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ORIGINAL ARTICLE

Promoting water consumption among children through a social network intervention: a cluster randomized controlled trial on a Caribbean island

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Abstract

Aim This study examined the effect of the evidence-based adapted social network intervention named *Kies Awa* (translation: *Choose Water*) on children's water and sugar-sweetened beverages (SSB) consumption. It also examined the moderating role of children's descriptive and injunctive norms of water and SSB consumption on the intervention's effect.

Subject and methods We conducted a cluster randomized control trial (RCT) where schools were randomized to one of two clusters: the intervention group (IG; *Kies Awa* intervention; 156 participants; $M = 11.08$, $SD = 1.00$; 53.8% girls) or the control group (CG; no intervention; 144 participants; $M = 11.32$, $SD = 0.96$; 52.8% girls). The primary outcome measure was water consumption and the secondary outcome was SSB consumption.

Results Linear mixed modeling analyses showed that water consumption increased significantly more among IG participants than in the CG ($\beta = 0.141$; $p = 0.015$). The effect on SSB consumption was moderated by perceived injunctive norms, which refer to social disapproval of consuming SSBs. Specifically, the intervention reduced SSB consumption for participants reporting high levels of injunctive norms ($\beta = -0.052$; $p = 0.037$).

Conclusion These findings suggest that *Kies Awa*, an evidence-based adapted intervention, could be implemented in other Caribbean islands to improve children's water consumption. This approach could be integrated into school health programs, contributing to public health. These findings may help achieve the United Nations' goal of ensuring healthy lives for all children, even in under-researched world regions.

Clinical Trial Registration: Main ID number: NL-OMON26157, preregistration date 2018-12-20. https://trialsearch.who.int/Trial2.aspx?TrialID=NL-OMON26157.

Keywords Sustainable development · Caribbean · Children · Evidence-based social network intervention · Water consumption · Cluster randomized controlled trial (RCT)

Water consumption is related to better health outcomes (Jequier and Constant 2010; Chouraqui 2023), such as the prevention of obesity (Citar Daziroglu and Acar Tek 2023; Stookey 2010) and dental cavities (Kim 2021). Concerningly studies from around the world have revealed that children consume insufficient amounts of water (Bottin et al. 2019; Suh and Kavouras 2019), coupled with excessive amounts of sugar-sweetened beverages (SSBs; Singh et al. 2015). The consumption of SSBs by children, including soda, sweetened fruit drinks, sports drinks, and sweetened milk beverages, has consistently been linked to weight gain (Jakobsen et al. 2023; Luger et al. 2017; Malik et al. 2006), dental decay (Kusama et al. 2022), type 2 diabetes (Yoshida and Simoes 2018), and cardiovascular diseases (Vos et al. 2017). Compared with other regions, the Caribbean region has the highest SSB consumption rates (Singh et al. 2015) and high obesity rates among children (Caribbean Public Health Agency 2015). These high rates put children in the Caribbean at high

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risk for health issues, requiring the promotion of good health practices among them.

Considering the context of inadequate water consumption and excessive SSB consumption, along with tendencies of early-life choices persisting into adulthood (Mikkila et al. 2005; Movassagh et al. 2017; Rodger and Papies 2022), targeting community health promotion strategies for children becomes an important health investment approach to create 'well-being societies' (World Health Organization 2021). Hence, researchers have implemented interventions aimed at promoting water consumption to reduce SSB consumption among children. Overall, these interventions effectively improved beverage consumption patterns (Avery et al. 2015; Franse et al. 2020; Vargas-Garcia et al. 2017). However, most of these interventions have been implemented in North America and Europe, which highlights the importance of conducting research outside of these WEIRD countries (Western, Educated, Industrialized, Rich, and Democratic) to inform strategies in other parts of the world that are under-researched. In doing so, contributions are made to the Sustainable Development Goals (SDGs) of the United Nations ("The 17 Goals" 2024), more specifically, Goal 3, which addresses children's health and well-being. These SDGs serve all children worldwide while referring to small island states as populations requiring more attention (UN DESA 2023). Giving this attention contributes to ensuring that children in all regions have an equal right to exposure to health-promoting activities.

Research on interventions aimed at promoting water consumption to reduce SSB consumption in the Caribbean region, including the Caribbean island Aruba, is scarce and much needed (Caribbean Public Health Agency 2015). For these reasons, two studies specifically related to improving and understanding water consumption were conducted. The first underscores the potential of continuing the path of a water promotion intervention approach rooted in social networks by successfully utilizing peers at schools (Franken et al. 2018). The second study confirms the importance of conducting research in the region by showing behavioral differences between the Caribbean and Europe, specifically regarding factors that influence water consumption (Franken et al. 2023). More specifically, this study indicated that the intrinsic motivation to consume water was more important for adolescents from Aruba than for those from the Netherlands. Therefore, the present study aimed to examine the effectiveness of a social network, evidence-based adapted intervention promoting water consumption and thereby reducing SSB consumption among children in Aruba. This strategy may contribute to better short- and long-term health outcomes and reduce the strain on public healthcare systems (Alcaraz et al. 2023; Cho et al. 2019).

Social network interventions

Social network interventions designate a set of individuals as 'influential peers' to spread specific messages or behaviors throughout a network (Valente 2012). Such interventions have shown promising results in changing health behaviors (Christakis and Fowler 2011; Latkin and Knowlton 2015), including increasing children's water consumption and reducing SSB consumption (Smit et al. 2016, 2021a). In Aruba, Franken et al. (2018) implemented the *Share* H_2O program, a social network intervention (SNI) originally developed in the Netherlands by Smit et al. (2016) that successfully increased water consumption and reduced SSB consumption among children in a Dutch study. This pilot SNI executed in Aruba also demonstrated similar effects in the intervention group. That is, water consumption increased among children in Aruba who were receptive to friends' injunctive norms. Injunctive norms refer to individuals' perceptions of whether others approve or disapprove of a particular behavior (Cialdini et al. 1991). In addition, SSB consumption decreased among children in the Aruban study, regardless of perceived social norms. Building upon these promising findings, we continued to pursue the path of this SNI approach for health promotion in school communities in Aruba. The findings and experience of this pilot study were used as input to adapt the intervention further to the Aruban context.

Adapting social network interventions to the local context

The *Share* H_2O intervention (Smit et al. 2016) was implemented in Aruba in the same way as in the Netherlands (Franken et al. 2018), and the findings described above served as input for adapting the intervention to Aruba's context. In addition, to adapt the intervention further, we used insights from a recent cross-country comparison of behavioral determinants. This cross-country research (Franken et al. 2023) revealed that, in comparison to the Netherlands, intrinsic motivation and friends' descriptive norms were more strongly associated with water consumption for individuals in Aruba. Intrinsic motivation refers to an individual's innate desire to drink water because it is inherently enjoyable (Ryan and Deci 2017). Friends' descriptive norms here refer to individuals' perceptions of the frequency of others drinking water (Cialdini et al. 1991). This study also showed that, for Aruba, favorable attitudes toward water consumption and the perception of having behavioral control over water consumption were key factors. Attitude refers to individuals' positive evaluations of water consumption, and behavioral control refers to individuals' perceptions that

one is able to and is in control of their water consumption behaviors (Ajzen 1991).

Thus, the two previous studies particularly showed that perceived injunctive and descriptive norms play an important role in Aruba. Furthermore, the cross-country comparison highlighted that water consumption factors differ between the Caribbean and Western Europe, which underlines the importance of considering these countries' distinctive geography and culture when adapting interventions to the regional context (Barrera et al. 2013; Kumanyika 2008). Therefore, the present study examined the effectiveness of an evidence-based adapted intervention for promoting water consumption, further examining the role of descriptive and injunctive norms. The details of the adaptations and reasons for doing so are described in the Methods section.

Study aims

The objectives of this study are to (1) test the effect of the evidence-based adapted social network intervention named *Kies Awa* (which translates to *Choose Water*) on children's water and SSB consumption and (2) examine the moderating role of children's descriptive and injunctive norms of water and SSB consumption on the intervention's effect.

Methods

Design

This study used a cluster randomized control trial (RCT) with schools as the unit of randomization. The participating schools were randomly assigned to one of two clusters: the intervention group (*Kies Awa* intervention) or the control group (no intervention). A randomized block design ensured balanced sample sizes among the groups. In addition, randomization was restricted based on the proximity of school locations to prevent contamination between the groups in the relatively small island setting. In the intervention group, participants were exposed to trained classroom peer influencers (PIs) promoting water consumption over SSB consumption (Franken et al. 2018; Smit et al. 2021a), while no intervention occurred in the control group. The primary outcome measure was water consumption and the secondary outcome was SSB consumption.

Using G*Power 3.1 (Faul et al. 2009), the sample size for this study was calculated based on the pilot SNI in Aruba (Franken et al. 2018), which found a small intervention effect size for water and SSB consumption ($\beta = 0.12$ and $\beta = -0.12$, respectively) that was then converted to Cohen's f ($f = 0.12$). For a repeated-measures ANOVA with an interaction between two groups and two repeated measures (power = 0.80, $\alpha = 0.05$), 140 participants were needed. To anticipate non-response, attrition, and missing data, a much larger number of participants were recruited (see Fig. 1 for the CONSORT flow diagram of participants).

Procedure

The intervention lasted eight weeks, from January to March 2019. Pre-measurements were conducted one week before the intervention started. Participants completed paper-and-pencil questionnaires at their schools before and after the intervention, available in both Papiamento and Dutch, the official languages in Aruba. The pre-measurement questionnaire contained questions related to their demographic information, water and SSB consumption, as well as questions regarding their descriptive and injunctive norms of water and SSB consumption. At pre-measurement, the intervention group participants also answered sociometric nomination questions to identify PIs.

The same consumption and behavior-related questions were answered at post-measurement in the eighth week of the intervention. At post-measurement, participants were also asked to explain the purpose of the research to determine their awareness of the social network component. Among them, none expressed awareness of the purpose of incorporating PIs to promote water consumption. The procedures of this study were approved by the Ethics Committee of the Faculty of Social Sciences at Radboud University (ECW2014-1003–203) and followed the data management protocol of the Behavioural Science Institute of Radboud University. This RCT study was preregistered (2018-12-20) and its main ID number is NL-OMON26157 (https://trialsearch.who.int/Trial2.aspx?TrialID=NL-OMON26157).

Participants

Figure 1 illustrates the CONSORT flow diagram of participants in this study. Eligible participants were 5th and 6th-grade public primary school children in Aruba whose schools met the criteria of not being involved in other curriculum-based health programs and not having participated in the pilot SNI. Eight schools (27 classrooms) were invited to participate. Active consent was obtained from the head of the educational inspection, school board, principals, and parents/caregivers. One principal and one teacher from another school declined participation, leaving seven schools. Four schools (255 children) were randomly assigned to the intervention group, and three schools (269 children) were assigned to the control group.

Of the 524 invited children, 19 parents did not give active consent, and 138 did not submit consent forms. Before the pre-measurement questionnaires were distributed, the children provided assent by signing a form, and five declined to participate. At pre-measurement, 12 children were absent.

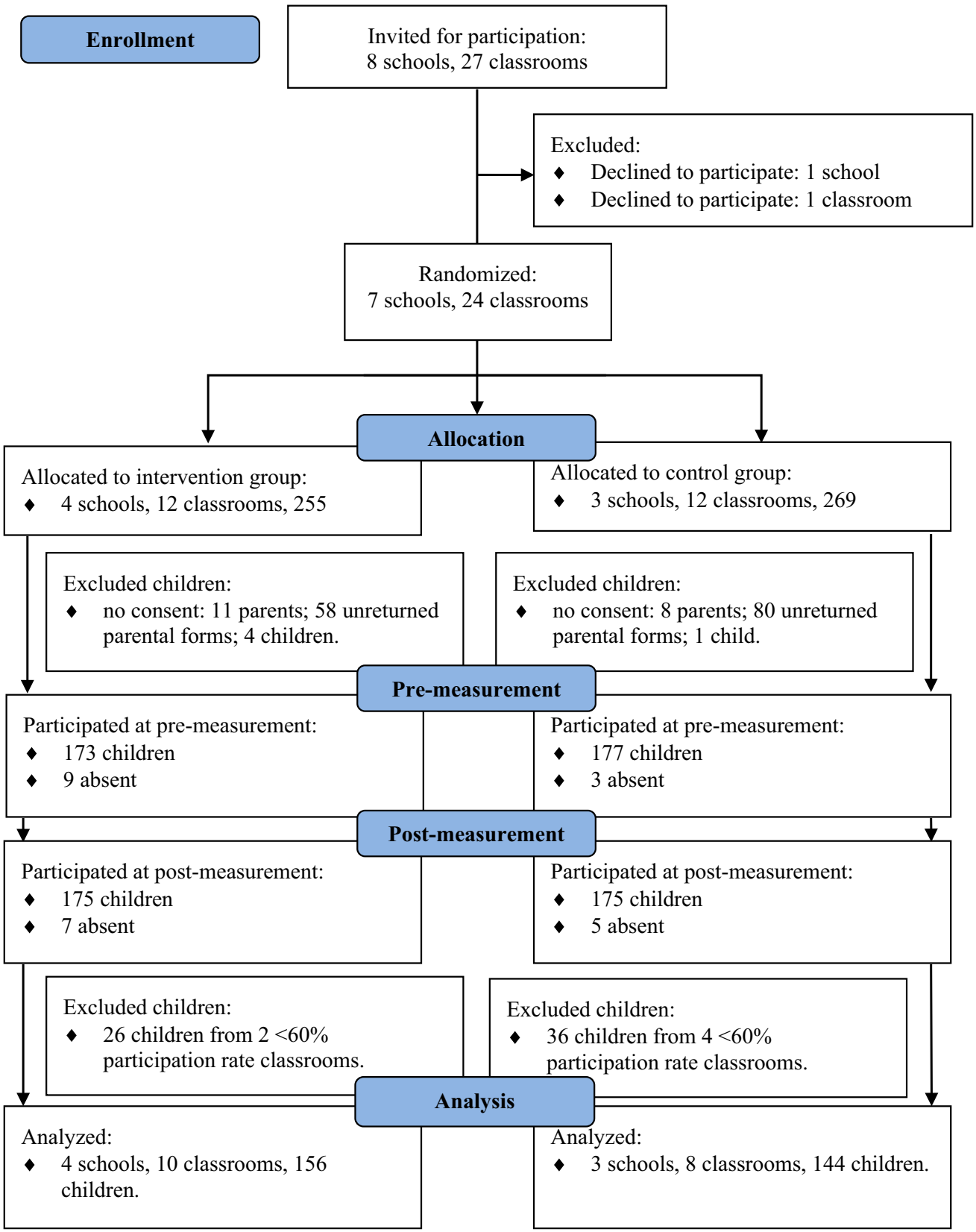

Fig. 1 CONSORT Flow Diagram of Participants

Similarly, due to absenteeism, 12 children could not complete the questionnaire at post-measurement. After data collection, six out of the 24 classrooms had a participation rate of less than 60%, which may hinder the examination of the effects of the SNI (Marks et al. 2013; Smit et al. 2021a). For this reason, two classrooms from the intervention group and four from the control group were excluded from the analysis. The final analytical sample consisted of 7 schools with 18 classrooms and 300 participants aged 9 to 14. Of these, the intervention group included 4 schools with 10 classrooms and containing 156 participants ($M = 11.08$, $SD = 1.00$; 53.8% girls), while the control group included 3 schools, 8 classrooms, 144 participants ($M = 11.32$, $SD = 0.96$; 52.8% girls).

The social network intervention

This study aimed to examine the effectiveness of an adapted SNI for promoting the healthy behavior of choosing water consumption over SSBs. The Aruban intervention, *Kies Awa* (Choose Water), was based on the Dutch *Share* H_2O intervention (Smit et al. 2021b), which utilized self-determination theory (SDT) techniques (Deci and Ryan 1985; Ryan and Deci 2017). We made two key adaptations for Aruba. We provide a brief overview of the intervention's approach before describing the two key adaptations.

Intervention approach

The Aruban intervention resembles the Dutch intervention in that it involved identifying PIs from each classroom, providing them with training, and offering follow-up support sessions. The training, facilitated by the first author, lasted 90 min. The training had two objectives. The first objective was to help PIs develop intrinsic motivation for water consumption through training materials that emphasize the benefits of water and drawbacks of SSBs, as well as by supporting their personal reasons for choosing water (Smit et al. 2021b). The second objective was to empower PIs to motivate their classmates to consume more water through two strategies: modeling the behavior (i.e., descriptive norms) by consuming more water themselves and communicating (i.e., injunctive norms) about consuming water (Cialdini et al. 1991). By practicing these skills, they also learned skills to address potential difficulties they may face in their role. Follow-up sessions were conducted during Week 3 and Week 6 to provide general support, facilitate sharing experiences, and review information. For a description of the SDT-based techniques and training components, refer to Smit et al. (2021b).

Kies Awa: Adaptations to the Aruban Context

We made two key adaptations to the training of the original Dutch *Share* H_2O intervention for the Aruban *Kies Awa* intervention: (1) adding roleplay techniques and (2) incorporating educational materials appropriate for Aruba.

Regarding the first adaptation, adding roleplay techniques allowed PIs to practice promoting water consumption and apply their knowledge in real-life school settings (Lanigan 2011; Lloyd et al. 2011). We added roleplay as a behavioral change technique for two reasons. The first reason was to address the social norms associated with water consumption identified as an important behavioral determinant in previous Aruban research (Franken et al. 2018, 2023). Through roleplay, PIs were encouraged to model the behavior of water consumption (to influence perceived descriptive norms) and to communicate about it (to influence perceived injunctive norms). In doing so, they motivated their classmates to increase their water consumption. During the main roleplay assignment, PIs engaged in various simulated scenarios. Working in pairs, they customized the scenarios to their preferences and discussed possible interactions between the 'peer influencer' and the 'classmate.' They then acted out their scenario, allowing other PIs to observe. To provide a clear understanding of their role through this roleplay assignment, the trainer enacted an example script where the classmate expressed thirst after playing tag at school, and the peer influencer recommended consuming water to quench thirst and regain energy, suggesting that they fill their water bottles at the water cooler.

The second reason to add roleplay as a behavioral change technique was to emphasize the importance of intrinsic motivation for water consumption in Aruba (Franken et al. 2023). Roleplay and discussions also served to encourage PIs to initiate water consumption autonomously and by spreading this behavior, motivating classmates to do the same (Ryan and Deci 2017; Smit et al. 2021b; Soenens and Vansteenkiste 2010). Through discussions and roleplay, PIs learned to identify opportunities (e.g., feeling thirsty after exercise) and difficulties (e.g., not having easy access to water in classrooms) and develop strategies to benefit from opportunities (e.g., encourage filling water bottles at water coolers) or face difficulties (e.g., encourage carrying a reusable water bottle to school).

During the roleplay assignment, PIs also learned to consider their own perspectives and those of their classmates regarding water consumption. They also learned to provide their classmates with reasons to, for example, choose to consume water after physical exercise at school instead of SSBs. By modeling and communicating about water consumption with their classmates, the PIs fostered a social environment that promoted intrinsic motivation among their classmates to consume more water as well (Smit et al. 2021b). In addition,

throughout the training, the PIs practiced their role through roleplay activities such as pouring water for each other, drinking together, communicating about it, and using positive nonverbal cues (e.g., nodding or thumbs-up).

Regarding the second adaptation, we incorporated educational materials appropriate for the Aruban context to provide PIs with more relevant reasoning to increase water consumption and to encourage PIs to promote water consumption among their classmates. The first reason to incorporate context-appropriate materials was to account for the important factors of having favorable attitudes toward water consumption and positive perceptions of behavioral control regarding water consumption that were identified in previous Aruban research (Franken et al. 2023; Ajzen 1991). For example, given that environmental preservation is a concern in Aruba, we made it more meaningful for PIs by emphasizing the environmental benefits of consuming water during the training. The materials included visual imagery and discussions emphasizing the ease of increasing water consumption, its positive impact on personal health, and the island's natural environment, wildlife, and marine ecosystems. To achieve these positive impacts, we emphasized the use of reusable water bottles (Smit et al. 2021b) to contribute to reducing the high amounts of litter associated with SSBs (Debrot et al. 2014; de Scisciolo et al. 2016; Hartley et al. 2015).

The second reason was that the original *Share* H_2O intervention materials were designed for a Dutch audience, requiring adaptations to align with Aruba's specific context. To establish a stronger connection between the intervention and the local context and encourage PIs to consume more water and less SSBs, we incorporated pictures of children and nature that resonated with the PIs. Additionally, we included recent Aruban consumption data to underscore the alarming levels of sugar intake among children in Aruba (Franken et al. 2018). As part of the training, the children also learned the skill of reading nutrition facts labels, enabling them to calculate the high number of teaspoons of sugar in SSBs. This knowledge was aimed at reinforcing their understanding that water consumption is essentially the only healthy option because it does not contain sugar.

Measures

Sociometric peer nominations

During pre-measurement at intervention schools, participants nominated PIs by writing a maximum of five names of classmates on five sociometric questions. These questions asked whom in their classroom they "wanted to be like," "looked up to," "respected," "regarded as good leaders," and "went for advice" (Campbell et al. 2008; Starkey et al. 2009). The role of a PI was offered to 15% of males and 15% of females, with most nominations preserving the sex distribution in each classroom (Campbell et al. 2008; Starkey et al. 2009). Due to the absence of two nominated peers from different classrooms, the next two most nominated peers were invited to participate. A total of 38 participants from ten intervention classrooms ($M = 4$ children per classroom, $SD = 0.21$) accepted the invitation and were trained as a PI to promote water consumption (50% females; M age = 11.3, $SD = 1.01$).

Water consumption

Water consumption was measured by asking participants at pre- and post-measurement how much water they drank during a normal school day. The answer options ranged from 0 = *zero glasses* to 7 = *seven or more glasses.* To facilitate participants' quantity estimation, the questionnaire illustrated that a glass also represents a bottle, a can, or a package (Franken et al. 2023; Smit et al. 2018).

Sugar-sweetened beverages consumption

SSB consumption was measured by asking participants at pre- and post-measurement how many glasses of (a) sweetened juice drinks, (b) soda, and (c) energy and sports drinks they drank on a normal school day. The answer options ranged from 0 = *zero glasses* to 7 = *seven or more glasses*. Examples of SSB brands or names were given. To facilitate participants' quantity estimation, the questionnaire illustrated that a glass also represents a bottle, a can, or a package (Franken et al. 2023; Smit et al. 2018). The average response across the three SSB consumption items was used to obtain each participant's total SSB consumption score.

Descriptive norms of water and sugar-sweetened beverages consumption

Participants' perceptions of their classmates' water and SSB consumption were measured at pre- and post-measurement by asking, "How often do your classmates consume water/SSB?" The answer categories ranged from 1 = *never* to 6 = *always* (Franken et al. 2023; Smit et al. 2018).

Injunctive norms of water and sugar-sweetened beverages consumption

Participants' perceptions of receiving approval from their classmates to consume water and disapproval to consume SSBs were measured at pre- and post-measurement by asking, "How often do your classmates approve/disapprove that you drink water/SSB?" Answer categories ranged from 1 = *never* to 6 = *always* (Franken et al. 2023; Smit et al. 2018).

Thirst level

Thirst level was included as a covariate given that it correlates with the beverage consumption of the participants (Franken et al. 2018; Smit et al. 2018). Therefore, before participants completed the questionnaire at pre- and post-measurement, they were asked to indicate their thirst level by answering "How thirsty are you now?" using a visual analog scale (VAS) of 16 cm ranging from 0 = *not thirsty at all* to 16 = *very thirsty* (Bevelander et al. 2012).

Statistical analyses

The mean and standard deviation were examined for each variable. Independent samples *t*-tests were used to determine whether the scores differed between the intervention group and control group at pre-measurement and post-measurement for all study variables. Pearson's correlations between the study variables were examined.

For the main analyses, we executed Linear Mixed Modeling (LMM) analyses in JASP Version 0.18.2 Intel (JASP Team 2024) to examine the effect of the intervention on the study outcomes of water consumption and SSB consumption. These regression-based hierarchical models take into account the four-level hierarchical structure of our dataset (Field 2013). Water and SSB consumption represented separate dependent variables for every child in a treatment group (intervention or control) in a classroom at a school. Repeated measures (level 1) were nested within children (level 2), who were nested within classes (level 3), which were nested within schools (level 4). We constructed our model in four steps to find the best-fitting model. To compare the models and to test whether predictors contribute to the explanation of the change in water consumption and SSB consumption, model fit was evaluated with an X^2 difference test, which is calculated as the difference between the deviance statistics (−2 log-likelihood) of the two models that are compared (Hox et al. 2017).

In the first step, for both outcomes, we ran a model that included four levels with time (pre- or post-measurement) as a fixed effect (predictor). With this model, we determined whether significant clustering (dependency in the data) occurred. For this purpose, we calculated intra-class correlations (ICC) for levels 2 (individuals), 3 (classes), and 4 (schools). If the ICC at a particular level was below 0.05, it indicated that no substantial clustering occurred at that level and that it could be removed from the model (Field 2013). In the second step, we removed those levels that displayed an ICC < 0.05. In the third step, we added along with time, the treatment group, and the interaction effect between treatment group and time as fixed effects. The significance of the treatment by time interaction effect was tested for our first objective regarding the main effect of *Kies Awa* on children's water and SSB consumption. In the fourth step, we added the covariate thirst level to examine whether our results changed after controlling for thirst level. Then, to further examine the model findings for changes in water and SSB consumption between pre- and post-measurement for each treatment group, we conducted paired sample *t*-tests.

For the second objective regarding testing for the moderating effect of children's descriptive and injunctive norms of water and SSB consumption on the intervention's effect, we included three-way interaction effects (treatment by time by norm) for each norm in each outcome model. To further understand the effect of the intervention on participants with low (1 *SD* below the mean) versus high (1 *SD* above the mean) levels of social norms for water and SSB consumption, significant interaction effects were further interpreted using simple slope analysis.

To explore the effect of the training on the PIs, we conducted two additional analyses. Paired sample *t*-tests were conducted to determine the impact of the training on the water and SSB consumption of the PIs. In addition, to explore the extent to which PIs used water promotion strategies, we computed means, standard deviations, and percentages (with a positive score of 3 or higher) for their post-measurement answers to questions regarding how often they used modeling and communication strategies to promote water consumption among their classmates (scale from 1 = *never* to 6 = *always*; Smit et al. 2021b).

Results

Descriptives

Descriptive statistics showed that participants' pre-measurement consumption averaged 3.93 (*SD* = 1.83) glasses of water and 1.06 (*SD* = 0.91) glasses of SSBs daily. Table 1 provides means, standard deviations, and (non)significant differences for all variables by intervention and control groups at pre-measurement and post-measurement. Table 2 shows Pearson's correlations between the study variables.

Main analyses

The Effect of *Kies Awa* on water consumption

To determine the effectiveness of *Kies Awa* for water consumption, we constructed four linear mixed effects models. Table 3 contains the results of the fixed effects and variance estimates for water consumption. The results of the first model determined to what extent we should take into account the hierarchical structure of our dataset. The total variance was split into four levels. The ICCs for water consumption were 0.377 (level 2), 0.042 (level 3), and 9.812^{-10}

Table 1 Descriptive Statistics for the Intervention and Control Groups at Pre-Measurement and Post-Measurement [1]

Measure	Pre-measurement							Post-measurement						
	Intervention			Control				Intervention			Control			
	M	*SD*	Range	*M*	*SD*	Range	*p* [2]	*M*	*SD*	Range	*M*	*SD*	Range	*p* [2]
Thirst (16-cm Visual Analogue Scale)	6.1	5.5	0–16	6.5	5.1	0–16	0.486	7.9	5	0–16	7.3	4.3	0–16	0.333
Water consumption (i.e., glasses)	3.7	1.8	0–7	4.2	1.8	0–7	0.009	3.9	1.9	0–7	4.0	1.7	0–7	0.822
Sugar-sweetened beverages consumption (i.e., glasses)	1.0	0.8	0–3.7	1.2	1	0–6.7	0.092	1.0	0.9	0–4.7	1.0	1.1	0–6	0.543
Descriptive norm water consumption	4.2	1.2	2–6	4.0	1.2	1–6	0.250	4.2	1.2	1–6	4.1	1.2	1–6	0.163
Descriptive norm sugar-sweetened beverages consumption	3.8	1.2	1–6	4.2	1.2	1–6	0.019	4.1	1.2	1–6	4.5	1.3	1–6	0.009
Injunctive norm water consumption	3.8	1.6	1–6	3.6	1.7	1–6	0.381	3.4	1.7	1–6	2.8	1.7	1–6	0.005
Injunctive norm sugar-sweetened beverages consumption	2.3	1.5	1–6	2.2	1.3	1–6	0.288	2.3	1.5	1–6	1.9	1.4	1–6	0.056

[1] $N = 300$; 156 participants were in the intervention group and 144 participants were in the control group. [2] p values reflect the differences in the means between the intervention and control groups at pre-measurement or post-measurement by independent samples t-tests

(level 4). This indicated a significant clustering of repeated measurements within children but not between children in the same classrooms and schools. Therefore, the class and school levels were removed from the model. The two-level model did not fit the data significantly worse than the four-level model (X^2 change = 5.675(2), $p > 0.05$; see Model 2, Table 3). Next, along with time, the treatment group and the interaction effect between time and treatment group were included in the model (see Model 3, Table 3). The model fit significantly improved with the addition of these fixed effects (X^2 change = 8.153(2), $p < 0.05$). It also showed a significant interaction effect between time and treatment group on water consumption ($p = 0.023$). In the fourth step, thirst level was added to the model (see Model 4, Table 3). This improved the fit of the model as well (X^2 change = 90.397(1), $p < 0.01$), and the interaction effect between time and treatment group remained significant after controlling for thirst level ($p = 0.015$; see Model 4, Table 3). This indicates that children in the intervention group consumed significantly more water units (i.e., glasses) over time compared to children in the control group after controlling for thirst level. Further examination of this effect by means of paired samples t-test showed a significant increase in water consumption in the intervention group ($M_{pre} = 3.63$, $SE = 0.15$; $M_{post} = 3.94$, $SE = 0.16$; $t(140) = -1.83$, $p = 0.035$) and a marginally significant decrease in water consumption in the control group ($M_{pre} = 4.20$, $SE = 0.15$; $M_{post} = 3.98$, $SD = 0.14$; $t(138) = 1.45$, $p = 0.075$).

The effect of *Kies Awa* on sugar-sweetened beverages consumption

For SSB consumption, the same four steps were taken to determine the effectiveness of *Kies Awa*, and the results are shown in Table 4. In the first model, the ICCs for SSB consumption were 0.488 (level 2), 2.797×10^{-10} (level 3), and 0.003 (level 4). This indicates a significant clustering of repeated measurements within children but not between children in the same classrooms and schools. Therefore, the class and school levels were removed from the model. The two-level model did not fit the data significantly worse than the four-level model (X^2 change = 0.13(2), $p > 0.05$; see Model 2, Table 4). Next, along with time, the treatment group, and the interaction effect between time and treatment group were included in the model (see Model 3, Table 4). The model fit was not significantly improved by the addition of these fixed effects (X^2 change = 2.762(2), $p > 0.05$). It also showed a nonsignificant interaction effect between time and treatment group on SSB consumption ($p = 0.325$). Next, thirst level was added to the model (see Model 4, Table 3). Model 4 resulted in a good fit of the model (X^2 change = 48.411(1), $p < 0.01$) but yielded a nonsignificant interaction effect between time and treatment group

Table 2 Pearson Correlations among the Variables at Pre-measurement (T1) and Post-measurement (T2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Thirst level T1	–	.425**	.218**	.084	.097	-.017	.078	.160**	.081	.077	-.023	-.022	-.027	-.084
2. Thirst level T2			.172**	.156**	.047	.040	.132*	.137*	-.090	.083	.229**	.187**	.037	-.007
3. Water consumption T1				.413**	.195**	.111	.076	.050	.058	.154*	.139*	.009	.056	-.029
4. Water consumption T2					.141*	.197**	.125*	.172**	.109	.081	.084	.076	.124*	.040
5. Sugar-sweetened beverages consumption T1						.498**	.029	-.022	.130*	.082	.038	-.018	.108	-.036
6. Sugar-sweetened beverages consumption T2							-.019	.076	.078	.068	.046	.062	.046	.031
7. Descriptive norm water consumption T1								.355**	-.029	-.113	.261**	.205**	.212**	.110
8. Descriptive norm water consumption T2									-.022	-.024	.256**	.339**	.125*	.071
9. Descriptive norm sugar-sweetened beverages consumption T1										.377**	-.069	-.043	-.108	-.060
10. Descriptive norm sugar-sweetened beverages consumption T2											-.081	-.096	-.119*	-.111
11. Injunctive norm water consumption T1												.315**	.297**	.169**
12. Injunctive norm water consumption T2													.141*	.421**
13. Injunctive norm sugar-sweetened beverages consumption T1														.230**
14. Injunctive norm sugar-sweetened beverages consumption T2														–

$N = 300$. * $p < 0.05$ and ** $p < 0.01$ indicate statistical significance

($p = 0.458$; see Model 4, Table 4). This indicated that SSB consumption did not significantly decrease in children in the intervention group over time compared to that in children in the control group after controlling for thirst level. Further examination of these results by means of paired samples *t*-test confirmed that the units (i.e., glasses) of SSBs consumed did not change significantly for children in the intervention group ($M_{pre} = 0.97$, $SE = 0.07$; $M_{post} = 0.99$, $SE = 0.07$; $t(142) = -0.19$, $p = 0.432$), nor for children in the control group ($M_{pre} = 1.15$, $SE = 0.08$; $M_{post} = 1.05$, $SD = 0.09$; $t(138) = 1.16$, $p = 0.123$).

The moderating effect of social norms on the effect of *Kies Awa* on water consumption

To test whether social norms influenced the effectiveness of *Kies Awa* on water consumption, we conducted moderation analyses for descriptive norm (Model 5A) and injunctive norm (Model 5B) separately (see Table 3). Model 5A, which included a three-way interaction term between the treatment group, time, and descriptive norm of water consumption, resulted in a significant improvement in the model fit (X^2 change 42.837(4), $p < 0.01$), but the three-way interaction term was nonsignificant ($p = 0.700$; see Model 5A, Table 3). Model 5B resulted in a good fit of the model (X^2 change 65.218(4), $p < 0.01$), but the three-way interaction term for the treatment group, time, and injunctive norm of water consumption was nonsignificant ($p = 0.086$; see Model 5B, Table 3). These findings indicated that children's perceived social norms in the intervention group did not moderate the effect of the intervention on water consumption.

The moderating effect of social norms on the effect of *Kies Awa* on sugar-sweetened beverages consumption

For SSB consumption, we also conducted moderation analyses for descriptive norm (Model 5A) and injunctive norm (Model 5B) separately (see Table 4). Model 5A resulted in a good fit (X^2 change 27(4), $p < 0.01$) but yielded a nonsignificant three-way interaction term for the treatment group, time, and descriptive norm of SSB consumption ($p = 0.297$; see Model 5A, Table 4). Model 5B resulted in a good fit of the model (X^2 change 43.943(4), $p < 0.01$), and a significant three-way interaction term for the treatment group, time, and injunctive norm of SSB consumption ($p = 0.037$) was found (see Model 5B, Table 4). The simple slopes of this significant interaction showed that, over time, in the intervention group, SSB consumption was reduced for children with high levels of injunctive norm, SSB consumption remained stable for those with mean levels of injunctive norm, and SSB consumption increased for those with low levels of injunctive norm. In the control group, SSB did not change much regardless of the levels of injunctive norm. These slopes

Table 3 Multilevel Regression Analysis Examining the Fixed Effects of the Intervention on Water Consumption over Time

Effect	Model 1		Model 2		Model 3		Model 4		Model 5A		Model 5B	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Fixed effects												
Intercept	3.946**	0.123	3.955**	0.088	3.960**	0.088	3.576**	0.136	2.975**	0.288	3.223**	0.200
Time	−0.022	0.057	−0.020	0.058	−0.018	0.057	0.020	0.059	0.261	0.236	−0.192	0.146
Treatment group					0.151	0.088	0.139	0.087	0.341	0.274	0.367	0.172
Time * treatment group					0.130*	0.057	0.141*	0.058	0.040	0.235	0.386*	0.146
Thirst level							0.057**	0.015	0.056**	0.015	0.055**	0.015
Descriptive norm									0.146*	0.063		
Time * treatment group *descriptive norm									0.021	0.056		
Injunctive norm											0.101*	0.044
Time * treatment group *injunctive norm											−0.067	0.039
Random components												
Child level variance	1.223		1.357		1.354		1.274		1.243		1.259	
Class level variance	0.138											
School level variance	3.187×10^{-9}											
Residual variance	1.887		1.890		1.855		1.818		1.816		1.790	
Deviance (−2 log-likelihood)	2269.692		2275.367		2267.214		2176.817		2133.980		2111.599	
X^2 change test	5.675(2), $p > 0.05$		8.153(2), $p < 0.05$		90.397(1), $p < 0.01$		42.837(4), $p < 0.01$		65.218(4), $p < 0.01$			

The treatment group was coded as 0 (control group) or 1 (intervention group)

The final model (Model 4) was built in steps and represents the best-fitting model

Model 1: model with time; Model 2: model with level 1 main effects; Model 3: model with between-level interaction terms; Model 4: model with the covariate thirst level

* $p < 0.05$, ** $p < 0.001$

Table 4 Multilevel Regression Analysis Examining the Fixed Effects of the Intervention on Sugar-sweetened Beverage Consumption over Time

Effect	Model 1		Model 2		Model 3		Model 4		Model 5A		Model 5B	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Fixed effects												
Intercept	1.030**	0.053	1.034**	0.047	1.036**	0.047	0.922**	0.071	0.726**	0.146	0.802**	0.093
Time	0.022	0.028	0.022	0.028	0.022	0.028	0.040	0.030	−0.015	0.115	−0.023	0.060
Treatment group					0.063	0.047	0.067	0.047	−0.152	0.140	0.046	0.075
Time * treatment group					0.028	0.028	0.022	0.029	0.142	0.115	0.135*	0.060
Thirst level							0.016*	0.008	0.016*	0.008	0.017*	0.008
Descriptive norm									0.044	0.032		
Time * treatment group *descriptive norm									−0.028	0.027		
Injunctive norm											0.051	0.027
Time * treatment group *injunctive norm											−0.052*	0.025
Random components												
Child level variance	0.431		0.434		0.431		0.401		0.397		0.393	
Class level variance	2.470×10^{-5}											
School level variance	0.003											
Residual variance	0.449		0.449		0.447		0.461		0.461		0.457	
Deviance (−2 log-likelihood)	1500.902		1501.032		1498.270		1449.859		1422.859		1405.916	
X^2 change test	0.13(2), $p > 0.05$		2.762(2), $p > 0.05$		48.411(1), $p < 0.01$		27(4), $p < 0.01$		43.943(4), $p < 0.01$			

The treatment group was coded as 0 (control group) or 1 (intervention group)

The final model (Model 4) was built in steps and represents the best-fitting model

Model 1: model with time; Model 2: model with level 1 main effects; Model 3: model with between-level interaction terms; Model 4: model with the covariate thirst level

* $p < 0.05$, ** $p < 0.001$

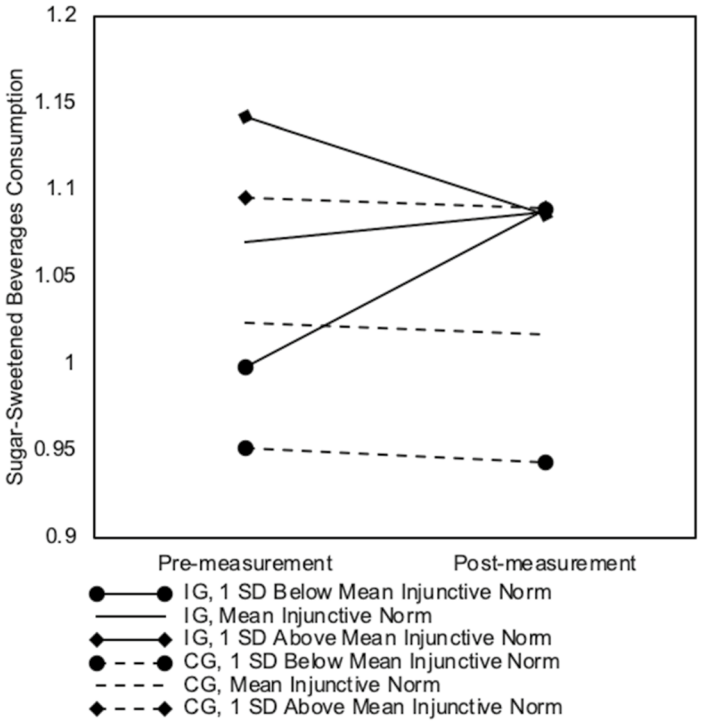

Fig. 2 Interaction Effects between the Intervention Group or Control Group and Low, Mean, or High Injunctive Norm of Sugar-Sweetened Beverages Consumption for Predicted Sugar-Sweetened Beverages Consumption

Note. IG = intervention group; CG = control group; SD = standard deviation. The SSB consumption predictions include a mean thirst level covariate.

indicated that the effect of *Kies Awa* on SSB consumption depended on the level of injunctive norm. Figure 2 illustrates these slopes of the interaction effects between the intervention group or control group and low, mean, or high injunctive norm of SSB consumption for predicted SSB consumption.

Additional analyses

We conducted two additional analyses to explore the effect of the training on PIs. First, a paired sample *t*-test was conducted to examine the impact of the training on the water and SSB consumption of the PIs ($n = 38$). After the training, the water consumption of the PIs significantly increased compared to that before the training ($M_{pre} = 3.46$, $SE = 0.30$; $M_{post} = 4.41$, $SE = 0.28$; $t(36) = -4.99$, $p = < 0.001$). However, there was no significant reduction in SSB consumption ($M_{pre} = 0.84$, $SE = 0.12$; $M_{post} = 0.82$, $SE = 0.12$; $t(37) = 0.19$, $p = 0.850$). These results indicate that after attending the training, the PIs consumed more water but not less SSBs.

Second, to explore which strategies the PIs applied to promote water consumption among their classmates after the training, we calculated means, standard deviations, and percentages (scoring ≥ 3). PIs indicated that they used modeling strategies, such as consuming water in each other's presence ($M = 4.68$, $SD = 1.47$) and consuming water together with each other ($M = 3.95$, $SD = 1.51$), which were used by 95% and 86% of PIs, respectively (scoring ≥ 3). Additionally, the PIs indicated using communication strategies, such as expressing approval for their classmates' water consumption ($M = 3.59$, $SD = 1.46$) and reminding their classmates about water consumption ($M = 3.68$, $SD = 1.29$), which were used by 78% and 89% (scoring ≥ 3) of the PIs, respectively. These explorative results suggest that during the intervention period, PIs used both modeling strategies and communication strategies within their social network. However, the PIs indicated the use of more modeling strategies than communication strategies.

Discussion

This study examined the effectiveness of *Kies Awa*, a social network intervention aimed at promoting water consumption and reducing SSB consumption among primary school children in Aruba. In addition to assessing the intervention's effect on consumption behaviors, the study also tested whether the prevailing social norms interacted with the intervention's effectiveness. The findings suggest that *Kies Awa* had a significant impact on increasing overall water consumption but did not reduce overall SSB consumption. Furthermore, the study revealed that injunctive norms, which refer to perceived disapproval from classmates regarding the consumption of SSBs, interacted with the effect of *Kies Awa*

on SSB consumption. This interaction effect indicates that the *Kies Awa* intervention leads to a reduction in SSBs only among children who already experienced that their peers disapprove of their consumption of SSBs.

Children's water consumption and the social environment

Children exposed to the *Kies Awa* intervention reported an increase in water consumption compared to children in the control group. Thus, it seems that incorporating PIs into interventions to promote water consumption can be a successful strategy for improving the water consumption of their peers in their social network at school. These findings are in line with research showing that peers in the social environment can play a role in influencing the food and beverage consumption of others (Herman and Polivy 2005; Hermans et al. 2012; Higgs 2015; Johnsunderraj et al. 2023; Lakin et al. 2003; Robinson et al. 2014; Salvy et al. 2012; Wouters et al. 2010).

However, the current study showed a more substantial effect on water consumption than a previously piloted social network intervention in Aruba. This previous pilot, a replication from the Netherlands, was implemented without adaptation to the local context (Franken et al. 2018). Consequently, it did not lead to an overall increase in water consumption, but only an increase was found among children who reported higher levels of perceived approval for their water consumption (i.e., injunctive norms) at the beginning of the intervention. The present study's main effect underscores the importance of evidence-based adaptations to interventions in a local context, as this approach resulted in a more substantial effect. This finding supports research emphasizing the importance of adapting interventions for better effectiveness in different community contexts (Barrera et al. 2013; Kumanyika 2008).

Children's sugar-sweetened beverages consumption and the social environment

We found that the effect of the *Kies Awa* social network intervention on children's SSB consumption depended on children's prevailing perceived injunctive norm about SSB consumption. Specifically, children in the intervention group who reported perceiving disapproval from others about their SSB consumption (i.e., high injunctive norm) before the intervention consumed less SSBs after being exposed to the intervention. Conversely, they consumed more SSBs when they did not perceive disapproval (i.e., low injunctive norm). This finding is in line with previous studies that found that normative peer influence plays a crucial role in shaping children's dietary behaviors (Herman and Polivy 2005; Higgs 2015; Robinson et al. 2014; Salvy et al. 2012; Wouters et al. 2010).

However, the present study's findings differ from those of a previously piloted study that found an overall reduction in SSB consumption without interactions with prevailing social norms (Franken et al. 2018). One possible reason for the less uniform effect on SSB consumption among the classmates of the PIs in the present study is that the PIs did not consume less SSBs after the training; thus, classmates were not given the example of consuming less SSBs during the intervention. In contrast, in the pilot study, PIs did give the example of consuming less SSBs, which could have led to a reduction in overall SSB consumption among their peers. Thus, both of these studies highlight that exposure to modeled behavior influences consumption behavior within SNIs, which is consistent with previous research (Latkin and Knowlton 2015; Salvy et al. 2012; Smit et al. 2021b).

Implications for future research

Concerning their beverage consumption, the children in this study did not meet the guidelines recommended by the Aruban health authorities, which state that children aged 9 to 12 should consume six to eight glasses of water or non-caloric beverages daily (DVG and IDEFRE 2012). This public health issue of inadequate hydration among children has also been found in other countries worldwide (Bottin et al. 2019; Suh and Kavouras 2019). Although water consumption improved after *Kies Awa*, the amount of water consumed by children, approximately four glasses, was still inadequate. Therefore, water consumption must be addressed further.

Additionally, the study findings indicate that children consumed approximately one glass of SSB daily. This daily SSB consumption is problematic, as even one serving of approximately 330 ml contains, on average, ten teaspoons of sugar (140–150 cal). Research has shown that eliminating such daily SSB consumption could prevent children from gaining weight (Malik et al. 2013; Zheng et al. 2015). Addressing this daily SSB consumption in future research is important because recent research involving Aruban preschoolers demonstrated that they already show an unhealthy lifestyle characterized by excessive sugar consumption from SSBs and candies (Curet and Vermeulen 2023).

Future research could also consider applying a mixed-methods approach to increase children's water consumption and reduce their SSB consumption, including for example, collaboration with PIs to improve the training materials of the intervention (Healthy Caribbean Coalition 2022; Zoellner et al. 2013; Smit et al. 2022). Furthermore, given our finding that *Kies Awa* can reduce SSB consumption among children who experience peers' disapproval regarding the consumption of SSBs, future co-created interventions could

consider influencing injunctive norms related to SSB consumption. For example, through co-creation, PIs could be trained to discourage daily SSB consumption on school premises by suggesting the consumption of SSBs only during special occasions on weekends among their classmates. This approach could replace the one glass of daily SSB consumption in this study with one glass of water, bringing children closer to meeting the health authority guidelines. In addition, future interventions may consider targeting this SSB consumption issue directly rather than indirectly by promoting water consumption (Battram et al. 2016; Dibay Moghadam et al. 2020; Zoellner et al. 2024).

In addition, collaborating more closely with PIs could help clarify children's knowledge and determine the best approach to improve beverage consumption. Co-creation also fosters children's advocacy, increasing their intrinsic motivation and that of others in their social environment to consume adequate beverages (Gillison et al. 2019; Healthy Caribbean Coalition 2022; Smit et al. 2021a).

After all, as adults, we should support children in cultivating healthy behaviors at a young age (Fernandez-Jimenez et al. 2018; Vargas et al. 2013) to prevent adverse health effects when they reach adulthood (Hu 2013; Zheng et al. 2015). This approach could be integrated into school health programs. Furthermore, changing behaviors later in life may be even more challenging (Abrignani et al. 2019; Hu 2013; Kelsey et al. 2014). Thus, children would benefit from future community intervention endeavors aimed at improving their beverage consumption.

Strengths, limitations, and implications

Interpreting our findings requires consideration of strengths, limitations, and implications. A strength of this study is that *Kies Awa* builds not only on a Dutch evidence-based intervention called *Share* H_2O but also on evidence from two previous Aruban studies. This approach resulted in a more substantial effect. Therefore, we recommend that future intervention research and practice apply such an evidence-based approach in new contexts to help contribute to public health. Furthermore, this research contributes to the SDGs addressing children's health ("The 17 Goals" 2024). These goals are intended for all children worldwide, while particularly referring to small island states, such as Aruba, as populations requiring more attention (UN DESA 2023). Hence, given that children are vulnerable members of populations, we contribute to children's right to expose them to health-promoting activities and interventions in under-researched regions such as the Caribbean (Healthy Caribbean Coalition 2022). This study also contributes to the growing body of evidence on the effectiveness of SNIs in promoting healthy behaviors (Campbell et al. 2008; Chung et al. 2017; Cruwys et al. 2015; Kelly et al. 1991; Latkin and Knowlton 2015; Robinson et al. 2014; Sebire et al. 2018; Story et al. 2002; Valente et al. 2003).

In addition to using self-reported measures, future research could use additional water consumption measures, such as analyzing urine samples (Armstrong et al. 2013), observing water consumption (Beets et al. 2014), or attaching flowmeters to water coolers (Loughridge and Barratt 2005; Smit et al. 2021a). Furthermore, we collected data only once after the intervention period, limiting the examination of mediation analyses and long-term effectiveness. Future research could incorporate additional time points to measure the perception of norms as mediating variables. Additional time points would facilitate assessing whether pre-measurement water consumption predicts norms (i.e., mediators) and subsequently predicts post-measurement water consumption (Fairchild and McQuillin 2010). Furthermore, while examining these long-term effects, the effects on preventing dental caries (Kim 2021) and weight gain among children (Citar Daziroglu and Acar Tek 2023; Stookey 2010) could also be investigated.

Conclusion

The social network intervention *Kies Awa* successfully promotes water consumption among children in Aruba, extending this approach beyond WEIRD countries. The next step is to discover ways the intervention can decrease SSB consumption more effectively for all children. The findings of this study demonstrate the importance of adapting interventions to suit new contexts. Furthermore, the knowledge acquired in this study can serve as input for intervention development that aims to motivate children in all parts of the world to consume more water, and with that, we can play our part in achieving Goal 3 of the SDGs, which is to ensure a healthy life for all children ("The 17 Goals" 2024). In the end, adults are responsible for implementing health-related policies so that children, who are vulnerable society members, live in community environments, such as schools, that encourage healthy behaviors (Healthy Caribbean Coalition 2022). Such school environments increase the likelihood of meeting health authorities' recommended guidelines and contributing to the development of healthier adults.

Author contributions Saskia CM Franken is the primary researcher and the corresponding author. Saskia CM Franken, Crystal R Smit, Rebecca NH de Leeuw, and Moniek Buijzen conceptualized and designed the study. Saskia CM Franken collected the data with the assistance of a data collector. Saskia CM Franken analyzed the collected data, and Marleen HM de Moor and Crystal R Smit directly accessed and critically verified the data and analyses, which Rebecca NH de Leeuw and Moniek Buijzen reviewed. Saskia CM Franken wrote the manuscript, and Crystal R Smit, Marleen HM de Moor, Rebecca NH de Leeuw, and

Moniek Buijzen critically reviewed it. All authors accept responsibility for the submitted version of this paper.

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Data availability The deidentified participant dataset analyzed for the present study is available from the corresponding author upon reasonable request.

Declarations

Ethics approval The Ethics Committee of Social Sciences at Radboud University approved the data collection procedures (ECSW2014-1003–203).

Consent to participate Informed consent was obtained from parents and assent was obtained from the children to participate in this study.

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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