






BMJ Open Citizen Science to improve healthy and active living among adolescents in four European countries: a protocol of the cluster randomised controlled trial of the Science Engagement to Empower aDolescentS (SEEDS) project

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ABSTRACT

Introduction Improving healthy lifestyles of adolescents is challenging. Citizen Science is a way to engage them in the design and delivery of interventions, and may also increase their interest in science, technology, engineering and mathematics (STEM). The Science Engagement to Empower aDolescentS (SEEDS) project aims to use an equity-lens, and engage and empower boys and girls from deprived areas by designing and cocreating interventions to promote healthy lifestyles, and to seed interest in STEM. **Methods and analysis** SEEDS is a cluster randomised controlled trial in four countries (Greece, the Netherlands, Spain and the UK). Each country will recruit six to eight high schools from lower socioeconomic neighbourhoods. Adolescents aged 13–15 years are the target population. High schools will be randomised into intervention or control group. Each country will select 15 adolescents from intervention schools called ambassadors, who will be involved throughout the project.

In each country, focus groups with ambassadors and stakeholders will focus on physical activity, snacking behaviour and STEM. The input from focus groups will be used to shape Makeathon events, cocreation events where adolescents and stakeholders will develop the interventions. The resultant intervention will be implemented in the intervention schools during 6 months. In total, we aim to recruit 720 adolescents who will complete questionnaires related to healthy lifestyles and STEM outcomes at baseline (November 2021) and after the 6 months (June 2022).

Ethics and dissemination The four countries obtained approval from their corresponding Ethics Committees (Greece: Bioethics Committee of Harokopio University; the Netherlands: The Medical Research Ethics Committee of the Erasmus Medical Center; Spain: The Drug Research Ethics Committee of the Pere Virgili Health Research Institute; UK: Sport and Health Sciences Ethics Committee of the University of Exeter). Informed consent will be

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ A strength of this study is that the Science Engagement to Empower aDolescentS (SEEDS) interventions will be developed in cocreation with adolescents.
- ⇒ Another strength of this study is that adolescents will stay involved during implementation and dissemination.
- ⇒ Mixed methods research will be applied to evaluate the SEEDS project, which is a strength as it will provide insights in barriers and facilitators of healthy lifestyles, and the use of Citizen Science in adolescent populations.
- ⇒ A strength is that the SEEDS interventions will be developed based on the voices of adolescents in all four countries. However, a resulting limitation might be that interventions differ between countries, which can make it more difficult to find intervention effects.
- ⇒ One follow-up measurement will take place, which limits this study in not being able to show longer-term or sustained effects.

collected from adolescents and their parents in line with General Data Protection Regulation legislation. The findings will be disseminated by conference presentations, publications in scientific peer-reviewed journals and during (local) stakeholders and public events. Lessons learnt and the main results will also be used to provide policy recommendations.

Trial registration number NCT05002049.

INTRODUCTION

Many adolescents do not meet the physical activity and nutritional recommendations.¹



The Health Behaviour in School-aged Children (HBSC) survey showed that only 19% of European adolescents meet the physical activity recommendations from the WHO.^{1 2} It is important to meet the recommendations for healthy lifestyles, as for example, sufficient physical activity reduces the risk of non-communicable diseases.³ Adolescents with a sufficient level of physical activity improve, among others, in cardiometabolic health, cognitive outcomes and mental health.² In addition, most adolescents have poor eating habits, like skipping breakfast and/or a low consumption of fruit and vegetables.¹ Adolescence is an important period to promote healthy lifestyles as this is a key stage when patterns of behaviour are established.⁴ Adolescents are experts in their own behaviour, and the WHO recommends engaging young people in the design and delivery of interventions to promote healthy lifestyles.^{5 6} From a health equity perspective, it is essential to ensure that adolescents from lower socioeconomic groups are also involved in this process,⁷ as less affluent adolescents are less likely to meet the current recommendations for healthy and active living.¹

Citizen Science may be a way to actively involve young people in research projects to cocreate innovative interventions that match their needs. Health is a growing area of interest in Citizen Science.⁸ According to the SOCI-ENTIZE consortium, Citizen Science refers to ‘(...) the general public engagement in scientific research activities when citizens actively contribute to science either with their intellectual effort or surrounding knowledge or with their tools and resources’.⁹ However, there are multiple views on Citizen Science and a common definition is lacking.¹⁰ Public participation can differ from collecting data such as crowdsourcing citizens, to so-called ‘extreme Citizen Science projects’ where citizens are involved in almost all parts of the research.^{11 12}

Citizen Science projects in which adolescents are actively involved may have other positive effects, for instance, on career paths and interest in science, technology, engineering and mathematics (STEM). There is a great need for individuals trained in STEM in the future workforce, as STEM careers are associated with the most advanced and productive sectors of the job market.¹³ STEM competences are a priority for adolescents who will join the labour market shortly.¹⁴ However, the number of students choosing these career paths is declining,¹⁵ and adolescents from low-income families are less likely to choose for STEM careers.^{13 16} Furthermore, a significant gender bias is seen, where only 1 out of 10 European girls are interested in pursuing a STEM career, compared with 3 out of 10 boys.¹⁴ Therefore, an equity-perspective that focusses on gender and socioeconomic status (SES) is warranted when studying STEM as an outcome in research projects. Participatory research methods, like Citizen Science, may greatly impact STEM interest, related skills and knowledge in youth, but can also raise awareness about their communities, the possibilities to make a change and the following actions in their own environment.¹⁷

The Science Engagement to Empower aDolescentS (SEEDS) project is designed to tackle both challenges, (a) promoting healthier lifestyles and (b) increasing STEM interest among adolescents from deprived areas. This multi-country project aims to listen to adolescents living in deprived areas and to empower them to make a change towards a healthy and active lifestyle, as previous research shows that adolescents from deprived areas lack to meet guidelines regarding healthy lifestyle behaviours.¹ In the SEEDS project, adolescents will have a key role in the cocreation process and the delivery of the intervention, as the WHO and previous studies recommended to actively engage adolescents in the research process.^{5 6} By doing so, we aim to increase STEM interest of adolescents from deprived areas, since they are less likely to choose for a STEM career.^{13 16} The SEEDS project will be evaluated through a cluster randomised controlled trial (c-RCT) on healthy and active living and STEM outcomes.

METHODS

Study design and timeline of the SEEDS project

SEEDS is a multi-country c-RCT in four European countries reflecting North Western and Southern Europe: Greece, the Netherlands, Spain and the UK. This project will target high schools located in neighbourhoods within the lowest tertile of SES indicators in each country.

This study uses a mixed methods design and compares the outcomes of adolescents in intervention high schools with the outcomes of adolescents in control high schools. Adolescents from the intervention high schools will be exposed to the SEEDS intervention, whereas control high schools will follow their regular curriculum. The SEEDS interventions include cocreation events with adolescents and stakeholders during which the intervention will be developed (Makeathon events) and an implementation phase. Adolescents will complete questionnaires (translated to their local language) related to healthy and active living and STEM outcomes at baseline (November 2021) and after 6 months (June 2022). A flowchart of the study is presented in figure 1.

High schools that are willing to participate will be randomised at a ratio of 1:1 within each country. Randomisation will be done by the researchers from each country and take place on the country level as the Makeathons and interventions will run at the same level. The randomisation code will be computer generated with Research Randomizer software (Geoffrey C. Urbaniak and Scott Plous, Lancaster, PA, USA).¹⁸ The allocation will not be blinded due to the nature of the intervention.

Recruitment and eligibility of high schools, adolescents and stakeholders

High schools will be recruited from low-income or deprived neighbourhood areas. The indicators used to define these neighbourhoods per country are presented in online supplemental appendix 1. Schools will receive an information letter with an explanation of the study, and

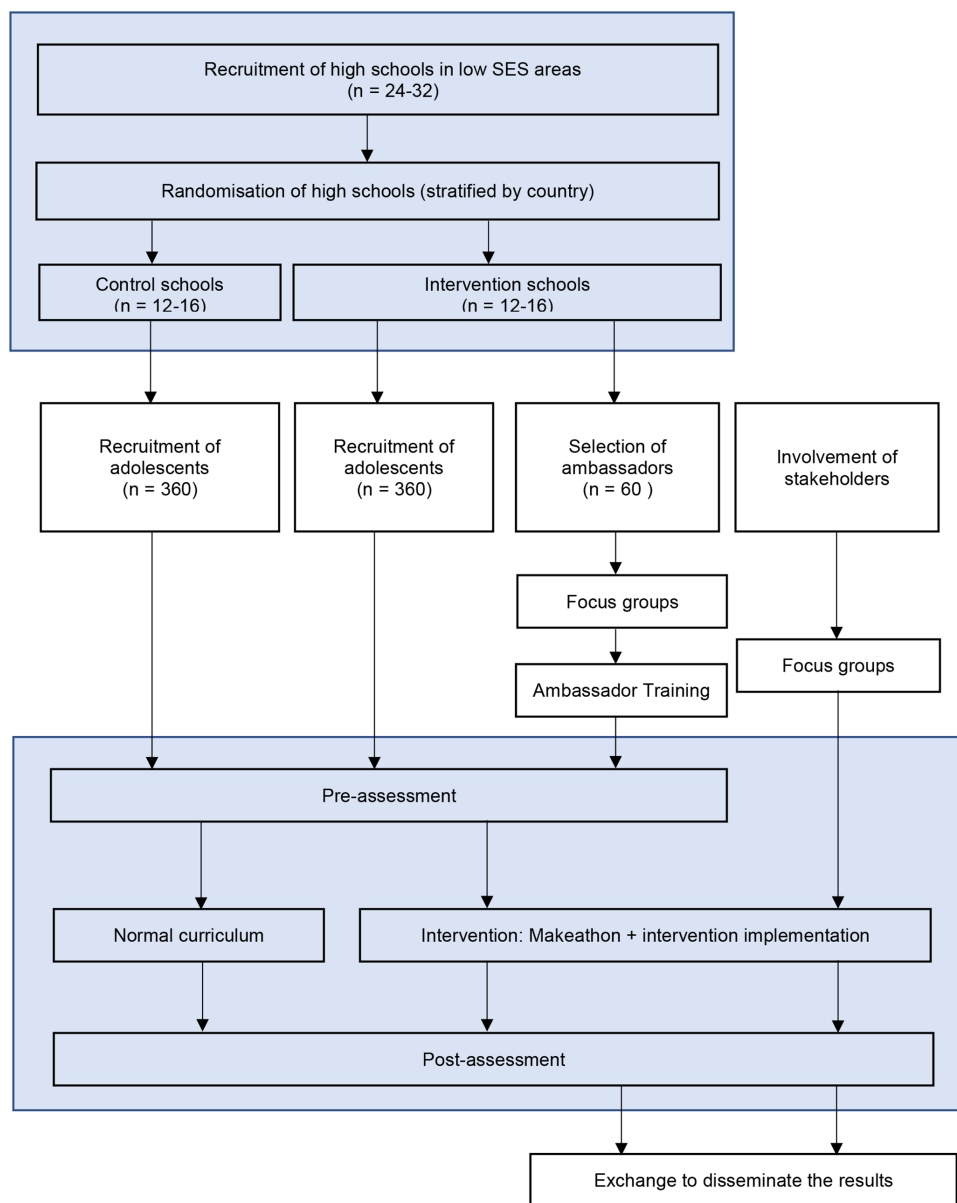


Figure 1 Flowchart of the Science Engagement to Empower aDolescentS project. SES, socioeconomic status.

once schools have agreed to participate in this project, they will be randomised. We aim to recruit 720 adolescents aged 13–15 years old from 24 to 32 high schools (6–8 high schools per country). Per country, this results in 90 adolescents from intervention high schools and 90 adolescents from control high schools. Our target population are adolescents aged 13–15 years old, so we will only recruit classes with pupils that are on average within this age range without further inclusion or exclusion criteria. There are no individual incentives or rewards for participation in this study. Both the adolescents and their parents/caregivers will complete an informed consent form before participation in the study, following General Data Protection Regulation (GDPR) legislation and ethical standards for each country. An example of the participant consent form for adolescents is provided in online supplemental appendix 2. Informed consents will be stored at a secured driver with restricted access

at each institute. Ethical approval is obtained for all four countries.

Three different groups will participate in SEEDS:

- ▶ Adolescents: all participating adolescents from high schools, from both intervention and control schools.
- ▶ Ambassadors: in each country, 15 adolescents from different intervention high schools will be selected. These adolescents will be called ambassadors.
- ▶ Stakeholders: important members of the Quadruple Helix relevant to the outcomes will be involved. The SEEDS project is rooted in the Quadruple Helix model including four sectors: government, community, business and academia.¹⁹ The SEEDS project focuses on public engagement by bringing together key players in both science and society, with a well-tailored local representation of stakeholders from the Quadruple Helix. The SEEDS project aims to foster the participation of adolescents who will actively participate in the

decision-making process along with members of, for example, local businesses, policy makers, civil society organisations or research institutes.

Phases of the SEEDS project

The different phases of the SEEDS project are visualised in figure 2. Below we describe each activity in more detail.

Phase 1: recruitment

► Recruitment of ambassadors

Per country, 15 ambassadors from different intervention high schools will be selected by teachers based on their leadership skills,^{20 21} their level of English and willingness to participate in SEEDS as ambassador (online supplemental appendix 3). Teachers will make sure the selected ambassadors are a good representation of their school or the different classes participating. Selected ambassadors will participate in the whole SEEDS project including the design and implementation of the intervention, interpretation of the data and dissemination of the findings.

Phase 2: focus groups

► Focus groups with ambassadors and stakeholders

Focus groups with ambassadors and stakeholders will be conducted. At least one focus group with ambassadors and one focus group with stakeholders will be conducted in each country. Focus groups will have a

maximum duration of 75 min, will be audio-recorded, transcribed and translated into English. Focus groups will be delivered in person or online, depending on the COVID-19 situation in the country. The question route of focus groups is based on the Theory of Planned Behaviour.^{22–24} The aim of the focus groups with ambassadors is to gain insights into the barriers and facilitators of key behaviours related to healthy and active living. Furthermore, the focus groups will provide input on how science and technology could help to change these behaviours and how to engage teenagers in all phases of the project.

Depending on the key behaviours adolescents want to address during the intervention phase, stakeholders will be invited to participate in focus group sessions. They will reflect on the barriers and facilitators the ambassadors have identified, indicate the feasibility of changing those behaviours during the 6-month intervention, identify ways stakeholders can support adolescents overcoming those barriers, and reflect on how science and technology could help to change these behaviours.

To ensure the feasibility and the Citizen Science approach, the results of the focus groups will guide the Makeathons and the intervention phase. Furthermore, those results are used for defining the primary and secondary outcomes and composing the

Phase 0	Preparation of Ethical approval	Ethical approval*
Phase 1	Recruitment of participants	Recruitment of high schools
		Randomisation of high schools
		Selection of ambassadors
		Involvement of stakeholders
Phase 2	Focus groups	Focus groups with ambassadors
		Focus groups with stakeholders
		Training of ambassadors
Phase 3a	Assessment	Pre-assessment by questionnaires (lifestyle and STEM outcomes)
Phase 4	Intervention	Makeathon events with ambassadors and stakeholders
		Development of intervention protocol
		Intervention implementation
Phase 3b	Assessment	Post-assessment by questionnaires (lifestyle and STEM outcomes)
Phase 5	Dissemination	Dissemination of the project

Figure 2 Timeline of the Science Engagement to Empower aDolescentS project with different phases. *The questionnaires and intervention will be defined during the focus groups and Makeathon with ambassadors and stakeholders. Therefore, an amendment to the ethical approval at different time points is needed in some countries. STEM, science, technology, engineering and mathematics.

Table 1 Programme of the SEEDS ambassador training

Module	Goal	Content
Module 1. Introduction to the SEEDS project	To inspire ambassadors about the SEEDS project, make them curious about science and get them involved	<ul style="list-style-type: none"> ▶ Introduction to the SEEDS project and Citizen Science ▶ Introduction to health, lifestyles and the health behaviours
Module 2. Research training	To introduce ambassadors to the versatility of research	<ul style="list-style-type: none"> ▶ Introduction into the core principles of research ▶ Data collection and data analysis ▶ Ethics
Module 3. Makeathon training	To prepare ambassadors for the Makeathon event, to make them feel valuable and confident to question and work through ideas	<ul style="list-style-type: none"> ▶ Introduction into Makeathons ▶ Skills training

SEEDS, Science Engagement to Empower aDolescentS.

questionnaire for premeasurement and postmeasurement. Therefore, focus groups are held with ambassadors before collecting the baseline data and before the interventions actually started.

▶ Ambassador training

Ambassadors will be trained to lead the SEEDS project in their class, school and country. The basic training of ambassadors consists of tutorials and exercises to practice the theoretical aspects outlined in [table 1](#). The programme can be extended with optional activities that differ in each country. For example, the ambassadors can be invited for a tour at the research institute. Training will be delivered in person or online, depending on the COVID-19 situation in the country.

Phase 3a and 3b: assessment

▶ Evaluation of the SEEDS project

To evaluate and compare if students adopted healthy lifestyles and if STEM outcomes have changed, all adolescents from intervention and control schools will complete questionnaires related to healthy and active living and STEM outcomes at baseline (before Makeathons in November 2021) and at follow-up (June 2022). The questionnaires include parts of validated and non-validated questionnaires detailed in the outcomes section. Data will be shared at a secured driver following general guidelines. Procedures were approved by the Data Protection Officers of each institute.

A process evaluation of the SEEDS project will be conducted using information on the course and results of the Makeathons as well as on the implementation of the intervention.

Phase 4: intervention

▶ SEEDS Makeathons: the cocreation event

Makeathons are organised to facilitate the cocreation of interventions.^{25 26} Each country will facilitate one or multiple Makeathon(s) where teams of ambassadors, interested adolescents from intervention high schools and stakeholders will create, develop and test

interventions using the input from the focus groups. Each team will be supported by a young facilitator (eg, university student or PhD student) making sure the team follows all steps and everyone is involved in the Makeathon event. Makeathons will have an average duration of 2–5 hours. The different steps within the Makeathons are explained in [figure 3](#). The covered behaviour change challenges will be the same in every country. The exact formulation of these challenges will be decided after the focus groups, but will be in line with being more physically active and pursuing a healthier diet. A third health behaviour adolescents feel is important to change is optional. Makeathons will be delivered in person or online, depending on the COVID-19 situation in the country. Each country decides to host one Makeathon per intervention high school, or a single Makeathon for all intervention high schools combined, depending on the COVID-19 situation and feasibility of each country and involved high schools. Researchers and facilitators will be present at each Makeathon to support the groups wherever needed, but without participating in the event. Stakeholders will be clearly briefed to ensure they create equitable relationships with the adolescents and that they do not diminish or demean their voices or ideas. Outcomes of the Makeathons will define the themes of interventions and concepts, the number of associated activities, and how the activities should be disseminated and implemented. Makeathons are considered as part of the intervention as adolescents actively participate in this event.

▶ SEEDS intervention

Each country will implement an intervention to improve determinants or health behaviours. An intervention protocol will be developed in each country to guide the implementation of the intervention. The duration, intensity and activities of the intervention will differ between countries, but the intervention implemented within each country will be the same in all participating intervention high schools. The

intervention may be implemented by ambassadors or adolescents (a peer-led approach) or by others (eg, the research team or stakeholders), and will target individual behaviours, environments, structural elements or a combination of before mentioned. Ambassadors and stakeholders will be engaged in the development of policy recommendations focused on the lessons learnt from the design and implementation of the interventions.

Outcomes

The SEEDS questionnaire used is presented in online supplemental appendix 4. Primary outcomes are the same for all countries and relate to the main aims of the SEEDS project: lifestyle behaviour and STEM. Although ambassadors are more involved in the scientific process, related to STEM, a spill-over effect to other adolescents in intervention high schools is expected as ambassadors are involved in implementation and delivery of the activities. Secondary outcomes include determinants of lifestyle behaviours, which are the same for all countries. An additional behavioural outcome varies by country and is therefore defined as a secondary outcome.

Primary outcomes

Lifestyle-related outcomes:

- ▶ Physical activity and prolonged sedentary time: outcomes will be assessed by a selection of validated questions of the HBSC study²⁷ and Physical Activity Questionnaire for Children.²⁸

- ▶ Snacking choices inside and outside school: outcomes will be assessed by the validated questions of the HBSC study.²⁷ We included a list of snack options from the HBSC study, and additionally included snacks frequently consumed by adolescents in each country.

STEM outcomes:

- ▶ Interest in life science: outcomes will be assessed by a selection of questions from the validated STEM interest survey.²⁹
- ▶ ‘Science Capital’: outcomes will be assessed by a selection of questions from the validated Science Capital survey.³⁰ Science capital refers to science-related cultural and social capital, but also science-related behaviour, for example, scientific literacy, science job affinity or attitudes or knowledge regarding science.³⁰
- ▶ Interest in STEM career pathways: outcomes will be assessed by a selection of questions from the validated Attitude towards STEM questionnaire.³¹

Secondary outcomes

- ▶ Health-related behaviour: as SEEDS is a Citizen Science project, during the focus groups ambassadors might choose additional behaviours that are not among the primary outcomes, they would like to address during the Makeathons and implementation phase. Questions to capture this additional behaviour will be added by each country.
- ▶ Determinants of each of the behaviours: according to the Theory of Planned Behaviour^{22–24} the main

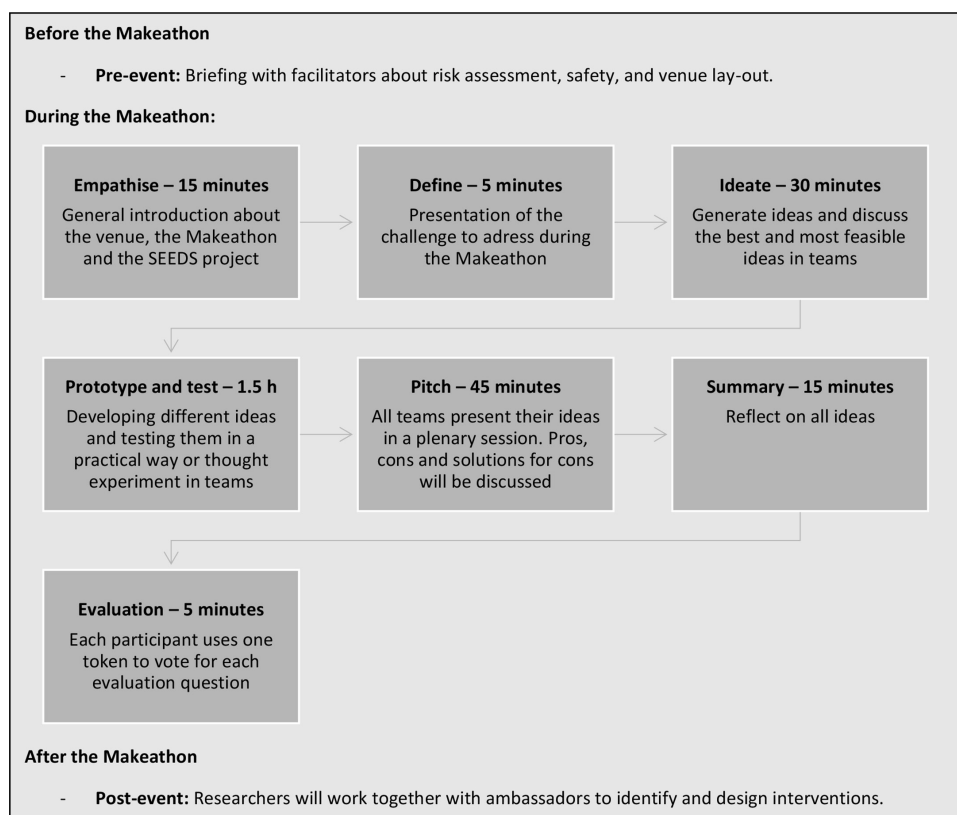


Figure 3 Steps and timeline of the SEEDS Makeathons. SEEDS, Science Engagement to Empower aDolescentS.

determinants of behaviour are attitudes, beliefs, subjective norms and perceived control, which all shape the behavioural intentions. For this purpose, several questions will be included to assess the determinants of behaviours, mainly related to attitudes and environmental factors, also considering the results of the focus groups, according to the guidelines provided by Ajzen.²²

Sociodemographic characteristics

- Questions will include gender, age, grade, level of education, country of birth of the child, country of birth of the parents and the validated Family Affluence Scale from the HBSC study.²⁷

Sample size

A statistical power analysis, using the UCSF calculator,³² was performed for the estimation of sample size for an anticipated difference in outcomes between intervention and control group, considering clustering at the school level. With 12 schools as clusters in the intervention group and accepting a type I error of 0.05 and at least 80% power, 720 subjects (360 in each group) are required for achieving an effect size of 0.35 with an intra-class correlation coefficient of 0.06 in physical activity changes. According to Cohen, 0.35 is the middle term between a small (0.2) and a moderate effect (0.5).^{33 34} According to the HBSC study, the mean and SD used are 4.17 and 2.07 days a week, respectively.

Statistical analysis

Continuous data that follow normal distribution will be presented as mean±SD, not normally distributed data as median (IQR) and categorical data as n (%). Comparisons of intervention and control groups at baseline will be examined using Student's t-test, the non-parametric Mann-Whitney tests, or Pearson's χ^2 test. Multiple imputation techniques will be used to handle missing data and a number of datasets will be generated based on the amount of missing data. Meta-analysis of the generated datasets will be performed to calculate the desired parameters. The effectiveness of the intervention will be evaluated using a multilevel mixed model controlling for sociodemographic characteristics and taking clustering at the school level into account. The intra-cluster correlation coefficients will be calculated.

Although power might be limited, we will conduct a subgroup analysis by country to explore if effects differ per country. As interventions and the targeted behaviour likely differ between countries it is important to provide these insights. Additional subgroup analyses will be performed for sociodemographic variables.

Two-sided p values<0.05 will be considered statistically significant.

Patient and public involvement

Participants and/or the public were not involved in obtaining funding or creating the SEEDS protocol. The European Citizen Science Association was involved in

obtaining funding and participates throughout the rest of the SEEDS project.

In this Citizen Science project, ambassadors and stakeholders will play a key role in all stages of the project.

Ambassadors will share their insights in focus groups and their input on barriers and facilitators of key behaviours related to active and healthy living and their experience will guide the formulation of the questions for the SEEDS Makeathons. Moreover, during the focus groups they can choose a third behaviour corresponding to healthy lifestyle that should be addressed during the Makeathon. In the SEEDS Makeathon, they will create, develop and test intervention ideas. Ambassadors will also be engaged in the development of the intervention and will be involved in the implementation of the final intervention, for instance, by guiding, delivering or promoting implementation, depending on the developed intervention in each country. In addition, ambassadors will be invited to participate in the dissemination SEEDS conference in Brussels, where ambassadors will share findings with ambassadors from the other pilot-countries, their peers who can attend virtually, stakeholders and researchers. In addition to the final conference, ambassadors will participate in other local dissemination events with, for example, policy-makers and stakeholders.

Stakeholders will participate in focus groups and their input on barriers and facilitators of key behaviours related to active and healthy living and their experience will be guiding the formulation of the questions for the SEEDS Makeathons. Furthermore, with their expertise and experience they will support ambassadors during the Makeathon. After that, they will be addressed for the development of the final intervention. During the intervention, they might be involved in implementation of different intervention components.

Both ambassadors and stakeholders will be involved in dissemination and the creation of policy recommendations.

DISCUSSION

Rooted in Citizen Science, the SEEDS project aims to engage and empower adolescents from deprived neighbourhoods in designing and co-creating interventions to promote healthy and active lifestyles, to seed interest in scientific methodologies and to promote STEM careers. The SEEDS project will be evaluated by means of a c-RCT with a mixed methods design. We will build on the qualitative data, in the form of focus groups with adolescents and stakeholders, to set the direction of the activities within SEEDS. We will evaluate the effects of the developed intervention on healthy lifestyles, and the effects of participating in a scientific project on STEM outcomes.

The latest HBSC international report revealed that adolescents are far away from healthy lifestyles.¹ The SEEDS project aims to advance in the field of health promotion by using Citizen Science, a relatively new approach within public health.³⁵ King *et al* used a youth-engaged



Citizen Science model to promote health equity in the community. Young people have been engaged in several participatory research processes and even all 20 projects involved youth in data collection, analysis and interpretation.³⁶ When looking broader at community based participatory research with youth, 23 out of 56 studies in the review of Jacques *et al* focused on health-related topics. Overall in this review, youth most often participated in identifying research goals, designing and conducting the research.³⁷ Although Citizen Science and participatory methods are an upcoming area of research, there is great variety in frequency and intensity of youth participation in the research process.^{36 37} King *et al* highlight that schools are relevant locations for actively engaging youth in participatory approaches to improve their local school environments,³⁶ which can be one of the focus points in the SEEDS interventions.

Advantages of using a Citizen Science approach include the increased research capacity, better knowledge usage and citizen benefits.³⁵ Within SEEDS, we involve adolescents in each step of the project to create better interventions, and to ensure that benefits of the project reach the adolescents involved. During the SEEDS Makeathons, we will bring people from different backgrounds together to accelerate the innovation process and facilitate knowledge exchange.³⁸ The most important aspects of the SEEDS Makeathon are cocreation between adolescents and stakeholders, learning from each other and networking. Therefore, the focus of Makeathons is on the cocreation process, not solely the resultant intervention. As a result, we will evaluate the effects of participating in a science project on STEM outcomes.

We need more people educated in STEM to meet future labour demands resulting from the social and economic transformation.³⁹ Literature is scarce about Citizen Science and cocreation for improving the STEM skills and interest of adolescents. A review showed the potential of STEM activities to increase students problem solving and creativity skills, and attitudes towards STEM disciplines.⁴⁰ Adolescents from low SES are underrepresented in STEM education and careers⁴¹ and it is necessary to put special interest on this group to improve their STEM interest. Therefore, we focus on adolescents growing up in lower SES neighbourhoods in four European countries.

The SEEDS project aims to involve stakeholders from the Quadruple Helix into the project. This will ensure that key players in the field of healthy lifestyles and STEM are brought together to reflect on health promotion and STEM interest. Stakeholders will participate in the focus groups and support the adolescents throughout the project in developing and implementing interventions. When disseminating the results, we will also collaborate with local policymakers and other important stakeholders.

Characteristics of the SEEDS project are summarised in [box 1](#). Strengths of this study include that adolescents in four European countries are in the lead of creating novel interventions to be implemented at their schools. Therefore, we expect to contribute new insights. First, we

Box 1 Overview of the SEEDS project

Population involved in SEEDS

- ⇒ Adolescents aged 13–15 years old from high schools in low SES neighbourhoods.
- ⇒ Ambassadors from intervention schools.
- ⇒ Stakeholders from the national and local community following the Quadruple Helix.

Intervention

- ⇒ Citizen Science project empowering adolescents to create a change.
- ⇒ Cocreation of health interventions during Makeathon events with ambassadors and stakeholders.
- ⇒ Implementation of the intervention in school year 2021–2022.

Control condition

- ⇒ Adolescents aged 13–15 years old from control high schools in low SES neighbourhoods, not receiving any of the SEEDS activities.

Outcomes of the SEEDS project

- ⇒ Understanding of barriers and facilitators towards active and healthy living.
- ⇒ Development of Makeathon methodology for cocreation events with ambassadors and stakeholders.
- ⇒ Evidence on effectiveness of interventions on physical activity and healthy snacking.
- ⇒ Evidence on effectiveness of participating in a science project on STEM outcomes.
- ⇒ Policy recommendations to guide future projects involving adolescents through Citizen Science.

SEEDS study design

- ⇒ Focus groups with adolescents and stakeholders.
- ⇒ Effect study on changes in physical activity, healthy snacking and STEM outcomes.

SEEDS, Science Engagement to Empower aDolescents; SES, socioeconomic status; STEM, science, technology, engineering and mathematics.

aim to provide new insights in how adolescents and local stakeholders describe and perceive the main barriers and facilitators related to a healthy and active living. Second, we aim to provide an understanding of how Makeathon events can be used to bring adolescents and stakeholders from the Quadruple Helix together, supporting adolescents in creating interventions. Third, this study will show if the SEEDS activities and intervention created a change in adolescents' behavioural and STEM outcomes. Fourth, the insights that will be gathered will pertain to adolescents living in more deprived areas and therefore have the potential to contribute to the reduction of socioeconomic inequalities in health.

This project will also have some limitations. First, needs are likely to be context-specific and might differ between countries. Therefore, interventions in all four countries may differ. It might be more difficult to compare interventions and find intervention effects due to this difference. At the same time, it is important that the intervention will meet the needs of adolescents in each country. Additional subgroup analyses by country will explore intervention specific effects and clustering at the school level will account for implementation differences.

To allow for comparison, we selected the same core questions on physical activity and snacking behaviour in all countries and used standardised protocols for cocreation and assessment tools. In this way, we will minimise the risk that the results cannot be compared between countries, without restricting diversity in the intervention's design. A second limitation is that we will use a self-reported questionnaire to capture changes in behaviour, which might lead to bias.⁴² Most of the questions are derived from commonly used, validated questionnaires. We will be able to compare behaviours in our population with reference populations participating in the HBSC study. Finally, our follow-up measurement will take place at the end of the school year, 6–8 months after the baseline measurements and 4–6 months after implementation of the interventions. According to the theory of Prochaska and DiClemente, a duration of at least 6 months is needed for behaviour change to stabilise when it involves physical activity.⁴³ This time window is likely sufficient to measure short term interventions effects, but longer term or sustained intervention effects will not be measured unless additional funding can be found.

Additionally, our study runs in a period (2021–2022) characterised by the COVID-19 pandemic. This poses additional risks for recruitment, data collection and implementation of interventions in schools that may face lockdown measures. We will mitigate this risk by allowing for a flexible study protocol, for example, allowing for an online delivery of the focus groups and Makeathons. Furthermore, the influence of COVID-19 on the external validity of our study cannot be ruled out. It is possible that the barriers adolescents face may be induced by the COVID-19 pandemic, and therefore the resultant intervention may differ from interventions that would have been created in other school years.

ETHICS AND DISSEMINATION

The SEEDS consortium will disseminate the findings from this study by conference presentations and scientific peer-reviewed journals. The findings will also be disseminated to the adolescents, high schools and stakeholders via our website, social media and information packages. Furthermore, together with ambassadors and stakeholders, we will be exploring other relevant routes to reach our target audience.

Lessons learnt from the design and implementation of the SEEDS intervention together with the main results of the evaluation will be used to provide policy recommendations for implementing and fostering the Citizen Science approaches to improve health behaviours and STEM outcomes at population level.

Due to the Citizen Science approach and using the results of focus groups in defining the primary and secondary outcomes and composing the questionnaire for premeasurement and postmeasurement, the trial was registered after the first focus group, but before collecting baseline data at the start of interventions. All

SEEDS activities will follow the principles of the Declaration of Helsinki,⁴⁴ the International Conference on Harmonization Good Clinical Practice guideline,⁴⁵ and the GDPR. This study protocol follows the Standard Protocol Items: Recommendations for Interventional Trials 2013 guideline⁴⁶ (online supplemental appendix 5).

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).

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