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Article

Evaluating the KickAsh!-intervention's effectiveness in preventing smoking among vulnerable Flemish adolescents: a non-randomized cluster-controlled trial

Kenji Leta [1]*, Emelien Lauwerier[1,2], Sara Willems[1], Babette Demeester[1], Veerle Van Oeckel[1], Maïté Verloigne[1]

[1]Department of Public Health and Primary Care, Ghent University, Corneel Heymanslaan 10, Ghent 9000, Belgium
[2]Department of Health Psychology, Open Universiteit, Valkenburgerweg 177, Heerlen 6419, the Netherlands
*Corresponding author. Department of Public Health and Primary Care, Ghent University, Corneel Heymanslaan 10, Ghent 9000, Belgium.
E-mail: kenji.leta@ugent.be

Abstract

Adolescents experiencing societal vulnerability are at heightened risk of smoking uptake, exacerbating health disparities. To address this, the KickAsh!-intervention was co-created with adolescents and youth workers in Flanders, Belgium, using the intervention mapping protocol (IMP), aiming to prevent smoking uptake among 10- to 16-year-olds, particularly those from disadvantaged backgrounds. This study evaluates its effectiveness on adolescents' smoking initiation behaviour and related determinants: smoking intention, attitude, self-efficacy beliefs, coping planning, perceived subjective norms, perceived social pressure, risk perception, and perceived smoking behaviour of peers and youth workers. A non-randomized cluster-controlled trial was conducted across 23 youth social work organizations, with 12 implementing the intervention over four months. Co-creation organizations were pre-assigned to the intervention group. Data were collected via questionnaires at baseline, post-intervention, and seven-month follow-up (total $N = 670$; mean age = 12.85 years, SD = 2.40; 63.2% boys). Generalized linear mixed models (GLMMs) in R were used to analyse intervention effects. A significant intervention effect was found for coping planning at post-test ($B = 0.57$, SE = 0.28, $P = .04$) and follow-up ($B = 1.32$, SE = 0.29, $P < .001$), with intervention participants showing an increase in preparing strategies to resist smoking. No significant effects were observed for smoking initiation behaviour or other determinants. This study found that combining co-creation with the IMP to develop a smoking prevention intervention yielded limited effects. High anti-smoking baseline levels and irregular adolescent attendance may have limited impact, highlighting challenges for implementing and evaluating interventions in youth social work settings.

Keywords smoking prevention, socially vulnerable adolescents, co-creation, youth social work, health inequalities

Contribution to Health Promotion Statement

- This study contributes to health promotion research by illustrating how co-creation enables the development of context-responsive interventions that reflect the lived experiences of adolescents and youth workers and align with practical realities of youth social work settings.
- The intervention was evaluated in youth social work settings, which offer a promising context for smoking prevention and health promotion among vulnerable adolescents by reducing financial and cultural barriers and focusing on emancipation.
- Given the limited changes observed in smoking-related outcomes, this study provides recommendations to improve the implementation and evaluation of health promotion interventions in youth social work settings.

Introduction

The global public health crisis stemming from the tobacco epidemic is of paramount concern, with over 8 million individuals affected by smoking-related diseases annually (Reitsma *et al.* 2021). Of particular concern is the vulnerability of adolescents to smoking initiation (i.e. the process of starting to smoke for the first time), due to the biological susceptibility of the adolescent brain to addiction (Goriounova and Mansvelder 2012, Yuan *et al.* 2015, Marcon *et al.* 2018). This predisposition elevates the

risk of developing harmful dependence and chronic diseases (e.g. cancer and cardiovascular diseases) throughout the life course (Hanson and Gluckman 2011, Wellman *et al*. 2018). Particularly relevant is directing attention to adolescents facing societal vulnerability (e.g. living in poverty, minority status, migration background), given their increased exposure to peer-induced smoking (Hiscock *et al*. 2012), residence in communities that endorse or encourage smoking (Arora *et al*. 2010), lower awareness and underestimation of tobacco's harm (Arora *et al*. 2010, Hiscock *et al*. 2012), and easy access to cigarettes (Novak *et al*. 2006, Arora *et al*. 2010, Siahpush *et al*. 2010). These factors not only heighten their likelihood of smoking initiation but also contribute to widening socioeconomic health disparities that tend to deepen over time (Wellman *et al*. 2018). Consequently, it is important to develop targeted intervention programmes tailored to these adolescents before the initiation of smoking (Stringhini *et al*. 2017, Wellman *et al*. 2018, Barrington-Trimis *et al*. 2020), thereby reducing the disproportionate burden of smoking-related health outcomes and narrowing associated health disparities (Marmot 2006, Wellman *et al*. 2018). Given that the average age for initiating smoking in Belgium is 16.6 years (Gisle *et al*. 2018), which is below the legal age for purchasing tobacco products (18 years), directing intervention programmes towards adolescents below this age threshold would likely be most effective (Nuyts *et al*. 2018, Xing *et al*. 2022).

Identifying the most suitable context for reaching adolescents experiencing societal vulnerability is crucial to ensure effective engagement in interventions. Schools are convenient settings in which health-promoting interventions for adolescents can be developed and implemented. They allow programmes to reach large groups of young people in a structured environment, where predictable schedules make it easier to integrate prevention activities consistently into daily routines (Arora *et al*. 2013, Thomas *et al*. 2013). However, adolescents experiencing societal vulnerability appear to be generally less motivated and engaged through these kinds of school-based programmes, indicating the need for out-of-school interventions (Bullock *et al*. 1996, de Vries *et al*. 2007). Given these considerations, we collaborated with adolescents participating in youth social work organizations and youth workers, who act as their primary point of contact in youth social work contexts (Van der Veken *et al*. 2020), to develop the KickAsh! smoking prevention intervention (Leta *et al*. 2023).

The KickAsh!-intervention targets individual and environmental determinants influencing smoking initiation behaviour, using creative intervention elements, such as smoke-free games and mood boards, that are informed by adolescents' lived experiences, alongside theory and scientific evidence (Leta *et al*. 2024). The intervention mapping protocol (IMP) (Bartholomew *et al*. 2016) and the double diamond model (DDM) (British Design Council 2026) were used during the co-creation of this intervention. For more information on the development of the KickAsh!-intervention see elsewhere (Leta *et al*. 2024, Demeester *et al*. 2025).

Following its development, the KickAsh!-intervention was implemented within youth social work organizations, particularly those offering accessible sports, leisure, and creative activities to prevent smoking initiation among adolescents aged 10–16, with a particular focus on those experiencing societal vulnerability. This study evaluates the impact of the KickAsh!-intervention by analysing changes in adolescents' smoking initiation behaviour (primary outcome) and related individual determinants: intention to start smoking, attitude, self-efficacy beliefs, coping planning, perceived subjective norms, perceived social pressure, risk perception, and perceived smoking behaviour of peers and youth workers (secondary outcomes), between the experimental and control groups at pre- (T0), post- (T1) and follow-up (T2) measurements. We hypothesized that the KickAsh!-intervention would lead to a significant increase in self-efficacy beliefs, coping planning, and risk perception related to smoking among participating adolescents, compared to no changes in the control group. Additionally, we expect it to reduce smoking initiation intentions and behaviour, favourable attitudes towards smoking, perceived subjective norms supporting smoking, perceived social pressure to start smoking, and perceived smoking behaviour among peers and youth workers within the intervention organizations, compared with the control group.

Materials and methods

Study design and group allocation

This study was part of a 4-year (2021–4) project to develop, implement, and evaluate smoking prevention actions among adolescents experiencing societal vulnerability and participating in youth social work organizations. Since vaping among adolescents was still in its early stages at the start of the project and not yet perceived as a significant issue, it was not identified as a key behaviour to address within the project. In Belgium, youth social work organizations provide support and activities for vulnerable young people, aiming to strengthen their well-being, participation, and inclusion in society (Ambrassade 2024). From the outset of developing the project proposal, two youth social work organizations (VZW Habbekrats and KAA Gent Foundation) participated as project partners, as they explicitly recognized smoking as a relevant issue among adolescents in their organizations. A study protocol was registered on Clinicaltrials.gov: NCT05920772. To evaluate the KickAsh!-intervention, we conducted a mixed-methods evaluation, including a non-randomized cluster-controlled trial with clustering occurring at the level of the youth social work organizations, and a qualitative process evaluation. This paper reports on effects measured via self-report questionnaires. The process evaluation will be addressed in a separate paper. This paper adheres to the Transparent Reporting of Evaluations with Nonrandomized Designs Statement to ensure comprehensive and transparent reporting of methods and findings (Centers for Disease Control and Prevention 2004, Des Jarlais *et al*. 2004), which is available as Supplementary File S1. Twenty-three organizations were recruited, with 12 implementing the intervention over a 4-month period, while the remaining 11 served as control sites. Random assignment to the control or intervention group was avoided to facilitate recruitment; some organizations, for instance, were only willing to participate as a control group due to time constraints or limited staff capacity to implement the intervention. Moreover, it was agreed in advance that the two organizations involved in the co-creative development phase would be allocated to the intervention group. During recruitment, the research team identified several organizational characteristics, including organizational size (small/mid-large), offered activities (sport/recreational), geographical location (urban/rural), percentage

of adolescents from low socioeconomic backgrounds, percentage of adolescents with a migration background, and age composition of adolescents. These characteristics informed the allocation process for the remaining 21 organizations as much as possible. Baseline measurements, serving as a pre-test (T0), were conducted in October 2023, followed by a 4-month intervention period. Although the initial plan was for the intervention to be implemented within three months, youth workers communicated the necessity for additional time. This was attributed to factors such as the closure of organizations during the Christmas holidays and competing priorities at the beginning of the New Year, affecting their capacity to implement all intervention components fully. As a result, post-test measurements were conducted at the end of February 2024, approximately one to five weeks after the intervention period (T1). Follow-up measures were conducted between September and November 2024 (T2).

Sampling and recruitment of youth social work organizations and participants

For this study, youth social work organizations in Flanders, Belgium, were purposefully enlisted. All eligible organizations across Flanders ($n = 70$) were contacted via email and phone for participation. For interested organizations, an (online) meeting was organized to provide a more detailed explanation of the study. Eligible organizations were expected to be able to engage at least 25 adolescents (meeting the further-specified inclusion criteria) during the 4-month intervention period. To reach and inform adolescents in these organizations about participation in the study, researchers recorded a brief video introducing themselves and explaining the study's purpose. Youth workers had the opportunity to show this video multiple times within their organizations, ensuring maximum reach among adolescents. Additionally, adolescents could take home information letters for their parents, facilitating broader dissemination of study details. The elaborated recruitment strategy is described in our study protocol (Demeester *et al*. 2025). A power analysis for clustered samples was executed to calculate the required sample size (Demeester *et al*. 2025). For the primary outcome of smoking initiation, it was estimated that having twelve settings in each group, with an assumed average of 25 adolescents per setting, would yield a minimum of 80% power to detect a small effect size of 0.3 (Crone *et al*. 2003, Suls *et al*. 2012, Thomas *et al*. 2015), accounting for an intracluster correlation coefficient of 0.07 (Shackleton *et al*. 2016). Ultimately, 23 youth social work organizations agreed to participate in this study, comprising 12 in the intervention group and 11 in the control group. However, three intervention and two control organizations withdrew from the study before completing the post-measurement questionnaires. Reasons for dropout included a high workload, lack of interest, and resistance from adolescents within their organizations to engage with the intervention materials and complete the surveys, as well as the departure of youth workers responsible for overseeing the intervention's implementation. In Supplementary File S2, a flowchart illustrates the progression of participating youth social work organizations throughout the study.

Although the intervention primarily targeted adolescents experiencing societal vulnerability, it was implemented for all adolescents within the organization to ensure inclusivity. Given the unique characteristics of youth social work organizations, many participants are likely to face varying degrees of vulnerability. Adolescents participating in the evaluation of the intervention had to meet the following inclusion criteria: aged between 10 and 16 years, with sufficient written and oral understanding of Dutch. All adolescents being present in the organization at the moment of data collection at T0, T1, and T2 were invited to complete the questionnaire. The questionnaire was pilot-tested with one adolescent from a co-creation partner organization. A few sentences were identified as difficult to understand and were simplified to improve clarity for the target age group. No major revisions were required. A researcher or youth worker was available to assist adolescents when they completed the questionnaire, in case they needed clarification on the questions. At the beginning of filling out the questionnaire, it was emphasized that it focused on traditional cigarette smoking, not vaping. Adolescents who completed all three measurements received a €15 voucher redeemable at leisure stores (e.g. sports or book shops) as appreciation for their participation.

Ethical considerations and data protection

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Committee of Medical Ethics at Ghent University Hospital, with reference number ONZ-2023-0366. In consultation with the data protection officer from Ghent University, the study's legal basis was established as public interest. This decision was based on the difficulty of obtaining written parental consent, the sensitive nature of the study concerning adolescent smoking behaviour, and the importance of respecting the discretion duty of youth workers. Nevertheless, we ensured that adolescents were fully informed through interactions with researchers and youth workers, as well as a recorded video presentation. Online informed consent was obtained from all adolescents who participated in this study. Parents were informed using an information letter provided at the outset of the study. Further details on the choice of public interest rather than 'active informed consent from parents' as the legal basis of this study are described in the study protocol (Demeester *et al*. 2025).

Intervention description

The overall objective of the KickAsh!-intervention was to prevent smoking initiation among adolescents experiencing societal vulnerability and participating in youth social work organizations. To identify and address key determinants associated with smoking initiation and grounded in adolescents' lived experiences, firstly, a qualitative study, serving as a needs assessment, was conducted within this project regarding factors influencing smoking uptake among adolescents participating in youth social work organizations (Leta *et al*. 2023). Secondly, the I-Change Model, a framework by De Vries (de Vries 2017), served as the theoretical foundation for identifying and addressing key determinants associated with smoking initiation. This model has previously been applied in the context of smoking prevention initiatives (Mohammed *et al*. 2016, de Vries 2017). The I-Change

Model provides a framework that considers various determinants, including motivational factors (e.g. attitudes, social influence beliefs, and self-efficacy beliefs), predisposing factors (e.g. psychological traits like personality or biological factors such as sex), awareness factors (e.g. risk perception), and informational factors (e.g. the quality, source, and delivery of messages) (de Vries *et al*. 2003). These determinants collectively influence an individual's intention to engage in smoking behaviour. The KickAsh!-intervention primarily focused on awareness and motivational determinants.

Furthermore, the intervention was co-created in collaboration with adolescents and youth workers from two youth social work organizations in Ghent, Belgium. During this co-creation process, the DDM was utilized, emphasizing a human-centred, co-creative design approach, ensuring the intervention was tailored to adolescents' needs while remaining sensitive to the youth social work context (Zwass 2010, Yau *et al*. 2023). A detailed account of the development process is provided in a separate publication (Leta *et al*. 2024). The intervention comprised various components designed to prevent smoking. Most components had a direct influence on smoking initiation by affecting several individual determinants of adolescents. These components included smoke-free games, mood boards, a smoke-free camp, and the Kick-Some-Ash! challenge. However, some components targeted adolescents by influencing their environment, namely, smoking policy in the organization and tips and tricks for youth workers. All components were developed using a combination of theoretical methods (Botvin *et al*. 1980, 1992, 2015, Bartholomew Eldredge *et al*. 2016, Compton *et al*. 2016) to change or influence these determinants or environmental factors. Table 1 presents an overview of the intervention components and the determinants or environmental (f)actors influenced. A more elaborate overview of the intervention components can be found in our study protocol (Demeester *et al*. 2025).

The components above were compiled into a digital toolkit as a website. Youth workers received access to the website and the mood boards for display within their organization, alongside the physical materials necessary to play the smoke-free games. Youth workers were asked to implement all toolkit components in their organizations during the intervention period. An implementation plan was provided to facilitate this, including instructions on using the toolkit, a QR code to access the website, and a logbook to record the components used. Furthermore, a timeline outlining the post- and follow-up measurement moments was provided. Recognizing the diversity of activities provided by these organizations, youth workers were given the flexibility to make practical adjustments to the materials (e.g. shortening their duration to fit within other activities) without altering the content, thereby increasing their suitability for their organization.

Questionnaire

The questionnaire incorporated items from four validated instruments, including the Health Behaviour in School-aged Children (HBSC) survey (Inchley *et al*. 2018), the European Smoking Prevention Framework Approach from de Vries and Kok 1986, de Vries *et al*. (2003), the web-based smoking prevention questionnaire designed by Cremers *et al*. (2015a, 2015b), and the International Physical Activity Questionnaire (IPAQ) (CRAIG *et al*. 2003). Firstly, the questionnaire comprised inquiries into adolescents' socio-demographic variables. Secondly, it encompassed questions probing smoking initiation behaviour and its associated determinants, aligning with the objectives of the KickAsh!-intervention. Thirdly, a negative control outcome was incorporated to minimize potential confounding biases in the study outcomes (Lipsitch *et al*. 2010).

Socio-demographics

Comprehensive socio-demographic information was collected, including sex, birth year, birth month, educational year, type of education, nationality, family composition, and the number of siblings. Additionally, the participants' attendance in the organization (e.g. daily, weekly, monthly) was assessed. The adolescents' socioeconomic status (SES) was determined using three items. First, it was assessed by questioning both parents' educational level (no schooling completed, primary school, secondary school, university college, and university). Secondly, adolescents' perception of family financial security was assessed using the question, 'How much money does your family have?' Response categories included: (i) not enough to get by, (ii) just enough to get by, (iii) we only have to worry about money for fun or extras, and (iv) we never have to worry about money. Lastly, perceived SES, which assesses adolescents' perceptions of whether their family has enough money to meet their needs, was assessed using a question from the HBSC survey (Simpson *et al*. 2005); 'How well off do you think your family is?' with five response categories: (i) not at all, (ii) not particularly, (iii) fairly, (iv) rather, and (v) very. Among these three SES indicators, the measure of family financial security (i.e. perceived family wealth) was selected for analysis due to its relatively low rate of missing responses compared to the other items. Research (Hammond *et al*. 2021) indicates that this indicator is a psychometrically sound measure (i.e. reliable and valid) regarding how adolescents perceive their family's SES, and can be especially valuable in adolescent research, where young people often struggle to know their parents' income or education. Finally, exposure to smoking within the family was questioned, asking adolescents who smoked in their family, with the following response categories: (i) nobody, (ii) mother, (iii) father, (iv) stepmother, (v) stepfather, (vi) brother(s), (vii) sister(s), (viii) grandparent(s), (ix) guardian, (x) foster mother, and (xi) foster father. These were dichotomized to: no exposure to smoking in the family (0), and exposure to smoking in the family (1).

Smoking behaviour

The primary outcome of the intervention, smoking initiation behaviour, was measured using the Model of Unplanned Smoking Initiation of Children and Adolescents (MUSICA) (Kremers *et al*. 2004), which assessed this behaviour through two questions (see Table 2). These two questions capture both the behavioural stage and the motivational stage of adolescent smoking, providing a nuanced understanding of the developmental process of smoking initiation behaviour. A first question classified adolescents into the group that best described their current smoking behaviour: never smokers (I have never smoked, not even a single puff), non-smoking deciders (I have tried smoking, but I don't smoke anymore), triers (I try smoking now and then), experimenters (I smoke less than once a month and I don't smoke every

Table 1 Components of the KickAsh!-intervention.

Intervention components	Content	Targeted determinant of adolescent (A)/ environmental (f)actor (EF)
1. Smoke-free organization		
Smoking policy	• Checklist for assessing smoking policy • Guidelines for improvement • 'Smoke-free label' for compliant organizations	• Organization (EF) • Policy (EF)
Tips and tricks for youth workers	• Being a role model in smoking prevention • Exercises to use with adolescents to enhance their life skills and coping strategies	• Social influence (EF) • Self-efficacy beliefs (A) • Coping planning (A)
2. Smoke-free tools		
Smoke-free games	• Instructions and materials for two smoke-free games • Youth workers can use or adapt the games to fit their organization	• Attitude (A) • Risk perception (A) • Perceived subjective norms (A) • Perceived social pressure (A)
Design a smoke-free game	• Guidelines for youth workers to create evidence-based, customized smoke-free games • Option to upload created games on the website	• Subject to choice of the youth workers
Mood boards	• Visual mood boards on smoking and health, climate impact, and child labour • Can be displayed throughout the organization	• Attitude (A) • Risk perception (A)
Smoke-free camp (optional)	• Script for a 2–3 day smoking prevention camp that incorporates various components of the toolkit.	• Attitude (A) • Risk perception (A) • Perceived subjective norm (A) • Perceived social pressure (A)
3. Kick-Some-Ash! challenge		
Participate by designing a smoke-free logo	• Social media challenge: create a smoke-free logo with adolescents • Best logo wins a prize	• Organization (EF) • Perceived subjective norm (A) • Attitude (A) • Risk perception (A) • Self-efficacy (A)

week, but at least once a month), regular smokers (I don't smoke every day but at least once a week and I smoke at least once a day), and quitters (I have quit, I always smoked less than once a week and I have quit after smoking at least once a week for a while). A second question was asked about their motivational stage, classifying adolescents into committers (I'm sure I'll never smoke), immotives (I don't think I'll ever smoke), progressives (I think I will start smoking at some point in the future and I think I will start smoking within five years and I think I will start smoking within one year), contemplators (I think I will start smoking within 6 months), preparers (I will start smoking within one month), and already smokers (I already smoke). Combining the results for both questions made it possible to distinguish seven stages of smoking initiation behaviour: (i) committed never smokers, (ii) immotive never smokers, (iii) immotive triers, (iv) immotive experimenters, (v) contemplating experimenters, (vi) immotive non-smoking deciders, and (vii) committed non-smoking deciders. A visual representation of the combinations is outlined in Supplementary File S3. Finally, as the KickAsh!-intervention focused on preventing smoking initiation behaviour (i.e. encouraging adolescents to be a committed never smoker), this variable was dichotomized, with 0 being the group of adolescents in stages two to seven, and 1 being the group with committed never smokers. Furthermore, two questions concerning tobacco use frequency were queried (i.e. life and month), as well as smoking onset age and intention to smoke in the coming year and future.

Determinants of smoking initiation targeted by the KickAsh!-intervention

Attitude towards smoking was measured by the question 'How do you feel about smoking?'. This was followed by eight items that addressed both perceived advantages and disadvantages of smoking. Four items comprised cognitive (dis)advantages and four items emotional (dis)advantages. Adolescents were required to respond to each (dis)advantage using a five-point Likert scale. Mean scores were calculated separately for the advantages and disadvantages. For the advantages, higher mean scores indicate a more positive attitude towards smoking. For the disadvantages, lower mean scores indicate a more negative attitude towards smoking.

Self-efficacy beliefs were assessed by six questions measuring adolescents' ability to resist smoking in various situations. Adolescents responded using a five-point Likert scale. These questions were then linked to six coping plan items, analysing whether adolescents had prepared any plans that prevented them from smoking in these situations. Answers were rated on a five-point scale. Mean scores were calculated for both scales. Higher values for self-efficacy beliefs indicate a greater feeling of capability to abstain from smoking in social situations.

Table 2 Questionnaire items assessing smoking behaviour.

Variable	Question	Response categories
Current smoking behaviour	Which of the following statements describes you best?	10-point scale (I have never smoked, not even one puff; I have tried smoking, but I don't smoke (anymore); I have quit; I always smoked less than once a week; I have quit after smoking at least once a week for a while; I try smoking now and then; I smoke less than once a month; I don't smoke every week, but at least once a month; I don't smoke every day, but at least once a week; I smoke at least once a day)
Motivational stage	Which of the following statements describes you best?	8-point scale (I'm sure I'll never smoke; I don't think I'll ever smoke; I think I will start smoking at some point in the future; I think I will start smoking within five years; I think I will start smoking within one year; I think I will start smoking within six months; I think I will start smoking within one month; I already smoke)
Tobacco use frequency (life)	On how many days (if any) have you smoked cigarettes in your life?	7-point scale (Never; 1–2 days; 3–5 days; 6–9 days; 10–19 days; 20–29 days; 30 days or longer)
Tobacco use frequency (month)	On how many days (if any) have you smoked cigarettes in the past month?	7-point scale (Never; 1–2 days; 3–5 days; 6–9 days; 10–19 days; 20–29 days; 30 days or more)
Smoking onset age	At what age did you first smoke a cigarette (more than a puff)?	10-point scale (Never; 8 years old or less; 9 years; 10 years; 11 years; 12 years; 13 years;14 years; 15 years; 16 years or older)
Intention to smoke	Do you plan to smoke in the coming year?	7-point scale (Certainly; most likely yes; rather yes; I don't know; rather not; most likely not; certainly not)
	Do you plan to smoke in the future?	7-point scale (Certainly; most likely yes; rather yes; I don't know; rather not; most likely not; certainly not)

Higher values for coping planning indicate that adolescents have prepared plans that prevented them from smoking (to ensure logical interpretation, the variables were reverse-scored prior to scale construction).

Social influence beliefs were measured by assessing perceived subjective norms and perceived social pressure concerning smoking. For perceived subjective norms, seven questions were asked to determine adolescents' perceptions of what important people in their environment think about smoking. A five-point Likert scale was used. Subscales were constructed for parents (i.e. mean scores of father and mother), siblings [i.e. mean scores for siblings (brother(s)/sister(s))], friends (i.e. mean scores of friends and best friend), and the youth social work organization (i.e. mean scores of youth workers and adolescents in the organization). Lower values indicate a lower perception that people in their social environment think they should start smoking.

The perceived social pressure measure consisted of seven items, addressing the same important others as the perceived subjective norm measure. Adolescents had to answer whether they ever felt pressure to smoke from these people on a five-point scale. The same subscales using mean scores were constructed as for the perceived subjective norm measure. Lower mean scores indicate that participants felt less pressured by their environment to start smoking (to ensure logical interpretation, the variables were reverse-scored prior to scale construction).

Furthermore, the smoking behaviour of environmental actors (peers and youth workers) was assessed. Adolescents' perceptions of smoking behaviour of other adolescents present in the organization were questioned via three questions. Adolescents had to answer on a five-point scale. Lower mean scores indicate fewer adolescents observing peers smoking while attending the organization. In addition, adolescents' perceptions of smoking behaviour of youth workers present in the organization were questioned via three questions. A mean score was calculated from these three dichotomous questions. Lower mean scores indicate that fewer adolescents observed youth workers smoking while attending the organization.

Lastly, risk perception regarding the consequences of smoking was assessed using a two-item scale: (i) perceived susceptibility, and (ii) perceived severity. A five-point Likert scale was used. Mean scores were calculated, with higher mean scores indicating that participants perceive smoking as riskier (to ensure logical interpretation, the variables were reverse-scored prior to scale construction). An elaborate overview of all questionnaire items per determinant is provided in Supplementary File S3.

Negative control outcome

A negative control outcome was included in the questionnaire to determine whether the KickAsh!-intervention influenced an outcome that it should not logically affect. This approach allows for assessing the potential influence of confounding bias on the results (Lipsitch *et al*. 2010). Cycling behaviour for transportation was evaluated using two items from the IPAQ (CRAIG *et al*. 2003). Adolescents were queried about the number of days in the previous week during which they cycled for at least 10 min as a means of transportation. Additionally, adolescents reported the duration of cycling on such days. The total minutes per week were then calculated.

Statistical analyses

All statistical analyses were conducted in R version 4.4.0 using RStudio as the integrated development environment on

Windows. Although the authors have expertise in the evaluation of health promotion programmes (Van Stappen *et al*. 2019, De Craemer *et al*. 2020, Vandendriessche *et al*. 2025), additional statistical expertise was consulted. For the primary outcome (i.e. smoking initiation), an intraclass correlation coefficient (ICC) of 0.05 was found, indicating that 5% of the variance in smoking initiation can be attributed to between-organization differences, suggesting multilevel analyses are warranted (Sommet and Morselli 2021). The effects of the intervention were analysed using generalized linear mixed models (GLMMs) due to the non-normal distribution of the dependent variables in each condition. In addition, these models could account for the clustering of repeated measurements within adolescents nested in youth social work organizations. A model was built for each dependent variable: smoking initiation behaviour, smoking intention within the next year, smoking intention in the future, attitude regarding perceived advantages, attitude regarding perceived disadvantages, self-efficacy beliefs, coping planning, perceived subjective norms (for parents, friends, siblings, and the organization), perceived social pressure (from parents, friends, siblings, and the organization), risk perception, and perceived smoking behaviour of peers and perceived smoking behaviour of youth workers in the organization. The variables condition, time and the interaction between condition and time were added to the model as fixed factors. In addition, based on the directed acyclic graph (see Supplementary File S5), the variable exposure to smoking within the family was identified as a confounder. The χ^2 test revealed a statistically significant association ($\chi^2 = 17.085$, $P < .001$) between exposure to smoking within the family and the condition to which adolescents were allocated. Participants in the intervention group were more likely to report exposure to smoking within the family (66.2%) compared to the control group (50.3%). Therefore, exposure to smoking within the family was added as a covariate in the analyses. As repeated measurements were conducted within adolescents, the models included individual adolescents as a random factor.

Next, we assessed the model with the best fit (across models with different distributional families) visually using posterior predictive checks in which we verified whether the model-predicted line resembled with the observed data line. Based on these graphs, we selected a model with a Gaussian variance function and an identity link function for all models. In these models, the estimates for the interaction between condition and time should be interpreted as the expected difference in change of the dependent variable from the pre-test to the post- and follow-up test between the intervention and control group, with the other variables in the model (i.e. exposure to smoking within the family) held constant.

Further, the necessity of including youth social work organizations as a random factor was assessed by comparing the established model with a model that included them as a random factor using ANOVA (analysis of variance). Significant differences were observed between the two models for the following dependent variables: intention to smoke within the next year, intention to smoke in the future (beyond the next year), attitude (perceived advantages), self-efficacy beliefs, and risk perception. Consequently, the variable organization was included as a random effect in the final models for these dependent variables. Next, assumptions were checked using the performance package (version 0.12.4). A sensitivity analysis was conducted to assess the influence of outliers on the impact of the KickAsh!-intervention on each dependent variable. Outliers were identified and removed from the models for the following variables: smoking intention (for the coming year and in the future), attitude (perceived advantages), social pressure (from parents, friends, siblings, and the organization), and smoking behaviour among adolescents and youth workers within the organization.

Lastly, since the baseline value of the outcome variable can act as a confounder when estimating a treatment effect, it was recommended to adjust for baseline values regardless of whether the difference between the intervention and control group at baseline is statistically significant (Twisk *et al*. 2018). Therefore, models were built in which the outcome variable measured at each follow-up time point is estimated by the treatment variable, time, the interaction between the treatment variable and time, and the baseline outcome measurement as fixed factors in the model. The regression coefficient for the treatment variable reflects the treatment effect at the post-measurement. The treatment effect at the follow-up measurement was estimated by the regression coefficient for the treatment variable after changing the reference category of the time variable. Confounders and random intercepts included in the initial models were also accounted for in these models (see Supplementary File S6). Statistical significance was determined at $P < .05$.

Results

Participant characteristics and descriptive outcome measures

Table 3 presents descriptive statistics for all unique participants per condition on the socio-demographic variables. There were no statistically significant differences between the intervention and control groups. A total of 482 unique adolescents participated in this study (272 in the intervention group and 210 in the control group), with the majority being boys (63.1%). The average age of these participants was 12.83 years (SD = 2.42). Regarding nationality, most were born in Belgium (73.8% in the intervention group and 81.5% in the control group). Most adolescents were regular attendees of youth social work organizations, with 81.8% of those in the intervention group and 86% in the control group visiting at least once weekly. Further, 56.9% of adolescents in the intervention group reported that their family had insufficient or just enough financial resources to make ends meet, compared to 50.4% in the control group.

At the time of the pre-test (see Table 4), of the adolescents who had smoked before (26.6% in the intervention group and 14.1% in the control group), the average age of the first cigarette smoked (more than a puff) was 12.98 (SD = 1.89) years. In the intervention group, approximately 67% of adolescents indicated they are exposed to smoking within the family, while in the control group, this was slightly less (54.7%). Additionally, the majority of adolescents were confident that they would definitely not smoke in the coming year (66.2% in the intervention group and 82.1% in the control group), and in the future (59.7% in the intervention group and 72.6% in the control group). According to the seven stages of smoking initiation outlined in MUSICA (Kremers *et al*. 2004), in the intervention group, 63.7% of adolescents were classified as committed never smokers, 26.5% as immotive never smokers, 7.1%

Table 3 Descriptive statistics of unique participants per condition.

	Intervention group	Control group
Number of adolescents	272	210
Age [mean (SD)]	12.94 (2.54) years	12.67 (2.24) years
Sex (% boys)	60.5%	66.9%
Nationality adolescent		
Belgium	73.8%	81.5%
Other country	26.2%	18.5%
Nationality father		
Belgium	36.7%	40.4%
Other country	59.3%	54.5%
Does not know	4.0%	5.1%
Nationality mother		
Belgium	43.1%	48.3%
Other country	54.4%	50.0%
Does not know	2.4%	1.7%
Type of education adolescent[a]		
Primary school	25.8%	21.9%
A-stream	16.5%	18.5%
B-stream	14.1%	14.0%
General education	7.3%	11.8%
Vocational education	21.4%	14.6%
Technical education	5.6%	7.3%
Arts education	0.8%	2.2%
Other	6.5%	6.7%
I don't know	2.0%	2.8%
Family composition		
Living with both parents	69.3%	65.4%
Living with a newly formed family	10.2%	5.4%
Living with relatives	13.1%	15.4%
Not living with family	7.4%	13.8%
Attendance in the organization		
Every day	16.9%	16.3%
Multiple days/week	40.7%	22.5%
1 day/week	24.2%	47.2%
Multiple days/month	6.5%	3.4%
1 or 2 times/month	3.6%	0.6%
Multiple days/year	4.4%	1.1%
1 or 2 times/year	0.8%	1.7%
This is my first time	2.8%	7.3%
Family financial security		
Not enough to get by	20.5%	19.4%
Just enough to get by	36.4%	31.0%
Enough to get by	43.2%	49.6%

[a]Types of education in Belgium: A-stream (first and second year of secondary education): designed for general academic education and preparation for higher education; B-stream (first and second year of secondary education): prepares students for direct entry into the labour market or vocational training; General education (starting from third year): aimed at preparing students for academic higher education, emphasizing theoretical knowledge; Vocational education (starting from third year): focuses on hands-on skills and prepares students for direct entry into the labour market or vocational training; Technical education (starting from third year): combines theoretical and practical education, preparing students for either higher education or technical professions; Arts education (starting from third year): specialized in arts education, including both artistic practice and general education subjects.

as immotive non-smoking deciders, and 2.7% as committed non-smoking deciders. In the control group, 73% of adolescents were classified as committed never smokers, 18.9% as immotive never smokers, 2.7% as immotive non-smoking deciders, and 5.4% as committed non-smoking deciders.

Table 5 provides an overview of the mean scores for all dependent variables across all measurement moments per condition.

Effect evaluation

The results of the effect evaluation (see Table 6) show a statistically significant intervention effect on coping planning at both post-test ($b = 0.57$, SE = 0.28, $P = .04$) and follow-up test ($b = 1.32$, SE = 0.29, $P < .001$). This corresponds to an average higher increase of 0.57 points at post-test and 1.32 points at follow-up on a

Table 4 Descriptive statistics for smoking-related variables of participants per condition at the pre-test.

	Intervention group	Control group
Number of adolescents	154	87
Age (mean) (SD)	13.54 (2.34) years	13.47 (1.83) years
Sex [*n* (%) boys]	64.9%	66.3%
Smoking frequency life		
Never	73.4%	85.9%
1–2 days	7.1%	5.9%
3–5 days	3.9%	0%
6–9 days	1.3%	0%
10–19 days	0.6%	3.5%
20–29 days	0.6%	4.7%
30 days or more	13.0%	0%
Average age of first cigarette smoked (mean) (SD)	12.96 (1.81) years	13.06 (2.16) years
Exposure to smoking within the family (% yes)	66.9%	54.7%
Smoking intention (coming year)		
Definitely yes	8.4%	1.2%
Most likely yes	2.6%	4.8%
Rather yes	0.6%	0%
Neutral	12.3%	4.8%
Rather not	2.6%	1.2%
Most likely not	7.1%	6.0%
Definitely not	66.2%	82.1%
Smoking intention (future)		
Definitely yes	5.8%	2.4%
Most likely yes	3.2%	4.8%
Rather yes	0.6%	1.2%
Neutral	15.6%	7.1%
Rather not	5.2%	1.2%
Most likely not	9.7%	10.7%
Definitely not	59.7%	72.6%
Stages of smoking initiation (MUSICA)		
Committed never smokers	63.7%	73.0%
Immotive never smokers	26.5%	18.9%
Immotive triers	0%	0%
Immotive experimenters	0%	0%
Contemplating experimenters	0%	0%
Immotive non-smoking deciders	7.1%	2.7%
Committed non-smoking deciders	2.7%	5.4%

Table provides descriptive statistics for smoking-related variables by condition at the pre-test only, as post-test and follow-up responses may already reflect changes resulting from the intervention.

5-point scale of the intervention group compared to the control group. In the intervention group, coping planning scores increased from 2.66 (SD = 1.51) at the pre-test to 2.83 (SD = 1.53) at the post-test, and further to 3.09 (SD = 1.55) at follow-up. In contrast, the control group showed a decline, with scores decreasing from 3.55 (SD = 1.48) at the pre-test to 3.21 (SD = 1.72) at the post-test, and further to 2.62 (SD = 1.75) at follow-up. However, in the additional analyses we conducted, controlling for baseline values (see Supplementary File S6), the level of coping planning no longer significantly differed between the intervention and control groups at both the post-test and follow-up test. Furthermore, no statistically significant intervention effects were found for smoking initiation behaviour and other related determinants (i.e. intention to start smoking, attitude, self-efficacy beliefs, perceived social norms, perceived social pressure, risk perception, and perceived smoking behaviour of peers or youth workers in the organization). Lastly, no statistically significant intervention effects were found for the negative control outcome (i.e. cycling behaviour for transportation), suggesting no confounding bias in the results.

Discussion

This study aimed to assess the impact of the KickAsh!-intervention on adolescents' smoking initiation behaviour and associated individual determinants, including intention to start smoking, attitude, self-efficacy beliefs, coping planning, perceived subjective norms, perceived social pressure, risk perception, and perceived smoking behaviour of peers and youth workers within youth social work organizations.

Table 5 Descriptive statistics of all dependent variables at all measurement moments per condition.

Dependent variables (mean) (SD)[a]	Intervention group ($N = 370$)			Control group ($N = 300$)		
	Pre ($N = 154$)	Post ($N = 110$)	Follow-up ($N = 106$)	Pre ($N = 87$)	Post ($N = 101$)	Follow-up ($N = 112$)
Smoking initiation behaviour (MUSICA) (% committed never smokers)	63.7%	60.7%	74.4%	73.3%	78.3%	81.6%
Intention to start smoking						
Year	2.16 (1.94)	1.84 (1.52)	1.82 (1.66)	1.53 (1.37)	1.40 (1.27)	1.42 (1.28)
Future	2.21 (1.81)	1.92 (1.49)	1.82 (1.65)	1.76 (1.56)	1.35 (1.08)	1.46 (1.28)
Attitude towards smoking						
Advantages	0.82 (0.82)	0.78 (0.95)	0.65 (0.91)	0.63 (0.78)	0.58 (0.89)	0.44 (0.62)
Disadvantages	2.43 (1.10)	2.62 (1.07)	2.51 (1.13)	2.39 (1.04)	2.30 (1.09)	2.41 (1.12)
Self-efficacy beliefs	4.05 (1.22)	4.21 (1.11)	4.40 (1.03)	4.28 (1.01)	4.56 (0.87)	4.41 (1.11)
Coping planning	2.66 (1.51)	2.83 (1.53)	3.09 (1.55)	3.55 (1.48)	3.21 (1.72)	2.62 (1.75)
Perceived subjective norm						
Parents	1.33 (0.65)	1.40 (0.85)	1.33 (0.67)	1.22 (0.48)	1.24 (0.56)	1.27 (0.73)
Friends	1.72 (0.93)	1.57 (0.82)	1.59 (0.87)	1.64 (0.78)	1.46 (0.93)	1.44 (0.76)
Siblings	1.49 (0.87)	1.48 (0.83)	1.40 (0.84)	1.40 (0.75)	1.46 (0.95)	1.37 (0.83)
Organization	1.56 (0.85)	1.54 (0.86)	1.41 (0.75)	1.64 (0.75)	1.47 (0.73)	1.42 (0.77)
Perceived social pressure						
Parents	1.32 (0.86)	1.40 (1.01)	1.51 (1.16)	1.20 (0.62)	1.28 (0.93)	1.38 (1.04)
Friends	1.57 (1.00)	1.51 (0.98)	1.49 (0.94)	1.42 (0.86)	1.28 (0.83)	1.52 (1.19)
Siblings	1.24 (0.64)	1.35 (0.84)	1.38 (1.00)	1.19 (0.66)	1.16 (0.72)	1.42 (1.16)
Organization	1.27 (0.69)	1.31 (0.68)	1.38 (0.90)	1.12 (0.42)	1.13 (0.53)	1.36 (1.05)
Risk perception	4.44 (0.93)	4.24 (1.13)	4.47 (1.00)	4.60 (0.78)	4.47 (0.98)	4.50 (1.15)
Perceived smoking behaviour: peers	1.67 (0.78)	1.66 (0.71)	1.61 (0.84)	1.29 (0.53)	1.30 (0.58)	1.24 (0.62)
Perceived smoking behaviour: youth workers	0.19 (0.33)	0.19 (0.33)	0.14 (0.30)	0.14 (0.30)	0.13 (0.31)	0.17 (0.35)

[a]All variables were measured using a 5-point Likert scale, except for the variables: 'smoking initiation behaviour (MUSICA)', which was a dichotomous variable with 1 = committed never smoker and 0 = other stages; 'intention to start smoking', which was assessed using a 7-point Likert scale; and 'smoking behaviour youth workers', which was the mean score of three dichotomous variables, with 0 = adolescents did not see youth workers smoking and 1 = adolescents saw youth workers smoking.

Contrary to our initial hypothesis, the KickAsh!-intervention did not significantly affect adolescents' smoking initiation or most related determinants (with the exception of coping planning), including their intention to start smoking. Similarly, McGee *et al.* (2016) found no significant improvement in non-smoking intentions among 9- to 10-year-olds in deprived communities after a sport-for-health intervention. Their programme combined interactive activities with coach training and also assessed smoking-related cognitions (attitudes and refusal self-efficacy). The authors attributed the absence of effect to already strong non-smoking intentions at baseline in both groups (mean scores of 11.8 and 11.7 on a total score of 12 for non-smoking intentions). This explanation may also apply to our study's findings. At baseline measurements (T0) (see Table 4), in the intervention group, 73.3% of adolescents reported no intention to smoke in the coming year (sum of 'definitely' and 'most likely' not smoking), and 69.4% indicated no intention to smoke in the future (sum of 'definitely' and 'most likely' not smoking). These relatively strong pre-existing intentions not to smoke may have reduced the intervention's potential impact, as there was less room for further change.

The level of coping planning significantly increased at both post-test and follow-up test in the intervention group, whereas the control group showed a decline. Coping planning refers to anticipating potential barriers that may emerge while performing certain actions and developing strategies to overcome them to achieve a goal (i.e. not starting with smoking) (Hsieh *et al.* 2019). Within the context of the KickAsh!-intervention, this improvement underscores its effectiveness in equipping adolescents with tools to recognize and navigate social situations that might lead to starting smoking. Such scenarios include environments where smoking is common (e.g. among friends), situations where they are offered cigarettes (e.g. by peers), or moments when they experience stress. In the KickAsh!-intervention, coping planning was primarily incorporated into the section with tips and tricks for youth workers (see Table 1). This section encouraged discussions with adolescents about potential situations where they might encounter smoking and helped them plan actions to resist starting. A similar study by Carrión-Valero *et al.* (2023) reported a significant reduction in smoking prevalence among high school adolescents (aged 15–17 years) over one academic year. This study engaged students, teachers, and parents in smoking prevention efforts. In this study, students in the intervention group also co-developed activities to enhance protective factors, reduce risk factors for smoking, and manage social influences that encourage tobacco

Table 6 Results of the models examining the intervention effects on smoking initiation behaviour and its determinants.

	Post-test (ref = pre-test)		Follow-up test (ref = pre-test)		Condition (ref = control group)		Interaction effect post-test x condition		Interaction effect follow-up test x condition	
	b (SE)	*P*	*b* (SE)	*P*	*b* (SE)	*P*	*b* (SE)	*P*	*b* (SE)	*P*
Variables[a]										
Smoking initiation behaviour (MUSICA)	0.03 (0.05)	0.62	0.08 (0.06)	0.15	−0.08 (0.06)	0.17	−0.05 (0.07)	0.51	0.02 (0.08)	0.81
Intention to start smoking										
Year	−0.07 (0.16)	0.69	0.09 (0.18)	0.62	0.51 (0.38)	0.20	−0.20 (0.22)	0.38	−0.19 (0.24)	0.42
Future	−0.34 (0.17)	0.05	−0.11 (0.18)	0.56	0.40 (0.29)	0.18	0.11 (0.23	0.63	−0.11 (0.25)	0.64
Attitude										
Advantages	0.01 (0.10)	0.91	−0.10 (0.10)	0.34	0.14 (0.16)	0.39	−0.01 (0.13)	0.95	0.03 (0.13)	0.85
Disadvantages	−0.08 (0.15)	0.58	0.01 (0.15)	0.95	0.04 (0.15)	0.76	0.27 (0.20)	0.16	0.05 (0.20)	0.80
Self-efficacy beliefs	0.24 (0.14)	0.09	0.05 (0.15)	0.73	−0.20 (0.18)	0.28	−0.12 (0.19)	0.52	0.26 (0.20)	0.18
Coping planning	−0.40 (0.21)	0.05	−0.90 (0.21)	<0.001	−0.84 (0.21)	<0.001	0.57 (0.28)	**0.04**	1.32 (0.29)	**<0.001**
Perceived subjective norm										
Parents	0.23 (0.19)	0.23	0.27 (0.20)	0.18	0.21 (0.22)	<0.001	−0.05 (0.26)	0.84	−0.18 (0.27)	0.50
Friends	0.19 (0.20)	0.34	0.14 (0.20)	0.50	0.04 (0.23)	0.87	−0.24 (0.27)	0.37	−0.14 (0.27)	0.60
Siblings	0.02 (0.22)	0.94	−0.09 (0.23)	0.69	−0.27 (25)	0.28	0.01 (0.29)	0.98	0.07 (0.30)	0.80
Organization	−0.12 (0.20)	0.57	0.01 (0.21)	0.98	−0.31 (0.20)	0.12	0.38 (0.27)	0.16	−0.02 (0.27)	0.93
Perceived social pressure										
Parents	0.12 (0.14)	0.45	0.19 (0.14)	0.19	0.12 (0.14)	0.40	−0.10 (0.18)	0.58	−0.10 (0.19)	0.59
Friends	−0.09 (0.13)	0.48	−0.04 (0.14)	0.76	0.19 (0.13)	0.15	0.002 (0.17)	0.99	−0.13 (0.19)	0.47
Siblings	−0.02 (0.11)	0.83	0.02 (0.11)	0.84	0.11 (0.10)	0.27	0.12 (0.14)	0.39	−0.06 (0.15)	0.70
Organization	0.05 (0.10)	0.59	−0.09 (0.10)	0.39	0.18 (0.10)	0.06	−0.02 (0.13)	0.85	−0.06 (0.14)	0.67
Risk perception	−0.14 (0.15)	0.34	−0.19 (0.15)	0.19	−0.13 (0.17)	0.47	−0.09 (0.19)	0.64	0.22 (0.19)	0.26
Smoking behaviour peers	0.02 (0.08)	0.84	−0.03 (0.08)	0.73	0.34 (0.08)	<0.001	0.005 (0.10)	0.96	0.003 (0.11)	0.98
Smoking behaviour youth workers	0.06 (0.04)	0.16	−0.03 (0.04)	0.50	−0.04 (0.08)	0.62	−0.06 (0.05)	0.22	0.07 (0.05)	0.17
Cycling behaviour for transportation	−5.04 (8.57)	0.56	2.81 (9.39)	0.76	37.59 (10.79)	0.001	−5.13 (11.76)	0.66	9.35 (12.58)	0.46

SE, standard error; *P*-values indicating significant effect have bold font. [a]Total score on 5, except for the variables: 'smoking initiation behaviour (MUSICA)', which was dichotomous, and 'intention to start smoking', which was assessed using a 7-point Likert scale; and 'smoking behaviour youth workers', which was the mean score of three dichotomous variables, with 0 = no (adolescents did not see youth workers smoking) and 1 = yes (adolescents saw youth workers smoking).

use. These objectives align with the KickAsh!-intervention life skills exercises, which youth workers could do with adolescents regarding, for example, inoculation theory (i.e. exposing adolescents to weak counterarguments against their beliefs that smoking is bad and providing them with responses that counter those arguments), and preparing coping strategies that enhance their self-efficacy beliefs. Notably, the study by Carrión-Valero and colleagues was conducted over an entire school year, compared to the four-month duration of the KickAsh!-intervention, and was implemented during school hours within a school setting, which facilitated structured participation.

Nevertheless, no significant effects were found on the other determinants targeted by the KickAsh!-intervention (i.e. attitude, self-efficacy beliefs, perceived subjective norms, social pressure, risk perception, and perceived smoking behaviour of peers and youth workers). These results do not align with the initial hypotheses. It was anticipated that the intervention would lead to changes in these determinants of smoking initiation. This expectation is particularly grounded in the I-Change model (de Vries *et al*. 2003), which served as the theoretical framework for this intervention. According to the model, addressing precursing factors, such as risk perception, attitudes, and self-efficacy beliefs, is essential for forming strong behavioural intentions not to start smoking (de Vries 2017). Therefore, these determinants must first change to establish and strengthen the intention to abstain from smoking. Furthermore, in contrast to this study, several other interventions targeting one or more determinants of smoking initiation (e.g. attitude and self-efficacy beliefs) among adolescents have reported significant effects (in the short term) on these determinants (Flay 2009, McGee *et al*. 2016, Selph *et al*. 2020).

The finding that only coping planning showed significant change may reflect the types of determinants most responsive to a brief intervention. Coping planning can shift relatively quickly through concrete strategy training and practice (Schwarzer 2008), whereas attitudes and perceived subjective norms tend to be more stable and are shaped by broader social and contextual factors (Ajzen 1991, Ajzen *et al*. 2007), making them potentially less amenable to change during the limited timeframe of the KickAsh!-intervention. The abstinent effects on smoking initiation and most determinants suggest that several factors could have influenced the effectiveness of this intervention. One

potential explanation is that, similar to the relatively high baseline percentages for the intention not to smoke, favourable values for all determinants were already evident at baseline. When adolescents score highly at baseline, there is limited room for improvement, making it less likely to detect a measurable intervention effect (Garin 2014, Raina *et al*. 2015). Additionally, variation in adolescents' exposure to the KickAsh!-intervention could be expected, depending on factors such as youth workers' implementation of the intervention components. Furthermore, our data showed that only 57.6% of adolescents in the intervention group attended youth organizations daily or multiple times a week (a relatively low rate compared to, e.g. a school context). This, in turn, could have led to adolescents' insufficient exposure to and engagement with the intervention components. While the low-threshold nature of youth social work offers several advantages, such as accessibility for diverse groups, it also poses challenges, including the flexibility for adolescents to join or leave activities as they please, which complicates implementation and exposure to the intervention components. Given these considerations, it would have been valuable to explore potential differences in intervention effects by level of implementation or exposure, and among participants with complete data across all three measurement points. Nevertheless, the limited sample size did not allow such analyses. To better understand how these challenges may have affected the effectiveness of the KickAsh!-intervention, the process evaluation will provide further insights (Moore *et al*. 2015, Skivington *et al*. 2024).

A key strength of this study is that the determinants targeted by the KickAsh!-intervention were grounded in adolescents' lived experiences and a robust theoretical framework, the I-Change model (de Vries 2017), which has been previously applied in research on smoking initiation behaviour (Cremers *et al*. 2015b). This ensured that key determinants relevant to smoking initiation were addressed during the development and evaluation of the intervention. However, the study also has important limitations. Firstly, the two co-creation organizations were preassigned to the intervention group, potentially introducing selection bias (Grubic *et al*. 2025). These organizations may have been implicitly primed beforehand, which could have increased awareness of non-smoking and contributed to baseline differences between the intervention and control groups. Furthermore, youth social workers in these organizations could have been more committed to implementing the intervention as intended. To reduce this risk, the other organizations were matched on several key characteristics, including size, type of activities offered, geographical location, socioeconomic and migration background of adolescents, and age composition, before being allocated to the intervention or control group to enhance comparability. Nonetheless, these organizations differed substantially in their working methods (e.g. sports-oriented versus recreational activities) and in the profiles of adolescents they served (e.g. adolescents experiencing school-related difficulties versus those facing challenging home environments). Moreover, because organizations were not randomly allocated, the possibility of selection bias due to unmeasured baseline differences cannot be ruled out. Secondly, initially, it was estimated that twelve youth social work organizations per group, with an average of 25 adolescents per organization, would be required to achieve a minimum of 80% power to detect a small effect size of 0.3, equating to a total of 600 adolescents (Demeester *et al*. 2025). Ultimately, 482 unique adolescents participated in the study, with 94 completing the measurements from baseline to post-test and 43 completing all three measurements. The dropout of five youth social work organizations combined with incomplete data from adolescents who did not participate in post- and follow-up measurements reduced the effective sample size, compromising the statistical power to detect small effect sizes and increasing the risk of not detecting significant effects (Sink and Mvududu 2010). As mentioned earlier, the unstructured participation and the flexibility for adolescents to join or leave activities at will made longitudinal follow-up more challenging. This limitation could have been mitigated by involving youth workers and adolescents in designing the evaluation plan (Step 6 of the IMP) as part of the co-creation process (Bartholomew *et al*. 2016). Their input could have helped identify optimal moments for data collection, select strategies aligned with adolescents' preferences and youth workers' practical constraints (e.g. introducing a short evaluation form for adolescents to complete immediately after an intervention component is implemented), and ensure more consistent participation across measurement points. More thorough involvement of all participating youth social work organizations in the evaluation planning could also have strengthened their sense of ownership and engagement, potentially increasing their commitment to the data collection and enhancing the overall quality of the evaluation.

Thirdly, since the intervention focuses on the process of starting to smoke for the first time, we dichotomized the stages of MUSICA (Kremers *et al*. 2004) into 0 and 1. However, by dichotomizing the variable 'smoking initiation behaviour', all adolescents who were in different stages than 'committed never smokers' were grouped under 0, which may influence the interpretation. Nevertheless, this decision seemed justified since there was very little variation in this variable (see Table 5), with 63.7% of the intervention group and 73% of the control group in stage 1 (i.e. committed never smoker), and 26.5% of the intervention group and 18.9% of the control group in stage 2 (i.e. immotive never smoker). At the time of baseline data collection, we did not yet know that such a high proportion of adolescents did not intend to smoke in the coming year or in the future; this became apparent only after analysing the data following completion of data collection across all three measurement points. Furthermore, we intentionally included all adolescents willing to participate in youth social work organizations, rather than restricting recruitment to adolescents who intended to smoke, to avoid stereotyping and ensure that all adolescents had the opportunity to take part in the study. Fourth, the presence of incomplete longitudinal data (i.e. most participants completed only one or two questionnaires) necessitated imputation of missing data (Ibrahim and Molenberghs 2009). Although sensitivity analyses were performed to assess the robustness of the findings, the results should be interpreted with caution, given the potential impact of reduced statistical power and incomplete data.

Fifth, adolescents' self-reporting could have introduced biases, such as social desirability bias, where adolescents may respond in ways they perceive as socially acceptable, particularly to questions about risky behaviours like smoking. However, research suggests that self-reported smoking behaviour among adolescents is generally reliable when anonymity is assured

(Dolcini *et al*. 1996). Accordingly, we took several measures at each point of data collection: (i) participants were explicitly informed that their responses would be handled confidentially, (ii) assurances were given that neither their parents nor youth workers would have access to their answers, and (iii) anonymity was guaranteed in the presentation of the KickAsh! study results. Sixth, the project originated from concerns raised by youth social workers; the initiative to address smoking behaviour, therefore, did not originate directly from adolescents themselves. However, through an initial needs assessment and a subsequent co-creation trajectory, we sought to incorporate adolescents' perspectives as thoroughly as possible to ensure that the intervention was relevant to their lived experiences and the challenges that may influence smoking initiation. Lastly, prevention of vaping was not explicitly included in the intervention or measured in the survey. At the start of the project (2021), vaping among adolescents was still in its early stages and was therefore not identified as a key behaviour to target within the intervention. However, during the years spent in youth social work organizations, vaping became increasingly prevalent and more urgent to tackle (Rosiers 2024), and youth workers emphasized the need for tools to address it effectively. In response, a follow-up study is now being conducted to integrate vaping prevention into the KickAsh!-intervention, ensuring that youth workers are equipped to address both smoking and vaping.

Conclusion

This study evaluated the effectiveness of a co-creatively developed, theory-based smoking prevention intervention tailored for adolescents in youth social work organizations. While the intervention showed a positive effect on coping planning, it did not yield the expected impact on smoking initiation behaviour or other targeted determinants. The unexpectedly smaller sample size may have influenced the statistical significance of the findings, underscoring that the unstructured and flexible participation of adolescents makes longitudinal follow-up within youth social work organizations particularly difficult. For future studies, involving participants more actively in the development of an evaluation plan could support the identification of optimal data collection moments, strategies that align with adolescents' preferences and youth workers' practical realities, and approaches to retaining the same participants across measurement points.

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Author contributions

Kenji Leta (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing—original draft, Writing—review & editing), Emelien Lauwerier (Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing—review & editing), Sara Willems (Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing—review & editing), Babette Demeester (Conceptualization, Investigation, Methodology, Project administration, Resources, Writing—review & editing), Veerle Van Oeckel (Formal analysis, Software, Validation, Visualization, Writing—review & editing), and Maïté Verloigne (Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Software, Supervision, Validation, Writing—review & editing).

Supplementary material

Supplementary material is available at *Health Promotion International* online.

Conflicts of interest

The authors declare that they have no conflicts or competing interests.

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Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

Consent for publication

All authors read and approved the final manuscript.

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