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POPULATION HEALTH INTERVENTION RESEARCH

Promoting healthy beverage consumption habits among elementary school children: results of the Healthy Kids Community Challenge 'Water Does Wonders' interventions in London, Ontario

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Abstract

Intervention This study examines the impact of London's Healthy Kids Community Challenge (HKCC) 'Water Does Wonders' interventions, which combined water infrastructure and education programs.

Research question How effective were the HKCC interventions at increasing water and decreasing sugar-sweetened beverage (SSB) consumption among grade 4–8 children in London, Ontario?

Methods Non-randomized controlled trial. Children's knowledge and beverage intake were measured before and after the interventions were implemented during the 2016–2017 school year. Children at intervention schools ($n = 521$) received education programs (Growing Chefs or UTRCA [Upper Thames River Conservation Authority]) and water bottle filling stations. Children at control schools ($n = 410$) received filling stations only. Multivariable linear mixed-model ANCOVAs were used to compare water and SSB consumption and knowledge across intervention groups, accounting for school-level clustering.

Results Children who received an education intervention and filling station compared with only a filling station consumed more water ($\beta = 2.18$ (95% CI − 1.87, 6.22) for Growing Chefs and $\beta = 2.90$ (95% CI − 0.23, 6.03) for UTRCA) and fewer SSBs ($\beta = -1.17$ (95% CI − 3.83, 1.49) for Growing Chefs and $\beta = -2.56$ (95% CI − 5.12, 0.001) for UTRCA) post-intervention, and had higher nutrition knowledge ($\beta = 1.57$ (95% CI − 1.68, 4.83) for Growing Chefs and $\beta = 2.02$ (95% CI − 0.35, 4.39) for UTRCA). These findings were not statistically significant.

Conclusions An intervention intended to promote healthy beverage consumption yielded effects in the expected direction; however, they were small and not statistically significant. This is likely because the educational interventions were not fully aligned with the goals of the 'Water Does Wonders' program, preventing them from evoking meaningful changes in dietary behaviours.

Résumé

Intervention Notre étude porte sur les effets d'interventions menées sous le thème de « L'eau fait des merveilles » du programme Action communautaire Enfants en santé (ACES) à London, en Ontario, qui ont combiné l'installation de bornes d'eau et des programmes d'information.

Question de recherche Les interventions du programme ACES ont-elles fait augmenter la consommation d'eau et réduit celle des boissons édulcorées au sucre (BÉS) chez les élèves de la 4^e^ à la 8^e^ année à London?

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Méthode Essai comparatif non randomisé. Les connaissances des enfants et leur consommation de boissons ont été mesurées avant et après la mise en œuvre des interventions durant l'année scolaire 2016-2017. Les élèves des écoles visées par l'intervention (n = 521) ont reçu des programmes d'information (Growing Chefs ou UTRCA [Upper Thames River Conservation Authority]) et des bornes d'eau. Les élèves des écoles témoins (n = 410) n'ont reçu que des bornes d'eau. Des modèles ANCOVA linéaires mixtes multivariés ont servi à comparer la consommation d'eau et de BÉS et les connaissances alimentaires dans les groupes visés par l'intervention, en tenant compte du regroupement des données par école.

Résultats Les élèves ayant reçu une intervention d'information et une borne d'eau, comparativement à une borne d'eau seulement, ont consommé plus d'eau (β = 2,18 [IC de 95 % -1,87, 6,22] pour Growing Chefs et β = 2,90 [IC de 95 % -0,23, 6,03] pour UTRCA) et moins de BÉS (β = -1,17 [IC de 95 % -3,83, 1,49] pour Growing Chefs et β = -2,56 [IC de 95 % -5,12, 0,001] pour UTRCA) après l'intervention et ont démontré des connaissances nutritionnelles supérieures (β = 1,57 [IC de 95 % -1,68, 4,83] pour Growing Chefs et β = 2,02 [IC de 95 % -0,35, 4,39] pour UTRCA). Ces résultats n'étaient toutefois pas significatifs.

Conclusions Une intervention visant à promouvoir la consommation de boissons saines a eu des effets dans le sens escompté, mais ces effets ont été légers et non significatifs. C'est probablement parce que les interventions d'information n'étaient pas pleinement en phase avec les objectifs de la thématique « L'eau fait des merveilles », ce qui a empêché l'apport de véritables changements dans les comportements nutritionnels.

Keywords Sugar-sweetened beverages · Water · Childhood obesity · Children's health · School-based intervention

Mots-clés Boissons édulcorées au sucre · Eau de boisson · Obésité pédiatrique · Santé de l'enfant · Intervention en milieu scolaire

Introduction

Despite substantial preventive public health efforts, childhood obesity remains one of the greatest threats facing children today (World Health Organization 2016), affecting roughly 30% of Canadians aged 5–17 (Roberts et al. 2012). Although obesity is a multifaceted issue with genetic, environmental, and behavioural components, research has identified poor diet including high added sugar intake as a key determinant of weight status, and the role of sugar-sweetened beverages (SSBs) in particular has been the focus of extensive inquiry.

Sugar-sweetened beverages, including regular pop, fruit-flavoured drinks, sports drinks, energy drinks, and sweetened tea, coffee, and milk drinks, are considered a major source of added sugar in the diet (Luger et al. 2017). Evidence has linked the consumption of SSBs, which are calorie dense and nutrient poor (James et al. 2004), to excess weight gain in childhood (Keller and Della Torre 2015; Malik et al. 2013; Trumbo and Rivers 2014) and this in turn is associated with adverse health outcomes, such as cardiovascular disease, type 2 diabetes, and hypertension (World Health Organization 2012). Data from the Canadian Community Health Survey (CCHS) (Garriguet 2019) suggest that, despite decreasing significantly since 2004, Canadian children's SSB consumption still well exceeds the recommended maximum intake of 8 ounces per week as set by the American Heart Association (Johnson et al. 2009), with the average youth aged 9 to 13 consuming approximately 4.73 ounces per day of soft drinks and fruit drinks (Garriguet 2019), and similar trends have been observed worldwide. Consequently, reducing SSB consumption as a means to improve dietary quality has become a global public health priority, and a movement has emerged to curtail children's SSB intake and to replace SSBs with water, a calorie- and sugar-free alternative.

A recent systematic review of interventions to reduce SSB consumption in children concluded that school-based education programs may be an effective and sustainable strategy (Avery et al. 2015). Virtually all children attend school, and spend a significant portion of their waking hours there, making these institutions a critical site in which to promote healthy behaviours among children of all socio-economic statuses (Richardson and Juszczak 2008). Along with education, changes to the school environment to support healthy habits may promote even greater improvements in children's beverage intake (Avery et al. 2015). In German elementary schools, for example, a significant increase in water intake was observed following a series of lessons on water combined with the installation of water fountains (Muckelbauer et al. 2009), while the provision of cups near fountains at Boston schools, along with a social marketing campaign to promote water consumption, resulted in significant improvements (Kenney et al. 2015).

The purpose of this study was to evaluate the effectiveness of a series of school-based interventions that combined water and nutrition education with environmental changes to support water consumption on increasing children's water consumption and decreasing their SSB consumption.

Intervention

The Healthy Kids Community Challenge (HKCC) was an Ontario-wide initiative led by the Ministry of Health and Long-Term Care that provided funding, training, and social marketing tools to 45 communities across the province to promote healthy eating, physical activity, and other healthy behaviours in children. Participating communities implemented programs and activities that fit within the HKCC's key themes, which included 'Run. Jump. Play. Everyday.', 'Choose to Boost Veggies and Fruits', 'Power Off and Play', and 'Water Does Wonders'.

The 'Water Does Wonders' activities in London, Ontario, consisted of three interventions, which were designed and implemented by the city's Child and Youth Network (CYN). Each participating school received a new automatic water bottle filling station, which dispenses cold, filtered water directly into refillable water bottles. Compared with traditional drinking fountains, filling stations are much faster and easier to use for filling water bottles, making them better able to meet the demand for water in schools. In addition, a subset of schools received one of two education interventions: the Growing Chefs program or the Upper Thames River Conservation Authority (UTRCA) program. Growing Chefs is a London-based organization that promotes nutrition through interactive cooking and food literacy workshops for children. The program was delivered in-classroom to each school and occurred twice during the school year. In addition to basic cooking skills, children learned the art of food presentation and the importance of healthy eating. The UTRCA program consisted of a series of activity stations designed to increase children's knowledge of water conservation and treatment. The program was initially delivered by UTRCA staff to the grade 7 students at each school, who then taught the grade 5s.

Research question

What was the effectiveness of the HKCC 'Water Does Wonders' interventions in London, Ontario, on promoting healthy beverage consumption habits in children? Did children who received a water bottle filling station and education program at their school consume more water and fewer SSBs and have higher water and nutrition knowledge following the interventions than children who received only a filling station?

Methods

Data source

This study used data collected by the Human Environment Analysis Laboratory (HEAL) at the University of Western Ontario (UWO) as part of an evaluation of the HKCC 'Water Does Wonders' theme interventions in London, Ontario, a city of approximately 383,000 people.

Setting and participants

The interventions occurred throughout the 2016/2017 school year and targeted grade 4–8 children (approximately 8–14 years) in 13 priority neighbourhoods across London. These neighbourhoods were identified in a community needs assessment conducted by the CYN, and had lower levels of education, lower household income, and more single-parent households than the city as a whole. Seventeen elementary schools within these neighbourhoods consented to participate in the study and self-selected into one of three groups on a first-come, first-serve basis: (1) Growing Chefs plus water infrastructure (5 schools); (2) UTRCA plus water infrastructure (6 schools); and (3) control group that received water infrastructure only (5 schools). All participating children were required to have written parental consent, and to provide personal assent prior to enrolling in the survey. This study was conducted in accordance with the Canadian Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans, and was approved by the UWO Non-Medical Ethics Board (108328), the Thames Valley District School Board, and the London District Catholic School Board.

Data collection and tools

Data collection occurred at two time points—before the interventions were implemented in October–November 2016 and following their cessation in April–June 2017. At each time point, research teams from the HEAL at UWO distributed youth surveys to participating students.

The youth survey, which was developed by the local 'Water does Wonders' creators and was not validated, consisted of 91 items under five domains: General Information, Drinking Habits, Types of Food and Drink Consumed, Eating and Drinking During the School Day, and Beverage Knowledge. Follow-up surveys assessing the Growing Chefs and UTRCA interventions also contained 2–3 additional items under the domain Program Knowledge to assess the impact and reception of these interventions. A questionnaire measuring basic demographics as well as the child's eating and drinking habits, and eating and drinking during the school day was also adapted for parents/guardians to supplement information collected from the youth survey.

Outcome measures

Beverage consumption Beverage consumption was assessed using a food-frequency questionnaire (FFQ), which asked children to record the number of times per day they consumed water, 100% fruit juice, fruit-flavoured drinks (including sports drinks), white milk, chocolate milk, regular pop, diet pop, energy drinks, coffee, and tea. SSB consumption was derived by summing the number of times per day the respondent reported consuming regular pop, fruit-flavoured drinks, energy drinks, and chocolate milk. Using the definition of sugar-sweetened beverages defined by the Centers for Disease Control and Prevention (CDC) (Centers for Disease

Control and Prevention 2010), chocolate milk was included as an SSB in the analyses, and 100% fruit juices and diet beverages were excluded. While sweetened coffee and tea drinks are considered SSBs under the CDC definition (Centers for Disease Control and Prevention 2010), they were not included in this analysis because the survey did not allow respondents to specify whether or not the tea and coffee beverages they consumed contained added sugar. To account for potential differences in children's interpretation of the 'times per day' measurement, water and SSB consumption frequency were divided by the total beverage consumption frequency reported by each child to obtain proportions.

Water and nutrition knowledge Nutrition knowledge was measured by summing the scores of 36 questions assessing children's knowledge of the sugar, caffeine, and water content of various foods and beverages, while water knowledge was measured using 8 questions assessing children's knowledge of the water treatment system, health benefits of water, and the world's water. Nutrition and water knowledge scores were summed to obtain an overall score, which could range from 0 to 44. For analysis purposes, knowledge scores were converted to percentages and treated as continuous.

Covariates

Socio-demographic characteristics, including sex (male/female), age (continuous in years), ethnicity (white/non-white), living arrangement (single-parent household/two-parent household/other), parent education (high school or less/college or university/graduate school), parent employment status (employed/unemployed), and household income level (low/low-middle/middle-high/high), were determined using self-administered surveys completed by both parent and child. Income-level classifications were made based on reported annual household income and number of people in the household, using methods described in the CCHS Derived Variable Specifications (Statistics Canada 2002). Families were considered low income if their total income was less than $15,000 for one to two people, less than $20,000 for three to four people, and less than $30,000 for five or more people; lower-middle income if their total income was $15,000–$29,999 for one to two people, $20,000–$39,999 for three to four people, and $30,000–$59,999 for five or more people; upper-middle income if their total income was $30,000–$59,999 for one to two people, $40,000–$79,999 for three to four people, and $60,000–$79,999 for five or more people; and high income if their total income was above $60,000 for one to two people, or above $80,000 for five or more people. Parent-reported socio-demographic data were used preferentially due to increased likelihood of accuracy; however, when they were missing, child-reported data were substituted.

Dietary intake, including daily servings of fruits and vegetables and weekly junk food consumption frequency, was assessed using the FFQ component of the youth survey. Junk food consumption was an aggregate variable, derived from summing the number of times per week a child reported consuming sweetened breakfast cereal, cake/pie/doughnuts, potato chips, chocolate bars, pizza, French fries, hot dogs, ice cream, candy, granola bars, and cookies. Information on drinking habits such as frequency of refillable water bottle use (never/rarely/sometimes/usually/always), milk program participation (yes/no), and permission to leave school grounds at lunch time (yes/no) was also collected using the youth survey.

Data analysis

Data cleaning was performed using SPSS 24, while all other statistical analyses were conducted using SAS 9.4. Fully conditional specification multiple imputation was performed to impute missing values, and forty imputed datasets were created, based on the recommendation that the number of imputations should approximately equal the percentage of incomplete cases (White et al. 2011). Household income level was not imputed due to the high probability that it was not missing at random.

Descriptive statistics including means and frequencies were used to describe the characteristics of the sample, as well as participants' beverage consumption habits and knowledge. Post-intervention beverage consumption and knowledge across the three intervention groups were compared using multivariable linear mixed model ANCOVAs, accounting for school-level clustering and adjusting for pre-intervention values, using the PROC MIXED procedure in SAS 9.4. Models additionally adjusted for: socio-demographic characteristics, including sex, age, ethnicity, household income level, maximum household education, living arrangements, and parental employment status; dietary variables, including junk food consumption frequency and daily servings of fruits and vegetables; and behavioural factors, including frequency of refillable water bottle use, participation in a school milk program, and permission to leave school grounds at lunch.

These confounders were selected based on the literature as well as theoretical plausibility. Age, for example, is a well-established determinant of children's beverage habits, with older children generally consuming more water and SSBs than younger children (Vieux et al. 2017), and there is evidence to suggest that males consume more SSBs (Hafekost et al. 2011). Racial differences in beverage consumption have also been established, and racial minorities have been shown to consume more SSBs than their Caucasian peers (Guerrero and Chung 2016), while Caucasian children consume more water (Drewnowski et al. 2013). Children whose parents are more highly educated and are employed may consume more water and less SSBs due to increased parental knowledge about the health effects of these beverages, as well as increased household income, which is directly correlated with water consumption (Vieux et al. 2017; Drewnowski et al. 2013). Eating habits, including fruit and vegetable consumption and junk food intake, are also often correlated with beverage consumption habits, and those who consume more SSBs generally consume more junk food and fast food and fewer servings of fruits and vegetables (Hafekost et al. 2011). Children who are allowed to leave the school grounds at lunch time likely have greater access to SSBs and other unhealthy foods, while children who participate in a school milk program may consume less water and SSBs due to beverage displacement. The relationship between using a refillable water bottle and total water intake has not been studied; however, it is plausible that individuals who keep a bottle of water with them at all times will consume more than those who have to go to the fountain or fill up a cup every time they want a drink.

Intention-to-treat analyses, in which children are analyzed in the intervention group they were assigned to, regardless of whether or not they actually received the intervention, were performed. Unadjusted and adjusted results are presented. P values < 0.05 were considered statistically significant. Two sensitivity analyses were performed: one using only non-imputed data (complete case analyses) and one including 100% fruit juice in the calculation of estimates of SSB consumption.

Results

Written parental consent was obtained for 1,504 (36.8%) of 4,086 eligible children, of whom 1,099 completed the baseline youth survey. One school ($n = 26$) withdrew from the study following baseline data collection and was thus excluded from the current analysis. Among the remaining study participants, 24 children did not have a corresponding parent survey, and 118 did not complete a follow-up survey, resulting in their exclusion. The final number of analyzed subjects was 931 parent–child dyads, representing 22.8% of eligible children and an 88.8% retention rate from baseline. Children who were lost to follow-up were more likely to be visible minorities and to live in a single-parent household; however, they did not differ in any other way from those who were retained.

Sample characteristics

Baseline socio-demographic, dietary, and behavioural information by intervention group is presented in Table 1, while follow-up dietary and knowledge information by intervention group is presented in Table 2. In looking at Table 1, slight differences in baseline age, parental education level, weekly junk food consumption frequency, and knowledge score were observed between the three intervention groups; however, they were otherwise comparable. Water made up a mean of 39.66% (± 19.49%) of children's total daily beverage consumption, while SSBs accounted for a mean of 21.98% (± 17.23%).

As is demonstrated in Table 2, a crude comparison of dietary and knowledge information across intervention groups at follow-up revealed significant differences in daily servings of fruits and vegetables, percentage of daily beverage consumption attributable to water, percentage of daily beverage consumption attributable to SSBs, and knowledge score. Within the full sample, a mean of 40.30% of children's total daily beverage consumption was attributable to water, while a mean of 21.65% was attributable to SSBs. Across the intervention groups, these values ranged from 38.15% to 42.57% and 20.03% to 23.14%, respectively.

The baseline and follow-up values of the main outcome variables (water consumption, SSB consumption, and knowledge score) are compared within each intervention group in Table 3. In all three groups, a significant difference in knowledge score was observed from baseline to follow-up; however, water and SSB consumption did not significantly change.

Intervention effects

A crude comparison of baseline and follow-up dietary and knowledge variables presented in Table 3 indicates that, overall, water consumption increased in the intervention groups and decreased in the control group, while SSB consumption decreased in the intervention groups and increased in the control group, though not significantly so. Knowledge scores increased significantly in all three groups. For all outcomes, the greatest improvements in beverage consumption habits and knowledge were observed among children in the UTRCA group, followed by the Growing Chefs group, and then the control group.

Table 4 presents the results of the linear mixed model ANCOVAs. After adjusting for clustering and socio-demographic, dietary, and behavioural confounders, participating in the Growing Chefs intervention was associated with a 2.18% (95% CI − 1.43, 6.27; $p = 0.218$) increase in the percentage of total daily beverage consumption attributable to water, while participating in the UTRCA intervention was associated with a 2.90% (95% CI − 0.23, 6.03; $p = 0.070$) increase in the percentage of total daily beverage consumption attributable to water, compared with controls. Similarly, participating in the Growing Chefs intervention was associated with a 1.17% (95% CI − 3.83, 1.49; $p = 0.387$) decrease in the percentage of total daily beverage consumption attributable to SSBs, while participating in the UTRCA group was associated with a 2.56% (95% CI − 5.12, 0.001; $p = 0.050$) decrease in the percentage of total daily beverage consumption attributable to SSBs, compared with controls. The Growing Chefs intervention was also associated with an increase in children's knowledge scores of 1.57% (95% CI − 1.68, 4.83; $p = 0.343$), while the UTRCA intervention was associated with an

Table 1 Baseline characteristics of the sample by intervention group

Characteristic	Total sample ($n = 931$)	Control ($n = 410$)	Growing Chefs ($n = 348$)	UTRCA ($n = 173$)	*P* value[a]
Age (mean ± SD)	10.56 ± 1.39	10.33 ± 1.39	10.64 ± 1.53	10.91 ± 1.20	< 0.0001*
Sex (*n* (%))					0.718
Male	405 (43.88%)	181 (44.69%)	146 (42.20%)	78 (45.25%)	
Female	518 (56.12%)	224 (55.31%)	200 (57.80%)	94 (54.65%)	
Race/ethnicity (*n* (%))					0.21
White	597 (64.12%)	258 (62.93%)	218 (62.64%)	121 (69.94%)	
Non-white	334 (35.88%)	152 (37.07%)	130 (37.36%)	52 (30.06%)	
Household income level (*n* (%))					0.117
Low	72 (7.73%)	38 (9.27%)	25 (7.18%)	9 (5.20%)	
Low-middle	105 (11.28%)	53 (12.935)	34 (9.77%)	18 (10.40%)	
Middle-high	132 (14.18%)	66 (16.10%)	40 (11.49%)	26 (15.03%)	
High	309 (33.19%)	123 (30.00%)	119 (34.20%)	67 (38.73%)	
Missing	313 (33.62%)	130 (31.71%)	130 (37.36%)	53 (30.64%)	
Maximum household education (*n* (%))					0.021*
High school diploma or less	106 (11.71%)	49 (12.31%)	36 (10.56)	21 (12.65%)	
College/university	643 (71.05%)	296 (74.37%)	228 (66.86)	119 (71.69%)	
Graduate school	156 (17.24%)	53 (13.32%)	77 (22.58)	26 (15.66%)	
Mother's employment status (*n* (%))					0.129
Employed	629 (75.06%)	264 (72.33%)	236 (75.40%)	129 (80.63%)	
Unemployed	209 (24.94%)	101 (27.67%)	77 (24.60%)	31 (19.38%)	
Father's employment status (*n* (%))					0.176
Employed	646 (93.49%)	282 (93.07%)	236 (92.19%)	128 (96.97%)	
Unemployed	45 (6.51%)	21 (6.93%)	20 (7.81%)	4 (3.03%)	
Child living situation (*n* (%))					0.526
Two-parent household	733 (79.67%)	318 (78.52%)	271 (78.78%)	144 (84.21%)	
Single-parent household	183 (19.89%)	85 (20.99%)	71 (20.64%)	27 (15.79%)	
Other	4 (0.43%)	2 (0.49%)	2 (0.58%)	/	
Frequency of refillable water bottle use (*n* (%))					0.339
Never	30 (3.34%)	15 (3.81%)	10 (2.98%)	5 (2.98%)	
Rarely	60 (6.68%)	34 (8.63%)	16 (4.76%)	10 (5.95%)	
Sometimes	210 (23.39%)	87 (22.08%)	89 (26.49%)	34 (20.24%)	
Usually	308 (34.30%)	140 (35.53%)	110 (32.74%)	58 (34.52%)	
Always	290 (32.29%)	118 (29.95%)	111 (33.04%)	61 (36.31%)	
Daily servings of fruits and vegetables (mean ± SD)	4.39 ± 1.99	4.42 ± 1.98	4.28 ± 1.93	4.54 ± 2.09	0.379
% Daily beverage consumption attributable to water (mean ± SD)	39.66 ± 19.49	38.44 ± 19.14	41.60 ± 19.48	38.62 ± 20.09	0.054
% Daily beverage consumption attributable to SSBs (mean ± SD)	21.98 ± 17.23	22.84 ± 16.89	20.65 ± 16.93	22.62 ± 18.51	0.154
Times junk food consumed per week (mean ± SD)	15.66 ± 10.08	16.06 ± 9.40	13.86 ± 9.49	18.30 ± 11.98	< 0.0001*
Participation in school milk program (*n* (%))					0.285
Yes	135 (14.77%)	67 (16.79%)	47 (13.70%)	21 (12.21%)	
No	779 (85.23%)	332 (83.21%)	296 (86.30%)	151 (87.79%)	
Allowed to leave school grounds at lunch time (*n* (%))					0.619
Yes	160 (17.49%)	66 (16.46%)	60 (17.54%)	34 (19.77%)	
No	755 (82.51%)	335 (83.54%)	282 (82.46%)	138 (80.235)	
Knowledge score (percentage) (mean ± SD)	66.48 ± 14.87	64.91 ± 14.77	67.41 ± 15.44	68.30 ± 13.60	0.003*

[a] For differences in baseline characteristics between intervention groups

*Significant at $\alpha = 0.05$

Table 2 Follow-up dietary and knowledge variables of the sample by intervention group

Characteristic	Total sample ($n = 931$)	Control ($n = 410$)	Growing Chefs ($n = 348$)	UTRCA ($n = 173$)	P value[a]
Daily servings of fruits and vegetables (mean ± SD)	4.55 ± 1.97	4.35 ± 1.95	4.78 ± 1.99	4.56 ± 1.96	0.012*
% Daily beverage consumption attributable to water (mean ± SD)	40.30 ± 18.69	38.15 ± 18.54	42.57 ± 18.35	40.80 ± 19.25	0.003*
% Daily beverage consumption attributable to SSBs (mean ± SD)	21.65 ± 16.86	23.14 ± 16.91	20.03 ± 16.42	21.38 ± 17.38	0.025*
Times junk food consumed per week (mean ± SD)	13.14 ± 9.23	13.43 ± 9.63	12.50 ± 8.78	13.73 ± 9.12	0.181
Knowledge score (percentage) (mean ± SD)	70.30 ± 14.03	67.98 ± 14.58	71.55 ± 13.54	73.28 ± 12.78	0.001*

[a] For differences in follow-up characteristics between intervention groups

*Significant at $\alpha = 0.05$

increase in children's knowledge scores of 2.02% (95% CI −0.35, 4.39; $p = 0.095$), adjusting for clustering and socio-demographic, dietary, and behavioural confounders. None of the observed effects were statistically significant.

Sensitivity analyses

Two sensitivity analyses were conducted to assess the robustness of the results. Table 5 presents the association between intervention group and beverage consumption and knowledge using non-imputed data only. The results of this complete case analysis were less precise but show similar effect sizes and directions, with the exception of SSB consumption in the Growing Chefs group, for which a very small increase was observed. Because of the ongoing debate surrounding fruit juices, and particularly whether or not their high sugar content puts them in the same class as SSBs, we also conducted a sensitivity analysis where 100% juice was classified as an SSB. The results, which are presented in Table 6, demonstrate statistically significant reductions in the percentage of total daily beverage consumption attributable to SSBs of 2.50% (95% CI −4.75, −0.25) in the Growing Chefs group and 4.83% (95% CI −7.62, −2.02) in the UTRCA group, suggesting that the interventions may have been more effective at discouraging juice consumption than any true SSBs.

Discussion

This study evaluated the effectiveness of a naturally occurring, school-based intervention to increase water consumption and decrease SSB consumption in elementary school children using a combination of education and environmental change. To our knowledge, this study provides the first empirical evidence of the impact of the 'Water Does Wonders' interventions associated with the provincially funded HKCC on promoting healthy behaviours in children.

Our results show a trend toward improved beverage consumption habits and knowledge following participation in the Growing Chefs and UTRCA interventions; however,

Table 3 Comparison of pre- and post-intervention beverage consumption and knowledge by intervention group

Characteristic	Control ($n = 410$)			Growing Chefs ($n = 348$)			UTRCA ($n = 173$)		
	Baseline	Follow-up	P value[a]	Baseline	Follow-up	P value[a]	Baseline	Follow-up	P value[a]
% Daily beverage consumption attributable to water (mean ± SD)	38.44 ± 19.14	38.15 ± 18.54	0.914	41.60 ± 19.48	42.57 ± 18.35	0.329	38.62 ± 20.09	40.80 ± 19.25	0.168
% Daily beverage consumption attributable to SSBs (mean ± SD)	22.84 ± 16.89	23.14 ± 16.91	0.783	20.65 ± 16.93	20.03 ± 16.42	0.459	22.62 ± 18.51	21.38 ± 17.38	0.250
Knowledge score (percentage) (mean ± SD)	64.91 ± 14.77	67.98 ± 14.58	< 0.0001*	67.41 ± 15.44	71.55 ± 13.54	< 0.0001*	68.30 ± 13.60	73.28 ± 12.78	< 0.0001*

[a] For differences in outcomes of interest from baseline to follow-up

*Significant at $\alpha = 0.05$

Table 4 Association between intervention group and beverage consumption and knowledge post-intervention

	Model 1: Percentage of total beverage consumption frequency attributable to water			Model 2: Percentage of total beverage consumption frequency attributable to SSBs†			Model 3: Knowledge score (%)		
	β	95% CI	*P*	β	95% CI	*P*	β	95% CI	*P*
Control group (filling station only) (reference)									
Unadjusted	/	/	/	/	/	/	/	/	/
Adjusted	/	/	/	/	/	/	/	/	/
Growing Chefs + filling station									
Unadjusted	2.42	− 1.43, 6.27	0.218	− 0.92	− 4.07, 2.23	0.568	2.09	− 1.49, 5.67	0.253
Adjusted	2.18	− 1.87, 6.22	0.291	− 1.17	− 3.83, 1.49	0.387	1.57	− 1.68, 4.83	0.343
UTRCA + filling station									
Unadjusted	2.89	− 0.21, 5.99	0.067	− 1.98	− 4.63, 0.67	0.143	2.49	0.04, 4.94	0.046*
Adjusted	2.90	− 0.23, 6.03	0.070	− 2.56	− 5.12, 0.001	0.050	2.02	− 0.35, 4.39	0.095

*Significant at $\alpha = 0.05$

CI confidence interval

†SSBs include fruit-flavoured drinks, regular pop, energy drinks, and chocolate milk

In model 1, adjusted analyses account for baseline water consumption, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline daily servings of fruits and vegetables, baseline weekly junk food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use

In model 2, adjusted analyses account for baseline SSB consumption, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline daily servings of fruits and vegetables, baseline weekly junk food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use

In model 3, adjusted analyses account for baseline knowledge score, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline water consumption, baseline SSB consumption, baseline daily servings of fruits and vegetables, baseline weekly junk food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use

statistical significance was not reached in adjusted analyses, and the observed effect estimates were small in magnitude. While discouraging, these results are consistent with other studies using similar education and environmental change interventions, which also observed small and non-significant changes in water or SSB consumption (Mantziki et al. 2016; Rausch Herscovici et al. 2013; Steyn et al. 2015). Taken together, these findings may indicate that education and environmental changes, even when combined, are simply not enough to evoke meaningful, sustainable changes in beverage consumption habits. To generate lasting behavioural change requires continuous motivation and support (Kelly and Barker 2016), which may not have been achieved here with only limited-term interventions. Long-term incorporation of water and nutrition education into all aspects of the day-to-day curriculum could potentially be more effective.

Alternatively, the lack of significant improvements in beverage consumption habits could be directly related to the lack of significant improvements in knowledge score following the interventions. Evidence of an association between dietary intake and knowledge has been demonstrated in a number of contexts, including child populations (Irwin et al. 2019; Asakura et al. 2017; Grosso et al. 2013; Kristjansdottir et al. 2006; Pirouznia 2001; Reinehr et al. 2003); however, our study observed just small improvements in knowledge score of 1.57–2.02%, which translated to students getting less than one additional question correct at follow-up compared with baseline. This was likely not enough to yield clinically significant behavioural changes. The lack of significant increases in knowledge score could again be because the education interventions were simply too short in duration, or it could be due to the content of the programs themselves, which were developed without the input of the researchers and did not fully align with the objectives of the 'Water Does Wonders' theme. Indeed, while the goal of the 'Water Does Wonders' theme was to increase water consumption and decrease SSB consumption, the UTRCA education program focused primarily on water treatment and conservation issues, and the Growing Chefs education program taught more general nutrition. As such, the minimal improvement in beverage consumption habits observed was not unexpected.

Although the interventions did not result in significant improvements in beverage consumption, the programs were generally well received by the participants themselves. Of the children who participated in Growing Chefs, for example, 50.6% reported learning how to cook a new food or dish, and about one third (34.2%) claimed that they are now willing to try the healthy foods introduced through the program (e.g., stir-fry, different fruits and vegetables) where they would not have done so before. Although 40.6% of children reported no

Table 5 Sensitivity analysis using non-imputed data only

	Model 1: Percentage of total beverage consumption frequency attributable to water			Model 2: Percentage of total beverage consumption frequency attributable to SSBs†			Model 3: Knowledge score (%)		
	β	95% CI	*P*	β	95% CI	*P*	β	95% CI	*P*
Control group (filling station only) (reference)									
Unadjusted	/	/	/	/	/	/	/	/	/
Adjusted	/	/	/	/	/	/	/	/	/
Growing Chefs + filling station									
Unadjusted	2.49	− 2.85, 7.82	0.266	− 0.93	− 5.35, 3.50	0.592	2.03	− 2.94, 6.99	0.321
Adjusted	1.28	− 3.56, 6.12	0.503	0.08	− 4.55, 4.72	0.962	0.46	− 3.50, 4.43	0.762
UTRCA + filling station									
Unadjusted	2.62	− 1.77, 7.01	0.173	− 1.93	− 5.68, 1.83	0.227	2.45	− 1.01, 5.91	0.120
Adjusted	2.44	− 2.43, 7.31	0.236	− 2.18	− 1.45, 0.22	0.220	1.78	− 1.93, 5.48	0.254

*Significant at $\alpha = 0.05$

CI confidence interval

†SSBs include fruit-flavoured drinks, regular pop, energy drinks, and chocolate milk

In model 1, adjusted analyses account for baseline water consumption, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline daily servings of fruits and vegetables, baseline weekly junk food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use

In model 2, adjusted analyses account for baseline SSB consumption, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline daily servings of fruits and vegetables, baseline weekly junk food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use

In model 3, adjusted analyses account for baseline knowledge score, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline water consumption, baseline SSB consumption, baseline daily servings of fruits and vegetables, baseline weekly junk food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use

change in their eating and drinking habits because of the program, 19.6% said they now eat healthier and 12.9% said they drink more water or fewer SSBs.

Children who participated in UTRCA reported learning about where our tap water comes from (20.4% of grade 7s and 19.4% of grade 5s), the water treatment system (17.4% of grade 7s and 19.4% of grade 5s), and the importance of conservation and ways to conserve water (20.4% of grade 7s and 13.9% of grade 5s) from the program. Additionally, of the grade 7 students who were selected to teach the UTRCA program to the grade 5s, the majority (69.2%) described the experience positively, using words such as 'fun', 'enjoyable', 'good', or 'rewarding'. One student, for example, said that 'it was nice to be leaders', while another wrote that 'it made [them] feel responsible', suggesting that there may be benefits to peer-led education beyond increases in knowledge.

Public health implications

Education programs are among the most commonly implemented public health strategies for changing dietary behaviours in children and are expected to improve beverage intake by providing participants with the knowledge required to make healthy choices. Our findings, however, suggest that short-term education programs combined with environmental changes to support healthy behaviours may not be effective at significantly improving beverage consumption in this age group. This could indicate the need for a longer program, particularly one that is integrated into the existing school curriculum, or it may suggest that a different approach is necessary; for example, the implementation of a school or province-level policy to further discourage SSB consumption, which have proven effective in other contexts (Bogart et al. 2016; Fung et al. 2013; Nanney et al. 2014). Alternatively, our findings may reflect an issue with the 'Water Does Wonders' education interventions specifically rather than education interventions in general, their having been short in duration and not having focused directly on water or SSB consumption, the primary outcomes of interest. This lack of overlap may have limited the ability of the programs to provoke significant changes in knowledge and thus behaviour, leading to the non-significant improvements in beverage consumption habits observed. Future interventions should therefore ensure that their educational components align with the goals of the environmental change, and that the evaluation of the intervention's effectiveness accurately reflects the intervention objectives.

It is important to note, however, that children who received both an education program and environmental change to their school environment had better outcomes at follow-up than those who received only environmental change (though not

Table 6 Sensitivity analysis including 100% fruit juice as an SSB

	Model 1: Percentage of total beverage consumption frequency attributable to water			Model 2: Percentage of total beverage consumption frequency attributable to SSBs†			Model 3: Knowledge score (%)		
	β	95% CI	*P*	β	95% CI	*P*	β	95% CI	*P*
Control group (filling station only) (reference)									
Unadjusted	/	/	/	/	/	/	/	/	/
Adjusted	/	/	/	/	/	/	/	/	/
Growing Chefs + filling station									
Unadjusted	2.38	− 1.50, 6.25	0.229	− 2.24	− 5.27, 0.79	0.147	2.08	− 1.51, 5.67	0.256
Adjusted	2.14	− 1.92, 6.20	0.302	− 2.50	− 4.75, − 0.25	0.029*	1.57	− 1.72, 4.86	0.349
UTRCA + filling station									
Unadjusted	2.89	− 0.21, 5.99	0.067	− 4.45	− 7.43, − 1.48	0.003*	2.45	00.04, 4.94	0.047*
Adjusted	2.91	− 0.23, 6.05	0.069	− 4.83	− 7.62, − 2.04	0.0007*	1.96	− 0.42, 4.34	0.106

*Significant at $\alpha = 0.05$

CI confidence interval

†SSBs include fruit-flavoured drinks, regular pop, energy drinks, chocolate milk, and 100% fruit juice

In model 1, adjusted analyses account for baseline water consumption, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline daily servings of fruits and vegetables, baseline weekly junk food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use

In model 2, adjusted analyses account for baseline SSB consumption, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline daily servings of fruits and vegetables, baseline weekly junk food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use

In model 3, adjusted analyses account for baseline knowledge score, sex, age, ethnicity, household income level, maximum household education, living arrangements, parental work status, baseline water consumption, baseline SSB consumption, baseline daily servings of fruits and vegetables, baseline weekly junk food consumption frequency, participation in school milk program, permission to leave school grounds at lunch, and frequency of refillable water bottle use

significantly so), demonstrating the value of combining multiple strategies and the need for a comprehensive approach to behavioural change. Future interventions should therefore continue to encompass multi-level strategies and should target all factors that may influence children's beverage consumption habits, including taste, availability in the home, and parent and peer modelling (Battram et al. 2016), in addition to knowledge and accessibility at school, which were the focus of our interventions. In designing future interventions, it would also be valuable to seek input from the teachers and students who will be receiving the program to maximize the likelihood of success. Teachers, after all, know best how their students learn, which can inform the design of the education programs, while students may be able to communicate the factors that are most important in influencing their beverage choices, allowing for these determinants to be targeted.

Study limitations

This study has several limitations. First, the HKCC 'Water Does Wonders' interventions in London were targeted toward children residing in disadvantaged neighbourhoods, and therefore, the results may not be generalizable to the broader population. The descriptive statistics of the sample presented in Table 1, however, reveal that just 7.73% of children came from low-income households, while only 11.71% had parents who had not attended post-secondary school. These values are similar to those of the 2016 census for the city of London, suggesting that poor representativeness is not a major issue.

Additionally, the use of self-reported dietary data is vulnerable to recall bias, particularly in children, and may be inaccurate compared with objective measures, while the use of an unvalidated survey tool could potentially introduce measurement bias. We also did not account for the varying amount of time between the intervention and the follow-up survey at each school; thus, if the effects of the interventions were only sustained short term, they may not have been fully captured. Likewise, if it took longer for the new water bottle filling station to change student drinking behaviour, the intervention effects of the stations may have been missed. The natural experiment design of the study also meant that it lacked a true control group receiving neither an education program nor a filling station. Such a control group would have been valuable for estimating the effect of environmental changes alone on beverage consumption habits, which cannot be discerned from the existing data. Similarly, the presence of a group that received only an education intervention and not a water bottle filling station would have allowed us to estimate the effect of education alone.

Furthermore, the ambiguous 'times per day' measure of water and SSB consumption, as opposed to a standardized volume measure such as cups or grams, may have been reported differently by each child, potentially resulting in measurement error. We attempted to correct for this by converting absolute frequencies into proportions in order to standardize responses; however, due to the subjective nature of the measure, we were unable to compare beverage intakes in our sample with those of the general population of Canadian children. We did, however, compare daily servings of fruits and vegetables reported by children in our study to those from the 2015 CCHS-Nutrition survey (Tugault-Lafleur and Black 2019), and found no significant differences. Therefore, it is reasonable to assume that beverage intake was similar as well.

Finally, due to the natural experiment design of the study, the content of the 'Water Does Wonders' education interventions did not fully align with the objectives of the 'Water Does Wonders' theme of the Healthy Kids Community Challenge itself, resulting in minimal improvements in beverage consumption habits or knowledge. While this is a peril of natural experiments and was completely out of the control of the researchers, it likely limited the ability of the interventions to generate any meaningful changes. It must be noted, however, that natural experiments, while messy and imperfect, are valuable for evaluating the real-world impact of policies and programs, particularly large-scale, publicly funded health interventions like those we have described here, where a true RCT is impractical (Craig et al. 2012). Therefore, rather than abandon them, care should be taken in future studies of this kind to promote closer and earlier collaboration between those developing the intervention and those evaluating it to ensure that the objectives of the intervention align with the content. Our study had high fidelity, after all, with education interventions generally delivered as intended; however, the content of the interventions themselves was poorly suited to address the objectives of the program, an issue that would have been avoidable if all those involved had worked together more closely from the beginning.

Conclusion

In this quasi-experimental, non-randomized controlled trial, we provided one of the first evaluations of the Ontario government's HKCC 'Water Does Wonders' interventions at promoting healthy beverage consumption habits in children. We found no statistically significant improvements in water and SSB intake or knowledge among children who participated in the Growing Chefs or UTRCA education programs and received new water infrastructure, compared with those who received new water infrastructure only. Given that the trends were in the expected direction, however, larger studies and interventions focusing on water and SSB consumption specifically are needed in order to better understand the potential impact of education interventions combined with environmental changes to improve children's dietary behaviours.

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Compliance with ethical standards

This study was conducted in accordance with the Canadian Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans, and was approved by the UWO Non-Medical Ethics Board (108328), the Thames Valley District School Board, and the London District Catholic School Board.

Conflict of interest The authors declare that they have no conflicts of interest.

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