a potential new approach to making decisions based on intrinsic and extrinsic factors, such as barriers and facilitators among the target population, and to increasing active engagement via PR in health interventions in order to effectively improve HLBs.

The specific aims are twofold:

- To identify the HLBs and to elucidate the intrinsic/extrinsic factors that act as barriers to and facilitators of HLBs among the target population, in order to adapt strategies for improving HLBs.

Objective 1: To analyse the change in time in dietary behaviours, including fruit, vegetables, and sweets consumption, and the associations with sociodemographic characteristics like sex, age, and SES, using HBSC data, from 2013/14 to 2017/18 in European adolescents. (Study 1: Queral J et al., submitted).

Objective 2. To determine the changes in restaurant and customer needs, barriers, interests, and food choices before and during the current COVID-19 pandemic in Tarragona Province (Spain) (Study 2: Besora-Moreno et al., 2023).

Objective 3: To describe and compare the four co-created interventions by adolescents of each European country of the SEEDS project to tackle unhealthy behaviours and determine if the barriers and facilitators identified in the focus groups are addressed in the interventions (Study 3: Queral J et al., submitted).

- To identify effective approaches to actively engaging adolescents in improving their HLBs through PR interventions published in the literature.

Objective 4: To evaluate the effectiveness of PR interventions compared to no PR intervention control groups on obesity and obesity-related HLBs in adolescents from high-income countries (HIC) (Study 4: Queral J, et al; submitted).

METHODS AND RESULTS

UNIVERSITAT ROVIRA I VIRGILI
PARTICIPATORY RESEARCH AS A NEW APPROACH TO MAKING DECISIONS AND INCREASING ACTIVE ENGAGEMENT IN HEALTH INTERVENTIONS FOR EFFECTIVELY IMPROVING HEALTHY LIFESTYLES BEHAVIOURS
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METHODS AND RESULTS

The overall results for each objective in this thesis can be found in four scientific articles showed below.

UNIVERSITAT ROVIRA I VIRGILI
PARTICIPATORY RESEARCH AS A NEW APPROACH TO MAKING DECISIONS AND INCREASING ACTIVE ENGAGEMENT IN HEALTH INTERVENTIONS FOR EFFECTIVELY IMPROVING HEALTHY LIFESTYLES BEHAVIOURS
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STUDY 1

Changes in time of fruit, vegetables and sweets consumption among European adolescents and associations with sociodemographic characteristics: a HBSC study

Judit Queral, Annemieke Warger, Lucia Tarro, Elisabet Llauradó, Rosa Solà, Wilma Jansen. Changes in time of fruit, vegetables and sweets consumption among European adolescents and associations with sociodemographic characteristics: a HBSC study. **Submitted**.

UNIVERSITAT ROVIRA I VIRGILI
PARTICIPATORY RESEARCH AS A NEW APPROACH TO MAKING DECISIONS AND INCREASING ACTIVE ENGAGEMENT IN HEALTH INTERVENTIONS FOR EFFECTIVELY IMPROVING HEALTHY LIFESTYLES BEHAVIOURS
Judit Queral Añó

Changes in time of fruit, vegetables and sweets consumption among European adolescents and associations with sociodemographic characteristics: a HBSC study

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Abstract

Background: European adolescents do not eat enough fruit and vegetables, and have a high sweet consumption. This study aims to analyse the changes in time of dietary behaviours related to sociodemographic characteristics, among European adolescents.

Methods: Health Behaviour in School Age Children data (2013/14 to 2017/18), of European adolescents, aged 11 to 15-years-old, were used. Family Affluence Scale identified socioeconomic status (SES). Changes in time of dietary behaviours and associations with sociodemographic characteristics were estimated by binary and multilevel logistic regression.

Results: 182719 adolescents were included. 10/36 European countries showed a significant increase in daily fruit and vegetables consumption and 12/36 countries a significant decrease in sweets consumption over 4 years.

The multilevel analysis showed that 13-and 15-year-old adolescents consumed less daily fruit and vegetables ($p<0.001$) and more daily sweets ($p<0.001$) than 11-year-old adolescents. Also, 15-year-old adolescents' sweets consumption change in time was less favourable ($p=0.006$).

Girls consumed more daily fruit, vegetables and sweets than boys ($p<0.001$).

Low SES adolescents consumed less daily fruit and vegetables than medium/high SES adolescents. Additionally, the low SES adolescents' vegetables consumption change in time was less favourable ($p<0.001$).

Conclusions: Dietary behaviour policy recommendations should be adapted for the sex, age and SES of the population.

Keywords: young people, dietary behaviour, Socioeconomics factors

Background

In 2017/18, more than half of 11-15-year-old European adolescents did not eat fruit or vegetables daily (at least one time per day) and 25% consumed sweets daily (at least one time per day). (1) These unhealthy behaviours can result in the development of non-communicable diseases. (2,3) Therefore, to know the insights into the establishment of healthy behaviours is essential to designing effective prevention policies. (4)

The key factors that influence children's dietary behaviours can be divided into: intrinsic (gender, age, genetics) and environmental factors. The environmental factors include family, peers, community, and social factors. (5) Social factors including socioeconomic status (SES), ethnicity, demographic characteristics, sociocultural education and exposure to media, are important determinants of adolescents' eating behaviours. (5,6)

According to data from the Health Behaviour in School Age Children (HBSC) study in 2010, older adolescents have less healthy lifestyles. (7) Adolescents with lower SES generally have worse dietary behaviours than higher SES adolescents. (8) For example, regarding fruit and vegetables intake, previous studies with HBSC trend-time data (2001 to 2010), highlighted that adolescents with a higher SES are more likely to consume daily vegetables and fruit than low SES. (9,10) In these studies, the SES was assessed by the Family Affluence Scale (FAS) based on the financial situation of the parents. (11) Also, in a Dutch cross-sectional study with 8-12-year-old population, children with mothers' high education level consumed more daily fruit and vegetables than the children with mothers' low education level. (12) That is, the authors of this study highlight that the economic difficulties of families and poor knowledge about the beneficial aspects of consuming fruit and vegetables are two of the major reasons for the low consumption of fruit and vegetables in low SES adolescents.

The evidence highlighted that despite the demographic characteristics and ethnic heritage, the European countries' dietary guidelines have key points in common: consume adequate amounts of grains, vegetables, and fruits with moderate intake of fats, sugars, meats, caloric beverages, and salt. (13) However, the report of HBSC of 2014 detected some variation in prevalence between countries and regions for many indicators that reinforce the importance of country-level factors and cultural norms in young people's health and well-being. (14)

Getting a dynamic view of changes over time in fruit or vegetable consumption of adolescents is challenging, which can be solved by using time-trending studies. Time-trend studies are a type of time series design (observational design), specifically the simplest version where the purpose of the analysis is a descriptive account of a pattern over time in a specific population. (15) Moreover, the study of epidemiology has often been used successfully to inform public health policy and practice. (16).

Hence, the present study was designed to get insight into the change over time in dietary behaviours in adolescents and provide directions for adequate policy measures in the future, considering the differences among populations in 36 European countries. The literature showed dietary trends regarding sugary and soft drinks, breakfast, fruit and vegetables consumption but these are from previous years (17,18) focused on specific European countries (19–21) or not considering SES characteristics. (22) The previous trend studies showed an improvement in dietary behaviours like an increase in daily fruit and vegetables consumption and a decrease in sugar-sweetened beverages consumption. (18,19,22)

For this reason, our present study aimed to analyse the change in time in dietary behaviours, including fruit, vegetables and sweets consumption, and the associations with sociodemographic characteristics like sex, age, and SES, using HBSC data, from 2013/14 to 2017/18 in European adolescents.

The present study hypothesises that dietary behaviours will improve over time, that is fruit and vegetables consumption increase and sweets consumption decrease. Also, older and low SES adolescents are expected to have worse dietary behaviours than younger and medium/high SES adolescents.

Methods

Study design, population and database

This study used data from the HBSC study (2013/14 and 2017/18). The HBSC study is a cross-national research study into the health and well-being of adolescents across Europe and North America conducted in collaboration with the World Health Organization (WHO). The present study followed The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: cross-sectional studies (Additional file 1).

In 2013/14, 42 countries in Europe and North America took part in the survey and 48 countries in 2017/18. (8,23) Each country uses cluster sampling to select every 4 years a proportion of young people aged 11, 13 and 15. (23) Countries were provided with sampling guidance notes and were required to submit a standardized sampling report with information on the strategy employed. This report is part of the metadata attached to each country and international data file. It was then collated and made available to the HBSC network by the Data Management Centre (MC) at the University of Bergen, Norway. (8,23) Data is collected in all participating countries through school-based surveys. (23) The HBSC study protocol of 2013/14 and 2017/18 has been previously explained in depth. (8,23)

The present study included data about fruit, vegetables and sweets consumption, and related sociodemographic characteristics (age, sex, SES) in 36 European countries from 2013/14 to 2017/18. Countries that are not in the Europe region or did not participate in both years' surveys were excluded. A total of 182719 European adolescents were included in the analysis from 2013/14 and 185245 from 2017/18.

The included participants have answered at least one of the principal outcomes (fruit, vegetables or sweets consumption) in both years' surveys.

Ethics

We used open data from the HBSC study, accordingly, all participating countries received ethical approval from their respective medical ethical committees. (8,23)

Study participants and their schools, parents/guardians were fully informed about the research and procedures regarding confidentiality and anonymity, access to data and data storage. Written and/or oral procedures for “informed” consent were used. (8,23)

Particularly, the present study was approved by the ethical commitment of Erasmus Medical Center (EMC), the Medisch Ethische Toetsings Commissie (METC) (Ref: MEC-2022-0771)

Outcomes and explanatory variables

The principal outcome is daily fruit, vegetables and sweets (chocolate and candy) consumption by the sum of answer options "once daily" and "more than once daily" from the question of weekly consumption to HBSC survey. (8,23)

The sociodemographic characteristics were used as explanatory variables:

SES scored by FAS III

The HBSC study developed FAS in 1998 and FAS III added more items in 2013/14. (24)

In the 2013/14 and 2017/18 survey cycles, FAS III was operationalized based on six items (car ownership, own (bed) room, times per year of holidays with family abroad, computer/tablet ownership, number of bathrooms, owning a dishwasher). (8)

In accordance with the total score, a relative measure was used to divide FAS into three categories indicating either low (lowest 20% of the sample, total score between 0-7), medium (middle 60% of the sample, total score between 8-11) and high (highest 20% of the sample, total score between 12-13) family affluence. (8,11) Present study used two categories of classification of FAS, low FAS and medium + high FAS, due to the low number of participants classified in high FAS, called low SES and medium/high SES here-after.

Age and sex

In both surveys participants were asked about their age and sex. Related to age, the adolescents were classified into 3 categories: 11-year-old (from 11 to < 13-year-old), 13-year-old (from 13 to <15-year-old) and 15-year-old (≥ 15-year-old).

Statistical analysis

Descriptive statistics of sex, age, FAS and dietary behaviours for each age category, sex and year of data collection were calculated as frequencies % (n).

The change in time of dietary behaviours was estimated by binary logistic regression. Separate models were used 1) for each country adjusted by sex, age and FAS; 2) for each sex adjusted by country, age and FAS and; 3) for each age-adjusted by country, sex and FAS.

To know how the FAS, age and sex differences in dietary behaviours have evolved (from 2013/14 to 2017/18) a multilevel binary logistic regression was used.

Firstly, an empty model was built to calculate the ICC (Interclass Correlation Coefficient) and assess the log odds between clusters. Then, intermediate models of each interaction term (age*year and sex*year and FAS*year) adjusted by main effects (age, sex, FAS and time) were carried out to see if there were significant differences between age, sex, and FAS categories in comparison with the reference level (11-year-old, boys and high + medium FAS) in each dietary behaviour and see the interaction effects over time. The results of the logistic regression analysis are presented as Odds Ratios (ORs) with 99% confidence intervals (CIs).

To ensure the validity of the results sensitivity analyses were done for different Cut-off points of the outcome. (Additional file 2) Statistical significance was set at $p<0.01$. Analyses were performed with SPSS (Version 28.0. Armonk, NY: IBM Corp).

Results

Sample characteristics

A total of 367964 participants were included in the analysis. The participants' characteristics and the descriptive results of dietary behaviours by survey year and overall are described (Table 1).

Table 1. Participants' characteristics separated by survey year and overall

	2013/14	**2017/18**		**Total**
Included participants (n)	**182719**	**185245**		**367964**
Sex	**% (n)**	**% (n)**	***p*-value [a]**	
Girls	50.8 (92874)	50.7 (93831)	0.284	50.7 (186705)
Boys	49.2 (89845)	49.3 (91414)		49.3 (181259)
Age category				
11 years old	32.3 (58458))	34.2 (62898)	**<0.001**	33.2 (121356)
13 years old	34.7 (62904)	34.4 (63331)	0.053	34.6 (126235)
15 years old	33.0 (59825)	31.4 (57804)	**<0.001**	32.2 (117629)
Family affluence Scale				
Low	41.4 (69418)	36.0 (63944)	**<0.001**	38.6 (133362)
Medium	50.8 (85113)	54.1 (95976)	**<0.001**	52.5 (181089)
High	7.9 (13179)	9.9 (17568)	**<0.001**	8.9 (30747)
Dietary behaviours				
Fruit consumption	**% (n)**	**% (n)**		**% (n)**
Never	2.9 (5262)	3.1 (5658)		3.0 (10920)
Less than once a week	5.9 (10694)	6.4 (11777)		6.1 (22471)
Once a week	9.8 (17796)	9.6 (17796)		9.7 (35592)
2-4 days a week	28.7 (52423)	25.9 (47899)		27.3 (100322)
5-6 days a week	15.2 (27715)	15.8 (29289)		15.5 (57004)
Once daily	17.8 (32560)	17.8 (32865)		17.8 (65425)
More than once daily	19.7 (35979)	21.5 (39754)		20.6 (75733)
Vegetables consumption				
Never	4.5 (8148)	4.7 (8681)		4.6 (16829)

Less than once a week	5.6 (10225)	5.8 (10747)	5.7 (20972)
Once a week	9.8 (17898)	9.3 (17224)	9.6 (35122)
2-4 days a week	25.6 (46572)	23.1 (42635)	24.3 (89207)
5-6 days a week	19.2 (34945)	19.2 (35382)	19.2 (70327)
Once daily	19.1 (34659)	19.7 (36365)	19.4 (71024)
More than once daily	16.2 (29490)	18.2 (33511)	17.2 (63001)
Sweets consumption			
Never	3.9 (7151)	4.0 (7315)	3.9 (14466)
Less than once a week	11.8 (21520)	12.2 (22486)	12.0 (44006)
Once a week	18.9 (34306)	18.6 (34393)	18.7 (68699)
2-4 days a week	28.1 (51217	28.4 (52381)	28.3 (103598)
5-6 days a week	12.9 (23551)	13.0 (24048)	13.0 (47599)
Once daily	12.6 (22869)	12.8 (23567)	12.7 (46436)
More than once daily	11.7 (21371)	11.0 (20345)	11.4 (41716)

a. p-value obtained with Chi^2 analysis

Bold: significant p-value (p<0.01)

No significant differences were found in the distribution by sex between the two survey years (p=0.284). On the contrary, more 11-year-olds and fewer 15-year-olds were observed in 2017/2018 compared to 2013/2014 (p<0.001). Also, more adolescents from medium/high SES and fewer adolescents from low SES were involved in 2017/2018 compared to 2013/2014 (p<0.001)

Prevalence of dietary behaviours

The prevalence of the daily consumption of fruit, vegetables and sweets consumption by age category and year split by sexes was shown (Additional file 3).

In comparison with the 2013/14 survey, the prevalence of fruit and vegetables consumption was significantly higher in 2017/18 in all age and sex categories ($p<0.001$), unless consumption in 15-year-old girls that showed a prevalence non-significantly higher in 2017/18 ($p=0.217$).

Regarding daily sweets consumption the prevalence decreased significantly from 2013/14 to 2017/18 in boys of 13-year-old ($p=0.006$). The girls and other age categories showed no significant decrease.

Change in time of dietary behaviours by country

The change in timed of the daily consumption of each dietary behaviour from 2013/14 to 2017/18 adjusted by age, sex and FAS split by country are presented (Table 2).

From 2013/14 to 2017/18, 10 of 36 European countries had a significant increase in daily fruit consumption and 16 of 36 countries showed a significant increase in daily vegetables consumption. Additionally, 10 of 36 countries resulted in a significant increase in both outcomes, with an OR range from 1.109 to 1.859 in daily fruit consumption and an OR range from 1.124 to 1.588 in daily vegetables consumption. Albania had the highest increase in daily fruit consumption [OR (99% CI) = 1.859 (1.582, 2.185), $p<0.001$], whereas the Czech Republic had the highest increase in daily vegetables consumption [OR (99% CI) = 1.588 (1.439, 1.753), $p<0.001$].

Regarding the daily sweet's consumption, from 2013/14 to 2017/18 12 of 36 European countries had a significant decrease with an OR range from 0.678 to 0.907. The Netherlands showed the highest decrease [OR (99% CI) = 0.866 (0.765, 0.980), $p=0.003$].

The change in time by country highlighted that daily fruit and/or vegetables consumption showed a positive and significant change in Eastern Europe, countries. On the contrary, daily sweets consumption was reduced in Western European countries. However, in both Western and Eastern Europe a negative and significant change of dietary behaviours was observed (Table 2).

Table 2. Change in time of daily dietary behaviours consumption adjusted by age, sex and FAS split by country from 2013/14 to 2017/18

Country	Daily fruit consumption [a,b]	Daily vegetables consumption [a,b]	Daily sweets consumption [a,b]
	OR (99% CI)[c]	OR (99% CI)[c]	OR (99% CI)[c]
Albania	1.859 (1.582, 2.185)**	1.430 (1.224, 1.670)**	1.157 (0.988, 1.355)
Austria	0.853 (0.750, 0.969)*	1.154 (1.007, 1.322)**	0.861 (0.749, 0.989)**
Belgium (Flemish)	1.505 (1.329, 1.704)**	1.311 (1.165, 1.474)**	1.024 (0.893, 1.176)
Belgium (French)	0.915 (0.827, 1.012)	1.048 (0.947, 1.160)	0.733 (0.661, 0.813)**
Bulgaria	1.008 (0.898, 1.132)	1.022 (0.912, 1.145)	0.750 (0.669, 0.841)**
Croatia	0.966 (0.864, 1.081)	0.973 (0.865, 1.096)	0.744 (0.661, 0.838)**
Czech Republic	1.470 (1.340, 1.612)**	1.588 (1.439, 1.753)**	0.984 (0.882, 1.097)
Denmark	0.759 (0.663, 0.869)*	1.071 (0.937, 1.224)	0.995 (0.758, 1.306)
Estonia	1.437 (1.276, 1.620)**	1.466 (1.291, 1.666)**	0.943 (0.826, 1.077)
England	1.109 (0.981, 1.254)	1.036 (0.917, 1.171)	0.827 (0.713, 0.959)**
France	0.935 (0.850, 1.029)	0.847 (0.771, 0.929)*	0.931 (0.835, 1.037)
Germany	1.001 (0.896, 1.118)	1.124 (0.995, 1.269)**	0.848 (0.750, 0.958)**
Greece	0.934 (0.823, 1.061)	0.969 (0.856, 1.098)	1.005 (0.854, 1.183)
Hungary	0.811 (0.712, 0.923)*	0.835 (0.730, 0.955)*	0.678 (0.592, 0.776)**
Iceland	1.042 (0.957, 1.135)	1.184 (1.083, 1.294)**	1.945 (1.530, 2.472)*
Ireland	1.077 (0.949, 1.221)	0.957 (0.845, 1.085)	0.704 (0.606, 0.819)**
Italy	0.914 (0.810, 1.032)	0.988 (0.865, 1.128)	0.890 (0.781, 1.015)
Latvia	0.979 (0.867, 1.105)	1.056 (0.936, 1.192)	0.770 (0.681, 0.871)**
Luxembourg	1.005 (0.880, 1.149)	1.166 (1.017, 1.336)**	1.068 (0.920, 1.240)
Malta	0.991 (0.843, 1.164)	0.815 (0.685, 0.971)*	2.109 (1.771, 2.512)*

Republic of Moldova	1.672 (1.495, 1.870)**	1.137 (1.017, 1.270)**	0.914 (0.811, 1.031)
Netherlands	0.950 (0.843, 1.071)	0.903 (0.806, 1.011)	0.866 (0.765, 0.980)**
Norway	0.807 (0.701, 0.929)*	1.048 (0.911, 1.207)	1.099 (0.805, 1.501)
Poland	1.151 (1.026, 1.290)**	1.198 (1.065, 1.347)**	0.907 (0.802, 1.025)
Portugal	1.255 (1.129, 1.395)**	1.322 (1.179, 1.482)**	1.025 (0.885, 1.187)
Romania	1.060 (0.938, 1.198)	0.858 (0.756, 0.974)*	0.938 (0.830, 1.059)
Russia	1.001 (0.888, 1.129)	0.935 (0.830, 1.055)	0.983 (0.870, 1.112)
Slovakia	1.259 (1.118, 1.418)**	1.496 (1.322, 1.694)**	0.985 (0.873, 1.110)
Slovenia	1.134 (1.020, 1.261)**	1.583 (1.415, 1.771)**	1.150 (1.001, 1.321)*
Spain	1.080 (0.972, 1.200)	1.387 (1.234, 1.559)**	1.106 (0.953, 1.282)
Sweden	0.993 (0.884, 1.116)	1.155(1.040, 1.282)**	1.604 (1.261, 2.040)*
Switzerland	0.941 (0.860, 1.030)	1.024 (0.936, 1.120)	1.027 (0.931, 1.132)
Ukraine	0.812 (0.731, 0.901)*	0.926 (0.835, 1.028)	0.859 (0.772, 0.956)**
Macedonia	1.182 (1.053, 1.327)**	1.194 (1.064, 1.340)**	0.966 (0.857, 1.090)
Scotland	0.862 (0.774, 0.960)*	0.885 (0.795, 0.985)*	0.729 (0.651, 0.815)**
Wales	1.069 (0.976, 1.171)	0.977 (0.893, 1.068)	0.945 (0.854, 1.045)

OR, Odds Ratio; CI, Confidence Interval

a. Positive change in time: an increase over time in daily fruit and vegetables consumption and a decrease in daily sweets consumption
b. Negative change in time: decrease over time in daily fruit and vegetables consumption and an increase in daily sweets consumption
c. Binary logistic regression of dietary outcomes adjusted by sex, gender, age, FAS split by country

**positive and significant change in time (p<0.01); *negative and significant change in time(p<0.01)

Change in time of dietary behaviours by age, sex and FAS categories

From 2013/14 to 2017/18 the change in time by age, sex, and FAS showed a significant increase in daily fruit and vegetables consumption and a significant decrease in daily sweets consumption in all age, sex, and FAS categories. (Table 3)

Multilevel analysis: main effects and interaction effects over time between sociodemographic characteristics in dietary behaviours

The multilevel analysis results showed as main effects differences and interaction effects over time (from 2013/14 to 2017/18) in dietary behaviours between sociodemographic characteristics (Table 4). Focussing on age categories, 13- and 15-year-old adolescents consumed less daily fruit and vegetables than 11-year-old adolescents ($p<0.001$). However, the interaction effects did not show significant change in time (from 2013/14 to 2017/18) differences ($p>0.01$). Furthermore, 13-and 15-year-old consumed more daily sweets than 11-year-old adolescents ($p<0.001$). In addition, the interaction effect showed that 15-year-old adolescents had a change in time significantly less favourable in sweets consumption than 11-year-old adolescents ($p=0.006$).

Related to sex, girls consumed more daily fruit, vegetables and sweets than boys ($p<0.001$). However, the interaction effect indicated a similar change in time between sex categories in fruit ($p=0.077$); vegetables ($p=0.888$) and sweets ($p=0.967$).

Regarding FAS categories, low SES adolescents consumed less daily fruit and vegetables than adolescents with medium/high SES ($p<0.001$). Additionally, the interaction effect showed a change in time less favourable in daily vegetables consumption in low SES adolescents than medium/high SES ($p<0.001$) but a similar change in time between FAS categories in daily fruit consumption ($p=0.195$). However, no significant differences were found for main effects and interaction effects over time in daily sweets consumption between FAS categories.

Table 3. Change in time in dietary behaviours daily consumption by age, sex and FAS from 2013/14 to 2017/18

	Fruit daily consumption OR (99% CI) change in time [a]	**Vegetables daily consumption** OR (99% CI) change in time [a]	**Sweet daily consumption** OR (99% CI) change in time [a]
		Age	
11 years old	1.062 (1.028, 1.096)*	1.089 (1.054, 1.125)*	0.948 (0.912, 0.986)*
13 years old	1.061 (1.027, 1.096)*	1.115 (1.079, 1.152)*	0.908 (0.876, 0.942)*
15 years old	1.045 (1.010, 1.081)*	1.081 (1.045, 1.118)*	0.906 (0.873, 0.940)*
		Sex	
Girls	1.044 (1.017, 1.071)*	1.095 (1.067, 1.124)*	0.927 (0.900, 0.955)*
Boys	1.066 (1.038, 1.096)*	1.093 (1.063, 1.124)*	0.911 (0.882, 0.940)*
		FAS	
Low FAS	1.071 (1.038, 1.105)*	1.056 (1.024,1.090)*	0.917 (0.887, 0.948)*
Medium + High FAS	1.045 (1.020, 1.070)*	1.119 (1.092, 1.146)*	0.921 (0.895, 0.947)*

This table shows the change in time from 2013/14 to 2017/18 in each dietary behaviour adjusted by age and/or sex and/or FAS and country split by age categories, sex and FAS categories. Abbreviations: OR, Odds Ratio; CI, Confidence Interval

a. Binary logistic regression of dietary outcomes adjusted by sex, age, FAS and country

*p-value <0.01

Table 4. Multilevel analysis: Main effects differences and Interaction effects in dietary behaviours between sociodemographic characteristics over time (from 2013/14 to 2017/18)

	Daily fruit consumption		Daily vegetables consumption		Daily sweet consumption	
	OR (99% CI) main effects [a]	OR (99 CI) interaction [b]	OR (99% CI) main effects [a]	OR (99 CI) interaction [b]	OR (99% CI) main effects [a]	OR (99 CI) interaction [b]
Age						
11 years old	Ref	Ref	Ref	Ref	Ref	Ref
13 years old	0.729 (0.706, 0.752)*	1.000 (0.956, 1.045)	0.847 (0.820, 0.875)*	1.024 (0.979, 1.072)	1.208 (1.163, 1.254)*	0.962 (0.913, 1.013)
15 years old	0.611 (0.592, 0.632)*	0.963 (0.920, 1.008)	0.809 (0.782, 0.836)*	0.976 (0.932, 1.022)	1.213 (1.168, 1.260)*	0.946 (0.897, 0.997)*
Sex						
Girls	1.375 (1.339, 1.412)*	0.975 (0.940, 1.012)	1.379 (1.342, 1.416)*	0.998 (0.961, 1.036)	1.201 (1.165, 1.238)*	0.999 (0.958, 1.043)
Boys	Ref	Ref	Ref	Ref	Ref	Ref
FAS						
Low FAS	0.712 (0.692, 0.733)*	1.020 (0.981, 1.059)	0.767 (0.745, 0.790)*	0.941 (0.905, 0.979)*	0.983 (0.952, 1.016)	0.998 (0.956, 1.042)
Medium + High FAS	Ref	Ref	Ref	Ref	Ref	Ref

This table shows the main effects difference between sociodemographic characteristics categories and interaction effects over time (2013/14 vs 2017/18) between sociodemographic categories in each dietary behaviour in comparison with the reference

category (11-year-old and medium + high FAS participants). Abbreviations: Ref, Reference level category; OR, Odds Ratio; CI, Confidence Interval.

a. Main effects differences between age, sex and FAS categories in dietary behaviours by the multilevel binary logistic regression with country as a level.
b. Interaction effects of age, sex and FAS categories over time (from 2013/14 to 2017/18) by multilevel binary logistic regression with country as a level.

*p-value <0.01

Sensitivity analysis

In the sensitivity analysis, the selected cut-off points were a) more than once daily fruit and vegetables consumption and b) weekly sweets consumption (Additional file 2). Regarding change in time by country, five extra countries showed significantly positive results in fruit and sweets consumption, and six extra countries in vegetables consumption. However, five countries showing positive and significant changes in time in the present study analysis, do not show in the sensitivity analysis.

Focusing on multilevel analysis, the main effects differences showed the same results as the original cut-off, except for low SES adolescents that had less sweets consumption (more than once daily) than medium/high SES.

Related to the interaction effect, in more than once daily fruit and vegetables consumption, the low SES adolescents showed a significantly more favourable change in time than medium/high SES adolescents in fruit consumption. Moreover, 13-15-year-old adolescent showed a less favourable change in time than 11-year-old adolescents in fruit and vegetables consumption.

Finally, in weekly sweets consumption, low SES adolescents showed a significantly less favourable change in time than medium/high SES adolescents.

Discussion

Main findings of this study and what is already known on this topic

In 36 European countries, the 39.3% and 37.3% of 11 to 15-years-old adolescents consumed fruit and vegetables daily in 2017/18. This increase compared to the previous HBSC report from 2009/10 which showed a prevalence of fruit consumption of 36.3% and a 33% in vegetables. (25) However, these improvements are not enough, as many adolescents still do not consume fruit and vegetables daily. Additionally, the prevalence of sweets daily consumption (chocolate and candy) was 23.8%. A HBSC trend from 2002 to 2014 study showed that in 2014 the 21% of girls and boys from the Czech Republic consumed sweets daily, but in the present study, this percentage is lower considering all European adolescents. (26)

According to the recommendation of the European Society for Paediatric Gastroenterology, Hepatology and Nutrition Committee on Nutrition, children and adolescents should reduce their sugar intake to <5% daily energy, meaning daily 27-32g of added sugar for adolescents between 13-15 years old. (27) For example, 50 g of chocolate (two squares) contains 27 g of added sugar, making it easy to exceed the recommendation of sugar added daily in the 23.8% of adolescents from the 2017/18 survey included in this study.

Focusing on change in time by country of fruit and vegetables consumption, a significant increase in daily fruit consumption in 10 of 36 European countries is shown, and a significant increase in daily vegetables consumption in 16 of 36 European countries. A similar study of HBSC data from 2002 to 2010 resulted in a significant increase in daily fruit consumption in 22 of 33 European countries, and in daily vegetables consumption in 18 of 33 countries. (18) These increase in fruit and vegetables consumption in more countries compared with the present study, it could be explained by the more survey years analysed by this study involved data of 3 waves of the HBSC survey (2002/03, 2006/07 and 2010/11) and the present study involved data of 2 waves (2013/14 and 2017/18), and the higher sample size. (18)

Most countries that increased daily fruit and vegetables consumption are from Eastern Europe. This observation is supported by a recent narrative review that highlighted the improvement of dietary patterns, including fruit and vegetables consumption, evident since 1990 in Western European countries, also visible in Eastern European countries in the last

two decades, since 2000. (28) A previous trend of fruit and vegetables consumption showed that the majority of countries with higher prevalence in 2010 were from Western Europe, whereas the majority of Eastern countries showed a lower prevalence of fruit and vegetables consumption. It can explain that in the present study, most Eastern countries had a significant positive catch-up because they set off with a lower prevalence. (18)

Currently, the WHO is implementing some policy recommendations to address fruit and vegetables consumption, e.g. EU school scheme: distribution of fruit, vegetables and milk from nursery to secondary school across the European Union. (29) Nevertheless, it is necessary to expand policy recommendations because the initiative of the school scheme did not involve all European countries (only 27 countries). Moreover, reinforcing this policy is necessary in low SES high schools considering that adolescents of low SES consume less fruit and vegetables than their peers with higher SES.

The change in time by country sweets consumption showed that the daily sweets consumption in adolescents decreased in 14 of 36 Europe countries. A previous study from Germany (1985 to 2016) also showed a decrease in the total sugar intake in children and adolescents since 2010. (30) The decrease in sugar consumption in the present study might be explained by the 2015 recommended WHO guideline about the reduction of sugar intake to less than 10% of total energy. (31) Due to this recommendation, some policy recommendations were carried out in Europe to restrict or eliminate the choice of sugar-added food or beverages and introduce the recommendation of fiscal measures like the taxation of sugar-sweetened beverages (SSB) and sugar-rich products. (32) Some European countries (Belgium, Finland, France, Hungary, Ireland, Norway, Portugal and United Kingdom) implemented taxes on SSB and/or sugar consumption between 2009 to 2018. (33) This can explain why most of these countries presented a positive and significant change over time in the present study. Nevertheless, this recommended sugar reduction is still important, as the present study showed that ≥20% of adolescents still consume sweets daily.

Recently, the European Programme of Work 2020–2025 was agreed upon by all 53 Member States of the WHO European Region aiming to promote healthy and sustainable diets, tackle the growing rates of obesity, and ensure good nutrition and food security through a range of activities such as, 1) promoting school nutrition policies, 2) restricting digital marketing of

unhealthy foods and non-alcoholic beverages to children and adolescents, 3) promoting policies to reduce salt, fats and sugars in the diet, including food product reformulation, 4) supporting fiscal policies including sugar-sweetened beverage tax and front-of-pack labelling, among others. (34) These initiatives provide a good opportunity to improve the dietary behaviours of children and adolescents taking into account the relevant results of the present study.

The present study showed that older adolescents consumed less daily fruit and vegetables than younger adolescents. These results are in line with a European trend from 2002 to 2010. (35) Additionally, the present study demonstrated that older adolescents consumed more daily sweets with a change in time less favourable than younger adolescents. A study from Germany between 1985 and 2016 showed the opposite, showing older children consumed less sugar than younger. (36) Justifying that the results differ among countries but, the present study analyses the overall European level.

Focussing on SES inequality, low SES adolescents consumed less daily fruit and vegetables than medium/high SES adolescents. Also, the change in time in daily vegetables was less favourable in low SES adolescents. These results are in line with a study among Nordic adolescents that showed that high SES students are more likely to report eating daily fruit and vegetables compared with low/medium SES adolescents. On the contrary, trends (from 2001/02 to 2009/10) in SES inequality in fruit and vegetable consumption did not differ across survey years. (9) No study showed any significant associations between SES and sweet consumption. (9) In summary, the less favourable change in time for low SES groups means inequities are increasing over time and probably reflect the devastating effects of the economic crisis on European society. (37) In future research, this potentially widening gap should be monitored.

Related to sex inequity, girls consumed more daily fruit, vegetables and sweets than boys, as a previous European adolescents' trend study. (35)

What this study adds

The present study provides new actual evidence about the change in time of dietary behaviours in European adolescents and the association with sociodemographic

characteristics. These findings are very important to further underpin the development of public health policies to improve the diet of European adolescents.

Limitations of this study

As more recent data are not freely available yet, the data on the study is limited to 2013/14 to 2017/18 period.

Related to future perspectives, studies with longer time-trend comparisons between European countries including more social factors (SES, ethnicity, demographic characteristics, sociocultural education and exposure to media) and more details on consumed quantities might provide further evidence.

Also, European policy recommendations in dietary behaviours should reflect the differences according to age, sex and SES and consider the influence in each European country. Key points to adapt policy recommendations should be, first of all, to offer fruit and vegetables in schools or high schools at the European level considering the SES of families: reaching low SES families to enable them to attain fruit and vegetable recommendations; and also, specify the fruit and vegetable recommendations related to sub-age categories like younger adolescents (10-12 years old), middle adolescents (12- 14 years old) and older adolescents (15-18 years old), not only divided by children or adolescents in general.

Conclusions

In 36 European countries, from 2013/14 to 2017/18, a significant and positive change in time as an increase in daily fruit and vegetables was shown in adolescents between 11-15-year-old, especially in East European countries, and a reduction in daily sweet consumption, especially in Western European countries.

Notably, older adolescents consumed less daily fruit and vegetables and more daily sweets than younger adolescents. In addition, girls consumed more daily fruit, vegetables and sweets than boys.

Related to SES inequality, low SES adolescents consumed less daily fruit and vegetables than adolescents with medium/high SES. In low SES, a less favourable change in time for vegetable consumption was shown.

Authors' contributions

JQ, AW and WJ have made substantial contributions to the conception, design of the work; acquisition, analysis and interpretation of data; and have drafted the work or substantively revised it. In addition, they have approved the submitted version and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

EL, LT and RS have made substantial contributions to the conception, design of the work; interpretation of data; and have drafted the work or substantively revised it. In addition, they have approved the submitted version and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of interest

The authors declare that they have no competing interests.

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Additional file 1: STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item Nº	Recommendation	Page Nº
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3 and 4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4 and 5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5 and 6

Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*5 and 6*
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	4 - 5 and 7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5 and 6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	4 and 5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4 and 7
		(b) Give reasons for non-participation at each stage	4 and 5
		(c) Consider use of a flow diagram	NA

Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	NA
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7 - 16
		(*b*) Report category boundaries when continuous variables were categorized	5 and 6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	17
Discussion			
Key results	18	Summarise key results with reference to study objectives	17-19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	20

Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	20
Generalisability	21	Discuss the generalisability (external validity) of the study results	20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for exposed and unexposed groups.

Additional file 2: Sensitivity analysis

Additional table 2a. Change in time of daily dietary behaviours consumption adjusted by age, sex and FAS split by country

Country	More than once daily fruit consumption		More than once daily vegetables consumption		Sweets weekly consumption	
	OR (99% CI)	*p*-value	OR (99% CI)	*p*-value	OR (99% CI)	*p*-value
Albania	1.918 (1.639, 2.244)**	<0.001	1.408 (1.185, 1.674)**	<0.001	1.080 (0.869, 1.341)	0.362
Austria	0.938 (0.803, 1.097)	0.294	1.061 (0.866, 1.298)	0.454	0.652 (0.545, 0.779)**	<0.001
Belgium (Flemish)	1.622 (1.361, 1.704)**	<0.001	1.577 (1.349, 1.843)**	<0.001	0.787 (0.673, 0.920)**	<0.001
Belgium (French)	1.221 (1.089, 1.369)**	<0.001	1.348 (1.203, 1.511)**	<0.001	0.688 (0.582, 0.768)**	<0.001
Bulgaria	1.075 (0.942, 1.228)	0.159	1.147 (1.005, 1.308)**	0.007	0.642 (0.547, 0.753)**	<0.001
Croatia	0.919 (0.800, 1.057)	0.119	0.967 (0.817, 1.145)	0.611	0.809 (0.696, 0.940)**	<0.001
Czech Republic	1.493 (1.333, 1.671)**	<0.001	1.523 (1.337, 1.736)**	<0.001	0.750 (0.662, 0.850)**	<0.001
Denmark	0.641 (0.547, 0.752)*	<0.001	0.936 (0.798, 1.098)	0.286	1.197 (0.933, 1.443)	0.013
Estonia	1.270 (1.103, 1.462)**	<0.001	1.341 (1.133, 1.587)**	<0.001	0.938 (0.774, 1.137)	0.390
England	1.255 (1.088, 1.447)**	<0.001	1.120 (0.973, 1.290)**	0.038	0.782 (0.650, 0.942)**	<0.001
France	0.994 (0.884, 1.117)	0.891	0.916 (0.817, 1.026)	0.046	0.905 (0.811, 1.009)	0.018

Germany	1.135 (0.989, 1.301)	0.018	1.387 (1.158, 1.662)**	<0.001	0.854 (0.728, 1.004)	0.012
Greece	0.836 (0.701, 0.966)*	0.008	0.958 (0.794, 1.157)	0.562	1.067 (0.913, 1.247)	0.282
Hungary	0.832 (0.711, 0.973)*	0,002	0.910 (0.763, 1.086)	0.169	0.826 (0.693, 0.985)**	0.005
Iceland	1.097 (0.992, 1.214)	0.018	1.141 (1.011, 1.288)**	0.005	0.978 (0.893, 1.071)	0.522
Ireland	1.021 (0.884, 1.181)	0.707	0.941 (0.811, 1.092)	0.294	0.880 (0.729, 1.061)	0.079
Italy	0.933 (0.799, 1.089)	0.248	1.023 (0.858, 1.220)	0.737	0.982 (0.835, 1.155)	0.779
Latvia	1.080 (0.923, 1.264)	0.206	1.315 (1.114, 1.553)**	<0.001	0.853 (0.724, 1.005)	0.013
Luxembourg	0.984 (0.837, 1.156)	0.769	1.290 (1.076, 1.547)**	<0.001	1.007 (0.852, 1.190)	0.919
Malta	1.039 (0.854, 1.263)	0.618	0.616 (0.499, 0.761)*	<0.001	2.248 (1.804, 2.800)*	<0.001
Republic of Moldova	1.849 (1.633, 2.093)**	<0.001	1.183 (1.042, 1.343)**	<0.001	0.716 (0.617, 0.832)**	<0.001
Netherlands	0.920 (0.784, 1.081)	0.183	0.954 (0.795, 1.144)	0.502	1.050 (0.873, 1.261)	0.497
Norway	0.738 (0.620, 0.877)*	<0.001	0.987 (0.815, 1.196)	0.863	1.122 (0.930, 1.353)	0.115
Poland	1.203 (1.050, 1.380)**	<0.001	1.209 (1.037, 1.409)**	0.001	0.760 (0.647, 0.892)**	<0.001
Portugal	1.355 (1.197, 1.534)**	<0.001	1.291 (1.113, 1.498)**	<0.001	0.789 (0.694, 0.898)**	<0.001
Romania	1.260 (1.093, 1.453)**	<0.001	0.861 (0.737, 1.006)*	0.013	1.054 (0.887, 1.253)	0.433

Russia	1.038 (0.904, 1.193)	0.486	0.926 (0.800, 1.072)	0.176	1.035 (0.880, 1.218)	0.582
Slovakia	1.445 (1.251, 1.668)**	<0.001	1.703 (1.448, 2.004)**	<0.001	0.845 (0.707, 1.011)	0.015
Slovenia	1.165 (1.028, 1.321)**	0.002	1.905 (1.623, 2.236)**	<0.001	1.092 (0.960, 1.242)	0.080
Spain	1.209 (1.060, 1.379)**	<0.001	1.508 (1.289, 1.765)**	<0.001	1.160 (1.036, 1.300)*	<0.001
Sweden	1.065 (0.917, 1.237)	0.275	1.243(1.100, 1.404)**	<0.001	1.259 (1.088, 1.456)*	<0.001
Switzerland	0.904 (0.812, 1.007)*	0.016	1.120 (0.998, 1.257)**	0.011	0.967 (0.845, 1.106)	0.519
Ukraine	0.821 (0.730, 0.924)*	<0.001	0.925 (0.825, 1.036)	0.077	0.798 (0.676, 0.942)**	<0.001
Macedonia	1.328 (1.161, 1.520)**	<0.001	1.193 (1.041, 1.367)**	<0.001	0.963 (0.816, 1.136)	0.554
Scotland	0.833 (0.736, 0.943)*	<0.001	0.944 (0.831, 1.073)	0.245	0.760 (0.628, 0.919)**	<0.001
Wales	1.124 (1.004, 1.259)**	0.008	0.913 (0.818, 1.019)*	0.034	0.886 (0.772, 1.015)	0.022

OR, Odds Ratio; CI, Confidence Interval

a. Positive change in time: an increase over time in daily fruit and vegetables consumption and a decrease in daily sweets consumption
b. Negative change in time: decrease over time in daily fruit and vegetables consumption and an increase in daily sweets consumption
c. Binary logistic regression of dietary outcomes adjusted by sex, gender, age, FAS split by country

**positive and significant change in time (p<0.01); *negative and significant change

Additional table 2b. Change in time in dietary behaviours daily consumption by age, sex and FAS from 2013/14 to 2017/18

	More than once daily fruit consumption OR (99% CI) change in time[a]	**More than once daily vegetables consumption** OR (99% CI) change in time[a]	**Sweets weekly consumption** OR (99% CI) change in time[a]
		Age	
11 years old	1.156 (1.114, 1.199)*	1.148 (1.103, 1.195)*	0.962 (0.923, 1.003)*
13 years old	1.098 (1.056, 1.142)*	1.162 (1.114, 1.212)*	0.932 (0.891, 0.974)*
15 years old	1.061 (1.017, 1.106)*	1.086 (1.039, 1.135)*	0.838 (0.800, 0.877)*
		Sex	
Girls	1.094 (1.061, 1.128)*	1.137 (1.100, 1.175)*	0.936 (0.903, 0.970)*
Boys	1.122 (1.086, 1.160)*	1.129 (1.089, 1.170)*	0.892 (0.861, 0.924)*
		FAS	
Low FAS	1.143 (1.100, 1.187)*	1.104 (1.061,1.150)*	0.880 (0.845, 0.916)*
Medium + High FAS	1.086 (1.056, 1.117)*	1.151 (1.116, 1.186)*	0.936 (0.906, 0.966)*

This table shows the change in time from 2013/14 to 2017/18 in each dietary behaviour adjusted by age and/or sex and/or FAS and country split by age categories, sex and FAS categories. Abbreviations: Odds Ratio; CI, Confidence Interval

a. Binary logistic regression of dietary outcomes adjusted by sex, age, FAS and country

*p-value <0.01

Additional table 2c. Multilevel analysis: Main effects differences and Interaction effects in dietary behaviours between sociodemographic characteristics over time (from 2013/14 to 2017/18)

	More than once daily fruit consumption		More than once daily vegetables consumption		Sweets weekly consumption	
	OR (99% CI) main effects [a]	OR (99 CI) interaction [b]	OR (99% CI) main effects [a]	OR (99 CI) interaction [b]	OR (99% CI) main effects [a]	OR (99 CI) interaction [b]
Age						
11 years old	Ref	Ref	Ref	Ref	Ref	Ref
13 years old	0.753 (0.725, 0.783)*	0.949 (0.900, 1.000)*	0.820 (0.786, 0.855)*	1.013 (0.957, 1.072)	1.378 (1.321, 1.439)*	0.969 (0.913, 1.027)
15 years old	0.670 (0.644, 0.698)*	0.893 (0.845, 0.943)*	0.781 (0.749, 0.815)*	0.932 (0.879, 0.988)*	1.504 (1.439, 1.571)*	0.873 (0.822, 0.927)*
Sex						
Girls	1.256 (1.216, 1.297)*	0.974 (0.932, 1.018)	1.234 (1.192, 1.278)*	1.003 (0.956, 1.052)	1.136 (1.096, 1.178)*	1.035 (0.986, 1.088)
Boys	Ref	Ref	Ref	Ref	Ref	Ref
FAS						
Low FAS	0.703 (0.679, 0.728)*	1.050 (1.003, 1.100)*	0.776 (0.748, 0.807)*	0.956 (0.909, 1.004)	0.921 (0.886, 0.957)*	0.938 (0.891, 0.986)*
Medium + High FAS	Ref	Ref	Ref	Ref	Ref	Ref

This table shows the main effects difference between sociodemographic characteristics categories and interaction effects over time (2013/14 vs 2017/18) between sociodemographic categories in each dietary behaviour in comparison with the reference category (11-year-old and medium + high FAS participants). Abbreviations: Ref, Reference level category; OR, Odds Ratio; CI, Confidence Interval.

a. Main effects differences between age, sex and FAS categories in dietary behaviours by the multilevel binary logistic regression with country as a level.
b. Interaction effects of age, sex and FAS categories over time (from 2013/14 to 2017/18) by multilevel binary logistic regression with country as a level

*p-value <0.01

Additional file 3

Additional table 3. Prevalence of daily dietary behaviours by age and year split by sex

			Daily fruit consumption		Daily vegetables consumption		Daily sweets consumption	
Sex	**Age**	**Survey**	**% (n)**	***p*-value [a]**	**% (n)**	***p*-value [a]**	**% (n)**	***p*-value [a]**
Boy	11	2013/14	40.4 (11604)	**<0.001**	35.3 (10081)	**<0.001**	21.3 (6071)	0.673
		2017/18	42.6 (13198)		37.4 (11531)		21.1 (6505)	
		Total	41.5 (24802)		36.4 (21612)		21.2 (12576)	
	13	2013/14	33.5 (10393)	**<0.001**	30.8 (9531)	**<0.001**	23.4 (7245)	**0.006**
		2017/18	34.8 (10956)		33.8 (10615)		22.5 (7066)	
		Total	34.2 (21349)		32.3 (20146)		23.0 (14311)	
	15	2013/14	28.6 (8319)	**<0.001**	29.5 (8583)	**<0.001**	23.5 (6821)	0.164
		2017/18	29.8 (8399)		31.7 (8893)		23.0 (6450)	
		Total	29.2 (16718)		30.6 (17476)		23.2 (13271)	
Girl	11	2013/14	47.2 (13967)	**<0.001**	41.3 (12187)	**<0.001**	22.8 (6731)	0.624
		2017/18	48.8 (15515)		44.3 (14042)		23.0 (7281)	
		Total	48.0 (29482)		42.9 (26229)		22.9 (14012)	
	13	2013/14	39.4 (12532)	**p<0.001**	37.2 (11813)	**p<0.001**	27.3 (8679)	0.144
		2017/18	41.5 (13207)		40.9 (12978)		26.8 (8501)	
		Total	40.5 (25739)		39.0 (24791)		27.0 (17180)	
	15	2013/14	36.4 (11163)	p=0.217	37.4 (11446)	**p<0.001**	27.2 (8342)	0.025
		2017/18	36.9 (10942)		38.7 (11463)		26.4 (7828)	
		Total	36.7 (22105)		38.0 (22909)		26.8 (16170)	

a. p-value obtained with Chi^2 analysis

Bold: significant p-value (p<0.01)

STUDY 2

Exploring restaurant and customer needs, barriers, interests, and food choices induced by the COVID-19 pandemic in Tarragona Province (Catalonia, Spain): A cross-sectional study

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Judit Queral Añó

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Exploring restaurant and customer needs, barriers, interests, and food choices induced by the COVID-19 pandemic in Tarragona Province (Catalonia, Spain): A cross-sectional study

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Background: COVID-19 has harmed restaurants, but customer preferences remain unknown. This study aims to determine the needs, barriers, interests, and food choice changes in restaurants and customers before and during the COVID-19 pandemic in Tarragona Province (Spain).

Methods: An observational cross-sectional study conducted in spring 2021 collected Mediterranean offerings, food safety, and hygiene information about the pandemic through online surveys and focus group interviews with restaurateurs and customers about the changes in their needs and new barriers.

Results: Fifty-one restaurateurs (44 survey, 7 focus group) and 138 customers (132 survey, 6 focus group) were included. In relation to the economic, emotional, and uncertainty restaurateurs' barriers detected, they implemented measures to tackle it: buy less and more often, reduce restaurant staff and reduce the restaurants offer, among others. Some customers reported changes in their restaurant orders, specifically increasing their takeaway orders. The Mediterranean diet offer (AMed criteria) remained without noticeable changes in any of the criteria. After lockdown, compared to before lockdown, restaurateurs increased their takeaway offerings by 34.1% ($p<0.001$) and their use of digital menus by 27.3% ($p<0.001$) because of customer demand. The use of local products in the menus remained high. The cleaning and disinfection tasks increased by 21.1% ($p=0.022$), and the use of hydroalcoholic solutions increased by 13.7% ($p=0.031$).

Conclusion: In restaurants, the first COVID-19 lockdown increased takeaway orders, sanitation, and digital communication. This study provides valuable information for adapting gastronomic offerings during challenging situations.

KEYWORDS

COVID-19, restaurant, customer, needs, barriers, mediterranean-offer

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1. Introduction

Recently, a worldwide pandemic caused by the SARS-CoV-2 virus broke out, various social and mobility restrictions have since been implemented (1), and Spain specifically was hit hard by the COVID-19 pandemic (2).

Before the COVID-19 pandemic, there had been a growing trend toward consuming food outside the home (3, 4), which was motivated by socioeconomic changes such as the increased involvement of women in work and a lack of time at home (5). This trend has been reduced due to the significant negative impact of the pandemic on the restaurant sector and the closure of restaurants (1, 6). An analytical *Google Trends* study showed that during the first months of 2020, which included the pandemic lockdown period, people's interest in restaurants dropped substantially worldwide, while interest in food security and takeaway food increased (7) due to the desire to reduce the risk of exposure to the virus, which led to online food purchases (8).

Although the evidence from Spain and Brazil suggests that SARS-CoV-2 is not transmitted through food (9, 10) and that it spreads primarily through small respiratory droplets in enclosed spaces, in the United States, the restaurant sector experienced a significant revenue shortfall caused by a sharp decline in customer demand and temporary interruptions of processes (2).

Moreover, during the first wave of the COVID-19 pandemic, people were in lockdown, and the changes in their restaurant food choice preferences remain unknown. Focusing on nutritional habits, an observational study from Poland suggests that during the pandemic, most of the population did not change their diet (11). However, 20% of people improved their eating habits with healthier eating, while another 20% of respondents worsened their eating habits (11). In addition, during the first COVID-19 pandemic lockdown, due to the increase in online work and the restrictions implemented, home delivery and takeaway orders increased, while the type of dishes requested did not vary relative to before the pandemic (11). Knowledge of the criteria used by customers when selecting a restaurant is critical for understanding food consumption trends (3). Therefore, to improve the ability of restaurant owners to respond adequately to customers, they must understand the behaviors of and factors influencing the decisions of consumers in the restaurant sector (3).

Despite the current negative circumstances arising from the COVID-19 pandemic, these circumstances have provided an opportunity to improve the resilience of the sector, defined as the ability to plan and prepare to adapt and recover from adverse situations (10). Two studies from Brazil and China highlighted that a common way for restaurants to adapt and reduce the impact of the COVID-19 pandemic was to increase their takeaway and food delivery offerings (10, 12). Thus, restaurants continued to offer their services and support at least some of their workers (10, 12).

To our knowledge, the present study is the first to attempt to determine the real impact of the COVID-19 pandemic on restaurants at a regional level.

Our hypothesis is that the needs, barriers, interests, and food choices of restaurants and customers differ before and during the current COVID-19 pandemic.

The main objective of this study was to determine the changes in restaurant and customer needs, barriers, interests, and food choices before and during the current COVID-19 pandemic in Tarragona Province (Spain). The specific objectives of this study were to identify the changes that restaurants and customers underwent before and during the current COVID-19 pandemic, specifically those related to food safety and food hygiene.

2. Materials and methods

2.1. Design and study population

The present study is an observational cross-sectional study that was conducted from April to June 2021 in Tarragona Province, Catalonia (Spain).

The study population was the owners of restaurants located in Tarragona Province and customers. The recruitment of restaurants was carried out by email and telephone calls, while customer recruitment was carried out by social networks. In addition, to ensure a proportionate number of restaurants was selected in each area, the number of inhabitants in the 10 counties of Tarragona Province was taken into consideration (13). Therefore, more restaurants were sampled from counties with more inhabitants (14).

In the restaurant sector, there were some restrictions such as a limit of customers inside the restaurant, a limit of the customers per table, 2 m between tables and limitations on the opening hours, and perimeter lockdown with their important consequences of society mobility. To determine the changes in customer and restaurant needs, barriers, interests, and food choices experienced by restaurateurs suffering under the circumstances of the COVID-19 pandemic, the following approaches were used:

a. An online survey that referred to the period before and during the current COVID-19 pandemic situation was conducted with the two study populations, restaurateurs and customers, to obtain quantitative information on the changes of interest. This type of quantitative approach identifies the total changes made by restaurateurs and customers.
b. Focus groups, formatted as a structured debate between a group of participants who could freely contribute their opinions and directed by a moderator (15) and in which questions were asked that referred to the period before and during the current COVID-19 pandemic situation, were arranged to provide qualitative information. The focus groups included members of the two populations, restaurateurs and customers, to identify their needs, barriers and changes implemented from the COVID-19 pandemic. This type of qualitative approach provides the reason for the changes in the needs of and barriers experienced by restaurateurs and customers.

This cross-sectional study followed the guidelines in the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement (16) (Supplementary material 1) and the Consolidated Criteria for Reporting Qualitative Research (COREQ; Supplementary material 2) (17). The protocol for this study was approved by the Ethics Committee of the Pere Virgili Institute (ref. 056/2021). All participants provided signed informed consent before their participation.

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2.2. Inclusion and exclusion criteria

For the restaurants, the inclusion criteria were as follows: (1) being a restaurant, hotel with a restaurant or camping ground including restaurant; (2) being located within Tarragona Province (Catalonia, Spain); (3) having a menu that includes dishes with local and seasonal foods; and (4) having signed the informed consent before the study. The restaurant exclusion criteria were as follows: (1) being a fast-food or ethnic restaurant; (2) offering only one type of product; and (3) belonging to a food chain. The restaurateurs of the included restaurants answered the survey and participated in the focus group. The restaurateurs were recruited through emails and phone calls.

Regarding restaurant customers, the inclusion criteria were as follows: (1) being over 18 years of age and a customer of restaurants located in Tarragona Province (Catalonia, Spain); (2) signing the informed consent before the study; (3) accepting the data protection conditions; and (4) accepting the privacy policy. The exclusion criterion for customers was failing to meet at least one inclusion criterion. Customer recruitment was performed through social networks.

2.3. Outcomes

The principal outcome was Mediterranean food offerings as assessed by the criteria for obtaining a Mediterranean Diet (AMed) accreditation (18). The AMed accreditation for restaurants that guarantees the offering of a menu based on the Mediterranean diet is led by the General Directorate of Public Health in the Department of Health of the Government of Catalonia.

The AMed accreditation contains a total of 17 criteria, 9 mandatory and 8 optional criteria. In the present study, to assess Mediterranean food offerings, 12 of the 17 AMed criteria were used, all 9 mandatory criteria and 3 of the 8 optional criteria, as shown in Figure 1 (available at www.amed.cat, accessed on 20 February 2021). Twelve of the 17 criteria were evaluated, but for the purpose of achieving the primary outcome, only the nine mandatory criteria were considered: (1) olive oil is used in dressings, and olive oil or high oleic sunflower are used for cooking; (2) 25% of the first course offerings are vegetables and/or legumes; (3) whole-grain products are included; (4) 50% of the second course offerings are based on fish, seafood, or lean meat; (5) 50% of the dessert offerings are based on fresh fruit (whole or prepared); (6) dairy desserts without added sugar are offered; (7) free non-packaged drinking water is offered; (8) wine, beer, and cava are measured in glasses or individual units; and (9) culinary preparations that do not require the addition of large amounts of fat and culinary techniques that use little or no fat are used. The 3 optional criteria analyzed were (1) including proposals of traditional and local cuisine, (2) prioritizing side dishes of vegetables and legumes, and (3) prioritizing fresh seasonal and local foods. The reason to select only 3 to 8 optional criteria was to prioritize the most adequate criterion to show changes in food restaurant offerings. Moreover, the criteria related to offering virgin olive oil in restaurant tables were excluded because the government had limited it for the COVID-19 pandemic situation.

The outcomes related to the AMed criteria before and during the current COVID-19 pandemic were reported at the same time.

The secondary outcomes from before and during the current COVID-19 pandemic included in this study were as follows:

Restaurants:

a. Provision of services and food safety and hygiene (19).
b. Barriers and needs: supplying healthy foods, using local products, addressing food allergies, and maintaining food hygiene and safety.

Customers:

a. Consumption habits, evaluation of the supply of dishes corresponding to the Mediterranean diet in the restaurant, and restaurant selection criteria.
b. Barriers and needs: restaurant visits, restaurant choice, perceptions of healthy food offerings, and management of food allergens.

2.4. Data collection

Data were collected through online surveys and focus groups with both restaurateurs and customers. Two different surveys were designed, one for restaurateurs and one for customers, which were answered during April–May 2021 and included questions related to the situation before and during the COVID-19 pandemic.

2.4.1. Surveys

All surveys (restaurateur and customer) were answered in online format.

The restaurateur survey was not anonymous; however, the data were treated anonymously using a code that was known only to one researcher. This survey was created by the authors and has 3 separate sections:

a. General information about the restaurant: name of the restaurant; type of establishment (restaurant, hotel, or camping ground); property characteristics (location, dimensions, capacity, terrace layout, type of ventilation, number of workers); last year's assessment (billing, reductions in personnel and temporary filing of occupation regulation applications, reductions in orders to suppliers, increases in expenses due to additional measures, financial aid); services offered before and after the COVID-19 pandemic (local product dishes, dishes without food allergens, vegetarian/vegan dishes, payment and order methods, menu formats, type of dishes consumed in the restaurant and as takeaway). This section included 23 questions that allowed us to describe the type of restaurant and its characteristics, while the last questions of this section responded to the changes made by restaurants during and after the COVID-pandemic. Questions were designed by the authors following the rules imposed by the government to determine the main changes made by restaurants;
b. The 12 selected Amed criteria (18) as "yes" or "no" answers, explained above;
c. Hygiene and food safety issues as "yes" or "no" answers. This section referred to the 4 key points of hygiene and food safety of restaurants: cross-contamination, processes, cleaning and

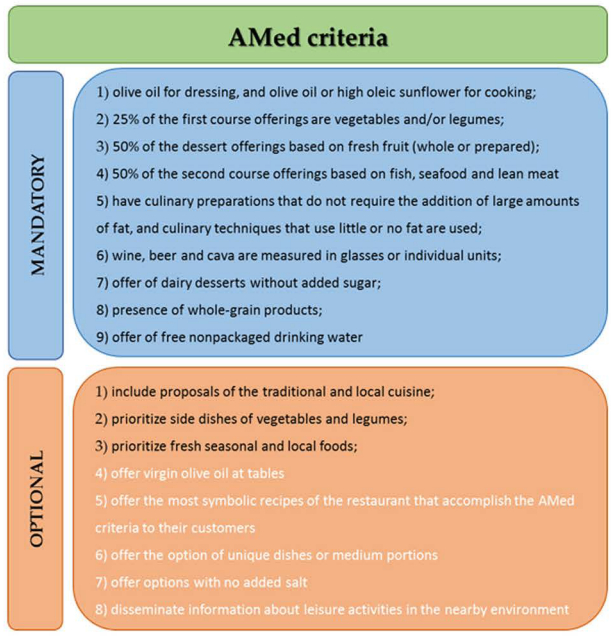

FIGURE 1
AMed criteria. The black quotes were the included in the analysis, and the white quotes were excluded.

disinfection, and management. The questions of this section were based on "Guide to Good Practices for the Hygiene of Restaurants" (19), published by the Government of Catalonia and officially recognized by the competent authorities of Catalonia in matters of food safety. The customer survey was completely anonymous, and there was no question about personal information; therefore, it was not possible to identify the person responding to the survey. This survey had two different sections:

a. Sociodemographic data. This section included 5 questions: sex, age, location, food allergy, or food intolerance, and whether customers had any difficulty finding restaurants with free allergen options.
b. Consumption habits, interests, and food choices questions were designed by the authors by adapting questions from the findings of this publication (11) to our local environment. This section included 20 questions referring to food allergy diagnoses and suitable restaurants; food consumption behaviors: type of restaurants visited frequently; location of restaurants; frequency of restaurant visits or takeaway food orders; reasons for decreases in frequency; knowledge of the AMed accreditation; perceptions of each AMed criteria satisfied by the restaurant menu offerings (Mediterranean offerings) and 2 extra questions about food-allergen and vegetarian/vegan option perceptions by customers; and customer criteria for restaurant selection: advertising, price, variety and type of dishes offered, presentation, service, hygiene in the establishment, environment, and customer evaluations published by other customers.

2.4.2. Focus groups

The focus groups were focused on (1) 6–12 restaurateurs (2 focus group sessions were conducted) and (2) 6–12 customers (1 focus group session was conducted) using the Teams online platform in line with the COVID-19 measures established by the competent local authorities. Each focus group session lasted 90 min. The attendees included one moderator, one study researcher and the restaurateur or customer participants.

The restaurateur and customer focus groups were organized around previously defined questions. Each focus group included the following six sections: (1) presentation of the participants; (2) presentation of the problem; (3) identification of barriers and needs; (4) food offerings (local products)/customer behavior regarding food; (5) food hygiene and safety; and (6) solutions from restaurateurs/solutions for restaurateurs provided by customers.

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In addition, the moderator provided some examples to ensure participation and understanding of the questions. Furthermore, two interactive platforms, menti.com and Kahoot, were used to encourage interactions among the participants. At the end of each of the six sections, the moderator summarized the discussion, and the participants were requested to confirm the information. Moreover, the focus group was recorded in audio format, and the researcher assistant took notes on the spot. Then, the focus group recordings were transcribed for analysis, and a report was made available to participants to confirm what they had discussed during the session.

2.5. Sample size

The sample size calculation was based on the main variable: the 9 compulsory AMed criteria for restaurants (18). A standard deviation (SD) of ±1.6 was assumed, drawing upon the preliminary results of a cross-sectional study developed in the same area (20). A two-tailed alpha risk of 0.05, a two-tailed beta risk of 0.2, and a difference equal to or greater than 1 point in the AMed criteria score were considered for calculating the sample size of restaurants. A follow-up loss rate of 20% was estimated, considering the high number of restaurants that have closed due to the COVID-19 pandemic (13, 14). Additionally, the 10 counties were classified into 2 groups: 5 counties with fewer than 50,000 inhabitants and 5 counties with more than 50,000 inhabitants. Thus, 36 restaurants were needed considering the number of inhabitants per 10 counties, proportionally. The sample size was calculated using GRANMO software (21).

The restaurant customer sample size was not calculated because the principal variables, the 9 compulsory AMed criteria, are related to restaurants.

The focus group sample size was estimated based on the available evidence (22). The recommendation is that there should be between 6 and 8 participants in focus groups for noncommercial topics because more than 10 participants make it difficult for the focus group to develop. We over-recruited participants for the focus groups due to the possibility that someone did not attend. For this reason, our range of sample sizes was 6 to 12 participants in each focus group.

2.6. Data analysis

2.6.1. Quantitative data

Categorical variables are reported as percentages, and continuous variables are reported as the mean ± SD. The McNemar test for categorical variables was used to compare the changes between the period before and the period during the pandemic. For comparison between restaurant vs. takeaway options during the same period of the pandemic, the Chi-squared test was used. The significance level was fixed at $p < 0.05$. The statistical program SPSS version 27 was used (IBM Corp. Released 2020. IBM SPSS Statistics, Version 27.0. Armonk, NY: IBM Corp).

2.6.2. Qualitative data

The focus groups were qualitatively analyzed using thematic analysis (23) to identify topics and themes, and the steps stated were followed to avoid researcher bias. The transcriptions of focus groups were reviewed, coded by open coding and then inductive methods, and discussed by two reviewers (MB-M, JQ). For interpretation of the focus group results, three different methods were used (24). First, the raw data, i.e., the exact words the participants said, were categorized according to the frequency with which something was said. Second, the descriptive information, i.e., a summary of the comments, was subsequently prepared by the analyst researcher who took notes during the focus group. Data were interpreted as raw data in summary form. Finally, the third method was the interpretive method, which consisted of the analyst researcher providing an interpretation of the data to help clarify the information obtained from the focus group.

3. Results

A total of 51 restaurateurs and 138 customers participated. Of the 51 restaurateurs, 44 participated in the survey and 7 in the focus group, whereas of the 138 customers, 132 participated in the survey and 6 in the focus group. Three online focus group sessions were conducted, 2 with restaurateurs and 1 with customers.

3.1. Results of the restaurant survey

3.1.1. Characteristics of restaurants as described in the restaurant survey

Of the 44 restaurants represented by the restaurateurs, most were located in the two most inhabited counties of Tarragona Province in Catalonia, Tarragonès (31.8%, $n = 14$) and Baix Camp (25%, $n = 11$). The most frequent establishments were restaurants (88.6%, n = 39), followed by hotels (6.8%, $n = 3$) and camping grounds (4.5%, $n = 2$). Regarding the ventilation used by the restaurants, 65.9% ($n = 29$) used air conditioners, and 15.7% ($n = 7$) did not have ventilation.

Regarding marketing and communication media, most restaurants used social networks (90.9%, $n = 40$) both before and during the COVID-19 pandemic. Posters, leaflets, and brochures for menus were used before and during the pandemic.

As an important consequence of the first wave of the COVID-19 pandemic in restaurants, 31.8% ($n = 14$) of restaurateurs had to throw away food, and 43.2% ($n = 19$) gave food away (data not shown in tables).

Table 1 shows the main changes undergone by restaurants due to the COVID-19 pandemic. Takeaway food orders increased significantly by 34.1% (47.7% ($n = 21$) to 81.8% ($n = 36$); $p < 0.001$). Additionally, the percentage of dishes with local products was maintained at a high level, approximately 90% before and during the current COVID-19 pandemic.

Regarding restaurant menu formats, the use of digital menus increased significantly by 27.3% (6.8% ($n = 3$) to 34.1% ($n = 28$); $p < 0.001$).

Additionally, the use of single-serving condiment packages increased by 61.4% (9.1% ($n = 4$) to 70.5% ($n = 31$); <0.001), and the use of single-use napkins increased by 20.5% (54.5% ($n = 24$) to 75% ($n = 33$); $p = 0.004$), whereas the use of cloth napkins, salthakers, and oil cruets decreased ($p < 0.05$), as shown in Table 1.

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TABLE 1 Restaurants' characteristics changes due to COVID-19.

	Variables	Before COVID $n=44\%$ (n)	Currently COVID# $n=44\%$ (n)	*p*-value*
Dishes offered	Dishes with local products	93.2 (41)	90.9 (40)	1
	Dishes without food allergens	88.4 (38)	86.0 (37)	1
	Vegetarian/vegan dishes	83.7 (36)	81.4 (35)	1
	Takeaway food	47.7 (21)	81.8 (36)	<0.001
Payment	Payment by credit card	100 (43)	95.3 (41)	_
	Payment with *bizum*	13.6 (6)	29.5 (13)	0.16
Menu format and demand	Menu in digital format	6.8 (3)	34.1 (28)	<0.001
	Use of ICT for the customer to place the order	4.5 (2)	13.6 (6)	0.219
	Use of ICT to write the customer's choice	11.4 (5)	20.5 (9)	0.125
Sales	Sales	31.8 (14)	34.1 (15)	1
Changes in the tables	Cleaning dishes and cutlery at a temperature >80°C	95.5 (42)	95.5 (42)	1
	Delivery of metal cutlery in sterilized bag	2.3 (1)	11.4 (5)	0.125
	Delivery of single-use cutlery	9.1 (4)	22.7 (10)	0.031
	Delivery of cloth napkins	52.3 (23)	38.6 (17)	0.031
	Delivery of single-use napkins	54.5 (24)	75 (33)	0.004
	Condiments available to customers as salt shakers and oil cruet	79.5 (35)	43.2 (19)	0.002
	Condiments available to customers in a single-dose format	9.1 (4)	70.5 (31)	<0.001

ICT: information and communication technology. #Currently COVID-19 pandemic situation. *McNemar test.

3.1.2. AMed criteria results from the restaurant survey

According to the survey responses regarding the AMed criteria, of the 44 restaurants, only 4.5% ($n=2$) had the AMed accreditation, 22.7% ($n=10$) did not have the AMed accreditation but knew it, and 72.7% ($n=32$) did not know the AMed accreditation (data not shown in tables).

Table 2 shows the results regarding the AMed criteria as reported by the restaurateurs. AMed criteria have not shown changes in any of the criteria studied before and after the COVID-19 pandemic. Focusing on the 9 mandatory AMed criteria, 100% ($n=44$) of restaurants provided olive oil for dressing and olive oil or high oleic sunflower for cooking and provided seasonal and local products before the COVID-19 pandemic and continued to do so during the pandemic. In contrast, half or fewer of the restaurants satisfied the three mandatory criteria: (1) Offer dairy desserts without added sugar, (2) Prioritize side dishes of vegetables and legumes, and (3) Offer free non-packaged drinking water, and these results were unchanged during the pandemic, as shown in Table 2.

3.1.3. Hygiene and food safety results from the restaurant survey

As the supplementary table (Supplementary material 3) shows, the number of restaurants that cleaned the goods reception area frequently, specifically, the number of restaurants cleaning that area ≥ 2 times/day, increased by a significant 21.1% (72.1 ($n=31$) to 93.2 ($n=41$); $p=0.022$). In addition, during the COVID-19 pandemic, the use of a hydroalcoholic solution, specifically for disinfecting cooking utensils, increased by a significant 13.7% from its level before the pandemic (6.3 ($n=3$) to 20.5 ($n=9$); $p=0.031$). The other items, which remained unchanged, are described in Supplementary material 3.

3.2. Results of the restaurateur focus group

A total of 7 restaurateurs participated in the focus group session, which lasted 90 min. During the session, after introducing the participants and moderator, 5 topics were discussed.

3.2.1. Problems due to COVID-19 in the restaurant sector

The restaurateurs were not satisfied with the way the authorities handled the COVID-19 situation in the restaurant sector. The restaurateurs believed that the measures imposed on this sector harmed employers, workers, and suppliers more than in other sectors where the measures were less stringent. (a) In addition, the lack of clarity in the messages issued by the administration and the short time that the restaurateurs had to adapt to the new measures, which were constantly changing, was a problem for them. (b) Moreover, some measures were difficult to implement, such as maintaining the required distance between customers (c).

a. "There have been many people affected by the issue. It has been economic chaos for many people, not just for employers, but for workers who have stopped earning, for suppliers who have not been able to serve, and many other things."
b. "The measures have been too strong, but at the same time they have made us dizzy, because it was now yes, now no, now this way, now this other way, and so on. Many have fallen, others have endured as best we could, but it has been almost a year and a half where almost no one has been able to make a profit."
c. "The tables must be separated by 2 m. However, customers at the same table must be 1 m apart. The problem is that anyone has

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TABLE 2 Mandatory and optional AMed criteria fulfilled by the included restaurants reported by restaurateurs.

AMed criteria	Before COVID $n=44\%$ (n)	Currently COVID# $n=44\%$ (n)	p-value*
AMed mandatory criteria[1]			
1. Olive oil for dressing, and olive oil or high oleic sunflower for cooking	100 (44)	97.7 (43)	---
2. 25% of the first course offerings are vegetables and/or legumes	95.5 (42)	93.2 (41)	1.000
3. 50% of the dessert offerings based on fresh fruit (whole or prepared)	95.5 (42)	93.2 (41)	1.000
4. 50% of the second course offerings based on fish, seafood and lean meat	93.2 (41)	90.9 (40)	1.000
5. Have culinary preparations that do not require the addition of large amounts of fat, and culinary techniques that use little or no fat are used	88.6 (39)	86.4 (38)	1.000
6. Wine, beer and cava are measured in glasses or individual units	86.4 (38)	90.9 (40)	0.500
7. Offer of dairy desserts without added sugar	54.4 (24)	56.8 (25)	1.000
8. Presence of whole-grain products	43.2 (19)	40.9 (18)	1.000
9. Offer of free non-packaged drinking water	25.0 (11)	29.5 (13)	0.500
Number of total AMed compulsory criteria fulfilled per restaurant (mean ± SD)[3]	6.8 ± 1.17	6.7 ± 1.47	
AMed optional criteria[2]			
10. Include proposals of the traditional and local cuisine	100 (44)	97.7 (43)	---
11. Prioritize side dishes of vegetables and legumes	93.2 (41)	93.2 (41)	1.000
12. Prioritize fresh seasonal and local foods	87.7 (43)	95.5 (42)	1.000

SD, Standard Deviation; AMed, Mediterranean Diet offer. 1: 9 compulsory AMed criteria; 2: 3 optional AMed criteria assessed from the 8 described in the Mediterranean Accreditation; 3: 12 total AMed criteria assessed from the total 17 AMed criteria. *McNemar test. #Currently COVID-19 pandemic situation.

accomplished the measures because these are impossible to accomplish."

3.2.2. Barriers of restaurateurs

The main barrier was the restrictions imposed by the authorities, specifically the national and municipal lockdown, and the rapid changes in limitations meant that large amounts of food, especially fresh products, had to be given away.

In addition, other important barriers were (1) economic, as the number of customers significantly decreased and consequently the income of the restaurateurs; (2) emotional barriers, such as anxiety, depression, demotivation, or fear of being infected and having to close their restaurant and of not having an income; and (3) not being able to provide good customer services because the limitations placed on hours and the number of customers prevented them from predicting how many people they could hire or how much food they would need. These barriers are described in Figure 2 with some examples from the focus group transcriptions.

Due to the barriers mentioned above, the restaurateurs needed to increase their income and reduce their costs; for this reason, the restaurateurs implemented certain measures such as buying food daily instead of weekly or reducing the restaurant staff, eliminating daily menus and reducing the number of dishes and products supplied to provide better service (d)(e).

In addition, other measures included web page updates and providing menus in QR format. Other tactics included commercializing their menus in supermarkets, providing takeaway services, or delivering food to nearby towns. (f) However, the restaurateurs commented that it was easier to make fast food for takeaway orders than local dishes.

d. "We cannot have a daily menu with only two people working. It has been necessary to reduce the staff, we have limited the supply, it is a lot of things. We are continuously making special offers to attract the people."
e. "What we have had to do is to buy daily. Before, I used to place orders twice a week and now we make a forecast for the next day, and especially with the fresh products, we buy them daily, precisely so that what has happened to us does not happen again."
f. "We had never offered takeaway food, and having to close, being in such a small town, it has been very good for us. I took the car and went through the Ribera d'Ebre and Terra Alta distributing, and that has helped us a lot, but in the long run, it is not an option that we value."

3.2.3. Food offered (local products)

The main restaurants provided healthy traditional and Mediterranean cuisine. The restaurants used local products, especially fruits, vegetables, and fish, and they did not have any problems obtaining products during the lockdown. (g) Although restaurateurs did not observe any changes in the demand for special dishes, they stated that more people are vegetarian or have food intolerances. All of them found that takeaway food was not a problem for these special cases (h).

g. "We work with seasonal and km 0 products, so nothing has changed for us."
h. "I have not noticed a change; there are more and more people who have special diets. Some diets are voluntary, such as veganism or vegetarianism, or the thousand variants that there are, or forced diets, such as people who have various allergies.

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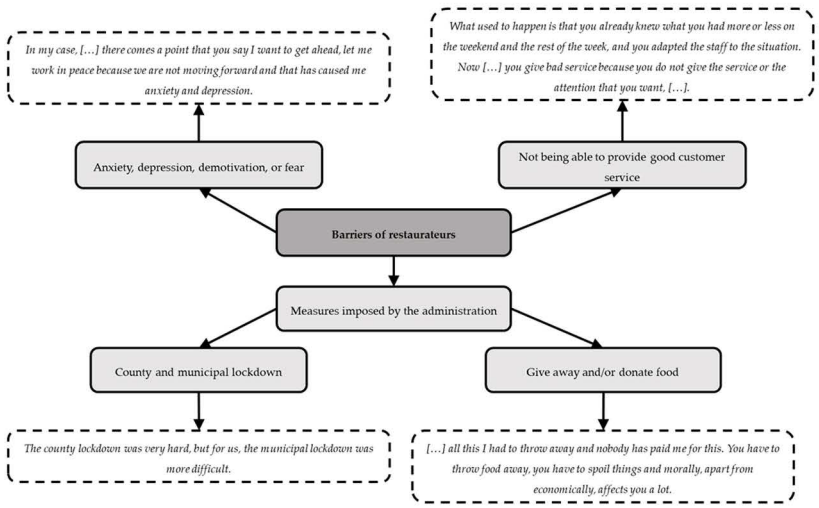

FIGURE 2
Barriers of restaurateurs.

However, we have to offer gluten-free bread, have a supply that considers these people, if not you further reduce the number of people who can come to your establishment."

3.2.4. Food hygiene and safety

Regarding food hygiene and safety, all the restaurateurs agreed that they handled and worked with foods in the same way as before COVID-19. Focusing on food delivery, they did not use isothermal bags to deliver the food, and only two restaurateurs included some instructions about the handling and storage of the delivered food (i).

i. "The temperature chain can be broken. On New Year's Eve, we had more than 100 daily meals, all takeaway and delivery. In addition, everything had to be heated later. However, we always give daily meals with an instruction sheet that explains how each dish should be heated and presented."

3.2.5. Solutions from restaurateurs

The possible solutions ideated by the restaurateurs were to reinvent themselves, generate income from atypical sources, and reduce expenses (j)(k)(l).

j. "Anyway, we have passed through it, we are enduring it, we are tired of enduring it, and the only solution is for it to end, for the restrictions to end and they let us work."
k. "It can help the people, that the COVID [lockdown] ends and that people come because the administration will not help with anything."
l. "It seems to me that we have to learn from each situation and adapt ourselves."

3.3. Results of the customer survey

3.3.1. Characteristics of customers as described in the customer survey

A total of 132 restaurant customers in Tarragona Province answered the survey, which focused on the differences in their choices before and during the current COVID-19 pandemic. Related to demographic characteristics, most were located in three counties of Tarragona Province in Catalonia, 59.1% ($n=78$) in Baix Camp, 13.6% ($n=18$) in Montsià, and 12.9% ($n=17$) in Tarragonès. Of the 132 customers, 34.1% ($n=45$) were men, and 65.9% ($n=87$) were women, with a mean age of 41.7 ± 14.6 years.

3.3.2. Characteristics of restaurant choices from the customer survey

Concerning the use of different digital formats to become aware of different options during the pandemic, specifically the use of marketing and communication media, the number of customers who selected restaurants through the use of social media significantly increased by 6% (37.9% ($n=50$) to 43.9% ($n=58$); $p=0.008$), while the tendency to use websites for this purpose increased by 17.4% (41.7% ($n=55$) to 59.1% ($n=78$); $p=0.052$). In addition, the number of customers with a preference for ordering from a digital menu increased by 57.5% since the start of the COVID-19 pandemic (20.5% ($n=27$) to 78.0% ($n=103$) $p<0.001$). Regarding the method of

payment, the number of customers who preferred to pay by credit card rather than by cash increased by 6.8% (84.1% ($n = 111$) to 90.9% ($n = 120$); $p = 0.012$).

Regarding the type of restaurant chosen by customers, after the start of the COVID-19 pandemic, the number of customers who preferred restaurants in rural areas over those in urban areas increased by 15.1% (22% ($n = 29$) to 37.1% ($n = 49$); $p < 0.001$). Moreover, the number of customers with a preference for terraces over indoor restaurant seating increased by 37.8% due to the pandemic (41.7% ($n = 55$) to 79.5% ($n = 105$); $p < 0.001$). In addition, the number of customers who reported eating outside of the home at least once a week decreased by 30.3% (74.2% ($n = 98$) to 43.9% ($n = 58$); $p < 0.001$), while the frequency of ordering food for takeaway out at least once a week increased by 12.9% after the start of the COVID-19 pandemic (6.8% ($n = 9$) to 19.7% ($n = 26$) $p < 0.001$).

3.3.3. Customer preferences for in-restaurant or takeaway dishes from the customer survey

Focusing on customer preferences for in-restaurant or takeaway food, there were no significant changes between the period before and the period during the current COVID-19 pandemic, as Table 3 shows. However, customers preferred to order the following types of food as takeaway orders rather than in-restaurant orders in the current COVID-19 pandemic situation: themed dishes from different countries [restaurant: 41.7% ($n = 55$) vs. takeaway: 59.8% (n = 79); $p < 0.001$), fast food (restaurant: 10.6% (n = 14) vs. takeaway: 28.0% ($n = 37$); $p < 0.001$], and dishes suitable for those with allergies [restaurant: 3.9% ($n = 5$) vs. takeaway: 4.5% ($n = 6$); $p < 0.001$]. Instead, the dishes that customers chose more frequently for consumption in the restaurant than for takeaway included seasonal vegetable-based dishes [restaurant: 30.3% ($n = 40$) vs. takeaway: 6.1% ($n = 8$); $p < 0.001$] and vegetarian dishes [restaurant: 9.8% ($n = 13$) vs. takeaway: 6.8% ($n = 9$); $p < 0.001$].

3.3.4. Perceptions of each AMed criteria satisfied by the restaurant menu offerings (mediterranean offerings)

Table 4 describes the perceptions of each AMed criterion accomplished by the dishes offered. The use of olive oil for cooking and dressing was the most highly valued by 99.2% ($n = 131$) of customers, followed by the use of fresh, local, and seasonal foods, with 98.5% ($n = 130$) of customers valuing positively the accomplishment of this criterion, and the pro-vision of traditional dishes and/or typical local dishes, with 95.5% ($n = 126$) of customers valuing positively the

TABLE 3 Preferences and comparison of dishes in the restaurant or takeaway.

Variables	Dishes chosen more often in the restaurant				Dishes chosen more often to takeaway or delivery				*p*-value restaurant vs. to takeaway currently COVID [#§]
	Gender	Before COVID *n*=132% (*n*)	Currently COVID[#] *n*=132% (*n*)	*p*-value*	Gender	Before COVID *n*=132% (*n*)	Currently COVID[#] *n*=132% (*n*)	*p*-value*	
Traditional dishes	Total	81.8 (108)	80.3 (106)	0.625	Total	26.5 (35)	23.5 (31)	0.219	0.438
	Men	97.8 (44)	97.8 (44)	1	Men	33.3 (15)	31.1 (14)	1	1.000
	Women	73.6 (64)	71.3 (62)	0.625	Women	23.0 (20)	19.5 (17)	0.375	0.768
Dishes based on seasonal vegetables	Total	29.5 (39)	30.3 (40)	1	Total	6.1 (8)	6.1 (8)	1	<0.001
	Men	28.9 (13)	26.7 (12)	1	Men	6.7 (3)	4.4 (2)	1	0.467
	Women	29.9 (26)	32.2 (28)	0.5	Women	5.7 (5)	6.9 (6)	1	<0.001
Country themed food	Total	40.9 (54)	41.7 (55)	1	Total	56.1 (74)	59.8 (79)	0.125	<0.001
	Men	33.3 (15)	33.3 (15)	1	Men	55.6 (25)	55.6 (25)	1	0.027
	Women	44.8 (39)	46.0 (40)	1	Women	56.3 (49)	62.1 (54)	0.125	0.008
Vegetarian dishes	Total	9.8 (13)	9.8 (13)	1	Total	6.8 (9)	6.8 (9)	1	<0.001
	Men	4.4 (2)	4.4 (2)	1	Men	6.7 (3)	4.4 (2)	1	0.001
	Women	12.6 (11)	12.6 (11)	1	Women	6.9 (6)	8.0 (7)	1	<0.001
Dishes suitable for allergy sufferers	Total	5.3 (7)	3.8 (5)	0.5	Total	4.5 (6)	4.5 (6)	1	<0.001
	Men	2.2 (1)	2.2 (1)	1	Men	2.2 (1)	2.2 (1)	1	0.022
	Women	6.9 (6)	4.6 (4)	0.5	Women	5.7 (5)	5.7 (5)	1	<0.001
Fast food	Total	13.6 (18)	10.6 (14)	0.219	Total	30.3 (40)	28.0 (37)	0.508	<0.001
	Men	20.0 (9)	13.3 (6)	0.25	Men	31.1 (14)	26.7 (12)	0.625	0.035
	Women	10.3 (9)	9.2 (8)	1	Women	29.9 (26)	28.7 (25)	1	<0.001
Others	Total	0.8 (1)	1.5 (2)	1	Total	6.1 (8)	5.3 (7)	1	0.104
	Men	2.2 (1)	4.4 (2)	1	Men	8.9 (4)	8.9 (4)	1	0.172
	Women	0.0 (0)	0.0 (0)	-	Women	4.6 (4)	3.4 (3)	1	-

*McNemar test; [§]Chi² test. [#] Currently COVID-19 pandemic situation.

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TABLE 4 Perceptions of each AMed criteria satisfied by the restaurant menu offerings (Mediterranean offerings).

Variables	Satisfied perceptions *n*=132% (*n*)
Olive oil for dressing, and olive oil or high oleic sunflower for cooking	99.2 (131)
Prioritize fresh seasonal and local foods	98.5 (130)
Include proposals of the traditional and local cuisine	95.5 (126)
Prioritize side dishes of vegetables and legumes	89.4 (117)
25% of the first course offerings are vegetables and/or legumes	87.9 (116)
50% of the second course offerings based on fish, seafood, and lean meat	87.1 (115)
Offer of free non-packaged drinking water	85.6 (113)
50% of the dessert offerings based on fresh fruit (whole or prepared)	81.8 (108)
Have culinary preparations that do not require the addition of large amounts of Fat, and culinary techniques that use little, or no fat are used	81.8 (108)
Offer of dairy desserts without added sugar	77.3 (99)
Wine, beer, and cava are measured in glasses or individual units	68.2 (90)
*Include dishes without food allergens	67.4 (89)
Presence of whole-grain products	66.7 (88)
*Include dishes Vegetarian/vegan dishes	57.6 (76)

*Two extra questions regarding food-allergens and vegetarian/vegan options were included.

accomplishment of this criterion. On the other hand, although the supply of vegetarian/vegan dishes, dishes without allergens, and whole grains was not highly valued by the restaurant customers, more than 50% positively valued the accomplishment of these criteria.

3.4. Results of the customer focus group

A total of 6 customers participated in the focus group, which lasted 90 min. During the focus group, after introducing the participants and moderators, 5 topics were discussed.

3.4.1. Problems due to COVID-19 in the restaurant sector

The feelings that customers had during the pandemic were the loss of and longing for social relationships and freedom, uncertainty, fear of contracting and spreading the disease, insecurity when going to public places such as supermarkets and restaurants, and anxiety about not knowing when the situation would end. (a) Despite these feelings, they agreed that the restaurant sector was severely affected, especially economically, by the harsh restrictions (b).

a. "I would also say that there has been a lot of social discomfort. On the one hand, you saw many people who were very afraid to go into public places, go to the supermarket, go to any bar, of meeting people for fear of contracting the disease, and on the other hand, you also saw people who were angry with the curfew due to the new schedules, which changed from time to time."
b. "We are a country in which we spend a lot of time on the streets because it is sunny, and we have a lot of daylight hours. Many times, we meet in a bar with friends and all these economic dynamics have perhaps been little contemplated, there was also all the pressure that for the first time we were all threatened by an unknown enemy. Therefore, mistrust has increased and this has led to very drastic measures."

3.4.2. Barriers of customers

The customers stated that they enjoy going to restaurants not only to eat but also for the experience, i.e., meeting other people, not needing to cook, and disconnecting from responsibilities. However, all this was interrupted by the COVID-19 pandemic. In this context, the main barriers that the focus group participants faced as customers were the restrictions and limitations; consequently, they preferred ordering takeaway food and being at home, and they were more selective regarding the restaurants they went to. They prioritized those that they already knew or those in which they had more confidence or that had outside areas. Figure 3 presents a summary of these barriers and some example transcriptions. On the other hand, age was also an important factor because younger peoplve were impatient to return to restaurants as before the pandemic, whereas older people exhibited insecurity and concern about easing the restrictions.

3.4.3. Behaviors related to food in restaurants

In this section, behaviors related to foods, healthy choices, and takeaway preferences were discussed. Regarding food behavior, when the customers went to a restaurant, they preferred more elaborate dishes over those they could cook in their homes, usually with simple techniques. The customers positively valued offerings of healthy dishes from restaurants, which allowed them to make choices in line with their preferences. Moreover, the customers stated that there was an increase in the number of people interested in local products, minimally processed or unprocessed food, and sustainability. (c) Concerning takeaway food, all participants increased their demand for takeaway food during the pandemic. They believe that over the next year, there will continue to be high demand for takeaway food (d).

c. "I believe that now this problematic period is, for restaurateurs, being combined with sustainability, going local, the km 0 movement, all of it. I go to the restaurant and order more elaborate things, but they can be very healthy, and, for example,

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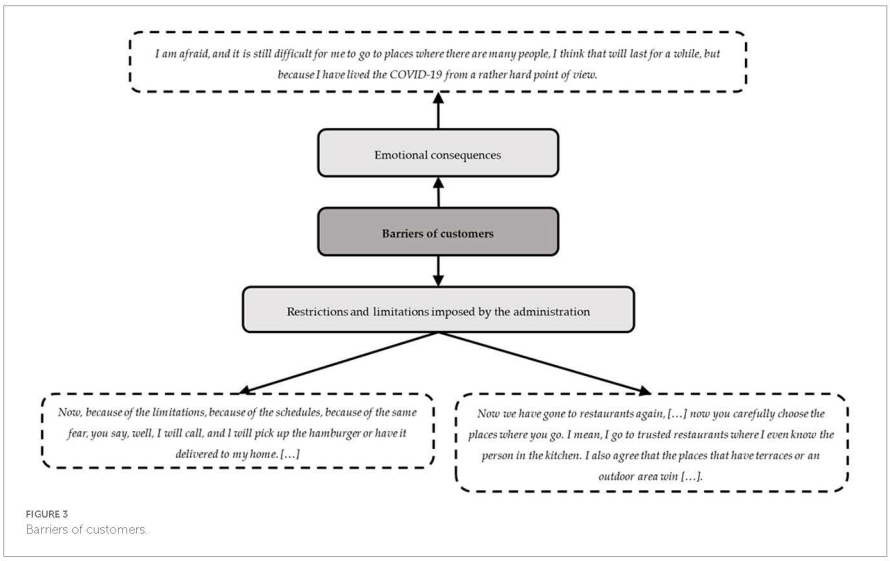

FIGURE 3
Barriers of customers.

I prefer that mushrooms come from here and not from I do not know where."

d. "Before, I would already order takeaway food, but as a result of the pandemic, it has become much more accentuated, and I think we will still have another year of high demand for takeaway food."

3.4.4. Food hygiene and safety

The customers felt comfortable with the measures and precautions that were taken by all staff at the restaurants. They stated that it would be interesting to maintain some of the changes made by restaurants beyond the COVID-19 pandemic, such as the use of a mask during service, as there are other pathogens in circulation, and it would be a way to increase safety. (e) Regarding takeaway food, customers explained that they had never been instructed on how to handle and preserve their food; however, it would be something they would value highly if it were done (f).

e. "Yes, I wanted to say that I do not miss anything; in contrast, I believe that there are hygienic things that have come to stay and that are not bad at all because COVID-19 is not the only disease that exists."

f. "No, in my case they have not given me instructions on how to preserve or cook the food, but it would be a nice touch."

3.4.5. Solutions for restaurateurs provided by customers

The customers explained that some establishments increased their self-service offerings or provided discount vouchers for people who worked nearby. As possible suggestions and solutions, the customers proposed trust and information as key factors needed for them to return to restaurants. They believed that it would be interesting for restaurants to advise and inform customers about the way that they work and about their monitoring of the COVID-19 security measures. (g) They also believed that it was important for restaurants to maintain their essence and take care of the close relationships with customers, waiting times between dishes, the volume of the music, and avoiding placing large groups in the center of the restaurant (h).

g. "I think that the key word is information, to give information to the customers, do it well, advise you to do it well and give information, and show us that they do it well."

h. "And I believe that the personal touch that each restaurateur has in their kitchen should not be lost, I mean, they should maintain this because of course, each place has its touch and people go for something that they have and they like. In addition, they cannot lose it."

3.5. Needs and interests of restaurateurs and customers

In this results section, different needs and interests were identified through the significant results from the surveys and from the frequency of certain ideas in the focus group discussions with the restaurateurs and customers. Figure 4 presents their needs and interests, including those related to self-security and consumption trends such as local food, among others.

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4. Discussion

The present cross-sectional study examined the impact of the COVID-19 pandemic on restaurants and their customers through information provided by restaurateurs and customers on a survey and in focus group discussions before and during the current COVID-19 pandemic. This study confirms the hypothesis that the needs, barriers, interests, and food choices of restaurants and customers have changed during the current COVID-19 pandemic.

According to the results, due to the COVID-19 pandemic, customers significantly decreased the frequency with which they went to restaurants while increasing their purchase of takeaway food, and at the same time, restaurants significantly increased their takeaway offerings. Most likely, this may be because of uncertainty, fear, and insecurity related to the pandemic situation, as they commented in the focus group. In this line, a narrative review highlighted a few directions for optimizing the at-home multisensory dining experience due to the takeaway format increasing during and after the pandemic (25).

Moreover, customers preferred to access menus in digital form and pay with cards rather than cash, leading to the need for restaurateurs to adapt. In the same way, restaurants increased their use of digital menus, although currently, only 28 of the 44 total restaurants who answered the survey offer a digital menu. Because restaurant menus are one of the most important types of marketing to promote business, and as we mentioned before, customers prefer menus in digital form, restaurants could improve their menus in digital form with an innovative approach (26).

A 2018 report about the behavioral habits and trends related to restaurants in Catalonia stated that 78% of subjects between 18 and 75 years of age ate outside of their home at least once a week (27). In the present study, even though the data focused only on restaurants in Tarragona Province, which was currently under COVID-19 pandemic restrictions, 43.9% of customers ate outside their home at least once a week, whereas 74.2% before the COVID-19 pandemic, in the same line as the 2018 report.

Regarding restaurant menu information, the results of the present study show that 59.1% of customers now use websites to obtain information. Our results are in accordance with a 2018 report that stated that 35.2% of people, especially young people (48.7%), search for information about restaurants on the Internet (27). Given this new demand, restaurants should consider maintaining updated websites to attract customers.

In the present results regarding Mediterranean offerings, some of the AMed criteria for restaurants, which include the use of olive oil, vegetable dishes, fruit desserts, and local products, among others, were positively perceived by customers. These results are in line with other studies that tried to help restaurateurs better adapt their menus to the Mediterranean diet or healthier diets by giving personalized directions to restaurateurs regarding the dishes listed on their menus. Such instructions included introducing more side vegetables, offering fruit for dessert, and using extra virgin olive oil for different types of cooking (20, 28–30). Additionally, the pandemic resulted in some changes to customer preferences, and restaurateurs could be interested in acting on those changes, such as by offering more vegetarian/vegan or allergen-free dish choices. The fact that our customer respondents increased their demand for local products could indicate an increasing awareness of the importance of sustainability for the planet (31).

In the present study, the results regarding hygiene and food safety, especially as they related to COVID-19, indicate that the restaurateurs increased their use of a hydroalcoholic solution and were much stricter about cleaning and disinfecting the restaurant and surfaces. In addition, the frequency with which restaurateurs cleaned significantly increased by 21.1%. Specifically, the number of restaurateurs who cleaned ≥2 times/day, particularly in the goods reception area, increased, a change highly valued by customers. Moreover, according to the focus groups, restaurateurs and customers were worried and awarded the importance of hygiene and food safety because customers were comfortable with new hygiene and food safety measures implemented by the restaurateurs. Currently, according to the Centers for Disease Control and Prevention (CDC), customers have tips to avoid food poisoning

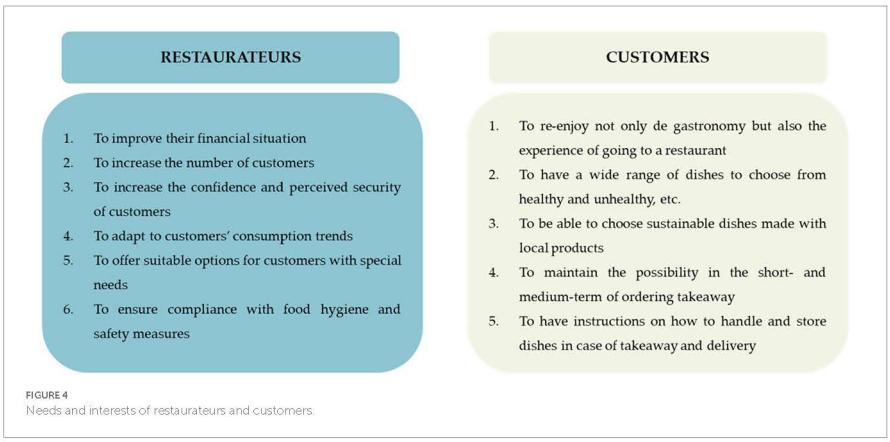

FIGURE 4
Needs and interests of restaurateurs and customers.

while eating out (32), and restaurants have information in some reports that highlights state food safety practices (33). This information goes in the same line as the results of the present study, highlighting that the present study shows information more specific to the local population. Additionally, in 2020, the guidelines published by the Catalan Food Safety Agency and the Technical Report of the European CDC (34, 35) became much stricter regarding the cleaning of rooms, facilities, surfaces and utensils, offices, furniture, changing rooms, hygienic service areas, and areas of frequent contact with the hands as measures to prevent the spread of SARS-CoV-2. Moreover, the recommended authorized disinfectant products were required to be registered in the Register of Nonagricultural Pesticides or Biocides or in the Official Register of Biocides of the General Directorate of Public Health, Quality and Innovation of the Ministry of Health (34, 35).

However, for general preventive cleaning and disinfection in restaurants, cleaning with water and detergents and the use of common disinfectant products was described as sufficient, but not in situations in which a possible case of COVID-19 was suspected (34, 35). In this context, in the present study, the use of a hydroalcoholic solution for disinfecting cooking utensils increased significantly by 13.7% from the period before to the period during the COVID-19 pandemic, although the most common option is to clean with hot soapy water. This motivation for cleaning is consistent with global recommendations to reduce the number of infections (36).

On the one hand, in the present study, the main barriers facing restaurateurs, detected through the focus groups, were verified, such as the measures imposed by the administration, the county and municipal lockdowns, and the limitations on hours and capacity, inducing a bad economic situation after the start of the COVID-19 pandemic, and emotional consequences such as anxiety or depression among the restaurateurs. One of the main concerns of our restaurateur respondents was their current economic situations, which were difficult because they had many economic losses due to the very restrictive regulations on restaurants that were constantly changing. The main restrictions were the absolute closure of all restaurants, restrictions on hours of operations, the requirement to provide exclusively outdoor seating such as terraces, limits on the numbers of tables and people, and reductions in restaurant capacity, depending on the wave of the pandemic (37).

On the other hand, in line with the focus group, the main barriers experienced by our customer respondents were the restrictions and limitations and the emotional consequences. In the present study, we verified that most of the customers reported a loss of social relationships and freedom after the start of the pandemic. This is justified because in Spain, the cultural practice of eating outside the home is driven by pleasure and social interactions with friends and family (38). In Spain, food is considered a means of socialization between individuals (38), and due to the pandemic, this has been very limited.

Finally, on the basis of the results of surveys and focus groups of the present cross-sectional study, some solutions could be implemented to enhance the COVID-19 consequences, such as reducing costs and offering discounts or reinventing themselves but taking into account customer preferences and comfort. Additionally, based on the needs and interests of restaurateurs and customers, some proposals for how restaurateurs can improve and adapt to new demands include increasing social media and technology in their sector, maintaining and updating hygiene and food security measures, maintaining and increasing AMed criteria according to customers' preferences, improving takeaway services, and strengthening restaurant essence (Table 5).

TABLE 5 Proposals to improve and adapt to the new demands faced by restaurateurs.

For restaurateurs	
Social media and technology	Promote the use of social media and websites to advertise the restaurant and inform customers about its menu.
	Increase the use of information and communication technology (ICT) for viewing the daily menu and placing orders, and have other alternatives for customers less familiar with ICT.
Hygiene and food security	Review and, if necessary, adapt to the measures recommended by the food safety agency about cleaning the different surfaces of the restaurant.
	Highlight the restaurant's compliance with the security measures.
	Ensure a safe distance between tables and customers, and prioritize seating on terraces and in well-ventilated areas of the restaurant whenever possible.
	Maintain the use of masks among dining room and kitchen staff and the additional hygiene practices after the COVID-19 pandemic ends.
Mediterranean offerings, customer food preferences	Promote and use local and seasonal products.
	Try to incorporate vegetarian/vegan dishes, allergen-free dishes, and whole grain products, as more than 50% of customers value these options.
	Include and promote dishes adapted to meet special needs and preferences. Obtain advice from professionals if necessary because such offerings increase customer confidence.
	Maintain and strengthen the essence of each restaurant despite the COVID-19 measures; customers go to restaurants not only for the food but also for the experience.
Takeaway and delivery instructions	Incorporate and maintain the demand for takeaway and delivery food and increase offerings of country themed and traditional food.
	Include some handling, cooking, and preservation instructions for takeaway and delivery food.
	Maintain the temperature chain (cold/heat) for delivery dishes.
	Consider the use of sustainable materials for takeaway and delivery.
Environment and the essence of the restaurant	Improve customer comfort by focusing on the service, the food, and the atmosphere of the restaurant.

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This study has some limitations. First, this cross-sectional study reflects the COVID-19 situation only in restaurants located in Tarragona Province; however, considering that the COVID-19 restrictions on restaurants have been applied in other geographic areas, the results could be generalizable. Second, the use of self-reported answers to online surveys could make it easy to doubt the quality of the answers. However, the collection of qualitative and quantitative information allows us to obtain more information about the needs and interests of restaurateurs and customers in the current COVID-19 pandemic situation. Third and finally, the restaurateurs and consumers who participated in the focus groups may have felt pressure from their peers, which could have affected their answers.

In contrast, as a strength, this cross-sectional study is the first to assess the impact of COVID-19 on restaurants in Catalonia and Spain. For this reason, it is necessary for restaurateurs to implement the above proposals to adapt to the current situation as a way to reduce the negative impact of the pandemic and for researchers to continue investigating these issues.

5. Conclusion

In restaurants, the first COVID-19 lockdown increased takeaway orders, increased sanitation, and improved digital communication with customers, while customers highly valued the use of local foods. Therefore, this study provides valuable information on how to adapt gastronomic offerings during this challenging situation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of the Pere i Virgili Institute (ref. 056/2021). The patients/participants provided their written informed consent to participate in this study.

Author contributions

MB-M, JQ, ST, EL, LT, and RS substantial contributions to the conception or design of the work, or the acquisition, analysis, or interpretation of data for the work, drafting the work or revising it critically for important intellectual content, provide approval for publication of the content, and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1137512/full#supplementary-material

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SUPLEMENTARY MATERIAL

Supplementary material 1. STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies.

	Item No.	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1-2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	3
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect	3-4

		modifiers. Give diagnostic criteria, if applicable	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5
Bias	9	Describe any efforts to address potential sources of bias	--
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) If applicable, explain how matching of cases and controls was addressed	---
		(*e*) Describe any sensitivity analyses	5-6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6-7

		(b) Give reasons for non-participation at each stage	6-7
		(c) Consider use of a flow diagram	---
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-8
		(b) Indicate number of participants with missing data for each variable of interest	6-15
Outcome data	15*	Report numbers of outcome events or summary measures	6-15
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-15
		(*b*) Report category boundaries when continuous variables were categorized	6-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	---
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-18

Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

Supplementary material 2. COREQ (COnsolidated criteria for REporting Qualitative research) Checklist.

Topic	ItemNo.	Guide Questions/Description	
Domain 1: Research team and reflexivity			
Personal characteristics			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	ST, EL and LT
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	SI: PhDs EL: PhD LT: PhD
Occupation	3	What was their occupation at the time of the study?	Researcher
Gender	4	Was the researcher male or female?	Females
Experience and training	5	What experience or training did the researcher have?	Researchers in health promotion (including different qualitative and quantitative methods expertise)
Relationship with participants			
Relationship established	6	Was a relationship established prior to study commencement?	Any
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	Goals of the project
Interviewer characteristics	8	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and	Reasons and interests in the research topic

		interests in the research topic	
Domain 2: Study design			
Theoretical framework			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	content analysis
Participant selection			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	Purposive
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	Email and telephone
Sample size	12	How many participants were in the study?	A total of 189 participants were included in the present study: 51 restaurateurs and 138 customers
Non-participation	13	How many people refused to participate or dropped out? Reasons?	---
Setting			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	Community

Presence of non-participants	15	Was anyone else present besides the participants and researchers?	No
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	Demographic data
Data collection			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Questions were approved by Ethical Committee.
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	3
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	Audio recording
Field notes	20	Were field notes made during and/or after the inter view or focus group?	Yes
Duration	21	What was the duration of the inter views or focus group?	Around 90 minuts
Data saturation	22	Was data saturation discussed?	Yes
Transcripts returned	23	Were transcripts returned to participants for comment and/or	The transcripts no, but the main results yes.

Developed from: Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

Supplementary material 3. Frequency and method of cleaning and disinfection for the different areas of the restaurants.

Variables	Frequency / Method	Before COVID n= 44 % (n)	Currently COVID[#] n= 44 % (n)	p-value*
Goods reception area	≥2 times/day	72.1 (31)	93.2 (41)	0.022
	1 time/day	20.9 (9)	6.8 (3)	0.109
	<1 times/day	7.0 (3)	0.0 (0)	---
Kitchen	≥2 times/day	90.9 (40)	95.0 (38)	1
	1 time/day	9.1 (4)	5.0 (2)	1
	<1 times/day	0.0 (0)	0.0 (0)	---
Counter	≥2 times/day	93.2 (41)	93.2 (41)	1
	1 time/day	6.8 (3)	6.8 (3)	1
	<1 times/day	0.0 (0)	0.0 (0)	---
Takeaway food collection area	≥2 times/day	92.5 (37)	95.0 (38)	1
	1 time/day	5 (2)	5.0 (2)	1
	<1 times/day	2.5 (1)	0.0 (0)	---
Dining room	≥2 times/day	95.5 (42)	95.5 (42)	1
	1 time/day	4.5 (2)	4.5 (2)	1
	<1 times/day	0.0 (0)	0.0 (0)	---
Changing rooms, lockers, and toilet areas	≥2 times/day	67.4 (29)	74.4 (32)	0.25
	1 time/day	25.6 (11)	23.3 (10)	1
	<1 times/day	7.0 (3)	2.3 (1)	0.5

Cooking utensils	Hot soapy water	81.8 (36)	77.3 (34)	0.625
	Bleach	38.6 (17)	43.2 (19)	0.625
	70% alcoholic solution	6.8 (3)	20.5 (9)	0.031
	Rinse with water	99.1 (4)	99.1 (4)	1
	Other products without alcohol or bleach	20.5 (9)	15.9 (7)	0.688
Surfaces	Hot soapy water	72.7 (32)	70.5 (31)	1
	Bleach	43.2 (19)	52.3(23)	0.219
	70% alcoholic solution	11.4 (5)	29.5 (13)	0.08
	Rinse with water	4.5 (2)	6.8 (3)	1
	Other products without alcohol or bleach	13.6 (6)	22.7 (10)	0.219
Facilities	Hot soapy water	59.1 (26)	63.6 (28)	0.688
	Bleach	56.8 (25)	61.4 (27)	0.688
	70% alcoholic solution	15.9 (7)	25 (11)	0.219
	Rinse with water	4.5 (2)	6.8 (3)	1
	Other products without alcohol or bleach	9.1 (4)	18.2 (8)	0.125
	Hot soapy water	72.7 (32)	68.2 (30)	0.625
	Bleach	38.6 (17)	38.6 (17)	1

Refrigeration and/or freezing appliances	70% alcoholic solution	9.1 (4)	20.5 (9)	0.063
	Rinse with water	9.1 (4)	9.1 (4)	1
	Other products without alcohol or bleach	22.7 (10)	25 (11)	1
Cooking and/or heating appliances	Hot soapy water	77.3 (34)	72.7 (32)	0.5
	Bleach	22.7 (10)	25 (11)	1
	70% alcoholic solution	11.4 (5)	18.2 (8)	0.25
	Rinse with water	9.1 (4)	9.1 (4)	1
	Other products without alcohol or bleach	20.5 (9)	29.5 (13)	0.219

*McNemar test

[#] Currently COVID-19 pandemic situation

UNIVERSITAT ROVIRA I VIRGILI
PARTICIPATORY RESEARCH AS A NEW APPROACH TO MAKING DECISIONS AND INCREASING ACTIVE ENGAGEMENT IN HEALTH INTERVENTIONS FOR EFFECTIVELY IMPROVING HEALTHY LIFESTYLES BEHAVIOURS
Judit Queral Añó

STUDY 3

Comparison of the four co-created interventions to improve physical activity and snacking behaviour in European adolescents: the SEEDS project

Queral J, Llauradó E, Wargers A, Jansen W, Manios Y, Senequier A, Williams CA, Vlachopoulos D, Solà R, Tarro L. Comparison of the four co-created interventions to improve physical activity and snacking behaviour in European adolescents: the SEEDS project. **Submitted**.

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Comparison of the four co-created interventions to improve physical activity and snacking behaviour in European adolescents: the SEEDS project

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ABSTRACT

Background: Adolescence is a crucial time for building healthy lifestyles. New approaches in the intervention design are necessary to achieve healthy lifestyles for adolescents. This study aimed to describe and compare the four co-created interventions by adolescents of each European country of the SEEDS project to tackle unhealthy behaviours and determine if the barriers and facilitators identified in the focus groups are addressed in the interventions.

Methods: The SEEDS project is a citizen science cluster randomised controlled trial based on the identification of the barriers and facilitators by focus groups, the intervention co-creation by a *makeathon* and its implementation in high school. The principal outcomes are the interventions co-created by participants in each country related to healthy snacks and physical activity assessed by the Template for Intervention Description and Replication (TIDieR) and the connection between the co-created interventions and the barriers and facilitators identified in focus groups.

Results: The co-created interventions have some points in common: type of activities proposed per behaviour, practical face-to-face activities, school hours implementation, external professionals, teachers or researchers as providers. However, the high diversity of activities per behaviour in each country makes difficult the comparison of the global frequency and duration of interventions. In all 4 countries, the physical activity barriers identified were insufficient space and time during breaks to be active and long-time sitting down during school hours which were addressed by active classes and breaks, as well as by getting active during school hours. The snacking behaviour barriers identified were unhealthy snacks offered in the school canteen and irregular meals during school hours which were addressed by offering healthier food and organizing competitions or challenges of healthy snacks. The key facilitators identified in both behaviours were peers, high school, and parents' influence, but these are not enough addressed in the co-created interventions.

Conclusions: The interventions co-created in each country have some common aspects such as the type of activities proposed per each behaviour, who provides the activities, and where and how the activities are implemented. Barriers identified in focus groups were addressed in the co-created intervention, but the facilitators were not enough addressed.

Keywords: citizen science, co-creation, makeathon, adolescents, school-based intervention

BACKGROUND

Adolescence is a crucial time for building the foundations of good health such as diet and PA behaviours (1). The last Health Behaviour in School-aged Children (HBSC) report showed that less than 20% of European adolescents meet the World Health Organization (WHO) physical activity (PA) practice recommendations of 60 minutes or more of moderate-to-vigorous physical activity each day. Related to dietary behaviours, two in three adolescents do not eat daily fruits and vegetables (2) as it is recommended. In addition, one in four adolescents eat sweets at least once a day and one in six consume sugary drinks at least once a day (2), considered an excessive consumption of sugary products. Additionally, social inequalities persist in PA and dietary behaviours because adolescents with low socioeconomic status (SES) have poorer healthy behaviours compared to their peers with a high SES (3)

This HBSC report highlights the need to promote good health with healthy behaviours. Adolescents need information and opportunities to feel involved in the design and implementation of interventions to improve their lifestyles (1). However, adolescents from deprived areas may be considered a hard-to-reach group because could be more difficult to engage in research and health education programmes than adults and children (4). To reduce the loss of adolescent participants in interventions, the evidence showed that participatory research approaches where children and adolescents work together with researchers reached a higher level of engagement in health and well-being interventions (5). Additionally, participatory research engages all relevant stakeholders with the potential to influence the target group based on the Quadruple Helix model from the government, community, business and academia (6), as a way to increase the efficiency of intervention to achieve positive changes (7).

In the last decade, evidence for participatory research for health interventions involving children and adolescents in different types of settings, like schools and communities, has been growing (8–11) and adolescents can be involved in different stages of the project. A recent narrative review described a big heterogeneity of participatory approaches and methods used in the development of health interventions for children and/or adolescents such as the use of community-based participatory research, codesign, participatory design, coproduction, and user-centred design (12). Although, this review provides valuable practical

guidance to use these participatory approaches, few of them evaluate their effectiveness (13).

Particularly, CS aims at engaging and actively involving citizens in generating new knowledge whilst producing scientifically legitimate and reliable results (14). There are multiple definitions of CS although, the European Citizen Science Association (ECSA) defined the 10 key principles to achieve good practice in CS, one of the most important is about the participation of the target audience in multiple stages of the scientific process from developing the research question to disseminating the results (15).

In the CS research approach, the collection of data includes tools, tasks, and structured activities such as focus groups to facilitate participation and share decision-making with participants. (12) Focus groups are used to obtain in-depth knowledge about the attitudes, perceptions, beliefs and opinions of participants regarding a specific health topic or issue (16), as a base to identify barriers and facilitators to enhance healthy lifestyle behaviours (HLBs) in adolescents.

In this context, Science Engagement to Empower aDoleScents (SEEDS) project aimed to listen to and empower adolescents from four European countries, Spain (Reus), the United Kingdom (Exeter), the Netherlands (Rotterdam) and Greece (Athens), living in deprived areas through a CS approach to make a change towards a healthy and active lifestyle and increase Science Technology Engineering and Mathematics (STEM) interest.

In the SEEDS project, a group of ambassadors was chosen among those adolescents with leadership skills. These ambassadors participated in different stages of the intervention: in the focus groups to collect data about the barriers and facilitators related to HLBs; and in the co-creation (by a *makeathon*) to co-create interventions together with their peers and with the support of key stakeholders, to be implemented in high schools.

The aims of the present work are:

To describe and compare the four co-created interventions by adolescents of each European participating country to tackle unhealthy behaviours (snacking behaviour and PA and sedentary behaviour).

To determine if the barriers and facilitators identified in the focus groups are addressed in the four co-created interventions according to each behaviour, for evaluating if the co-created interventions are adapted to the real demands of the adolescents.

Hypothesis

Barriers and facilitators identified in focus groups with ambassadors about snacking and PA behaviour are addressed in the co-created interventions.

METHODS

The methodology of the SEEDS project is explained in depth in the study protocol (17).

Design of study

The present study compared four different 6-month interventions of a multicentre cluster Randomised Controlled Trial (c-RCT) carried out in four European countries (Greece, The Netherlands, the United Kingdom and Spain) that adopted the CS approach.

The SEEDS project had 5 phases: 1) ambassadors and adolescents' recruitment; 2) focus groups; 3) intervention: defined activities of intervention by co-creation event (*makeathon*) and implementation of intervention of their adolescent peers; 4) pre-post-assessment of intervention; and 5) dissemination.

In every country, at least one focus group with a minimum of 3-4 ambassadors and one focus group with stakeholders was carried out and they had a maximum duration of 75 min. The focus groups were audio-recorded, transcribed, and translated into English. The focus groups with ambassadors aimed to gain insights about the barriers and facilitators related to healthy and active living. Moreover, ambassadors could choose extra behaviour to work on, such as screen time. Depending on the answers of ambassadors in the focus groups, some stakeholders were invited to participate in another focus group to discuss the barriers and facilitators identified and to indicate the feasibility of changing the behaviours in the 6-month intervention (17).

The focus groups' insights led to the creation of the two questions that address the co-creation process through a *makeathon*. A question related to 1) being more physically active inside high school and sitting less during school hours, and 2) improving snacking behaviours

outside and/or inside the high school. The *makeathon* was a co-creation event to create and develop the intervention to be implemented in high schools. Ambassadors (and their peers, depending of the country) participate in the co-creation process and are supported by facilitator agents (a person who acts as a near link with participants like Master and PhD Students related to health topics) and some key stakeholders. The *makeathon* events lasted between 2-5 hours and the steps are explained in depth in the protocol article (17).

Participants

The SEEDS project targeted high schools located in low socioeconomic neighbourhoods defined by different statistical official tools in each country (18–22). The high schools received an information letter explaining the study, and once schools agreed to participate in this project, the high schools included were randomised as intervention or control. Then, adolescents from 13 to 15 years old and, specifically adolescent ambassadors with leadership skills and their families signed the informed consent to participate in the project.

In each country, a total of 3-4 intervention and 3-4 control high schools were recruited and 15-21 ambassadors were recruited from intervention high schools in total (minimum four per intervention high school). Ambassadors were the leaders of the class who were selected by the teachers considering their leadership skills (23,24).

Outcomes and analysis of data

The principal outcomes of the present study are:

a) The interventions co-created by participants in each country related to lifestyle-related outcomes, healthy snacks and PA, were assessed by the *Template for Intervention Description and Replication Checklist* (TIDieR) (*Additional file 1*), a quality checklist to describe interventions (25). The TIDieR checklist was used to compare the co-created interventions in each of the four SEEDS participating countries (similarities and differences). This checklist details important intervention aspects, and each of these aspects has been compared among countries considering if it is focused on PA or snacking behaviour: 1) name; 2) Why: rationale, theory, or goal; 3) What: materials and procedures; 4) Who provided: expertise, background and any specific training; 5) How: modes of delivery the intervention; 6) Where: location(s); 7) When and How much: number of sessions, schedule, duration, intensity or dose; 8) Tailoring: If the intervention was planned to be personalised, titrated or adapted; 9)

Modifications: describe the changes (what, why, when, and how); and 10)How well: intervention adherence or fidelity assessment and strategies were used to maintain or improve fidelity.

b) The connection between the co-created interventions of each country and the barriers and facilitators identified related to each behaviour. The barriers and facilitators related to healthy snacks and PA those ambassadors found in their lives to follow a healthy lifestyle were extracted from the audio-recorded and transcribed information of the focus group by ambassadors in each country. Then, the insights from focus groups led to the creation of the two questions that address the co-creation process (*makeathon*).

RESULTS

Description and comparison of interventions designed according to TIDieR by ambassadors and their peers in each country

The four interventions co-created lasted 6 months in total. The interventions were divided into two components, the PA activities and healthy snacking activities. The goal of PA activities was to increase PA inside the high school and reduce sedentary time and the goal of healthy snacking activities was to improve the choice of healthy snacks inside and/or outside the high school. The intervention of each country is explained in depth using the TIDieR checklist in *Additional file 2*. However, a summary of each country's intervention is detailed in *Figure 1 and Figure 2*.

Related to the type of intervention per country, there were some similarities and differences among the activities co-created in each country:

1) The type of co-created activities focused on improving PA are similar among countries. However, the number and frequency of activities differed a great deal ("when and how much" TIDieR aspect): a) Workshop to practice new sports: the Netherlands (NL) during 2 months and Spain (SP) during 4 months, b) Active practice in PE lessons: United Kingdom (UK) during 2 months and Greece (GR) during 5 months, c) Active breaks or be active during school hours: SP (1 time/15 days during 4 months), NL (2 months, sessions not specified) and UK (1-4 times/week during2 months).

2) The type of co-created activities focused on improving snacking behaviour is similar among countries. However, the number and frequency of activities differed a lot ("when and how much" TIDieR aspect): a) Healthy school canteen: GR (during 5 months) and NL (meetings of 45-90 min to create a healthy canteen, but not implemented during SEEDS project), b) Training adolescents about nutrition: SP (1 session of 90 min) and NL (10 online lessons of 30 min/lesson), c) Cooking workshops: SP (1 session of 60 min) and NL (4 sessions of 90 min/session), d) Challenge/Competition of healthy snacks: SP (1-2 challenges/week during 3 months) and UK (1-4 challenges/week during 3 months).

Focusing on "where" and "how" TIDieR aspects, most of the PA and snacking behaviour activities were implemented during school hours and face-to-face. The PA activities were implemented during PE classes and breaks between high school classes. However, the snacking activities were implemented at different moments of the day: during school hours (GR and SP intervention), outside high school (UK intervention), during extracurricular hours in high school or online at home (NL intervention).
In addition, regarding the "who provided" TIDieR aspect, the activities related to PA behaviours were provided by PE teachers when implemented in PE classes or by researchers with the collaboration of ambassadors and peers, and by external professionals (only in SP intervention). The activities focused on snacking behaviours were provided by external professionals (SP and NL intervention), owners of the canteen (NL and GR intervention) or researchers with the collaboration of ambassadors and peers (NL, UK and GR intervention).
Related to the "how well" TIDieR aspect, the participation in the activities was assessed using a list/checklist of attendance in most of the activities of PA and snacking behaviours, or recurrent meetings with participants to know how the activity was going on.

Overall, the SP and NL interventions had a lot of similar types of activities between them such as in the PA behaviour the active breaks and workshops to practice new sports; and in the snacking behaviour, training with adolescents and cooking workshop. The UK had at least one common activity for each behaviour with the other countries (active breaks with SP and NL, competition of healthy snacks with SP and actively participating in PE classes with GR). And,

GR only had one common activity with NL (healthy canteen) and another with the UK (actively participating in PE classes). In addition, GR intervention was composed of only one activity per behaviour whereas the other countries' interventions were composed of at least two activities per behaviour.

The connection between interventions co-created and the barriers and facilitators identified by ambassadors

A summary of barriers and facilitators per country is explained in *Additional file 3*: 1) PA and sedentary behaviours during school hours and physical education (PE) classes; and 2) snacking behaviour within and outside school hours.

Firstly, regarding PA, there are two common barriers in all countries: insufficient space and time during breaks to be active and long-time sitting down during school hours (GR, SP, NL, and UK). These barriers were solved by some activities like active classes and active breaks (SP), more PA opportunities during breaks (NL) and getting active during school hours (UK). However, GR intervention did not have any intervention activity to solve these barriers.

Additionally, the barrier of lack of variation in sports and activities during the PE classes was detected in three countries (GR, SP, and NL). All of them solved the barrier with an activity in their intervention: 1) a workshop to meet new sports in PE classes and after school (NL); 2) a larger variety of activities in PE classes (GR); and 3) sports day to practice lesser-known sports (SP). Even though the UK ambassadors did not detect this barrier, they designed an activity in the intervention as a challenge to participate actively in PE classes.

The barrier of the lack of clean material in PE classes was only mentioned by GR and was addressed by providing better and new equipment for PE classes.

Some external barriers include the duration and frequencies of PE classes per week (GR and NL), the warm temperatures during the summer season that burden the PA practice (GR and SP), and the unbalanced groups during PE class activities that demotivated the students (SP and NL) were not tackled with any action or activity during the intervention.

The common facilitator detected in three countries (GR, NL and UK) was the peer influence to motivate participants to get active during school hours and PE classes. This aspect may be

considered in all the interventions because the SEEDS project empowered the ambassadors and their peers' involvement in the design and implementation of the interventions about PA.

Secondly, focusing on snacking behaviours, two countries (GR and NL) detected as a barrier that the school canteen offered unhealthy snacks. This aspect was solved with a similar activity in those countries, by adding healthier food choices in the school canteen (GR) and creating a healthy school canteen (NL).

The other common barrier detected was that students did not eat anything during high school hours (SP and UK). The SP intervention tried to solve it with the competition of healthy snacks and the free fruit service, and the UK intervention launched a challenge to increase progressively the healthy snacks eaten each week.

Two common facilitators were detected in different countries. The first one was that the high schools are not allowed to bring energy drinks to students (SP and NL), however, they can consume them outside the school. For this reason, a workshop/training about healthy eating and/or PA to conscience adolescents about the importance of healthy eating (SP and NL), and a cooking workshop about healthy snacks were implemented to have ideas to bring at high school or cook at home (SP and NL). The second common facilitator was parents' restriction or control of unhealthy snacks consumed by their adolescents (NL and UK), but no activity of the NL and UK intervention involved parents, one of the reasons was the restrictions on COVID-19 situation in high schools that did not allow the external people entrance. However, in the SP intervention, despite the ambassadors not identifying the parents as a facilitator, online training about healthy eating and PA was implemented for parents of adolescents.

The connection between barriers and facilitators with the intervention by PA and snacking behaviours in each country is summarized in *Figure 1 and Figure 2*.

DISCUSSION

The results of the present study confirmed partially the hypothesis because barriers identified in focus groups are addressed in the co-created interventions, but not enough of the facilitators.

The co-created interventions in the present study have key points in common between them related to the type of activities per PA or snacking behaviour, and these activities are based on practical face-to-face activities like training, lessons, workshops, challenges, and competitions. Moreover, these are implemented during school hours mainly by external professionals and teachers but sometimes by the project researchers with or without ambassadors' collaboration. However, the frequency and duration of the activities differed among countries. The adaptation of the interventions to the local barriers and facilitators of participants is crucial to allow the improvement in engagement of participants in interventions and ensure sustainability in the long-term (25).

The previous literature on children and adolescent school-based interventions to improve healthy lifestyles such as nutrition and PA outcomes, and preventing obesity without participatory approaches, showed different types of activities in interventions.

Related to PA behaviours, most studies combined educational materials (theoretical activities), changes to the school environment and/or school curricula like active academic lessons, active recess, high-intensity activity into PE classes or increasing the frequency or duration of PE classes or sessions. (26–28). Related to dietary behaviours, previous interventions combined some theoretical activities including web-based interventions such as motivational text messages through technology, guidebooks, workbooks, seminars and educational lessons and posters given by professionals for students, teachers or parents, and some practice activities to change the environment including healthier food options in the canteen, restricting the access to vending machines, serving breakfasts in the classrooms to ensure the students eat a healthy meal, cooking workshops (26–30).

The principal differences between the previous literature and the SEEDS project are that in the previous literature there was non-active involvement of participants in interventions, there was a predominant use of theoretical activities in front of practical activities, and a lack of challenges and competition activities implemented. However, there are common points

between the previous literature and the SEEDS project, including the predominant face-to-face activities, the implementation of the intervention during school hours, and the use of training, lessons, and workshops (26–30).

Two questions were used in the *makeathon* to start designing the interventions. Although participants of the *makeathon* did not have the whole list of barriers and facilitators mentioned during the focus groups available during the *makeathon*, there was a connection between the co-created interventions and the barriers earlier identified. The results showed that the common PA barriers identified in almost three countries during focus groups are: 1) insufficient space and time during breaks to be active; 2) the long-time sitting down during school hours; and 3) the lack of variation in sports in PE classes. To address these barriers, common interventions were co-created: 1) active breaks; 2) getting active during school hours; 3) a workshop or sports day to meet new sports in PE classes; and 4) a larger variety of activities in PE classes. Focusing on snacking behaviours, fewer common barriers were identified. Mentioned barriers were only identified in two countries: 1) the school canteen offered unhealthy snacks; and 2) some students did not eat anything at high school. From these barriers identified, the common interventions co-created to address them were: 1) adding healthier food choices in the school canteen; and 2) a healthy snacks competition or challenge and the free fruit service at high school. However, the common facilitators detected in the SEEDS project such as peers in PA behaviours, and family and high schools in snacking behaviours, were not addressed in the co-created interventions. This could be because the participants of the *makeathon* did not have any information about facilitators, and this should be an aspect to improve. A systematic review that included studies from 13 countries from different continents, but mostly Europe, described some common PA barriers and facilitators in line with our study, the limited PA opportunities during school hours and breaks and the lack of students' choice/autonomy in PE classes were detected as barriers and the influence of the peers was identified as a barrier and facilitator (31). Other qualitative studies expressed some common barriers and facilitators similar to the present study including the type and quality of food items in the canteen, the lack of variety or the easy access to unhealthy food near the school. (32,33) Additionally, the family was identified as a facilitator for healthy eating (32,33).

The recent literature showed that the detection of barriers and facilitators related to lifestyle behaviours in adolescents is the key to the future design and implementation of the interventions (31–35). However, most studies did not identify this information before the co-creation process, and their inclusion is necessary to achieve interventions addressed to the real problems of the target group and also the sustainability of these projects.

Currently, limited evidence is available on identified insights (like barriers and facilitators) in focus groups before the co-creation and implementation of interventions. A recent systematic review of methods and approaches to improve health outcomes used to enable children, adolescents, families, and carers to be involved in a participatory approach included twenty-six studies, and only seven of them used focus groups as an integral method to co-design or co-produce or co-create interventions defined as co-creation in the present manuscript (36). However, this systematic review did not analyse the effectiveness of the interventions (36). In the literature, the focus group method is used as a tool to collect data in different steps of a participatory research study:

Before the co-design of the intervention, information from the focus group can provide some insights into the co-creation of the intervention (37,38).

In a co-creation process (39,40), the focus groups are used to ideation/design stage previous to co-creation of interventions (41).

After the design of interventions to know the feedback of participants and improve other future interventions (42–44).

For all mentioned above, the participatory research process used in the SEEDS project is a valid method to addressed the most important barriers identified in the focus groups and could be used in future participatory research projects. However, the necessity to find a new way to ensure the address of facilitators is highlighted. Therefore, future participatory research interventions should identify facilitators of the target group and use them in the co-creation process to address the majority of the facilitators identified in the co-created interventions.

Although the facilitators are not enough addressed in the co-creation interventions, the SEEDS project contributes to the literature with new information about the comparison of co-created interventions by participatory research, according to barriers and facilitators identified in the focus groups with the target group.

However, some limitations detected are: 1) the limited duration of the intervention (six months) to address some of the barriers because the frequency or duration of the PE classes depends on adolescent external agents like the norms of the high school or department of education; and 2) the limited budget provided to each intervention country to carry out the activities. Also, another limitation is that the focus groups consider the opinion of ambassadors, a selection of all adolescent participants, and when the intervention is co-created by all the ambassadors and their peers, as happened in SP, NL and GR, new barriers or facilitators could be detected.

Finally, the importance of involving relevant stakeholders is highlighted, not only in the focus group process and co-creation, but also in the implementation, to achieve the sustainability of the intervention co-created.

In conclusion, the interventions co-created in each country have some common aspects such as the type of activities proposed per each behaviour, who provided the activities, and where and how the activities are implemented. However, a country-specific adaptation is important for a feasible implementation of the intervention activities. Moreover, barriers identified in focus groups were addressed in the co-created intervention, but the facilitators were not sufficiently addressed. For this reason, the participatory research process used in the SEEDS project is a valid method to address the most important barriers identified in the focus groups. However, the necessity to find a new way to ensure the address of facilitators is highlighted.

LIST OF ABREVIATIONS

Citizen Science (CS)

Cluster Randomized Controlled Trial (c-RCT)

European Citizen Science Association (ECSA)

Greece (GR)

Health Behaviour in School-aged Children (HBSC)

Healthy lifestyle behaviours (HLBs)

Netherlands (NL)

Physical Activity (PA)

Physical Education (PE)

Science Engagement to Empower Disadvantaged aDoleScents (SEEDS)

Science Technology Engineering and Mathematics (STEM)

Socioeconomic status (SES)

Spain (SP)

United Kingdom (UK)

World Health Organization (WHO)

DECLARATIONS

Ethics approval and consent to participate

The four pilot countries (Greece, the Netherlands, Spain, and the UK) obtained approval for the study from their corresponding Ethics Committee.

Greece: The study was approved by the Bioethics Committee of Harokopio University (ethical approval code: 953/10-3-2021).

The Netherlands: The Medical Research Ethics Committee of the Erasmus Medical Centre, Rotterdam, The Netherlands decided that the regulations from the Dutch Medical Research Involving Human Subjects Act (Dutch abbreviation WMO) do not apply to this research protocol. Therefore permission was granted by the committee for the execution of this study and for publications in a later stage of the study (permission ID: MEC-2021-0396).

Spain: The Drug Research Ethics Committee (CEIm) of the Pere Virgili Health Research Institute (Reus, Spain) granted the permission for executing this study and for publications in a later stage of the study (n° Ref. CEIM: 085/2021).

The UK: The study has been approved by the Sport and Health Sciences Ethics Committee of University of Exeter, ref. numbers (21-03-24-B-02, 21-07-14-B-04).

All participants and parents received the information letter and signed the informed consent.

Consent for publication

All participants and parents received the information letter and signed the informed consent.

Availability of data and material

Data availability under the requesting to the principal investigator of SEEDS project (rosa.sola@urv.cat).

Competing interests

The authors declare that they have no competing interests.

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Author's contribution

JQ, EL, AW, WJ, YM, DV, SC, RS and LT contributed to the design of the study. JQ, EL, RS and LT analysed and interpreted the results and wrote the first draft of the manuscript and AW, WJ, YM, DV, SC contributed to the manuscript by critical revisions and giving comprehensive feedback on multiple drafts. JQ, EL, AW, WJ, YM, DV, SC, RS and LT read and approved the final manuscript.

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FIGURE LEGENDS

Figure 1. Description of PA interventions by TIDieR and connection with barriers and facilitators detected by ambassadors. Blue: Greece's intervention; Green: Spain's intervention; Yellow: The Netherlands's intervention; Orange: The United Kingdom's intervention.

Figure 2. Description of snacking behaviour interventions by TIDieR and connection with barriers detected by ambassadors. Blue: Greece's intervention; Green: Spain's intervention; Yellow: The Netherlands's intervention; Orange: The United Kingdom's intervention.

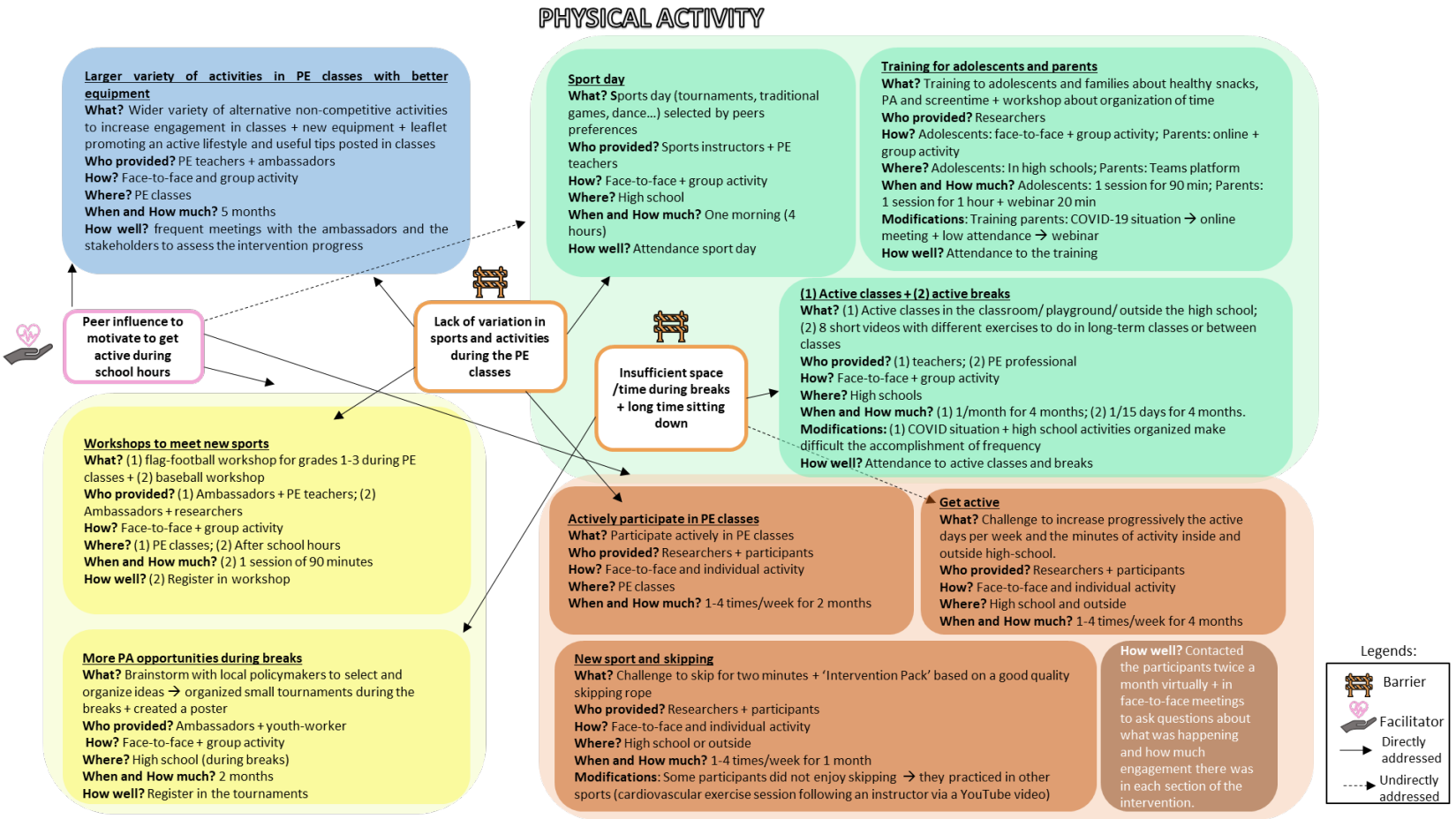
ADDITIONAL MATERIAL

Additional file 1.pptx; The TIDieR (Template for Intervention Description and Replication) Checklist

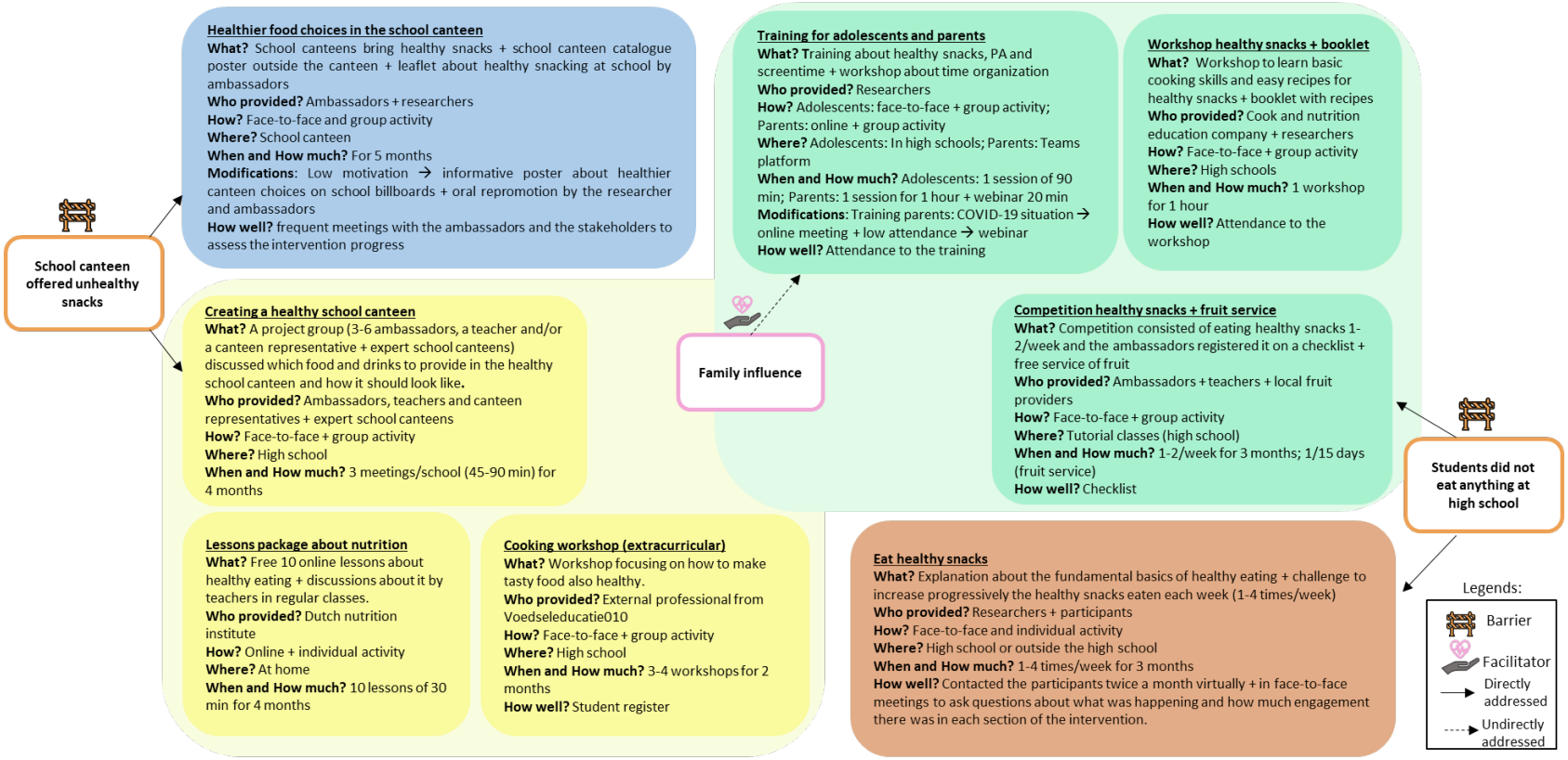
Additional file 2.pptx; Intervention description of each country

Additional file 3.pptx; Summary barriers and facilitators identified in each country by ambassadors

UNIVERSITAT ROVIRA I VIRGILI
PARTICIPATORY RESEARCH AS A NEW APPROACH TO MAKING DECISIONS AND INCREASING ACTIVE ENGAGEMENT IN HEALTH INTERVENTIONS FOR EFFECTIVELY IMPROVING HEALTHY LIFESTYLES BEHAVIOURS
Judit Queral Añó



SNACKING BEHAVIOUR



ADDITIONAL MATERIAL

Additional material 1. The TIDieR (Template for Intervention Description and Replication) Checklist

TIDieR
Template for Intervention Description and Replication

The TIDieR (Template for Intervention Description and Replication) Checklist*:
Information to include when describing an intervention and the location of the information

Item number	Item	Where located **	
		Primary paper (page or appendix number)	Other † (details)
	BRIEF NAME		
1.	Provide the name or a phrase that describes the intervention.	_____	_____
	WHY		
2.	Describe any rationale, theory, or goal of the elements essential to the intervention.	_____	_____
	WHAT		
3.	Materials: Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (e.g. online appendix, URL).	_____	_____

4.	Procedures: Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities.	_____	_____
	WHO PROVIDED		
5.	For each category of intervention provider (e.g. psychologist, nursing assistant), describe their expertise, background and any specific training given.	_____	_____
	HOW		
6.	Describe the modes of delivery (e.g. face-to-face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group.	_____	_____
	WHERE		
7.	Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features.	_____	_____
	WHEN and HOW MUCH		
8.	Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity or dose.	_____	_____
	TAILORING		
9.	If the intervention was planned to be personalised, titrated or adapted, then describe what, why, when, and how.	_____	_____

	MODIFICATIONS		
10.‡	If the intervention was modified during the course of the study, describe the changes (what, why, when, and how).	_____	_____
	HOW WELL		
11.	Planned: If intervention adherence or fidelity was assessed, describe how and by whom, and if any strategies were used to maintain or improve fidelity, describe them.	_____	_____
12.‡	Actual: If intervention adherence or fidelity was assessed, describe the extent to which the intervention was delivered as planned.	_____	_____

Additional material 2. Intervention description of each country

PA INTERVENTIONS

GR intervention

This intervention consisted of offering a wider variety of alternative non-competitive activities for the participants to increase engagement in classes. The PE teachers agreed on allowing a free section after the basic typical program they were obliged by the ministry curriculum at each lesson so that the pupils would use to try different activities such as body training exercises, team activities with circulating exercises and more free games with balls. In addition, the researchers offered unusual new materials for the PE classes such as mattresses, hula hoop rings and balls. Also, a supportive leaflet promoting an active lifestyle and giving useful tips was created by the ambassadors and was distributed to participants and posted in all classes.

The participation in this intervention was assessed with small discussions and interviews every 10-15 days with the ambassadors and the stakeholders to see how intervention were being developed. The only problem detected was during the last month of the intervention when the hot sun discouraged some participants from engaging in the lesson, but that was a school facilities problem that could not be tackled practically.

SP intervention

The Spanish intervention was composed of 3 activities:

1) *Training adolescents and parents about healthy lifestyle behaviours, PA and screen time (explained above)*
2) *Active classes and active breaks*

   On one hand, the active class activity consisted of one active class in the classroom, in the playground or outside school per month for 4 months. The teachers were responsible for organizing these active classes with the support of researchers.

   This activity suffered some modifications due to the difficulty of accomplishing the temporalization because high schools were overloaded due to the COVID situation, and the direction of the high school had already organized all the trips

outside the schools. The modification was that some high schools only did one active class and one high school did not do any one.

On the other hand, the active breaks aimed to promote active breaks in high school and reduce sedentarism. The researchers contracted a qualified professional in physical education (PE) to create short videos with different exercises to do in long-term classes (2h) or between those classes in which students stay in the same classroom between different subjects. The active pauses consisted of playing these videos once every 15 days by the teachers. In total 8 videos of 2-3 minutes were recorded by the PE professional. The videos were sent to the contacts of every high school and distributed to the rest of the teachers of the high schools.

This activity did not suffer any modification.

Both activities were assessed by a list of attendance and the feedback from the teachers.

3) *Sport day*

During sports day the participants practised some different sports like lesser-known sports to encourage the participation of all students regardless of their gender or physical condition. Researchers hired sports instructors and organized the sports day with the PE teachers at the high school. The sports chosen by adolescents were: trapela, ultimate, colpbol, basketball, hockey, handball, badminton, volley, and dance.

This activity did not suffer modifications, but one high school did not participate because they were overwhelmed with work to organise it.

The participation was assessed with a list of attendance.

NL intervention

The Dutch intervention was composed of 3 activities:

1) *Workshop to meet new sports*

The PE teachers take in account the preference of ambassadors and rest of the participants to organize a workshop of new sports in high school. In one high school PE teacher organized a flag football workshop for grades 1 -3 during PE classes for 2 months. One the other high school. PE teacher noted that baseball was mostly named, and a sport not already performed in the regular PE classes. The researchers contacted Sportbedrijf Rotterdam to arrange a baseball workshop after school hours that lasted 90 minutes.

The participation on the workshop was assessed by a student register.

2) *More PA opportunities during breaks*

More PA opportunities during breaks can vary from new material, new activities/games and/or competition elements. The adolescent project group on PA did a brainstorm with local policymakers working at the city of Rotterdam who focus on active school days and smart breaks to gain insight into the opportunities for their own school. They used the Now-How-Wow-matrix to select and organize ideas. Ideas were shared with the PE teachers at both schools. The main idea was that ambassadors organized small tournaments during the breaks. However, this activity did not take place due to: 1) Ambassadors did want to organize the tournaments and the youth-workers contract was finished, and 2) The lack of time at the end of the school year and not many students present at school in the last weeks. However, the youth-workers want to continue with it in the following academic year (2022-2023).

3) *Final event*

Researchers wanted to organize a final event with a celebration of the healthy school canteen and competition elements in both exercise and nutrition. Due to a lack of time and students not regularly attending in the last weeks of the academic year, the final event did not take place.

UK intervention

The United Kingdom intervention was composed of 3 activities:

1) *Get more active!*

Participants were instructed to have their own views on what represented getting more active for themselves. This activity was a 4-month challenge where participants should increase progressively every month the times per week that were active inside and/or outside high school (from 1 to 4 times/week) and the minutes that they were active (from 10 minutes to more than 20 minutes per time).

To assess the participation in the intervention, researchers contacted the participants twice a month virtually or in face-to-face meetings to ask questions about what was happening and how much engagement there was in each section of the intervention.

2) *Actively participate in PE classes*

This activity consisted of a 2-month challenge. The adolescents should tried to they best and increased their active participation in PE classes every month from 1 to 4 times per week.

To assess the participation in the intervention, researchers contacted the participants twice a month virtually or in face-to-face meetings to ask questions about what was happening and how much engagement there was in each section of the intervention.

3) Learn to skip!

The goal of this 1-month challenge activity was to work up towards being able to skip for two minutes, there would be no negative consequences if they did not meet this mark. Participants were given a good quality skipping rope as part of the 'Intervention Pack' and a demo of what skipping can look like from someone who has been doing it for 16 years. However, some participants did not enjoy skipping or felt more comfortable doing other forms of exercise – such as a cardiovascular exercise session following an instructor via a YouTube video.

To assess the participation in the intervention, researchers contacted the participants twice a month virtually or in face-to-face meetings to ask questions

about what was happening and how much engagement there was in each section of the intervention.

HEALTHY SNACKING INTERVENTIONS

GR intervention: Healthier food choices in the school canteen

The activities focused on healthy snacking in Greece aims to bring healthier choices available for adolescents in the school canteen. To improve the food offered in the school canteen, the school canteen owners per school were asked to provide foods like fruits and juices, whole-grain cereal bars, whole-grain bagels and custom-made toasts. Additionally, the ambassadors posted a school canteen catalogue poster outside the canteen and made a leaflet about healthy snacking at school with the support of researchers to share with their fellow peers to boost the overall change in the snacking lifestyle of the school. The printed leaflet was distributed to every participant and was posted in every classroom of the schools. These changes in the canteen and the catalogue and leaflets were available during the 5 months of the intervention.

During the 5 months, every 10-15 days, small discussions and interviews were conducted with the ambassadors and the stakeholders to see how the activities were being developed. This constructive feedback helped pinpoint weaknesses and was useful for re-evaluating strategies for possible problems arising. Based on this feedback, the ambassador and researchers detected the low motivation of the participants to choose the available healthy options offered by the canteen. For this reason, the intervention suffered some modifications, ambassadors and researchers created an informative poster about healthier canteen choices on school billboards and carried out an oral repromotion.

SP intervention

The Spanish intervention was composed of 3 activities:

1) *Training adolescents and parents about healthy lifestyle behaviours, PA and screen time*

The training with adolescents was carried out face-to-face and the topics were healthy snacks, the importance of practising PA and being alert about screen time. The researchers of SEEDS prepared a 1.5-hour training based on a presentation with PowerPoint with two short videos and a final workshop to reflect on how and on what adolescents spend their time. In addition, all participants received a tote bag with the SEEDS' logo with a weekly and monthly planner and a booklet with the final intervention they designed with all the activities they would carry out during 5 months of intervention. The training was token place at high school.

The participation in the training was assessed with a list of attendance and it was high, even though some students were confined due to COVID-19 situation. The adolescents enjoyed this activity a lot due to the accessibility to the researchers to ask whatever and the different things they learned, especially about processed food eaten as snacks and the time they spent in front of screens.

The parents' training had the same topics as the training of adolescents. The training lasted 1 hour and was carried out online via Teams because COVID restrictions did not allow parents to enter high schools.

The participation was assessed with a list of attendance. Contrary to the adolescents' training, attendance was very low. For this reason, the training was adapted and researchers prepared a 20-minute webinar for the parents who wanted to attend the training and were not able to come. Besides the webinar, the researchers of SEEDS prepared two infographics with some important information about different options for healthy snacks and how to read the food labels correctly.

2) *Workshop of healthy snacks and an eBook with the recipes*

In the workshop, the adolescents made 5 recipes for healthy snacks and at the end received an eBook with all the recipes. The workshop lasted 1 hour and took

place in conditioned areas of the high school and the material and food were provided by the hired company. The workshop was held by a cooking and nutrition education company and supported by SEEDS project dietitians.

The participation was assessed with a list of attendance. The attendance was high and sdolescents enjoyed a lot with this workshop and tasted some recipes and ingredients for the first time.

3) *Competition of healthy snacks and free fruit service*

This activity aimed to improve the healthy snacks at high school through competition-driven environmental change. It consisted of eating healthy snacks once or twice a week and ambassadors registered through a checklist the snacks eaten by their peers in high school. Once the researchers got the checklist, scored the snacks according to healthy or less healthy, to know the winning class to be awarded. The competition lasted 3 months.

The activity suffered some modifications because at the beginning, researchers planned a challenge that consisted of providing a monthly recipe for adolescents and if they brought this recipe to high school they would obtain an extra point in the competition. Despite that, this challenge was not carried out. Although, those adolescents who brought a recipe from the eBook given in the healthy snacks workshop, were given an extra point in the competition.

In addition, the researchers contacted fruit providers to supply fruit for all the adolescents to the high schools once every 15 days for 3 months.

The participation was assessed with the checklist mentioned before. Also, the feedback from the teachers was fantastic, they explained that adolescents would like to continue with the supply of fruit during the next academic course.

NL intervention

The Dutch intervention was composed of 3 activities:

1) *Creating a healthy school canteen:*

A project group formed within 3-6 ambassadors, a teacher and/or canteen representative and an expert from a company of school healthy canteens in The Netherlands did some meetings in high school and lasted 45 minutes – 90 minutes each time. During those meetings, the project group discussed various topics, like which food and drinks to provide in the healthy school canteen and what it should look like. Also, they worked on adjusting products in the canteen and school policies and paying attention to healthy nutrition in lessons.

This is an ongoing process as it is not always possible to create a healthy canteen and earn a scale for this during a couple of months.

2) *Lesson package about nutrition*

This activity used the "Weet wat je eet" online lesson package developed by the Dutch nutrition institute to give lessons about nutrition to adolescents. This package consisted of 10 online lessons during 4 months about healthy eating for students aged 12 to 15 years old. Each lesson takes about 30 minutes and consists of information, videos, interactive assignments and tests.

Due to the lack of time and a full curriculum which was already formed there were some modifications to the activity. The teachers could not discuss the lessons during a regular class (Biology, mentor class, homework class) and they could not follow the progress of students in an online teacher environment. However, next academic year (2022-2023) high schools planned to reduce the number of lessons in this lesson package to 5-6 lessons and plan to implement this lesson package into the curriculum.

3) *Cooking workshop*

The cooking workshop focused on how to make tasty food also healthy. Detailed content of the workshop was determined by an external professional in combination with the wishes of the students, for example healthy lunches to be offered to students at their canteens were part of the activity. During the intervention 3-4 extracurricular workshops of 90 minutes take place.

The participation was assessed with a register because the places were limited to 15 persons and the students could register.

UK Intervention: Healthy eating

Participants were encouraged to make healthy eating/snacking decisions for the duration of the intervention. Researchers explained some of the fundamental basics of healthy eating and invited participants to consider these when appropriate and make the necessary decisions to ensure the changes were implemented. This intervention had a duration of 3 months and each week the participants should increase the number of healthy snacks consumed during the week, from 1 to 4 times per week.

To assess the participation in the intervention, researchers contacted the participants twice a month virtually or in face-to-face meetings to ask questions about what was happening and how much engagement there was in each section of the intervention.

Additional file 3. Summary barriers and facilitators identified in each country by ambassadors

Country		***Barriers***	***Facilitators***
Greece	PA	School hours: - Insufficient space and time to get active during breaks - Tiredness at the end of the school day - Long-time sit down PE classes: - Duration and frequency of the classes - Warm temperature in summer - The lack of variation in the activities - Lack of clean mattress equipment - Students do not want to wear athletic outfits	PE classes: - Teacher support - Take their mind off the daily pressure of the lessons and have fun with their friends (peers)
	Snacking	- The school canteen offers limited (healthy) choices	
Spain	PA	School hours: - Teacher inflexibility to be active during classes and breaks - The lack of time between classes to be active	PE classes: - The space is big enough - The material is enough to do activities

		- Long-time sit down - A lot of theory classes PE classes: - Warm temperature in summer - The lack of variation in the activities - The unbalance of the groups during activities	- Duration and frequency of the classes are appropriate
	Snacking	- Irregular meals during school hours (some students did not bring breakfast at high school) - Influence of friends' decisions related to unhealthy snacking outside high school	- Rules about sweets and energy drinks at high school - Providing healthy sandwiches for students with economic difficulties
Netherlands	PA	School hours: - Lack space to move during the breaks - Long-time sit down PE classes: - Duration and frequency of the classes - Lack of space - Girls do not want to compete against boys (unbalanced)	School hours: - Peers (do the same thing during recess) - Opportunity of extracurricular activities at school

		- Students do not like activities in front of the whole class - Peers' complaints (demotivate the others) - The lack of variation in the activities	
	Snacking	- Breaks are too short to eat - Not much healthy food and drinks options in the vending machine or the canteen	- Rules about energy drinks at high school - Parents restriction of unhealthy snacks consumption
United Kingdom	PA	School hours: - Insufficient space to get active during breaks - Long-time sit down	PE classes: - Gets competitive and work together with their peers.
	Snacking	- Some students do not eat anything during school hours	- Students can request their parents to add healthier options to shopping basket - Near accessibility of healthy snacks (near shops)

STUDY 4

Effectiveness of participatory research interventions on obesity and obesity-related behaviours in adolescents: a systematic review and meta-analysis

Judit Queral, Annemieke Wargers, Elisabet Llauradó, Wilma Jansen, Rosa Solà, Lucia Tarro, Famke JM Mölenberg. Effectiveness of participatory research interventions on obesity and obesity-related behaviours in adolescents: a systematic review and meta-analysis. **Submitted**

UNIVERSITAT ROVIRA I VIRGILI
PARTICIPATORY RESEARCH AS A NEW APPROACH TO MAKING DECISIONS AND INCREASING ACTIVE ENGAGEMENT IN HEALTH INTERVENTIONS FOR EFFECTIVELY IMPROVING HEALTHY LIFESTYLES BEHAVIOURS
Judit Queral Añó

Effectiveness of participatory research interventions on obesity and obesity-related behaviours in adolescents: a systematic review and meta-analysis

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ABSTRACT

Context: Adolescence is an optimal period to promote healthy lifestyles because behaviour patterns are established in this stage. Interventions developed with participatory research (PR) methodologies could increase adherence and effectiveness of interventions.

Objective: This study aims to evaluate the effectiveness of PR interventions compared to no (PR) intervention control groups on obesity and obesity-related HLB in adolescents from high-income countries.

Data Sources: Nine databases (Embase, Medline ALL, Web of Science Core Collection, PsycINFO, ERIC, CINAHL, Scopus, and Cochrane Central Register of Controlled Trials) were searched from 2000 to 2021 for RCTs and non-RCTs (in English) that used a PR methodology engaging adolescents (11-18 years old) in interventions for obesity prevention in high-income countries.

Data Extraction: Two researchers independently performed the data extraction and risk-of-bias assessment.

Data Analysis: Eleven studies were included, of which 9 were pooled in a meta-analysis. Seven studies used a youth-led methodology, one co-creation and three studies combined both methods. Five studies focused on both physical activity (PA) and nutrition, four on PA and two on nutrition. The pooled mean difference between the intervention and control groups was 0.05 servings/cups per day (95% CI=0.03, 0.07; N=2434, p<0.00001) for fruit consumption and -0.02 servings/cups per day (95% CI=-0.03, -0.01; N=2434, p<0.00001) for vegetable consumption. Instead, the pooled analysis found no significant effects on Moderate-Vigorous PA, total PA and PA self-efficacy.

Conclusions: The PR interventions may have positive effects on fruit consumption, but overall evidence for effectiveness on other healthy lifestyle behaviours was inconclusive due to limited studies and the heterogeneity of the studies included. More high-quality PR interventions should be performed and more evidence is needed on the most effective PR methodology.

Registration: PROSPERO (CRD42021254135)

Keywords: Effectiveness, Participatory Research, adolescents, lifestyle, obesity, nutrition, physical activity

INTRODUCTION

The World Health Organization (WHO) states that around one in 10 young people aged 5–17 years are overweight or obese and these levels have increased rapidly in recent years.[1] The prevalence of obesity in Europe is higher in high-income countries (HIC) compared to low- and middle-income countries.[2] Possibly, because in most high- and middle-income countries unhealthy food is highly accessible, relatively cheap and heavily promoted. This unhealthy food contains high levels of saturated fat, sugar and/or sodium, causing major health risks.[3,4] Most adolescents show poor eating behaviours, like not consuming enough fruit and vegetables.[5] Also, just 19% of European adolescents meet the physical activity (PA) recommendations from the WHO.[5] Health behaviour affects life expectancy as well as well-being throughout the life course.[6] As in adolescence patterns of behaviour related to diet, PA, social relations, and others [7] are established, it is the optimal period to promote a healthy lifestyle.[8,9]

There are a multitude of interventions focussing on promoting healthy lifestyles among adolescents. However, a recent systematic review concluded that there is limited evidence of an effective strategy in interventions focusing on nutrition and/or physical activity, to reduce z-Body Mass Index (BMI) score in adolescents between 13-15 years old.[10] In addition, the WHO calls for youth engagement, especially on topics related to their own health.[11] One way to address health issues in adolescents is by so-called participatory research (PR), in which adolescents are actively involved in the research process.[12] By empowering adolescents, for example, in designing public health interventions, interventions will likely be more effective and increase the adherence of the participants.[13]

However, a challenge is how to engage adolescents in PR interventions. There are various strategies for how target groups are involved in PR, and Community-Based Participatory Research (CBPR) is the most popular.[12] CBPR is defined as *"collaborative interventions*

that involve scientific researchers and community members to address diseases and conditions disproportionately affecting health disparity populations".[14] In addition, other PR frameworks exist, like (Participatory) Action Research (AR) or Citizen Science (CS).[15]

Hawke et al. identified several key elements to maximize the value and feasibility of ongoing youth engagement in research environments such as valuing youth expertise, creating active participation through focus groups, or explaining research concepts.[16] Broadly, English et al. divided PR into three levels of participation in the research process: 1) Crowdsourcing (public only collaborates in data collection); 2) Limited PR (public only collaborates in data collection and problem definition); and 3) Extreme CS (public collaborates in problem definition, data collection, analysis and interpretation, dissemination, and public health action).[17]

Furthermore, PR interventions including co-creation could also be effective in creating health behaviour changes through the engagement of adolescents.[18] During co-creation all users (stakeholders and the target group) are involved in the research process. They will not only give insights into their needs, but also collaborate in the design, development, and implementation of the intervention.[19] Leask et al. structured the co-creation for health interventions into four sections: planning, conducting, evaluating and reporting.[13]

PR with adolescents was found to be an effective strategy on several health-related topics already, like promoting sexual health, [20,21] changing smoking habits, and reducing drug use among adolescents.[22,23] In the last decade, PR is more often used to change obesity-related healthy lifestyle behaviours (HLB) and prevent chronic diseases, like obesity, through nutritional education and PA.[24-26] In addition, in the adolescent population, there is some evidence about the use of co-creation strategies to improve some health aspects such as cardiovascular disease, [27] overweight and obesity, [28] mental health, [29,30] PA [31,32] and nutrition.[33]

Whereas previous literature showed some systematic reviews of PR health interventions in children and adolescents, most of them were focused on the characteristics of the PR methodology instead of effectiveness on health outcomes.[34-38] Therefore, this systematic

review including meta-analysis aims to evaluate the effectiveness of PR interventions compared to no (PR) intervention control groups on obesity and obesity-related HLB in adolescents from HIC. This comprehensive overview may guide future interventions that aim to engage and empower adolescents in their own HLB.

METHODS

This systematic review and meta-analysis included randomized controlled trials (RCTs) and non-randomized controlled trials (non-RCTs) that evaluated PR interventions with the aim to improve obesity and obesity-related HLB among adolescents. This systematic review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) (Supplementary file 1) [39] and was registered in PROSPERO International Prospective Register of Systematic Reviews (reference: CRD42021254135).

Search strategy & selection criteria

The following electronic databases were searched for eligible studies: Embase, Medline ALL, Web of Science Core Collection, PsycINFO, ERIC, CINAHL, Scopus, and Cochrane Central Register of Controlled Trials.[40-47] Google Scholar was also searched.

The search strategy, defined in close collaboration with a bibliographical expert, and selection criteria were framed according to the PICOS tool [48]:

a) Population: adolescents, general population, living in HIC, both girls and/or boys, age within the range of 11 and 18 years old, (in case of mean age, the mean and lowest or highest age within this range);
b) Intervention: interventions with a participatory element engaging adolescents, like co-creation or co-designed interventions, CS, CBPR, AR, youth-led interventions;
c) Comparison: studies with a control group (CG) following their normal curriculum or receiving no (PR) intervention;

d) Outcome: obesity or obesity-related health behaviours, including dietary behaviours and PA;
e) Study design: RCTs and non-RCTs, including pilot studies.

We included studies published in English from January 2000 to June 2021. Studies were excluded when they did not meet one or more inclusion criteria. Furthermore, protocols, abstracts, grey literature, correspondence letters, government statistic summaries, book chapters, dissertations and conference summaries were excluded. Authors were contacted when a full-text report was not available.

Data collection and analysis

Study Review and data extraction

The search strategy of the studies that matched the inclusion criteria has been carried out with the online platform Rayyan QCR.[49] All titles and abstracts were screened for inclusion by two independent researchers (JQ and AW). After this first screening, full-text studies were read and assessed according to predefined inclusion criteria by two independent researchers (JQ and AW). Discrepancies were resolved after discussion with researchers EL, LT and FM. Variables collected from the included studies were: a) author; b) year of publication; c) country; d) Study design; e) analytical strategy; f) number of participants in the intervention and control group, respectively; g) number and category of stakeholders and facilitators; h) age of participants; i) gender of participants; j) aim of the intervention; k) type of intervention and setting (if the setting is the school, specify the number of schools); l) duration of the intervention and duration of follow-up after cessation intervention (in case there is) ; m) intensity of the intervention; n) Cost of intervention; o) Cost-effectivity; p) strategies included in the intervention; q) outcomes at the end of intervention (lifestyles improvement, health literacy, well-being, STEM carers, science interest, science literacy, skills and abilities) and outcomes at follow-up; r) tools used for assessing outcomes; s) type of evaluation (qualitative or quantitative); t) timeline of evaluation; u) effectiveness of strategies (results): results of our own

defined primary outcomes and results of our own defined secondary outcomes: and; v) risk of bias of the studies included.

Outcomes

The primary outcomes of this review are changes in obesity (e.g., weight status, Body BMI, BMI-z-scores, etc.) and obesity-related HLB, like nutrition and PA behaviours.

Secondary outcomes were other distal obesity-related HLBs or outcomes following the Theory of Planned Behaviour (TPB) [50]: attitudes, subjective norms, perceived behavioural control and intentions.

Quality assessment

The quality of included studies was assessed by two different tools: the RoB2 for RCTs and the ROBINS-I for non-RCTs.[51,52] In both tools the articles were assessed on different domains (5 in Rob2 and 7 in ROBINS-I). Each domain was scored as low, some concerns/moderate and high risks of bias. An overall bias classification was assigned to each study.

Meta-analysis

The meta-analyses were conducted for primary and secondary outcomes reported by at least three studies. Results were presented as a quantitative synthesis of aggregate participant data and statistically studied in a random or fixed-effects model of meta-analysis, depending on the heterogeneity of the studies included. Random effects were used when tools used to assess the same variable or units differed among studies. The meta-analysis was performed in *Review Manager (RevMan) version 5.4*. [53] The difference in the intervention group from baseline to the end of the intervention as compared to the mean difference in the control group was pooled. If the difference between groups over time was not available, the authors of the respective study were contacted. Differences were calculated using RevMan when authors did not provide this information.

In the meta-analysis, the effect size was represented by standardized mean differences and the 95% CI, because all outcomes were continuous. Between-study heterogeneity was calculated with the I^2 statistic, with values >75% indicating considerable heterogeneity.[54] The meta-analysis was synthesized for each identified outcome into a forest plot showing the difference between the PR intervention group (IG) compared to the CG. In addition, if a study included in the meta-analysis received a high weight in the results, we did a sensitivity analysis removing this study from the analysis.
Outcomes that could not be pooled were narratively described.

RESULTS

Literature search

From the 6363 records identified, 24 were included for full-text assessment (see Figure 1). Finally, 11 studies met the inclusion criteria and were included.[32,55-64] Nine out of eleven studies were included in the meta-analysis for five primary outcomes: fruit consumption, vegetable consumption, total PA, moderate-to-vigorous PA (MVPA) and PA self-efficacy. [32,55-58,60-62,64]

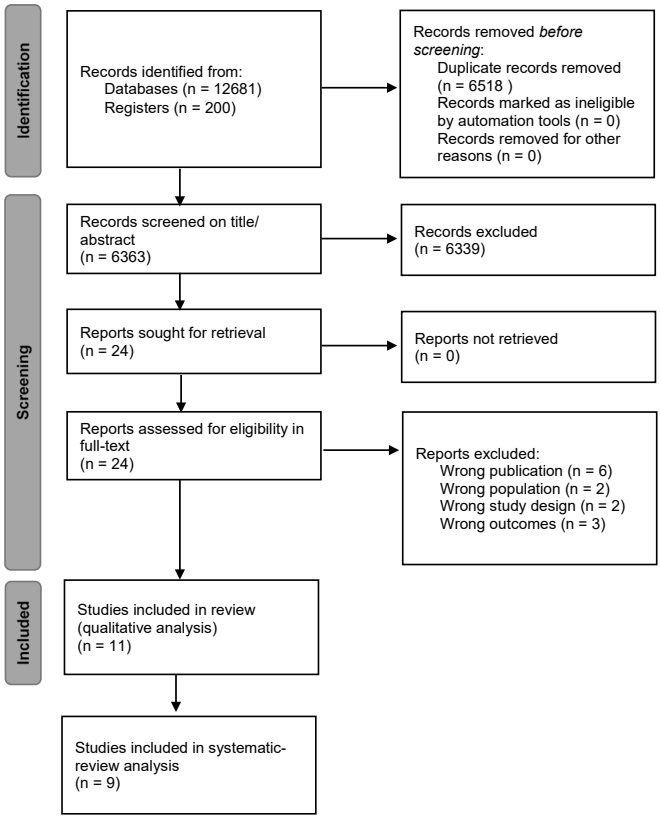

Figure 1. PRISMA 2020 adapted flow diagram

Study characteristics

A total of 7 cluster-RCTs (c-RCTs) [55-57,59,61,62,64] and 4 non-RCTs [32,58,60,63] were included in this review. Table 1 presents the characteristics of included studies**.** Five studies had a CG that did not receive the intervention at all.[55,57,60,62,63] Three studies specifically mentioned that CG followed the usual curriculum of high school.[32,58,61] In two studies the CG received the intervention after data collection on follow-up.[59,64] Lastly, in one study the CG did not receive the intervention, but they received the materials to carry out a part of the intervention but without further training as in the IG.[56]

Most studies were carried out in the United States (n=6), [56-60,62] followed by the United Kingdom (n=3),[55,61,64] New Zealand (n=1) [63] and Belgium (n=1).[32] The majority of studies were carried out in the school setting (n=9), [32,55,56,58,59,61-64] and two studies were carried out in the community.[57,60] The intervention duration varied greatly between the studies, including 5 short-term studies between 5-24 weeks,[55,59-62] 4 medium-term studies between 7-21 months [32,57,58,64] and 2 long-term studies of 2-3 years.[56,63]

Participants characteristics

The total number of participants across all included studies was 14440, ranging from 58 to 3039 per study. The age range of the participants was between 11-25 years old and both boys and girls participated in all studies, except for two interventions that only focussed on girls.[32,61] One study aimed at two age groups, 9-12 years old and 13-15 years old, but in this review, only the results of the older group are described.[57] In 10 of 11 studies, other types of participants, like stakeholders and/or facilitators, participated in the intervention besides the adolescents. Regarding the quadruple helix classification, stakeholders from Society [57,60] and Academics [59,63] provided support to adolescents and/or were involved in implementing and developing the intervention. Various facilitators were involved to support, train, educate and mentor adolescents, for example, health students, expert staff, school coordinators or older year peers.[55,56,58,61,62,64]

PR elements

Different terms were used to describe the participatory elements of the intervention. The term youth-led in this review refers to youth-led, peer-led, student-led, peer-mentored, and peer-supported interventions. Co-creation refers to co-created, co-developed and co-designed interventions. Regarding the different types of participants in the interventions the term peer-leaders in this review refers to youth leaders, peer educators, peer supporters and peer mentors.

Six studies evaluated youth-led interventions [56,57,59,61,62,64] where adolescents delivered a part of the intervention. In one study adolescents were involved in the co-creating phase of the intervention,[32] and four studies combined youth-led activities and co-creation activities.[55,58,60,63]

Meta-analysis

Nine of 11 studies were included in the meta-analysis.[32,55-58,60-62,64] Included primary outcomes were total PA, MVPA, fruit consumption, and vegetable consumption. The meta-analysis of fruit and vegetable (servings/cups per day) consumption included four studies [56,57,60,62] with a total sample of 2434 in IG and 2504 in CG. The pooled analysis showed a significant increase in daily fruit consumption, with 0.05 servings/cups per day in the IG as compared to the control group (95% CI=0.03, 0.07; p<0.00001; I^2= 0%, p heterogeneity= 0.56) (Figure 2). We also found a significant decrease in daily vegetable consumption of 0.02 servings/cups per day in the IG as compared to the control group (95% CI=-0.03, -0.01; p<0.00001; I^2=0%, p heterogeneity= 0.89). (Figure 3) However, no significant intervention effects were found for total PA and MVPA. (Figure 4). We could also pool the secondary outcome of PA self-efficacy, but also no intervention effect was found (Figure 4).

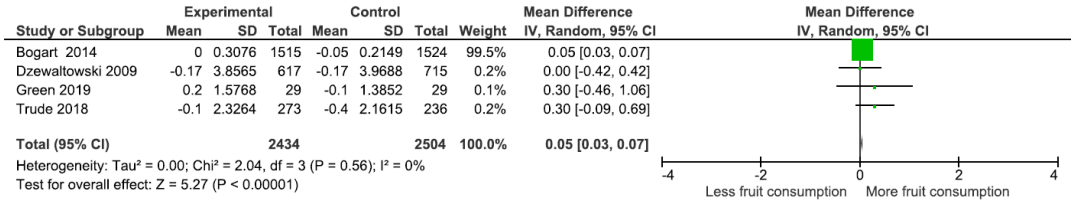

Figure 2. Meta-analysis of daily fruit consumption

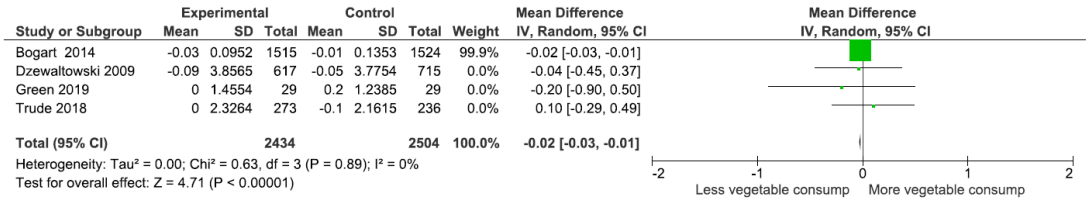

Figure 3. Meta-analysis of daily vegetables consumption

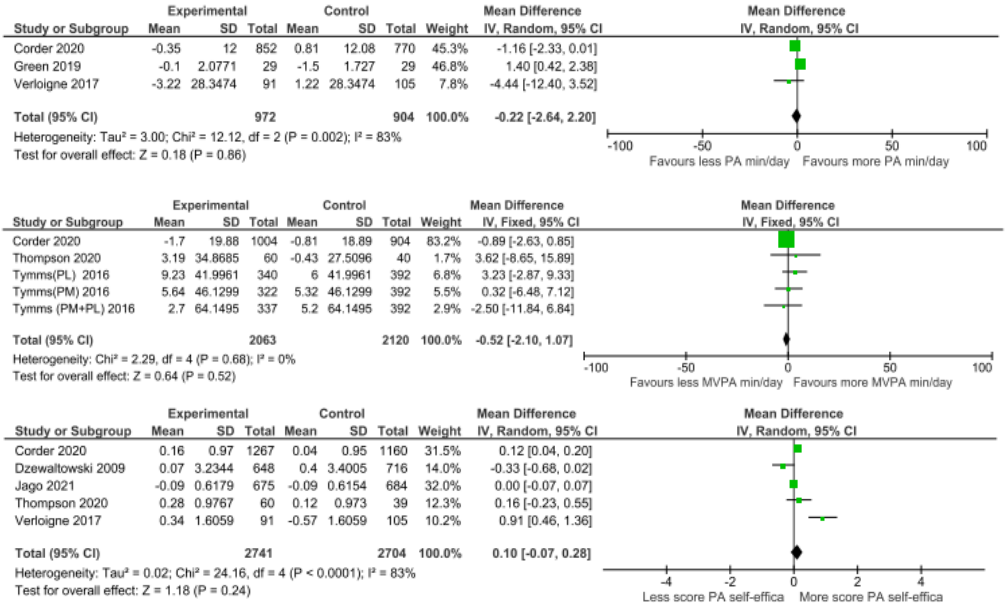

Figure 4. Meta-analysis of PA outcomes

As the study of Bogart et al. received a large weight, we excluded this study in a sensitivity analysis. After excluding this study, the meta-analysis showed no significant changes in fruit and vegetable consumption in the intervention group as compared to the control group. (Figure 5) That is, the heterogeneity of studies included made it difficult to obtain solid results.

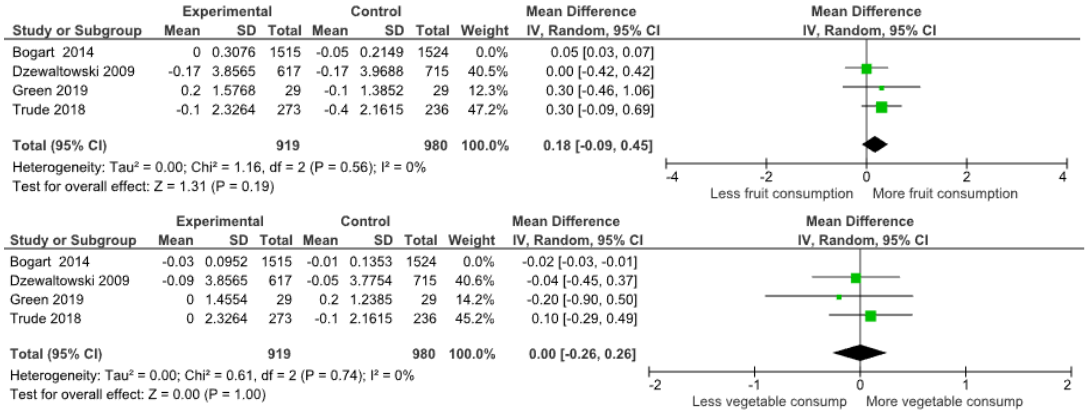

Figure 5. Sensitivity analysis of fruit and vegetables consumption

Primary outcomes

The main methods to assess the PA outcomes were accelerometers [55,56,61,64] and/or validated questionnaires (Table 2).[32,55,58,60] Most studies assessing nutrition outcomes used validated questionnaires (Table 2).[56-58,60] Obesity outcomes were measured by validated anthropometric methods (Table 2).[63]

The results of primary outcomes were classified into 3 sections related to the type of outcomes assessed:

Studies on PA outcomes

Four studies reported only PA outcomes (Table 2).[32,55,61,64] Only one co-created PA intervention by Verloigne et al. showed a significant increase in the IG compared to CG on extracurricular sports participation.[32] Regarding the other primary PA-related outcomes there were no significant intervention effects.[32] The other three studies on PA outcomes, all including a youth-led intervention and one adding co-creation, did not find a difference in PA between the IG and CG.[55,61,64]

Studies on nutrition outcomes

Two studies reported only on nutrition outcomes (Table 2). [57,59] A youth-led marketing campaign intervention by Nanney et al. resulted in a significant increase in school breakfast participation in IG compared to CG (p=0.03).[59] In addition, a youth-led obesity prevention intervention co-designed by students of Trude et al. found a significant effect on the decrease of % of kcal from sweet snacks and desserts in IG compared to CG [Effect (95% CI)= -3.5 (-7.0; -0.1), p< 0.05]. [57]

Studies combining obesity outcomes, PA and/or nutrition

Five studies reported on both PA and nutrition outcomes, [56,58,60,62,63] of which one also focused on obesity outcomes (Table 2).[63] Only a co-created and youth-led health campaign intervention by Green et al. showed significant results for both PA and nutrition outcomes. The intervention resulted in a significant increase in daily PA in IG compared to CG [F (1, 52)= 10.932, p= 0.002]. Additionally, a significant increase in the frequency of fruit consumption in IG compared to CG has been found [F(1,48)= 12.827, p< 0.001].[60] Two studies showed significant results in PA or nutrition outcomes separately (Table 2).[56,62] A youth-led school environmental intervention by Dzewaltowski et al. showed a significant increase in the IG of the mean % of 30-minute blocks/day of vigorous PA (p= 0.003) and MVPA (p= 0.005) compared to the CG.[56] In addition, a youth-led social marketing campaign intervention by Bogart et al. showed a significant minor decrease in lunch served in both IG and CG. However, students from the IG were 8.9% more likely to obtain lunch after the intervention compared to the CG.[62] In addition, the reduction of unhealthy snacks sale in IG was significantly larger than in the CG [b(SE)= -0.03 (0.01), p< 0.01).[62] On the other hand, regarding the food consumption outcomes, Bogart et al. showed that the IG more often drank tap water than the CG [b(SE)= 0.18 (0.09), p< 0.05].[62] The other two studies, both combining a youth-led and co-creation intervention, did not find any significant differences in PA, nutrition and/or other obesity-related HLB outcomes.[58,63] Besides PA and nutrition, Utter et al. was the only study

included in this review that also focused on obesity outcomes, but it showed no significant results.

Secondary outcomes

Nine studies presented information on at least one distal obesity-related HLB outcome or a secondary outcome following the TPB. The results of the secondary outcomes are presented in Table 3.

Attitude and knowledge

Two of three studies showed significant effects on attitude and knowledge towards HLB.[32,58,62] The youth-led social marketing campaign intervention of Bogart et al. resulted in a significant increase in positive attitudes about satisfaction and knowledge of eating in the cafeteria, an increase in a positive attitude towards drinking tap water, and an increase in knowledge about healthy eating and PA compared to CG.[62] In line with this, the youth-led and co-created health curriculum intervention of Thompson et al. showed a significant increase in PA knowledge in IG compared to CG.[58]

Subjective norm

One of five studies reported significant effects on subjective norms related to HLB.[32,55,56,61,63] A significant increase in the fruits and vegetables group norm was shown, as the students disagreed with their friends' influence in the decision to eat more fruits and vegetables, in the IG compared to CG. That is, the opposite of the intended directions.[56]

Perceived behavioural control

Three of five studies reported significant effects on perceived behavioural control related to HLB.[32,55,56,58,61] The youth-led health curriculum intervention of Thompson et al. showed a significant increase in PA self-efficacy in IG compared to CG.[58] Also, the co-created PA intervention of Verloigne et al. showed an increase of self-efficacy in the IG,

compared to a decrease in the CG.[32] In contrary to this, the youth-led school environmental intervention of Dzewaltowski et al. resulted in a significant increase in PA self-efficacy in CG compared to IG. This study also showed a significant decrease in fruit and vegetable self-efficacy in IG compared to CG.[56]

Intention

One of two studies reported significant effects on intentions towards HLB.[61,62] The youth-led social marketing campaign intervention of Bogart et al. showed an increase in the intentions to drink tap water and water from a refillable bottle in IC compared to CG.[62]

Behaviour

Five studies reported on distal obesity-related HLB: television use, refillable bottle use, purchase of food items, and well-being. However, no significant results were found on those outcomes.

Risk of bias

Only one study had a low overall bias score. [55] Three RCTs showed some concerns, all due to the selection of the reported results.[57,59,61] Three RCTS showed high overall bias, all due to bias in the measurement of the outcome and some additionally due to deviations from intended interventions.[56,62,64] Out of the non-RCTS, three studies were assessed as having moderate overall bias due to moderate scores in various domains, but all showed moderate bias in the measurement of outcomes. [32,58,63] One non-RCT was assessed as having serious bias, mainly due to confounding.[60] Detailed information on the quality assessment can be found in Supplementary file 2.

DISCUSSION

This systematic review and meta-analysis aimed to provide an overview of the effectiveness of interventions that actively engage adolescents in addressing obesity and obesity-related HLB. We identified 11 studies that used PR methodologies in HLB

interventions for adolescents in school and community settings. The findings of 4 studies could be pooled on daily fruit consumption and vegetable consumption. We found a significant increase in daily fruit consumption and a significant decrease in daily vegetable consumption in PR interventions in the IG compared to the CG. However, effect sizes were small, and this finding was not maintained after sensitivity analyses. No significant effects on PA outcomes were found in the meta-analysis. However, 6 out of 11 included studies reported significant positive results in at least one PA or nutrition outcome in favour of the IG.

Most of our studies are performed in the United States. Since 2010 the United States Department of Agriculture created the Fresh Fruit and Vegetable Program to help subsidize the purchase of fresh fruits and vegetables during breaks at school. This could also partly explain the small increase in fruit consumption we found in the meta-analyses.[65] Nevertheless, vegetable consumption did not show a positive change. Possibly, for adolescents, it is easier to introduce fruit as a snack, due to less preparation time and no need to cook, rather than vegetables which are mostly part of lunch or dinner.[66] Vegetable consumption might be more linked with parents' decisions, and fruit consumption with self-efficacy.[67]

Regarding secondary outcomes, two studies showed a significant increase in PA knowledge. Similar results are shown in a systematic review of promoting PA interventions with participatory elements in rural communities which reported that 4 out of 20 interventions noted positive changes in PA knowledge.[68] Although our findings highlight that adolescents improve their knowledge and perception of the benefits and barriers of PA, PA behaviour is not improved. It might be difficult to apply knowledge to practice in the short intervention time, and information on the long-term effects of those PR interventions is currently lacking. Furthermore, one study included in our systematic review reported some significant results in favour of the CG on secondary outcomes, like PA self-efficacy, FV self-efficacy and the perceived influence of friends on FV.[56] Dzewaltowski et al. explain that this was due to increased awareness of the difficulty to change HLBs, resulting in decreased confidence levels of adolescents in the IG.[56]

Currently, there is more evidence on the effectiveness of, mainly school-based, HLB interventions without PR methodologies.[69-73] However, the WHO calls for active involvement of the target population to provide benefits for participants' health.[11] In comparison with systematic reviews of non-PR interventions focussing on adolescents' obesity and/or obesity-related HLB, our study is focused on the active engagement of adolescents, but shows less positive results for those PR interventions. One explanation for our modest findings might be the limited number of studies included in both our review and meta-analysis. PR is a relatively new and therefore less common methodology, specifically on this topic and when solely focussing on adolescents.

Limited reviews are available on the effectiveness of PR interventions on health outcomes in youth. One the one hand, a systematic review of Frerichs et al. about the impact of child and youth participatory interventions on obesity-related HLBs concluded that 13 out of 18 included PR interventions reported significant improvements in at least one of the outcomes on weight, PA or dietary changes (increase in fruit, vegetables and water consumption and decrease in snacks/desserts consumption) compared to the CG.(153) Whereas the results of nutrition and PA outcomes are similar to our review, we included a broader range of secondary obesity-related HLBs outcomes, like PA self-efficacy and nutrition knowledge. In addition, the present review analysed some nutrition and PA outcomes by a meta-analysis. Furthermore, the present review specifically focussed on healthy adolescents, resulting in a smaller number of included studies. Besides that, the participatory methodologies in the present study are following a different classification, such as youth-led (implement, conduct and support intervention) and/or co-creation (design and create intervention), whereas Frerichs et al. classified it as functional (training adolescent to implement strategies) or interactive (design and/or implement interventions).[74] The present review included three similar studies as the review of Frerichs et al., while the other studies included by Frerichs et al. did not follow the inclusion criteria of the present systematic review (i.e. the age of the population and the health situation of participants).

On the other hand, a previous meta-analysis by Halvorsrud et al. investigated the effectiveness of specific co-creation approaches regarding adult-focused health policy and healthy service research. Co-creation approaches turned out to improve physical (i.e. BMI) and mental health, health-promoting behaviour (i.e. healthy eating and physical activity, etc) and self-efficacy.[75] Another review by Halvorsrud et al. focused on photovoice, a specific co-creation approach, without age restrictions, and showed improved health knowledge.[76] Some PR interventions included in the present review also improved on similar outcomes of those two studies. However, the results of the reviews of Halvorsrud et al. are hard to generalize towards the adolescent population, as the authors mention the form of co-creation varies for different target populations.[75] For this reason, the method of PR may influence effectiveness and different forms might be needed for each target group.

The PR interventions included in the present review showed similarities and differences. Most studies used a youth-led methodology and focussed on the school setting. One study combining youth-led and co-creation is the only study that showed significant results in both PA and nutrition outcomes. Studies with a youth-led methodology showed significant results in nutrition and some secondary obesity-related HLB outcomes. However, the duration of the interventions, the number of participants, and the obesity-related HLB outcome measures varied greatly. This makes it hard to generalize the findings of our study and to draw conclusions based on the used PR methodology. For this reason, future studies should compare different PR interventions, like youth-led, co-creation, and a combination of those, to investigate which method is most effective in improving obesity and/or obesity-related HLB in adolescents.

A strength of this systematic review and meta-analysis, is the specific focus on adolescents, as previous reviews focused on both children and adolescents or only on adults. Furthermore, the meta-analysis results of PR interventions on nutrition outcomes like fruits and vegetable consumption are novel as previous evidence has only been narratively described. Another strength of the present study is the great variety of obesity-related HLB outcomes included in, both primary and secondary outcomes.

However, this study also has some limitations. Firstly, due to a lack of studies using PR methodologies for HLB interventions in adolescents, a small number of studies could be included in this systematic review. Secondly, the included studies showed great variation in the duration of the study, type and intensity of participatory elements used and the number of adolescents included, which makes it hard to generalize the results. Thirdly, only a few outcomes could be analysed in the meta-analysis due to a great variety of study outcomes and methods used to assess these outcomes. Additionally, the significant increase found in daily fruit consumption was mainly due to one of the studies, and effectiveness is not maintained after sensitivity analyses. Lastly, most included studies had a high risk of bias or the quality assessment showed some concerns.

This review showed that adolescents can be involved in various stages during the development, implementation and evaluation of obesity and obesity-related HLB interventions delivered in schools and communities. There is limited insight on effectiveness, therefore there is a need for high-quality PR interventions. Furthermore, due to the limited number of studies included and the heterogeneity between studies, the best methodology for PR interventions remains unknown. Future research should focus on the kind of participatory methodology that is most effective to improve HLB among adolescents. To know if increased PA knowledge and self-efficacy will lead to improved PA behaviour, we would suggest including more follow-up measurements.

CONCLUSIONS

Overall, the meta-analysis showed a small desired effect on fruit consumption, a small undesired effect on vegetable consumption, and no effects on PA outcomes. Limited evidence, due to the amount and heterogeneity of studies, was found for some other primary and secondary outcomes, including PA practice, PA knowledge and PA self-efficacy. More high-quality (intervention) studies on PR methodologies are warranted and should also focus on the most effective PR methodologies.

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Declaration of interest

The authors declare that they have no competing interests

LIST SUPPORTING INFORMATION INCLUDED

Supplementary file 1. PRISMA checklist

Supplementary file 2. Quality assessment of RCTs and non-RCTs

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FIGURE LEGEND

TABLE LEGEND

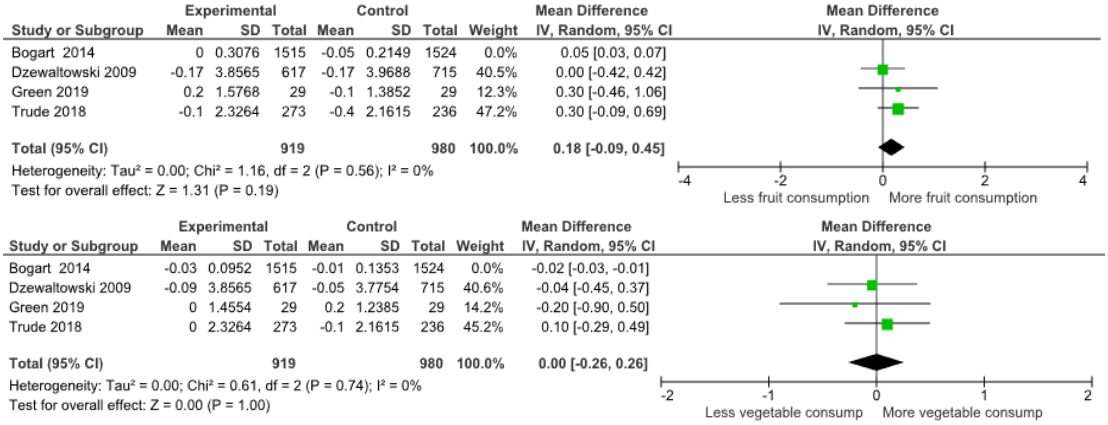

Figure 5. Sensitivity analysis of fruit and vegetables consumption (cup or servings/day)

Table 1. Description of included studies

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
Bogart et al. (2014)	Cluster-RCT	Students for Nutrition and eXercise (USA)	5-week youth-led obesity-prevention intervention with youth-led social marketing campaign	1. School food environment changes 2. Youth led-club and social marketing	Youth-led • Discussing healthy lifestyle with peers and family • Conducting taste tests • Giving out promotional items and healthy lifestyle information to peers and family	Training or supporting youth leaders • Bachelor level students • PhD level clinical psychologist • PhD level public health researcher	School (5/5)	Mean (SD)= 1515(323)/1524 (266)	12-13 yo boys and girls Mean age NR

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
Corder et al. (2020)	Cluster-RCT	GoActive (UK)	12-week youth-led PA promotion intervention co-designed with adolescents	1. Choice in PA activities 2. Novelty of activities 3. Mentorship of older adolescents who lead activities in class 4. Competition of earning points with doing activities 5. Rewards when reaching point levels 6. Flexibility of performing activities outside school hours	Youth-led and co-creation by older adolescents • Choosing weekly activities • Encouraging younger adolescents to engage in sessions	Training school staff • Health trainers Supporting youth leaders • Class tutors (teaching staff)	School (8/8)	1543/1319	13-14 yo boys and girls IG: Mean (SD) = 13.2 years (0.4) CG: Mean (SD) = 13.2 years (0.4)

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
Dzewaltowski, et al. (2009)	Cluster-RCT	Healthy Youth Places (USA)	2 years youth-led PA and nutrition intervention	1. Expert staff delivering intervention training to school site coordinators 2. School environmental advocacy groups with youth and involved adults 3. Implementation of interventions in/around school	Youth-led • Creating awareness and visibility within school regarding healthy lifestyle • Implementing lifestyle changes in school environment	Training school staff • Expert staff Supporting advocacy groups • Adult school site coordinators • Adults involved in targeted implementation sites	School (8/8)	1007/1204	11-13 yo boys and girls IG: Mean (SD) = 12.36 years (0.40) CG: Mean C = 12.40 years (0.43)

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
Green, et al. (2019)	Non-RCT	Youth Health Leadership Program (USA)	6-weeks PA and nutrition intervention co-created by youth with a youth-led health campaign	1. Content sessions about health, diet and PA 2. Application of learnings in community 3. Development and implementation of a health campaign	Co-creation • Meetings about engaging youth and families • Finalizing the intervention in a planning committee Youth-led • Developing and implementing a health campaign	Involved in development of intervention • 17 Youth-serving organizations • Community-based organisations • Parental advisory committee	Community (NA)	29/29	12-18 yo boys and girls Mean age NR

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
Jago, et al. (2021)	Cluster-RCT	Peer-Led physical Activity iNtervention for Adolescent girls (UK)	10-weeks youth-led PA promotion intervention	1. Process to nominate influential peers 2. Training PLAN-A trainers for intervention delivery 3. Training program to the peer supporters 4. Youth-led intervention to promote PA	Youth-led • Promoting PA among their peer group	Training youth-leaders • Female freelance trainers with backgrounds in PA promotion and/or education	School (10/10)	758/800	13-14 yo girls IG: Mean (SD) = 13.80 years (0.33) CG: Mean (SD) = 13.80 years (0.31)

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
Nanney, et al. (2019)	Cluster-RCT	School Breakfast Program (USA)	2 waves of 12-weeks school breakfast intervention with youth-led marketing	1. Team guiding change or expansion of school breakfast 2. Providing grab-and-go breakfast outside of the cafeteria 3. Allowing students to eat breakfast in the hallways 4. Youth-led marketing campaign	Youth-led • Developing and implementing a marketing campaign	Guiding or supporting school breakfast changes • School wellness committee + additional stakeholders • University educators Facilitators supporting youth-leaders: Marketing firm	School (8/8)	NR Median: 528.5/314.5	14-16 yo boys and girls Mean age NR

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
Thompson, et al. (2020)	Non-RCT	Health Action and Research Training (USA)	8-month and youth-led health curriculum intervention co-created by youth	1. Training of youth educators 2. Youth-led healthy lifestyle lessons	Co-creation • Creating lessons with healthy lifestyle activities Youth-led by older adolescents • Teaching healthy lifestyle lessons	NR	School (Classes: 5/4)	70/44	14-17 yo boys and girls IG: Mean (SD) = 14 years (0.85) CG: Mean (SD) = 16 years (0.55)

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
Trude, et al. (2018)	Cluster-RCT	B'more Healthy Communities for Kids (USA)	2 waves of 8-month childhood obesity prevention intervention with youth-led educational sessions	1. Food promotion by wholesalers 2. Collaboration with corner stores and carryout restaurants to promote healthier food options 3. Nutrition education sessions in recreation centers 4. Social media and texting program	Youth-led • Conducting education sessions about nutrition	Training youth leaders • Graduate students, public health educators, or dietitians trained in nutrition and education Supporting a healthy food environment	Community: (14/16)	283/251	13-15 yo boys and girls Mean age NR

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
				5. Policy regarding healthy food environment 6. Selection of healthier food 7. Training of intervention deliverers and data collectors		• City stakeholders			
Tymms, et al. (2016)	Cluster-RCT	MOVE (UK)	Two different interventions, 3 intervention groups PM: 21-months	1. Training of teachers by the research team 2a. PM: mentoring sessions regarding PA in PE class	Youth-led by older adolescents (PM) • Supporting younger adolescents by	NR	School (PM 14; PL 14; PM+OL 14 / C 15)	PM: 322 PL: 340 PM+PL: 337 C:392	11-12 yo boys and girls PM: Mean (SD) = 11.85 years (0.46)

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
			youth-led PA intervention PL: 21-months PA knowledge intervention with participatory learning PM and PL combined: 21 months intervention	2b. PL: collecting and interpreting own PA data	improving their PA habits				PL: Mean (SD) = 11.84 years (0.32) PM+PL: Mean (SD) = 11.72 years (0.31) CG: Mean (SD) = 11.79 years (0.40)

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
Utter, et al. (2011)	Non-RCT	Living 4 Life (New Zealand)	3-years youth-led obesity prevention intervention co-created with students	1. Student health councils designing and implementing activities 2. Breakfast clubs with physical activity 3. Lunch-time activities 4. After-school dance 5. Health weeks 6. Combined student–staff initiatives within the school environment	Youth-led and co-creation: • Designing and implementing intervention activities	Supporting youth leaders • Intervention coordinator	School (4/2)	953/681	15-18 yo boys and girls Mean age NR

Author (year)	Study design	Name of intervention (country)	Description of intervention	Key elements of intervention	Description of participatory elements	Stakeholders and facilitators involved in the intervention	Setting (IG/CG)	Number of participants at baseline (IG/CG)	Description of study population (age range, mean if reported)
Verloigne, et al. (2017)	Non-RCT	Co-creational approach to promote PA (Belgium)	7-month school specific PA intervention co-created with students	1. Co-creation sessions to develop the intervention School 1: 2. Sport sessions during lunch breaks School 2: 2. Facebook page to promote healthy lifestyle/ 3. Fitness activity School 3: 2. Walk during lunch break	Co-creation • Developing the school specific intervention	NR	School (3/3)	91/105	15-25 yo girls IG: Mean (SD) = 15.5 years (0.6) CG: Mean (SD) = 16.4 years (1.0)

CG = control group; IG = intervention group; PA= Physical Activity; PE = physical education; PL = Participative learning; PM= peer-mentoring; NA = not applicable; NR = not reported; RCT = randomised controlled trial; SD = standard deviation; UK = United Kingdom; USA = United States of America, yo= years old

Table 2. Results primary outcomes

Author (year)	**Outcome**	**Method** *Kind of measure* *Validation*	**Results directly after intervention** *Description*	*(Baseline IG, Post IG) VS (Baseline CG, Post CG) difference* # *Post-intervention difference IG VS CG*
PA-related outcomes				
Corder et al. (2020)	MVPA (min/day)	Wrist-worn activity monitors (Axivity) (validated)	The intervention did not result in a significant change of MVPA.	# Mean Difference (95% CI)= -0.81 (-5.28; 3.66)
	Sedentary activity (min/day)	Wrist-worn activity monitors (Axivity) (validated)	The intervention did not result in a significant change of sedentary activity.	# Mean Difference (95% CI)= 8.34 (-6.44; 23.13)
	Light intensity activity (min/day)	Wrist-worn activity monitors (Axivity) (validated)	The intervention did not result in a significant change of light intensity activity.	# Mean Difference (95% CI)= -8.54 (-21.70; 4.63)

Author (year)	Outcome	Method	Results directly after intervention	
	Overall activity (acceleration in milli-g)	Wrist-worn activity monitors (Axivity) (validated)	The intervention did not result in a significant change of overall activity.	# Mean Difference (95% CI)= -1.06 (-3.83; 1.70)
	PA	Self-reported YPAQ survey – 28 items (validated)	The intervention did not result in a significant change of self-reported PA.	# Mean Difference (95% CI)= 0.62 (-0.15; 1.38)
Dzewaltowski, et al. (2009)	VPA after school (% of 30-min blocks/day)	Self-reported PDPAR survey (non-validated)	The intervention resulted in a significant increase in 30-min blocks spent on VPA in intervention schools compared to control schools.	Mean difference (95% CI) = 1.47 (-2.5257; 5.4657)* ✓
	MVPA after school (% of 30-min blocks/day)	Self-reported PDPAR survey (non-validated)	The intervention resulted in a significant increase in in 30-min blocks spent on MVPA in intervention schools compared to control schools	Mean difference (95% CI) = 0.78 (-5.08; 6.64)* ✓
	Students doing VPA after school (% of at	Self-reported PDPAR survey (non-validated)	The intervention did not result in a significant change in the % of students doing at least 30 minutes of VPA each day.	Mean difference (95% CI) = 0.78 (-15.93; 17.49)*

Author (year)	Outcome	Method	Results directly after intervention	
	least one 30-min block/day)			
	Students doing MVPA after school (% of at least two 30-min block/day)	Self-reported PDPAR survey (non-validated)	The intervention did not result in a significant change in the % of students doing at least 60 minutes of MVPA each day.	Mean difference (95% CI) = 1.31 (-18.59; 21.22)*
Green, et al. (2019)	PA (min/day)	Self-reported NYPANS survey - 1 item (validated)	The intervention resulted in a significant difference in daily PA in intervention participants (stable) compared to control participants (decrease).	F (df) = 10.932 (1, 52) ✓
Jago, et al. (2021)	Weekday MVPA (min/day)	Accelerometer (ActiGraph) (validated)	The intervention did not result in a significant change of weekday MVPA.	Mean Difference (95% CI)= -2.84 (-5.94; 0.25)
	Weekend MVPA (min/day)	Accelerometer (ActiGraph) (validated)	The intervention did not result in a significant change of weekend MVPA.	Mean Difference (95% CI)= -0.97 (-11.49; 9.55)

Author (year)	Outcome	Method	Results directly after intervention	
	Weekday sedentary activity (min/day)	Accelerometer (ActiGraph) (validated)	The intervention did not result in a significant change of weekday sedentary time.	Mean Difference (95% CI)= 2.51 (-12.37; 17.38)
	Weekend sedentary activity (min/day)	Accelerometer (ActiGraph) (validated)	The intervention did not result in a significant change of weekend sedentary time.	Mean Difference (95% CI)= 3.44 (-22.03; 28.91)
Thompson, et al. (2020)	MVPA (min/day)	Self-reported adapted Leisure-Time PA Questionnaire (validated)	The intervention did not result in a significant change in MVPA.	F(df)= 0.77 (98)
Tymms, et al. (2016)	MVPA (min/day)	Accelerometer (ActiGraph) (validated)	The intervention did not result in a significant change in MVPA.	# Mean Difference (95% CI): PL vs CG = 3.23 (-2.87; 9.35) PM vs CG = 0.32 (-6.48; 7.12) PL+PM vs CG = 2.50 (-11.84; 6.84)

Author (year)	Outcome	Method	Results directly after intervention	
Utter, et al. (2011)	Lunch-time activity (%)	Self-reported survey (non-validated)	The intervention did not result in a significant change on lunch-time activity.	NR
	After-school activity (% doing any in past 5 days)	Self-reported survey (non-validated)	The intervention did not result in a significant change on after-school activity.	NR
Verloigne, et al. (2017)	Extra-curricular sports participation (min/day)	Self-reported Flemish PA Questionnaire (validated)	The intervention resulted in a significant increase in extracurricular sports participation in the intervention school compared to control schools.	B (SE)= 0.73(0.01) ✓
	Total PA (min/day)	Self-reported Flemish PA Questionnaire (validated)	The intervention did not result in a significant change on daily PA.	B (SE)= -4.44 (4.06)
	Active transportation to school (min/day)	Self-reported Flemish PA Questionnaire (validated)	The intervention did not result in a significant change on active transportation to school.	B (SE)=-0.85 (2.25)

Author (year)	Outcome	Method	Results directly after intervention	
	Active transportation leisure time (min/day)	Self-reported Flemish PA Questionnaire (validated)	The intervention did not result in a significant change on active transportation in leisure time.	B (SE)= -5.49 (3.30)
	Sports participation leisure time (min/day)	Self-reported Flemish PA Questionnaire (validated)	The intervention did not result in a significant change on sports participation in leisure time.	B (SE)= 0.01 (0.07)
Nutrition-related outcomes				
Bogart et al. (2014)	Number of cafeteria lunch meals served (per student each day)	Cafeteria participation records (non-validated)	The intervention resulted in a significant decrease in lunch meals served in the cafeteria in intervention schools compared to control schools.	b(SE)= 0.04 (0.01) ✓
	Number of snacks sold (per student each day)	School store sales data (non-validated)	The intervention resulted in a significant decrease in the number of unhealthy snacks sold in intervention schools compared to control schools.	b(SE)= -0.03 (0.01) ✓
	Tap water consumption	Self-reported survey – 1 item	The intervention resulted in a significant increase in tap water consumption in	b(SE)= 0.18 (0.09) ✓

Author (year)	Outcome	Method	Results directly after intervention	
		(non-validated)	intervention schools compared to control schools.	
	Number of fruits served (per student each day)	Cafeteria participation records (non-validated)	The intervention did not result in a significant change in number of fruits served.	b(SE)= 0.04 (0.02)
	Number of vegetables served (per student each day)	Cafeteria participation records (non-validated)	The intervention did not result in a significant change in number of vegetables served.	b(SE)= -0.02 (0.02)
Dzewaltowski, et al. (2009)	FV consumption (servings/day)	Self-reported YAQ survey – 2 items (validated)	The intervention did not result in a significant change in FV consumption.	Mean difference (95% CI) = 0.3 (0.77; 0.83)*
	Fruit consumption (servings/day)	Self-reported YAQ survey – 1 item (validated)	The intervention did not result in a significant change in fruit consumption.	Mean difference (95% CI) = 0.00 (-0.42; 0.42)*

Author (year)	Outcome	Method	Results directly after intervention	
	Vegetable consumption (servings/day)	Self-reported YAQ survey – 1 item (validated)	The intervention did not result in a significant change in vegetable consumption.	Mean difference (95% CI) = -0.04 (-0.45; 0.37)*
Green, et al. (2019)	Fruit consumption (frequency)	Self-reported NYPANS survey - 7 item (validated)	The intervention resulted in a significant difference in the frequency of fruit consumption, with a bigger decrease in control participants compared to intervention participants.	F (df) = 12.827 (1,48) ✓
	Fruit consumption (cups/day)	Self-reported NYPANS survey - 1 item (validated)	The intervention did not result in a significant change of amount of fruit consumption.	Mean Difference (95% CI)= 0.30 cups/day (-0.46; 1.06)*
	Vegetable consumption (frequency)	Self-reported NYPANS survey - 4 items (validated)	The intervention did not result in a significant change of frequency of vegetable consumption.	Mean Difference (95% CI)= 0.10 (-1.09; 1.29)*

Author (year)	Outcome	Method	Results directly after intervention	
	Vegetable consumption (cups/day)	Self-reported NYPANS survey - 1 item (validated)	The intervention did not result in a significant change of amount of vegetable consumption.	Mean Difference (95% CI)= -0.20 (-0.90; 0.50)*
	High fat products consumption (frequency)	Self-reported NYPANS survey - 3 items (validated)	The intervention did not result in a significant change of frequency of high fat products consumption.	Mean Difference (95% CI)= -0.60 (-1.58; 0.38)*
	High sugar products consumption (frequency)	Self-reported NYPANS survey - 4 items (validated)	The intervention did not result in a significant change of frequency of high sugar consumption.	Mean Difference (95% CI)= -0.90 (-1.99; 0.19)*
	High sodium products consumption (frequency)	Self-reported NYPANS survey - 2 items (validated)	The intervention did not result in a significant change of frequency of high sodium consumed.	Mean Difference (95% CI)= -0.60 (-1.77; 0.57)*
	Eating at fast food restaurants (frequency)	Self-reported NYPANS survey - 1 item (validated)	The intervention did not result in a significant change of frequency of eating at fast food restaurants.	Mean Difference (95% CI)= -0.40 (-0.90; 0.10)*

Author (year)	Outcome	Method	Results directly after intervention	
Nanney, et al. (2019)	Change in school-level SBP participation (%)	School meal software (non-validated)	The intervention resulted in a significant increase in SBP participation in intervention schools compared to control schools.	Mean Difference (95% CI)= 7.4 (6.55; 8.25)* ✓
Thompson, et al. (2020)	FV consumption (times/day)	Self-reported youth risk behaviour surveillance system survey - 3 items (validated)	The intervention did not result in a significant change on FV consumption.	F(df)= 0.01 (100)
Trude, et al. (2018)	Sweets consumption (% kcal/day)	Self-reported BKFFQ (validated)	The intervention resulted in a significant decrease in consumption of sweets in intervention participants compared to control participants.	Effect (95% CI)= -3.5 (-7.0; -0.1) ✓
	Total caloric intake (kcal/day)	Self-reported BKFFQ (validated)	The intervention did not result in a significant change in caloric intake.	Effect (95% CI)= 189.1 (-132.9; 510.9)
	Sugary beverage consumption (kcal/day)	Self-reported BKFFQ (validated)	The intervention did not result in a significant change in consumption of sugary beverages.	Effect (95% CI)= 10.7 (-47.2; 68.7)

Author (year)	Outcome	Method	Results directly after intervention	
	Fruit punch consumption (ounces/day)	Self-reported BKFFQ (validated)	The intervention did not result in a significant change in consumption of fruit punch.	Effect (95% CI)= 0.1 (-3.1; 3.3)
	Dietary total sugar (grams/day)	Self-reported BKFFQ (validated)	The intervention did not result in a significant change in consumption of grams of sugar.	Effect (95% CI)= 2.9 (-13.1; 19.1)
	Dietary sodium (mg/day)	Self-reported BKFFQ (validated)	The intervention did not result in a significant change in consumption of sodium.	Effect (95% CI)= -30.5 (-219.9; 158.3)
	Fruit consumption (cups/day)	Self-reported BKFFQ (validated)	The intervention did not result in a significant change in consumption of fruit	Effect (95% CI)= 0.2 (-0.1; 0.6)
	Vegetable consumption (cups/day)	Self-reported BKFFQ (validated)	The intervention did not result in a significant change in consumption of vegetables.	Effect (95% CI)= 0.1 (-0.2; 0.2)
	Fat consumption (servings/day)	Self-reported BKFFQ (validated)	The intervention did not result in a significant change in consumption of fat.	Effect (95% CI)= -0.1 (-0.5; 0.2)

Author (year)	Outcome	Method	Results directly after intervention	
Utter, et al. (2011)	Soft drink consumption (% consuming on all of past 5 days)	Self-reported survey (non-validated)	The intervention did not result in a significant change on soft drink consumption.	NR
	Breakfast consumption (% eating on 0 of past 5 days)	Self-reported survey (non-validated)	The intervention did not result in a significant change on breakfast consumption.	NR
Obesity-related outcomes				
Utter, et al. (2011)	BMI	Anthropometric measures (height and weight) by trained research staff - calculated as kg/m^2	The intervention did not result in a significant change on BMI.	Mean difference (95% CI)= 0.58 (-0.90; 2.06)*
	BMI-z	WHO Child Growth Standards	The intervention did not result in a significant change on BMI-z.	Mean difference (95% CI)= 0.14 (-0.16; 0.44)*
	Weight (kg)	Tanita BC-418 body composition analyser	The intervention did not result in a significant change on weight.	Mean difference (95% CI)= 1.73 (-1.03; 4.49)*

Author (year)	Outcome	Method	Results directly after intervention	
	Body fat (%)	Tanita BC-418 body composition analyser +equations validated for this population	The intervention did not result in a significant change on body fat.	Mean difference (95% CI)= 1.07 (-2.33; 4.47)*
	Prevalence of obesity (%)	WHO Child Growth Standards	The intervention did not result in a significant change on prevalence of obesity.	NR

CG = control group; CI = confidence interval; IG = intervention group; MVPA = moderate to vigorous physical activity; NR = not reported; NYPANS = Youth Physical Activity Nutrition Study; PA= physical activity; PDPAR = Previous Day Physical Activity Recall; PL = Participative learning; PM= peer-mentoring; SE = standard error; VPA= vigorous physical activity; YPAQ = Youth Physical Activity Questionnaire; BKFFQ = Block Kids 2004 Food Frequency Questionnaire; SBP = School Breakfast Program; BMI = body mass index; WHO = World Health Organization.

✓= significant result favouring intervention

* = difference calculated by researchers with *RevMan 5.*

Table 3. Results secondary outcomes

Author (year)	**Outcome**	**Method** *Kind of measure* *Validation*	**Results directly after intervention** *Description*	*(Baseline IG, Post IG) VS (Baseline CG, Post CG) difference* # *Post-intervention difference IG vs CG*
Bogart et al. (2014)	Attitudes about the cafeteria	Self-reported survey - 2 items (non-validated)	The intervention resulted in a significant increase in positive attitudes about eating in the cafeteria in intervention schools compared to control schools.	b (SE)= 0.13 (0.05) ✓
	Attitudes about drinking water	Self-reported survey – 1 item (non-validated)	The intervention resulted in a significant increase in positive attitudes about drinking tap water in intervention schools compared to control schools	b (SE)= 0.20 (0.09) ✓
	Knowledge about healthy eating/PA	Self-reported survey – 6 items	The intervention resulted in a significant increase of knowledge about healthy eating/PA in	b (SE)= 0.12 (0.04) ✓

Author (year)	Outcome	Method	Results directly after intervention	
		(non-validated)	intervention schools compared to control schools.	
	Intentions to drink tap water	Self-reported survey - 1 item (non-validated)	The intervention resulted in a significant increase in intentions to drink tap water in intervention schools compared to control schools.	b (SE)= 0.10 (0.05) ✓
	Intentions to drink from a refillable bottle	Self-reported survey - 1 item (non-validated)	The intervention resulted in a significant increase in intentions to drink from a refillable bottle in intervention schools compared to control schools.	b (SE)= 0.11 (0.05) ✓
	Refillable bottle use	Self-reported survey - 1 item (non-validated)	The intervention did not result in a significant change on refillable bottle use.	b (SE)= 0.12 (0.09)
Corder et al. (2020)	PA self-efficacy	Self-reported RPPPA self-efficacy scale - 8 items (validated)	The intervention resulted in a significant increase of PA self-efficacy in intervention schools compared to control schools.	# Mean Difference (95% CI) = 0.12 (0.02; 0.23) ✓

Author (year)	Outcome	Method	Results directly after intervention	
	Social support for PA	Self-reported European Youth Heart Study survey – 9 items (validated)	The intervention did not result in a significant change on social support for activity.	# Mean Difference (95% CI) = 0.00 (-0.06; 0.06)
	Well-being	Self-reported Edinburgh-Warwick Wellbeing Scale survey – 14 items (validated)	The intervention did not result in a significant change on well-being.	# Mean Difference (95% CI) = -0.04 (-0.11; 0.02)
Dzewaltowski, et al. (2009)	PA self-efficacy	Self-reported YPS survey - 3 items (non-validated)	The intervention resulted in a significant increase in PA self-efficacy in control schools compared to intervention schools.	Mean difference (95% CI)= -0.33 (-0.68; 0.02)* X
	PA proxy efficacy – parents	Self-reported YPS survey - 4 items (non-validated)	The intervention did not result in a significant change on PA proxy efficacy of parents.	Mean difference (95% CI) = 0.04 (-0.30; 0.38)*

Author (year)	Outcome	Method	Results directly after intervention	
	PA proxy efficacy – peers	Self-reported YPS survey - 2 items (non-validated)	The intervention did not result in a significant change on PA proxy efficacy of peers.	Mean difference (95% CI) = -0.01 (-1.62; 1.60)*
	PA proxy efficacy – school	Self-reported YPS survey - 6 items (non-validated)	The intervention resulted in a significant increase of PA proxy efficacy of school in intervention schools compared to control schools.	Mean difference (95% CI) = 0.44 (0.13; 0.75)* ✓
	Influence of friends on PA (PA group norm)	Self-reported YPS survey - 1 item (non-validated)	The intervention did not result in a significant change on PA group norm, the influence of friends on PA.	Mean difference (95% CI)= -0.03 (-0.40; 0.34)*
	FV self-efficacy	Self-reported YPS survey - 3 items (non-validated)	The intervention resulted in a significant decrease in FV self-efficacy in intervention schools compared to control schools.	Mean difference (95% CI)= -0.18 (-0.64; 0.28)* X
	FV proxy efficacy – parents	Self-reported YPS survey - 3 items (non-validated)	The intervention did not result in a significant change on FV proxy efficacy of parents.	Mean difference (95% CI)= 0.20 (-0.20; 0.60)*
	FV proxy efficacy – school	Self-reported YPS survey - 9 items	The intervention did not result in a significant change on FV proxy efficacy of school.	Mean difference (95% CI) = 0.03(-0.32; 0.38)*

Author (year)	Outcome	Method	Results directly after intervention	
		(non-validated)		
	Influence of friends on FV (FV group norm)	Self-reported YPS survey - 1 item (non-validated)	The intervention resulted in a significant increase in the FV group norm, so more disagreement that friends influence to eat FV in the intervention schools compared to control schools.	Mean difference (95% CI) = 0.16 (-0.11; 0.43)* X
Green, et al. (2019)	*No secondary outcomes*			
Jago, et al. (2021)	PA motivation - autonomous	Self-reported BREQ-2 survey - … items (validated)	The intervention did not result in a significant change of autonomous PA motivation	Mean difference (95% CI) = 0.04(-0.17; 0.25)*
	PA motivation - controlled	Self-reported BREQ-2 survey - … items (validated)	The intervention did not result in a significant change on controlled PA motivation	Mean difference (95% CI) = -0.06(-0.24; 0.12)*
	PA self-efficacy	Self-reported Physical Activity Self-Efficacy Scale – 8 items	The intervention did not result in a significant change of PA self-efficacy	Mean difference (95% CI)= 0.00 (-0.10; 0.10)*

Author (year)	Outcome	Method	Results directly after intervention	
		(validated)		
	PA social support	Self-reported survey – 6 items (validated)	The intervention did not result in a significant change of PA social support	Mean difference (95% CI)= 0.03 (-0.11; 0.17)*
	Peer norms for PA - prevalence	Self-reported survey – 2 items (non-validated)	The intervention did not result in a significant change of peer support of PA (prevalence)	Mean difference (95% CI)= -0.04 (-0.13; 0.05)*
	Peer norms for PA - importance	Self-reported survey – 2 items (non-validated)	The intervention did not result in a significant change of peer support of PA (importance)	Mean difference (95% CI)= 0.09 (-0.04; 0.22)*
	Peer norms for PA - acceptance	Self-reported survey – 2 items (non-validated)	The intervention did not result in a significant change of peer support of PA (acceptance)	Mean difference (95% CI)= 0.01 (-0.10; 0.12)*
Nanney, et al. (2019)	*No secondary outcomes*			

Author (year)	Outcome	Method	Results directly after intervention	
Thompson, et al. (2020)	PA Knowledge	Self-reported HART survey – 4 items (non-validated)	The intervention resulted in a significant increase of PA knowledge in intervention schools compared to control schools.	F (df) = 14.71 (98) ✓
	Readiness to participate in regular PA (stage of change)	Self-reported HART survey (non-validated)	The intervention did not result in a significant change readiness to participate in PA.	F (df) = 0.12 (99)
	PA self-efficacy	Self-reported HART survey - 6 items (non-validated)	The intervention resulted in a significant increase of PA self-efficacy in intervention schools compared to control schools.	F (2,97) = 1.27 ✓
	PA enjoyment	Self-reported HART survey - 5 items (non-validated)	The intervention did not result in a significant change on PA enjoyment.	F(df)= 1.31 (99)
	Nutrition knowledge	Self-reported HART survey – 4 items (non-validated)	The intervention did not result in a significant change on nutrition knowledge.	F(df) = 0.33 (99)
	Readiness to consume FV (stage of change)	Self-reported HART survey	The intervention did not result in a significant change readiness to consume FV.	F(df)= 0.04 (99)

Author (year)	Outcome	Method	Results directly after intervention	
	FV self-efficacy	(non- validated) Self-reported HART survey - 6 items (validated)	The intervention did not result in a significant change on FV self-efficacy.	F(df)= 0.95 (97)
Trude, et al. (2018)	Purchase of healthier food (items/week)	Self-reported CIQ (non-validated)	The intervention did not result in a significant change on purchase of healthier food.	Effect (95% CI) = −1.4 (−3.6; 0.8)
	Purchase of unhealthier food (items/week)	Self-reported CIQ (non-validated)	The intervention did not result in a significant change on purchase of unhealthier food.	Effect (95% CI) = −0.7 (−2.6; 1.2)
Tymms, et al. (2016)	Well-being	Self-reported KIDSCREEN-27 – 27 items (validated)	The intervention did not result in a significant change on well-being.	# Mean Difference (95% CI): PL vs CG = 0.90 (−0.88; 2.69); PM vs CG = 0.70 (−2.57; 1.17); PL+PM vs CG = 1.93 (−4.98; 0.70)

Author (year)	Outcome	Method	Results directly after intervention	
Utter, et al. (2011)	Television use (% using on all of past 5 days)	Self-reported survey (non-validated)	The intervention did not result in a significant change on television use.	NR
	School encourages activity (% reporting a lot)	Self-reported survey (non-validated)	The intervention did not result in a significant change on schools encouraging activity.	NR
	School encourages healthy eating (% reporting a lot)	Self-reported survey (non-validated)	The intervention did not result in a significant change on schools encouraging healthy eating.	NR
	Healthiness of school canteen (% reporting its mostly healthy)	Self-reported survey (non-validated)	The intervention did not result in a significant change on healthiness of school canteens.	NR
Verloigne, et al. (2017)	PA self-efficacy	Self-reported survey – 4 items (validated)	The intervention resulted in a significant increase in PA self-efficacy in intervention schools compared to control schools.	B (SE) = 0.91 (0.23) ✓
	Perceived benefits of PA	Self-reported survey – 6 items	The intervention did not result in a significant change in perceived benefits of PA.	B (SE) = -0.10 (0.10)

Author (year)	Outcome	Method	Results directly after intervention	
		(validated)		
	Perceived barriers of PA	Self-reported survey – 5 items (validated)	The intervention did not result in a significant change in perceived barriers of PA.	B (SE) = -0.03 (0.12)
	Peer modelling of PA	Self-reported survey – 1 item (validated)	The intervention did not result in a significant change in peer modelling of PA.	B (SE) = 0.07 (0.16)
	Peer co-participation in PA	Self-reported survey – 1 item (validated)	The intervention did not result in a significant change in peer co-participation in PA.	B (SE) = 0.27 (0.17)
	Peer encouragement to do PA	Self-reported survey – 1 item (validated)	The intervention did not result in a significant change in peer encouragement to do PA.	B (SE) = 0.02 (0.21)
	Parental modelling of PA	Self-reported survey – 1 item (validated)	The intervention did not result in a significant change in parental modelling of PA.	B (SE) = -0.11 (0.16)

Author (year)	Outcome	Method	Results directly after intervention	
	Parental co-participation in PA	Self-reported survey – 1 item (validated)	The intervention did not result in in a significant change in parental co-participation in PA.	B (SE) = -0.28 (0.15)
	Parental encouragement to do PA	Self-reported survey – 1 item (validated)	The intervention did not result in a significant change in parental encouragement to do PA.	B (SE) = 0.34 (0.22)

BREQ-2 = Behavioural Regulation in Exercise Questionnaire-2; CG = control group; CI = Confidence Interval; CIQ = Child Impact Questionnaire; FV = fruit and vegetable; HART = Health Action and Research Training; IG = intervention group; PA= Physical Activity; PL = Participative learning; PM= peer-mentoring; RPPPA = Reynolds' Psychosocial Predictors of Physical Activity; SE = standard error; YPS = Youth Psychosocial Survey;

✓= significant result favouring intervention; X: significant result favouring control

* = Difference calculated by researchers with *RevMan 5.4.1*

SUPLEMENTARY MATERIAL

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	3 and 4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	5
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6 and 7
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6 and 7

Section and Topic	Item #	Checklist item	Location where item is reported
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	7
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	7 and 8
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	7 and 8
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	8

Section and Topic	Item #	Checklist item	Location where item is reported
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	8
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	6
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	7
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	7
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	8 and 9
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	-
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	9
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	-

Section and Topic	Item #	Checklist item	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	-
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	9 and 10
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	10
Study characteristics	17	Cite each included study and present its characteristics.	10
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	17
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	11-13
	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	17

Section and Topic	Item #	Checklist item	Location where item is reported
Results of syntheses	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	12-14
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	-
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	13 and 14
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	-
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	-
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	18
	23b	Discuss any limitations of the evidence included in the review.	21 and 22
	23c	Discuss any limitations of the review processes used.	21 and 22
	23d	Discuss implications of the results for practice, policy, and future research.	21 and 22
OTHER INFORMATION			

Section and Topic	Item #	Checklist item	Location where item is reported
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	6
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	-
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	-
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	23
Competing interests	26	Declare any competing interests of review authors.	23
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Tables

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71 For more information, visit: http://www.prisma-statement.org/

QUALITY ASSESSMENT OF RCTs AND non-RCTs

Supplementary Table 1. Quality assessment for randomised controlled trials (n=7) using the Rob-2 tool

Author (year)	Overall bias	Domain 1 – randomisation process	Domain 2 – Deviations from intended interventions	Domain 3 – Missing outcome data	Domain 4 – Measurement of the outcome	Domain 5 – Selection of the reported result
Bogart (2014)	High	Low	High	Low	High	Some concerns
Corder (2020)	Low	Low	Low	Low	Low	Low
Dzewaltowski (2009)	High	Low	Low	Low	High	Some concerns
Jago (2021)	Some concerns	Low	Low	Low	Low	Some concerns
Nanney (2019)	Some concerns	Low	Low	Low	Low	Some concerns
Trude (2018)	Some concerns	Low	Low	Low	Low	Some concerns
Tymms (2016)	High	Low	High	Low	High	Some concerns

Supplementary Table 2. Quality assessment for non-randomised controlled trials (n=4) using the ROBINS-I tool

Author (year)	Overall bias	Domain 1 – Bias due to confounding	Domain 2 – Bias in selection of participants into the study	Domain 3 – Bias in classification of interventions	Domain 4 – Bias due to deviations from intended interventions	Domain 5 – Bias due to missing data	Domain 6 – Bias in measurement of outcomes	Domain 7 – Bias in selection of the reported result
Green (2019)	Serious	Serious	Low	Low	Low	Moderate	Moderate	Low
Thompson (2020)	Moderate	Low	Low	Low	Low	Moderate	Moderate	Low
Utter (2011)	Moderate	Low	Moderate	Low	Moderate	Moderate	Moderate	Low
Verloigne (2017)	Moderate	Low	Low	Low	Low	Low	Moderate	Low

SUMMARY OF RESULTS

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PARTICIPATORY RESEARCH AS A NEW APPROACH TO MAKING DECISIONS AND INCREASING ACTIVE ENGAGEMENT IN HEALTH INTERVENTIONS FOR EFFECTIVELY IMPROVING HEALTHY LIFESTYLES BEHAVIOURS
Judit Queral Añó

SUMMARY OF RESULTS

In this thesis, two relevant gaps to address are identified and four studies are carried out to tackle them.

To solve the first gap identified about the need to detect HLBs in order to determine how intrinsic and extrinsic factors act as barriers and facilitators among the target population, and how they can influence and help to adapt strategies for improving HLBs, three studies were carried out.

In the change in time (from 2013/14 to 2017/18) study of 36 European countries regarding dietary behaviours including daily fruit, vegetable, and sweet consumption, the HBSC data showed that 10 of the 36 countries exhibited a significant and positive change over time, that is, an increase in daily fruit and vegetable consumption in adolescents between 11 and 15 years old, especially in Eastern European countries. Moreover, 12 of the 36 countries showed a significant and positive change over time, that is, a reduction in daily sweet consumption, especially in Western European countries. Intrinsic factors, such as age and sex, and extrinsic factors, such as SES, are assessed. Notably, 13- and 15-year-old adolescents consumed fewer fruits and vegetables and more sweets on a daily basis than 11-year-old adolescents. In addition, 15-year-old adolescents had a significantly less favourable change in time in sweet consumption than 11-year-old adolescents. Regarding sex, girls consumed more fruit, vegetables, and sweets than boys on a daily basis. Focusing on SES, low SES adolescents consumed fewer fruits and vegetables on a daily basis than adolescents with a medium/high SES. Additionally, the interaction effect showed a change in time less favourable in daily vegetable consumption in low SES adolescents than in those with a medium/high SES, which means that inequities are increasing over time (**Study 1:** Queral et al, editor submitted).

A cross-sectional study examined the impact of the COVID-19 pandemic on restaurants and their customers using information provided via a survey and focus group discussions to determine the intrinsic and extrinsic factors including the barriers, needs, interests,

and food choices before and during the COVID-19 pandemic in Tarragona Province. On the one hand, the survey results highlighted that the MD offer (AMed criteria) in restaurants underwent no noticeable changes, but restaurants significantly increased their takeaway offerings, their use of digital menus, and the use of single-serving condiment packages and napkins, because of customer demand. In addition, cleaning and disinfection tasks increased. The customers positively perceived the use of olive oil, vegetable dishes, fruit-based desserts, and local products, among others, as Amed criteria. On the other hand, results of the focus groups highlighted that the principal barriers for restaurateurs are the restricted measures imposed by the administration, the limitations on hours and capacity, and emotional consequences such as anxiety or depression. The principal barriers for customers are the imposed restrictions and limitations and the emotional consequences. In conclusion, the barriers, needs, interests, and food choices of restaurants and customers have changed during the COVID-19 pandemic. For this reason, the researchers provided some proposals to improve and adapt to the new demands faced by restaurateurs (**Study 2:** Besora-Moreno et al., 2023).

The study that compared four different interventions of the SEEDS project, a European multicenter c-RCT that followed the CS approach, concerning the barriers and facilitators detected in focus groups, showed that the co-created interventions have some key points in common: type of activities proposed per behaviour; practical face-to-face activities; school hours implementation; external professionals, teachers, or researchers as providers. However, the high diversity of activities per behaviour in each country makes difficult the comparison of the global frequency and duration of interventions. In all four countries, the physical activity barriers identified were as follows: insufficient space and time to be active during breaks and long-time sitting down during school hours. These were addressed by active classes, active breaks and getting active during school hours. The snacking-behaviour-related barriers identified were unhealthy snacks being offered in the school canteen and irregular meals during school hours; these were addressed by offering healthier food and organizing competitions or challenges related

to healthy snacks. The key facilitators identified in both behaviours were peers, the high school, and the parents' influence. However, a limited use of facilitators identified in focus groups is shown in the co-created interventions (**Study 3:** Queral et al., editor submitted).

To solve the problem of scare evidence of the second gap regarding the most effective PR approaches for improving HLBs in adolescents, a study was carried out.
A systematic review and meta-analysis that included seven c-RCTs and four non-RCTs provided an overview of the effectiveness of PR interventions to improve obesity and obesity-related HLBs. In the meta-analysis a significantly small increase was detected in daily fruit consumption and a significantly small decrease was detected in daily vegetable consumption in the PR interventions in the IG compared to the CG, but there were no significant effects on PA outcomes. However, the systematic analysis determined that 6 out of the 11 included studies reported significant positive results in at least one PA or nutrition outcome in favour of the IG. Most studies used a youth-led approach and focused on the school setting, but only the study combining a youth-led approach and co-creation showed significant results in both PA and nutrition outcomes. Due to, the limited number of studies included and the heterogeneity between studies, the best approach for PR interventions remains unknown. Future research should focus on the kind of participatory approach that is most effective in improving HLBs among adolescents (**Study 4:** Queral, et al., editor submitted).

Overall, based on the results obtained in the present thesis, four key findings are presented (*Figure 11*):

1. Dietary behaviours change over time in European adolescents related to sex, age, and SES of the population, depending on each European country.
2. The barriers, needs, interests, and food choices of restaurants and customers have changed during the COVID-19 pandemic. In restaurants, the first COVID-

19 lockdown increased takeaway orders, sanitation measures, and digital communication.

3. The interventions co-created in each country share some common aspects and address the barriers identified in focus groups. However, the facilitators are not sufficiently addressed.
4. PR-related literature is still scarce and more high-quality PR intervention studies are warranted to determine the most effective PR approach.

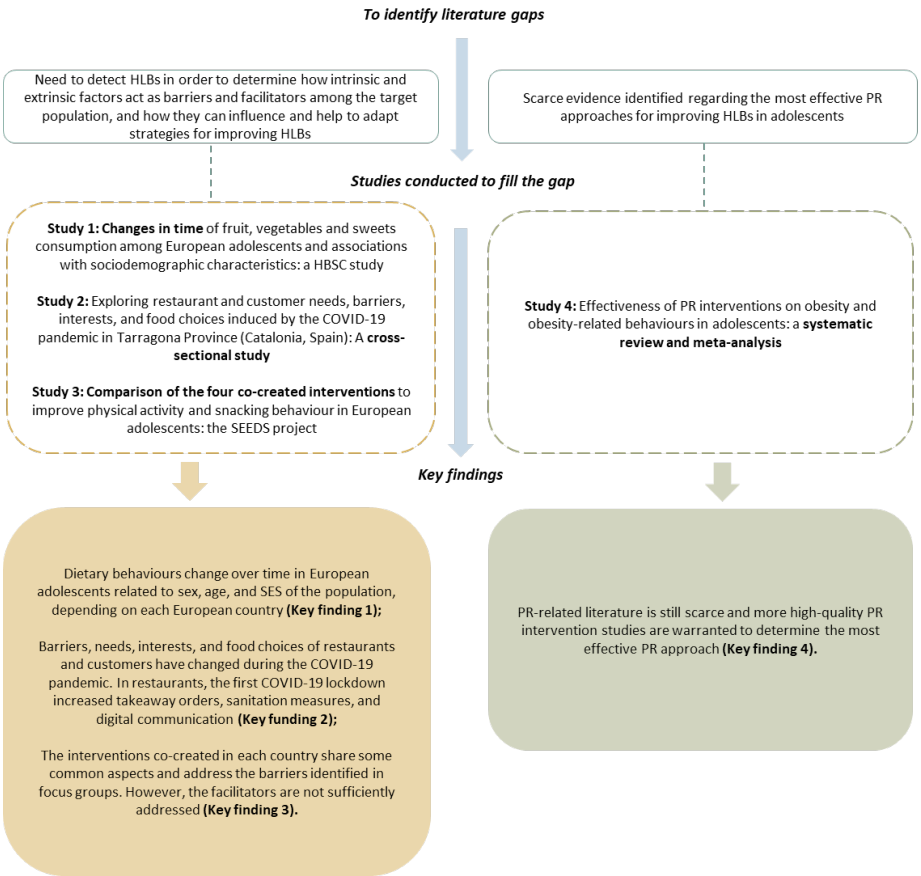

Figure 11. Key findings of the present thesis from the identified gaps. Abbreviations: HLBs, Healthy Lifestyle Behaviours; PR, participatory research; SEEDS, Science Engagement to Empower aDoleScent; SES, Socioeconomic status. Source: designed by the author.

GENERAL DISCUSSION

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GENERAL DISCUSSION

The hypothesis of the present thesis is verified regarding the total involvement of the target population in the interventions by PR, based on the identification of intrinsic and extrinsic factors that act as barriers to and facilitators of healthy lifestyle behaviours (HLBs), is essential for designing tailored specific interventions and it can have a positive impact on HLBs. The results identified the importance of assessing the HLBs and the intrinsic and extrinsic factors that act as barriers and facilitators among the target population of the study before designing an intervention. They also highlight the potential of involving the target population in the research process to enhance their adherence to the health intervention and increase their HLBs. In this regard, this thesis presents PR as a potential new approach based on the identification of intrinsic and extrinsic factors that act as barriers and facilitators of HLBs among the target population; it demonstrates the value of adapting strategies for increasing the population's active engagement in health interventions that aimed to improve HLBs.

To address the first gap in the literature, regarding the need to detect HLBs in order to determine how intrinsic and extrinsic factors act as barriers and facilitators among the target population, and how they can influence and help to adapt strategies for improving HLBs (**Study 1, Study 2, and Study 3**), a specific aim of this thesis is to identify the HLBs and to elucidate the intrinsic/extrinsic factors that act as barriers to and facilitators of HLBs among the target population, in order to adapt strategies for improving HLBs.

The evidence highlighted the poor HLBs in the European population, especially in adolescents; this is because, during this life stage, people establish their future patterns of behaviours (10,11). Studies that assess change over time provide a valuable opportunity to determine the status of HLBs in European adolescents and the progression of these behaviours over time (**Study 1**). As a result, the change in time study based on HBSC data allows us to evaluate the impact of the actions and policies

implemented on the improvement of HLBs among European adolescents (**Study 1**), such as the sugar tax policy and the actions and policies implemented in schools to provide free fruit and vegetables (154,155). **Study 1** identified relevant improvements in fruit and vegetable consumption and sweet consumption, which constitute promising results for European adolescent health. Specifically, the study identified a significant increase in daily fruit and vegetable consumption in 10 of the 36 European countries and a significant decrease in sweet consumption in 12 of the 36 European countries over four years, until 2017/2018. However, nowadays, based on the results of this study, the HBLs of adolescents remain far from the established recommendations, as the literature shows (55). However, the change in HLBs of European adolescents (11 to 15 years old) identified from 2013/2014 to 2017/2018 showed promising results regarding the effectiveness of the health policies implemented during the recent years (**Study 1:** Queral, et al., submitted).

In addition, the change in time study identified the influence of key intrinsic and extrinsic factors, such as age, sex, and SES, which influenced HLBs among European adolescents (**Study 1:** Queral, et al., submitted). Specifically, older adolescents (13 to 15 years old), boys, and adolescents with a low SES exhibited more unhealthy lifestyle behaviour patterns than the youngest adolescents (11 years old), girls, and medium/high SES adolescents. Conversely, girls had higher daily sweet consumption than boys, a finding previously observed in the literature (55,156). Concerning the adolescent age stage, unhealthy behaviours among older adolescents and the implications of a low SES are key factors to consider when addressing important challenges, as described previously (55,157).

Furthermore, the identification of these key intrinsic/extrinsic factors that are involved in the HLBs of the adolescents will allow for the design of specific European policies and actions that may prove more effective in improving HLBs among the target population (**Study 1:** Queral, et al., submitted).

Another way to improve HLBs is the detection of the intrinsic and extrinsic factors that act as barriers and facilitators; this method was also applied in cross-sectional study of restaurants (**Study 2:** Besora-Moreno et al., 2023) (152). Specifically, the COVID-19 pandemic offered researchers the opportunity to analyse the real situation among the population before acting, as it was example of a society undergoing constant change (158). For this reason, **Study 2** analysed how the COVID-19 pandemic was involved in changing the needs, barriers, interests, and food choices of the target population. Additionally, the results of this study showed the potential utility of analysing barriers and facilitators, as a step of PR approach, in other contexts, such as in restaurants, considering that their community influence increased up over the years (112). Hence, the use of the PR approach highlighted the importance of listening to the target population to create and implement actions that are adapted to their real situation (i.e. barriers and facilitators) (159,160).

The results of **Study 2** show that, in restaurants, the first COVID-19 lockdown increased takeaway orders, increased sanitation, and improved digital communication with customers, meanwhile customers highly valued the use of local foods in Tarragona (Spain). Therefore, based on the needs, barriers, and interests of restaurateurs and customers identified in the study, some proposals for how restaurateurs can improve and adapt to new demands are presented: a) increasing social media communication and technology in their sector, b) maintaining and updating hygiene and food security measures, c) maintaining and increasing AMed criteria (adherence to the MD in restaurants) according to customers' preferences, d) improving takeaway services, and e) strengthening the restaurant's essence (**Study 2:** Besora-Moreno et al., 2023) (152).

All the evidence presented above guided the execution of the SEEDS project, in which the European adolescents used their voices to improve their HLBs and those of their peers (151), based on a real necessity identified. Previous studies independently detected barriers and facilitators of HLBs among the target population (160,161) or directly co-created interventions with the target population without identifying barriers

and facilitators (162,163). However, little evidence exists regarding the effectiveness of analysing the barriers and facilitators of the population and then, in the same study, applying the knowledge acquired to design the co-creation process. For this reason, the SEEDS project, based on a PR approach, involves adolescents in every stage of the research; this is considered an extreme CS approach. First, the barriers and facilitators related to HLBs among European adolescents were identified and then the co-creation process was designed via a *makeathon*, using the insights gained to construct the questions that would be solved during the co-creation process (151). Thus, **Study 3** contributed to ensuring that the barriers identified during the focus groups were addressed in the co-designed interventions. However, the facilitators were not enough addressed (**Study 3:** Queral et al, submitted). Thus, based on the results obtained in the SEEDS project, the PR process used in the SEEDS project is a valid method to address the most barriers identified in the focus groups. However, the necessity to find a new way to ensure the address of facilitators in the co-creation process is highlighted, and an option could be that a list of facilitators identified during the focus groups will be available during the co-creation process for participants.

Based on the results, regarding the importance of analysing the real situation of the target population before the implementation of the interventions obtained in **Study 1, Study 2, and Study 3**, the analysis of the effectiveness of the PR approach is still in progress. For this reason, a second research gap was identified; the scarce evidence identified regarding the most effective PR approaches for improving HLBs in adolescents. To address this gap, a systematic review and meta-analysis were conducted with the aim of evaluating the effectiveness of PR interventions compared to non-PR intervention control groups on obesity and obesity-related HLBs in adolescents from HIC (**Study 4:** Queral et al., submitted). The results showed a small desired effect on fruit consumption, a small undesired effect on vegetable consumption, and no effects on PA outcomes; these findings highlighted that the heterogeneous use of the PR approaches made it

difficult to conduct a robust comparison between the PR studies with the aim of improving HLBs in adolescents, as shown by **Study 4**.

Based on the evidence provided in the present thesis and concerning the PR approach, in particular extreme CS, which were applied in the SEEDS project, this thesis presents a standardized proposal for the PR methodology used to improve HLBs, following the PAR cycle process (133), in order to facilitate the homogeneity in future studies, allowing for a comparison of effectiveness (*Figure 12).*

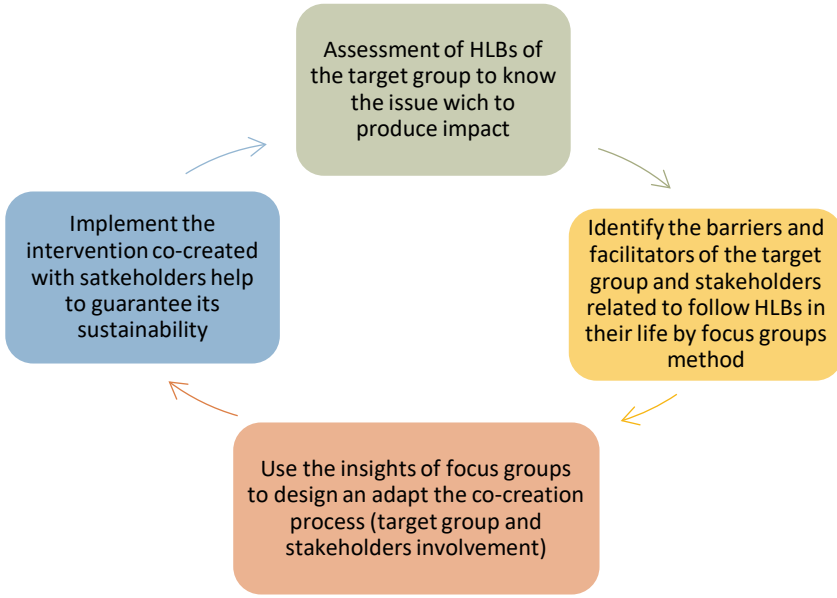

Figure 12. Standardized proposal of Participatory Research methodology. Abbreviations: HLBs, Healthy Lifestyle Behaviours. Source: designed by the author

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FUTURE PERSPECTIVES

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FUTURE PERSPECTIVES

Based on the present thesis, the author has identified future perspectives (*Figure 13*).

First, the constant assessment of the changes in time of adolescents' HLBs should be conducted. Moreover, soon, changes in time studies will provide information about the different policies implemented (the school-children fruit and vegetable policy and the sugar tax policy) during the last decade with the aims of increasing fruit and vegetable consumption and reducing the sugar consumption of European adolescents.

Second, given that the present thesis does not analyse the effectiveness of the SEEDS project, a major challenge involves elucidating the effectiveness of the SEEDS project in improving lifestyles (snacking behaviours and PA) and interest in science, based on the use of CS. Moreover, this study contributes to providing evidence about PR interventions through high-quality RCTs, such as the SEEDS project, in order to study the effectiveness of HLBs and their long-term maintenance.

As there is evidence about the relationship between healthy and science literacy and HBLs, the analysis of their association in the SEEDS project data will make a valuable contribution to the literature.

Additionally, and considering the data obtained by the SEEDS project, the relationship between health determinants and patterns of HLBs will be identified. This finding will contribute to improving the efforts to change specific determinants related to HLBs, achieving the most effective interventions.

Furthermore, this new PR approach could be applied to other target populations such as young children, who are considered a key population for tackling the obesity epidemic in Europe. This will contribute to improving the evidence regarding the effectiveness of the PR approach with high-quality RCTs.

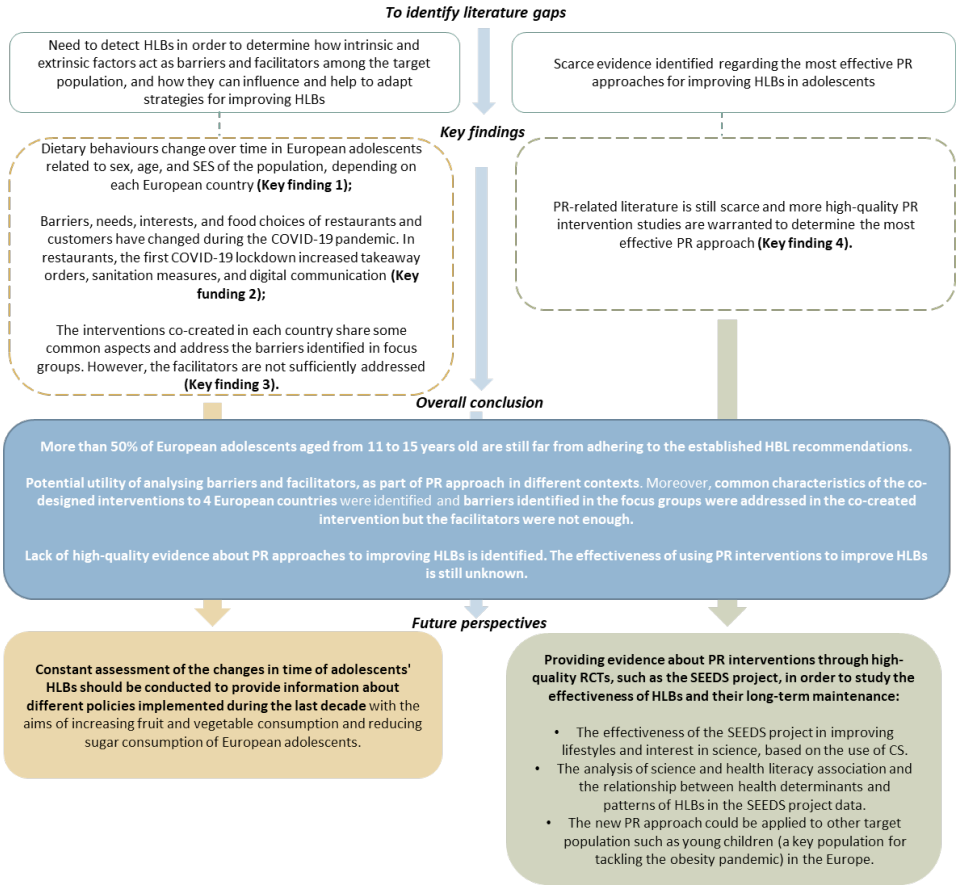
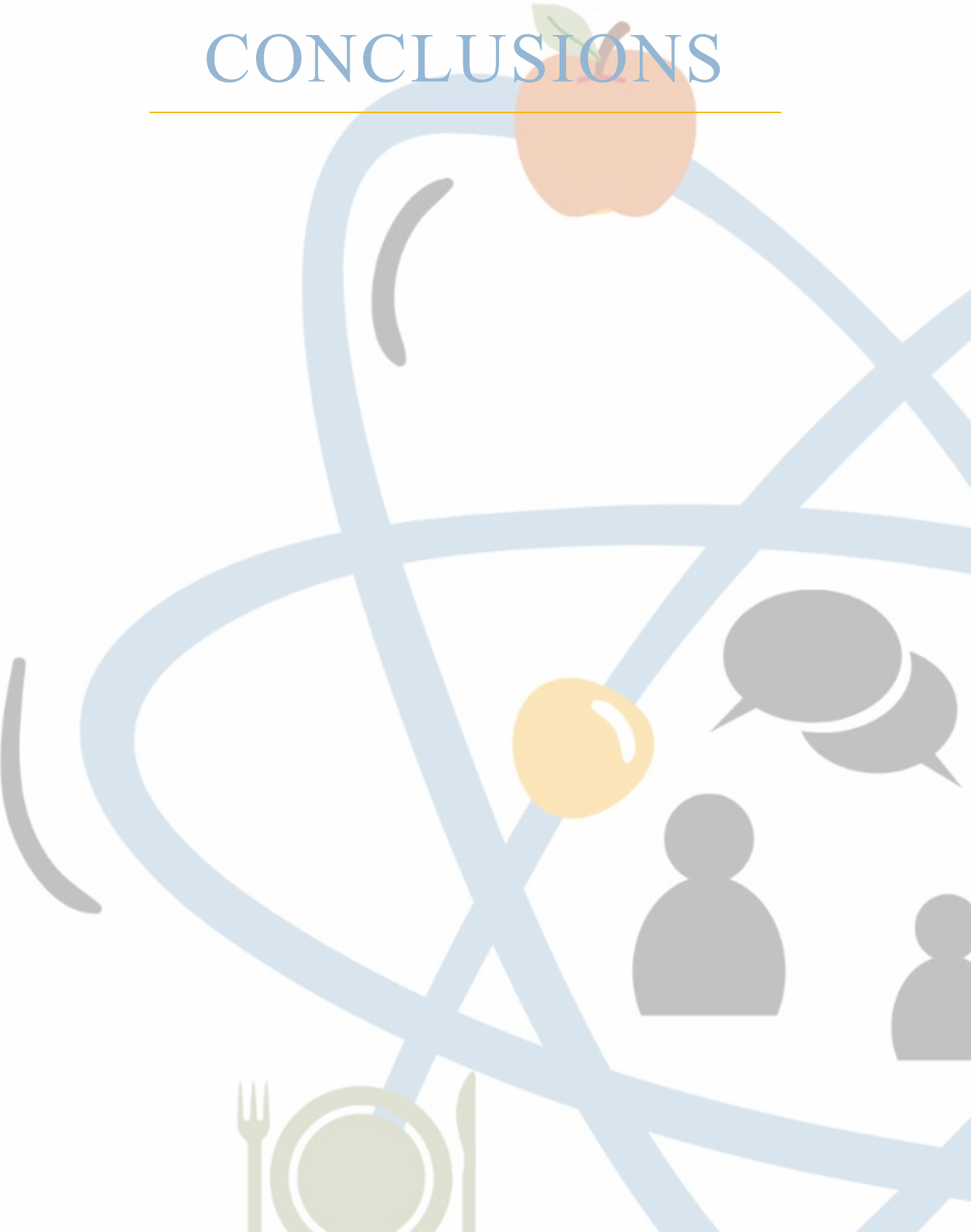


Figure 13: Future perspective of the present thesis from the results obtained. Abbreviations: HLBs, Healthy Lifestyle Behaviours; PR, participatory research; SEEDS, Science Engagement to Empower aDoleScent; CS, Citizen Science. Source: designed by the author.

CONCLUSIONS



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CONCLUSIONS

According to the results obtained in the present thesis, the following conclusions can be drawn:

1. Based on the changes in time study of dietary behaviours in 36 European countries, from 2013/14 to 2017/18, in adolescents between 11 and 15 years old **(Study 1)**:
    - A significant and positive change over time, in terms of an increase in daily fruit and vegetable consumption was shown in adolescents between 11 and 15 years old, especially in Eastern European countries; a reduction in daily sweet consumption was identified, especially in Western European countries.
    - More than 50% of 11 to 15 years old adolescents are still far from accomplishing the established HLBs recommendations (daily fruit and vegetable consumption).
    - Older adolescents (13 to 15 years old) consumed fewer fruits and vegetables and more sweets on a daily basis than younger adolescents (11 years old). In addition, girls consumed more fruits, vegetables, and sweets than boys on a daily basis.
    - Regarding SES inequality, low SES adolescents consumed fewer fruits and vegetables on a daily basis than adolescents with a medium/high SES. In low SES adolescents, a less favourable change in time for vegetable consumption was shown.
    - Studies presenting longer time-trend comparisons between European countries and including more social factors (SES, ethnicity, demographic characteristics, sociocultural education, and exposure to media) and more details regarding quantities consumed might provide further evidence.

- European policy recommendations for dietary behaviours should reflect differences according to age, sex, and SES and consider the influence of each European country.
-

2. Based on a cross-sectional study exploring intrinsic and extrinsic factors that act as needs, barriers, interests, and the food choices affected by the COVID-19 pandemic in Tarragona Province restaurants and customers **(Study 2)**:
   - The needs, barriers, interests, and food choices of restaurants and customers have changed during the COVID-19 pandemic.
   - During the first COVID-19 lockdown, restaurants showed an increase in takeaway orders, sanitation, and an improvement in digital communication with customers, while customers highlighted the importance of using local foods.
   - This study provides valuable information on how to adapt gastronomic offerings in challenging situations facilitating decision making.

3. After the SEEDS project was executed, a study was conducted to compare the co-created interventions of each of the four European participant countries **(Study 3):**
   - The co-created interventions in each country share some common aspects such as the type of activities proposed per each behaviour, who provides the activities, and address barriers identified in focus groups. However, the facilitators were not sufficiently addressed.
   - The adaptation of the interventions to the country's characteristics is a key aspect of the PR process.
   - The PR process used in the SEEDS project is a valid method to address the most important barriers identified in the focus groups. However, the necessity to find a new way to ensure the address of facilitators is highlighted.

4. Concerning the systematic review and metanalysis of PR's effectiveness in improving HLBs **(Study 4)**:
    - The meta-analysis showed a small desired effect on increase fruit consumption, a small undesired effect on vegetable consumption, and no effects on PA outcomes.
    - Limited evidence was found for some other primary and secondary outcomes, including PA practice, PA knowledge, and PA self-efficacy, due to the limited number and heterogeneity of the studies.
    - More high-quality intervention studies on PR methodologies are needed to identify the most effective PR methodologies for improving HLBs.

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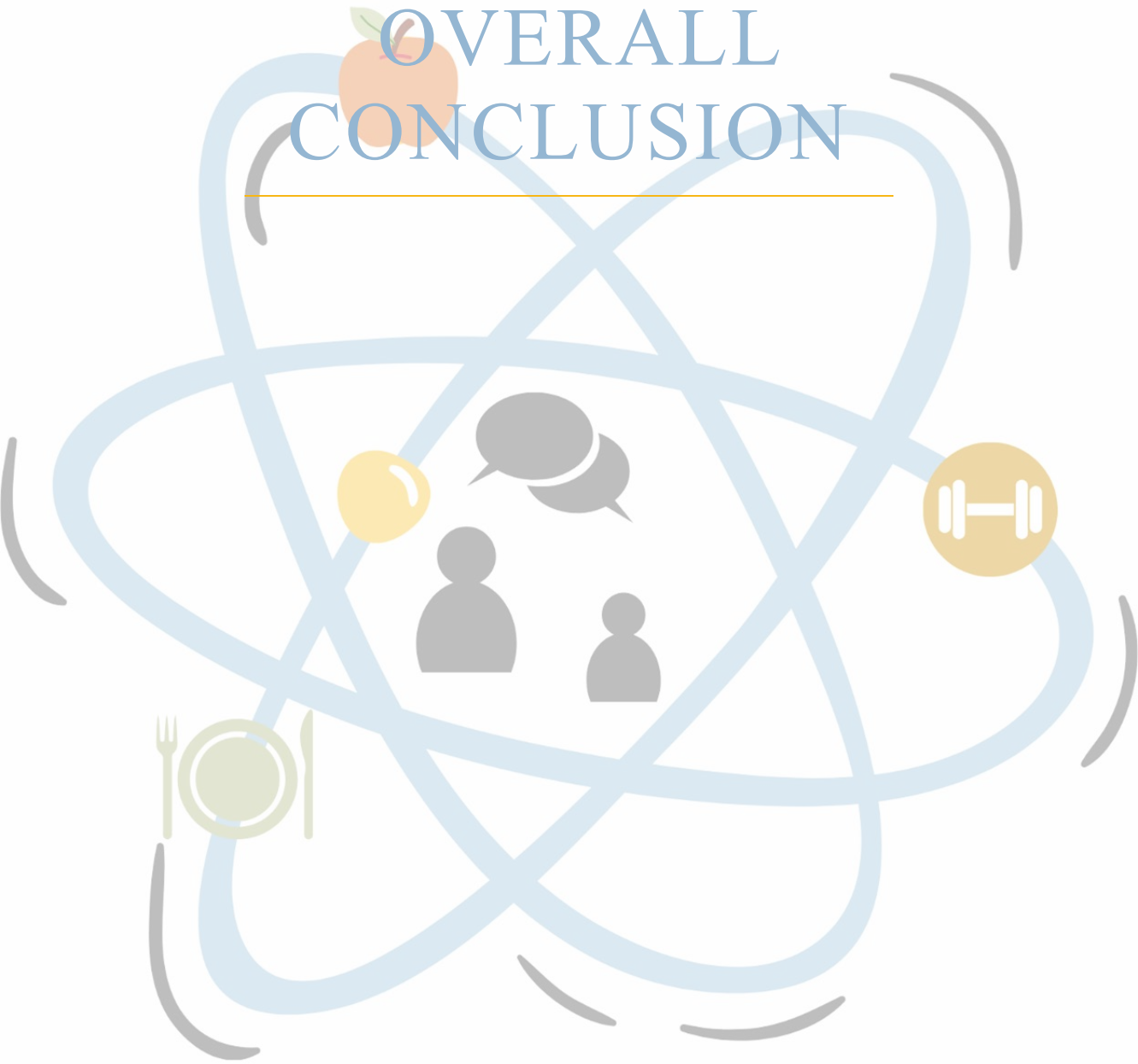
OVERALL CONCLUSION



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OVERALL CONCLUSION

According to a change in time study based on HBSC data, more than 50% of European adolescents aged from 11 to 15 years old are still far from adhering to the established HBL recommendations. Moreover, the results showed the potential utility of analysing barriers and facilitators, as part of PR approach in different contexts, such as in a health intervention aimed at European adolescents and in a study of restauranteurs that addressed the challenges of the COVID-19 pandemic. Moreover, the common characteristics of co-designed interventions of four European countries were identified, and the barriers identified in the focus groups were addressed in the co-created intervention, but not enough to address the facilitators of adolescents. Finally, lack of high-quality evidence about PR approaches to improving HLBs is identified, and the effectiveness of using PR interventions to improve HLBs is still unknown.

As an overall conclusion, the present thesis provides evidence about PR as a potential new approach to making decisions based on intrinsic and extrinsic factors that act as barriers to and facilitators of HLBs among the target population. However, high-quality evidence concerning the effectiveness of PR interventions in improving HLBs is needed.

Therefore, the most important direction for future research perspective involves analysing the effectiveness of the SEEDS project to verify whether the PR approach increases the active engagement of the target population in health intervention and effectively improves HLBs in the European adolescent population.

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