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Original Research

An Evaluation of the Reach and Effectiveness of a Diabetes Prevention Behaviour Change Program Situated in a Community Site

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Key Messages

- Greater dissemination of prediabetes risk perception might result in greater physician referral and participant engagement.
- Strategies are needed to increase physician referral and patient response to recruitment methods to reach more individuals at risk of type 2 diabetes.
- The program demonstrated diabetes risk-reducing benefits to enrolled individuals up to 6 months after the program.

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ABSTRACT

More than 350 million people are living with prediabetes. Preventing type 2 diabetes (T2D) progression can reduce morbidity, mortality and health-care costs. Interventions can support people with diet and physical activity behaviour changes; however, many interventions are university-based, posing barriers (e.g. accessibility, limited reach and maintenance), which highlight the need for community intervention. Limited research has comprehensively evaluated programs in community contexts. The purpose of this study was to pragmatically examine the reach and effectiveness of a diabetes prevention behaviour change program in the community using the RE-AIM framework. Demographic and outcome data were collected through telephone screening and survey data, and analyzed using descriptive and multivariate analyses. Over 2 years, 9,954 individuals were identified by a medical laboratory as living with prediabetes. Information letters were sent by the laboratory to individuals upon physician approval (N=2,241, 22.5%) as a main form of recruitment. From this, 271 individuals and an additional 160 individuals via other recruitment methods contacted the research team (N=431). Two hundred thirteen adults with prediabetes were enrolled (87.4% Caucasian, 69.7% female; 95% program completion). Analyses of 6-month follow-up data revealed significant maintenance of reductions in weight and waist circumference and improvements in physical function, self-reported physical activity and all-food frequency items except fruit intake (N=121, d=0.21 to 0.68, $p < 0.05$ to 0.001). The program demonstrated diabetes risk-reducing benefits for enrolled individuals. Future work is needed to increase physician referral and participant response rates and to explore program expansion through digitization to reach more individuals at risk of developing T2D.

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RÉSUMÉ

Plus de 350 millions de personnes vivent avec le diabète. La prévention de la progression du diabète de type 2 (DT2) peut réduire la morbidité, la mortalité et les coûts des soins de santé. Les interventions peuvent aider les personnes qui modifient leur comportement en matière d'alimentation et d'activité

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physique. Toutefois, de nombreuses interventions universitaires posent des obstacles (p. ex. accessibilité, portée limitée et maintien), qui mettent en évidence la nécessité des interventions communautaires. Peu de recherches ont permis d'évaluer de façon exhaustive les programmes dans des contextes communautaires. Le but de la présente étude était d'examiner de façon pragmatique la portée et l'efficacité d'un programme communautaire de prévention du diabète axé sur le changement des comportements à l'aide du cadre RE-AIM. Nous avons procédé à la collecte des données démographiques et sur les résultats par une présélection téléphonique et des données d'enquêtes, et les avons examinées à l'aide d'analyses descriptives et multivariées. Sur une période de 2 ans, un laboratoire médical a permis de recenser 9954 individus vivant avec un prédiabète. La principale forme de recrutement reposait sur l'envoi par le laboratoire de lettres d'information aux individus après approbation de leur médecin (N=2241, 22,5 %). De là, 271 individus et 160 individus de plus au moyen d'autres méthodes de recrutement sont entrés en contact avec l'équipe de recherche (N=431). Nous avons recruté 213 adultes atteints de prédiabète (87,4 % de personnes caucasiennes, 69,7 % de femmes; 95 % d'achèvement du programme). Le suivi de 6 mois a révélé un maintien significatif de la diminution du poids et de la circonférence abdominale, et de l'amélioration de la capacité physique fonctionnelle, de l'activité physique autorapportée et de la fréquence de consommation de tous les aliments, excepté la consommation de fruits (N=121, d=0,21 à 0,68, p <0,05 à 0,001). Le programme a permis de démontrer les avantages de la réduction du risque de diabète chez les individus recrutés. D'autres travaux seront nécessaires pour accroître l'acheminement et les taux de réponse des participants, et examiner l'expansion du programme grâce à la numérisation pour joindre de plus d'individus exposés au risque d'apparition du DT2.

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Introduction

Prediabetes represents a warning sign of future type 2 diabetes (T2D) development due to progressing pathophysiological features of insulin resistance and beta-cell dysfunction (1). It is expected that, by 2045, 629 million people worldwide will be living with diabetes (2), necessitating increased attention towards diabetes prevention. The prevalence of T2D can be reduced by up to 80% if those at risk modify diet and exercise behaviours (1). Landmark diabetes prevention program (DPP) trials have demonstrated the efficacy of diet and exercise modification for T2D prevention (3,4). The United States DPP, a 1-year intensive intervention aimed at reducing T2D risk through diet and physical activity, helped patients lose weight and reduce T2D risk by 58% to 71% (3). However, such trials are intensive and difficult to implement and sustain in real-world settings (5).

Translating DPPs into real-world settings is a valuable investment owing to the increasing economic burden that diabetes places on health care (6). Housing programs within a community site, coupled with a laboratory recruitment partnership, can help reach people both within and outside of health-care settings (7). Based on a report of reach and use of evidence-based diabetes prevention services in the United States, physician referral rates to these services were extremely low (5%) (8). In a study that examined DPP implementation in the United States, sites that received referrals from health-care providers had higher attendance and longer patient engagement in the program than mass media strategies (9). Such studies highlight the influence physicians can have in facilitating diabetes prevention, while also indicating opportunities for improvement.

The Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework (10) is a frequently applied implementation framework used to guide research in real-world settings and assess the internal and external validity of health programs (11,12). Based on evaluation goals, framework users often place greater emphasis on some RE-AIM dimensions than others (10). Within this study, reach and effectiveness dimensions are evaluated. Understanding reach allows for a better understanding of effectiveness for the program's intended target population (13). Reach is defined as the absolute number, proportion, characteristics and representativeness of individuals who are willing to participate in the program (i.e. program name- Small Steps for Big Changes [SSBC]), and effectiveness is the effect of SSBC on important outcomes (10).

Reach is commonly misinterpreted for adoption and not fully assessed or documented. In a review of RE-AIM studies, 86% of articles assessed reach; however, descriptive reports on who was involved, recruitment methods and how participants differed from nonparticipants were seldom reported (12.3%) (14). This study aims to address these gaps (15), while also understanding if a DPP delivered within a Canadian community site, and using a physician referral system through a regional medical laboratory recruitment partnership, reached its intended audience and was effective for that audience. The purpose of this study was to evaluate the reach and effectiveness of SSBC. Five research questions were posed: 1) How are participants being reached?; 2) What is the demographic makeup of individuals interested in engaging in the program?; 3) What demographic variables influence program completion?; 4) How representative are participants compared with individuals living with prediabetes in Kelowna and Canada?; 5) Is there preliminary evidence for program effectiveness 6 months after the 3-week intervention?

Methods

SSBC overview

Prevalence rates of T2D in British Columbia are higher than the national average (9% vs 7%, respectively) (16), and access to prevention programs is absent. SSBG was developed as a brief evidenced-based, diet and exercise counselling DPP designed for feasible translation into communities to fill this gap in diabetes prevention care. Evidence emerged for the efficacy and acceptability of a laboratory trial (17,18); thus, to optimize reach and potential effect, SSBG was offered in a community site in 2017. SSBC was designed to offer a time-efficient, 3-week intervention and 1-year follow up (see Appendix A for full program details).

Study sample and recruitment

This study was part of a larger pragmatic project where people living with prediabetes participated in a brief intervention in a Canadian community site (17). Pragmatic trials are designed to evaluate interventions in real-life routine practice conditions. Participant recruitment involved program information letters sent via a physician referral system through a regional medical laboratory (hereafter referred to as "laboratory") recruitment partnership, online forums (i.e. social media), promotional materials (i.e. pamphlets and posters), word of mouth and community events between May 2017 and April 2019. The laboratory partnership was the main

source of recruitment and was used to identify individuals living at risk of prediabetes, obtain physician approval and subsequently inform potential participants of the DPP. Laboratory recruitment occurred through a 5-step process. First, any glycated hemoglobin (A1C) test run through the laboratory via a physician requisition was evaluated using the American Diabetes Association (ADA) (19) prediabetes classification (A1C=5.7% to 6.4%). It should be noted that ADA criteria for prediabetes classification were used in this study rather than Diabetes Canada guidelines (A1C=6.0% to 6.4%), as such a range has the potential to offer prevention efforts to more individuals; A1C levels lower than 6.0% are also associated with an increased risk for diabetes (20). Second, the laboratory informed physicians via fax of all patients deemed to be living with prediabetes, which included DPP information. Third, physicians indicated, through return fax to the laboratory, which, if any, patients were approved to be sent a program information letter via mail. Fourth, these letters were sent by the laboratory to all physician-approved patients. Finally, if patients were interested in the program, they contacted the research team and were screened for eligibility.

Data collection and procedures

Upon receiving ethical approval from the institution's Research Ethics Office, SSBG was advertised through the aforementioned recruitment types. Interested participants contacted the research team by email or telephone. All potential participants were screened for eligibility via telephone, where age, sex, body mass index (BMI) and medical history were obtained. Participants were eligible if they: 1) were between 18 and 65 years old; 2) were able to read and speak English; 3) had an A1C value between 5.7% and 6.4% (21) or completion of the ADA risk questionnaire indicating high risk (score $\geq$5); 4) had a BMI between 22 kg/m^2 and 40 kg/m^2; 5) had blood pressure lower than 160/99 mmHg; and 6) had no previous history of cardiovascular disease and were not on hormone therapy. Exclusion criteria included: 1) T2D diagnosis; 2) explicit contraindications to exercise (e.g. musculoskeletal injury); 3) uncontrolled major depression; or 4) not having physician clearance for exercise. Eligible participants provided informed consent and completed a demographic questionnaire before program commencement (see Table 1 for a complete list of variables). Individuals deemed ineligible were asked to report the same demographic information during a telephone conversation.

Reach: Reach was comprehensively assessed using Gaglio et al's (14) criteria. The absolute number (valid denominator) was identified by assessing the number of people classified as having prediabetes (via A1C screening) by the laboratory. Proportion was assessed through the number of people classified as having prediabetes and who obtained physician clearance to receive a program invitation letter. Recruitment strategies were analyzed to examine the effectiveness of enlisting eligible people, and descriptive methods detailed the influence of inclusion and exclusion criteria on people reached. Representativeness was assessed through descriptively comparing demographic variables of individuals eligible for the program to 3 samples: 1) individuals who were ineligible; 2) population-level demographics of adults within the same city; and 3) nationally.

Effectiveness: Preliminary effectiveness evidence was examined to determine whether behaviours and diabetes risk factors were sensitive to change 6 months after the program. All measures are described below.

Anthropometrics: Weight (700 seca, seca) and waist circumference were taken by the same trained research assistant at each time point.

6-minute walk test (6MWT): The 6MWT was used as a submaximal test of cardiorespiratory fitness and is a standardized protocol (21) commonly used in large pragmatic trials. Participants were instructed to walk laps around 2 cones spaced 20 m apart as briskly as possible, refraining from talking and stopping if needed. The covered distance at 6 minutes was measured to the nearest 0.1 m.

Brief food frequency measure (FFM): The FFM is used to track dietary behaviours in a time-efficient manner, which is paramount in pragmatic trials (22). Participants were asked about their intake of 5 foods within the past week: fruits, vegetables, sweets, bread and rice/pasta. Fruits and vegetables were rated on a 6-point scale: 1 (1 per week or less), 2 (2 to 3 per week), 3 (4 to 6 per week), 4 (1 per day), 5 (2 per day) and 6 (3+ per day). Increases in average vegetable scores and no changes in fruit scores suggest improved intake in line with program goals. Sweets, bread and rice/pasta were each rated on a 6-point scale: 1 (<1 per week), 2 (1 per week), 3 (2 to 3 per week), 4 (4 to 6 per week), 5 (1 per day) and 6 (2+ per day). FFM also uses a composite score for refined carbohydrates (sum of bread and rice/pasta). Decreases in sweets, bread, rice/pasta and refined carbohydrate scores suggest that intake improved in line with program goals.

Self-reported exercise (metabolic equivalents [METs]): Participants reported the number of 30-minute light, moderate and vigorous exercise bouts engaged in during the past week using a validated modified Godin Leisure-Time Exercise Questionnaire (23,24), whereby MET scores were calculated using active =24+, moderately active =14-23 and insufficiently active =<14.

Statistical Analyses

Descriptive statistics were calculated to summarize study sample characteristics and intervention effectiveness. Pearson chi-square analyses or analyses of variance (ANOVAs) were used to compare characteristics of those who completed, did not complete and were ineligible for SSBC. Bonferroni post hoc correction was used to examine differences between groups for continuous variables. Repeated-measures ANOVAs with time as the within-subject factor were run to examine changes in weight, waist circumference and 6MWT scores across the pre-, post- and 6-month time points. Follow-up planned contrasts were run to examine pre-to-post and pre-to-6-month differences. Paired-sample *t*-tests were used to examine pre-to-6-month differences in food frequency scores and self-reported exercise. Cohen's *d* was used to assess magnitude change (small =0.2, medium =0.5 and large =0.8) (25). Descriptive statistics are reported for the total sample and by sex.

Results

Reach

As noted, the main recruitment strategy involved a laboratory partnership. From this strategy, a valid denominator of 9,954 potential participants was identified based on laboratory results (see Figure 1 for full details). There are 13 laboratories within the Okanagan region that service all physician-requested blood requisitions. Sixty-six percent of 9,954 faxes sent to physicians were not returned/responded to despite receiving notification that their patient had a prediabetes classification. Physicians responded to 3,399 (34%) faxes, of which 2,241 individuals were identified as appropriate for SSBG and subsequently sent an information letter. Of those identified as program appropriate, 271 (12%) contacted the researcher about SSBC. Of the total sample population who

Table 1
Study participant characteristics and differences across 3 groups (completed program, did not complete program and ineligible for program participation)

Participant characteristics	Total sample (N=431)	Completed program (N=203)	Did not complete program (N=158)	Ineligible (N=70)	p
Age (years), N (%)					
Missing	111 (25.8%)	0 (0%)	96 (60.8%)	15 (21.4%)	
M (SD)	57.2 (8.0)	57.06 (7.0)	55.7 (7.6)	59.58 (11.0)	0.03*
Range	19-84	19-68†	30-66†	29-84	
Sex, N (%)					
Missing	2 (0.005%)	0 (0%)	2 (1.3%)	0 (0%)	
Male	130 (30.2%)	59 (29.1%)	48 (30.4%)	23 (32.9%)	0.83
Female	299 (69.4%)	144 (70.9%)	108 (68.4%)	47 (67.1%)	
Ethnicity, N (%)					
Missing	193 (44.5%)	4 (2.0%)	135 (85.4%)	54 (77.1%)	
Caucasian	208 (48.3%)	173 (85.2%)	20 (12.7%)	15 (21.4%)	0.73
Other	30 (7.0%)	26.1 (12.8%)	3 (1.9%)	1 (1.4%)	
Education, N (%)					
Missing	207 (48.0%)	14 (6.9%)	139 (88.0%)	54 (77.1%)	
High school diploma or less	41 (9.5%)	34 (16.7%)	1 (0.6%)	6 (8.6%)	0.17
Currently in or university or college	3 (0.7%)	3 (1.5%)	0 (0%)	0 (0%)	
College/apprenticeship/trades certificate	97 (22.5%)	81 (39.9%)	13 (8.2%)	3 (4.3%)	
University certificate/diploma/degree	64 (14.8%)	57 (28.1%)	3 (1.9%)	4 (5.7%)	
Postgraduate degree	19 (4.4%)	14 (6.9%)	2 (1.3%)	3 (4.3%)	
Income ($), N (%)					
Missing	224 (52.0%)	31 (15.3%)	139 (88.0%)	54 (77.1%)	
0 to 24,999	14 (3.2%)	10 (4.9%)	2 (1.3%)	2 (2.9%)	0.28
25,000 to 49,999	52 (12.1%)	40 (19.7%)	8 (5.1%)	4 (8.6%)	
50,000 to 74,999	47 (10.9%)	41 (20.2%)	3 (1.9%)	3 (4.3%)	
75,000 to 99,999	41 (9.5%)	34 (16.7%)	1 (0.6%)	6 (8.6%)	
100,000 to 124,999	26 (6.0%)	22 (10.8%)	3 (1.9%)	1 (1.4%)	
Over 125,000	27 (6.3%)	25 (12.3%)	2 (1.3%)	0 (0%)	
Marital status, N (%)					
Missing	202 (46.9%)	11 (5.4%)	137 (86.7%)	54 (77.1%)	
Single	34 (7.9%)	27 (13.3%)	5 (3.2%)	2 (2.9%)	0.27
Married/common law	161 (37.4%)	139 (68.5%)	13 (8.2%)	9 (12.9%)	
Separated/divorced/widowed	34 (7.9%)	26 (12.8%)	3 (1.9%)	5 (7.1%)	
Employment status, N (%)					
Missing	203 (47.1%)	10 (4.9%)	138 (87.3%)	55 (78.6%)	
Full-time	89 (20.6%)	78 (38.4%)	6 (3.8%)	5 (7.1%)	0.26
Part-time work (occasional, contract)	36 (8.4%)	32 (15.8%)	3 (1.9%)	1 (1.4%)	
Retired	75 (17.4%)	58 (28.6%)	8 (5.1%)	9 (12.9%)	
Other (e.g. student, unemployed)	28 (6.5%)	25 (12.3%)	3 (1.9%)	0 (0%)	
A1C, N (%)					
Missing	195 (45.2%)	34 (16.7%)	106 (67.1%)	55 (78.6%)	
M (SD)	5.9 (0.3)	5.86 (0.3)	5.9 (0.3)	6.1 (0.7)	0.01**
Range	5.0-7.4	5.7-6.9	5.7-6.9	5.0-7.4	
Baseline BMI, N (%)					
Missing	169 (39.2%)	3 (1.5%)	104 (65.8%)	63 (90.0%)	
M (SD)	31.7 (6.7)	31.4 (6.6)	33.0 (6.9)	30.9 (7.8)	0.32
Range	18.9-53.2	21.0-53.2	18.9-52.7	22.5-46.0	
Normal weight (18.5 to 25 kg/m^2)	36 (8.4%)	29 (14.3%)	6 (4.8%)	1 (1.4%)	
Overweight (25 to 30 kg/m^2)	81 (18.8%)	63 (31.0%)	14 (8.9%)	4 (5.7%)	
Obese (30+ kg/m^2)	144 (33.4%)	108 (53.2%)	34 (21.5%)	2 (2.9%)	
Smoking, N (%)					
Missing	205 (47.6%)	13 (6.4%)	138 (87.3%)	54 (77.1%)	
Yes	21 (4.9%)	13 (6.4%)	3 (1.9%)	5 (7.1%)	0.004**
No	205 (47.6%)	177 (87.2%)	17 (10.8%)	11 (15.7%)	
Par-Q+, N (%)					
Missing	153 (35.5%)	0 (0%)	101 (63.9%)	52 (74.3%)	
Passed	231 (53.6%)	180 (88.7%)	42 (26.6%)	9 (12.9%)	0.001***
Required Clearance	47 (10.9%)	23 (11.3%)	15 (9.5%)	9 (12.9%)	

BMI, body mass index; *M*, mean; *ParQ*, Physical Activity Readiness Questionnaire; *SD*, standard deviation.
*p<0.05, **p<0.01, ***p<0.001. Not all frequencies add up to 100% due to missing data. The chi-square difference test was used to measure between-group differences for categorical variables. Independent sample *t*-tests were used to measure between-group differences for continuous variables.
† Eligible age range changed during this study in November 2018 from 18 to 65 to 18 to 70.

contacted the research team (N=431), 63% were recruited through the letter received from the laboratory. One hundred sixty potential participants were identified through other recruitment strategies, with online forums being the second most effective recruitment strategy (11%) besides laboratory letters.

Two differences were found when exploring demographic variables between laboratory recruitment and other recruitment types. First, more women than expected were recruited via laboratory letter, whereas more men used other recruitment types (p=0.013). Second, significant differences were found across age groups: more adults between 55 and 64 years old were recruited via laboratory letter than expected, and more individuals older than 65 years used other recruitment methods (p=0.001). No differences were found for recruitment type across ethnicity.

Regarding the second research question, 431 participants directly contacted the research team about SSBC; 70 participants (16.2%) were deemed ineligible and 148 (34.3%) deemed the program unsuitable at this time (Figure 1). Most interested participants were female (69.7%) and Caucasian (87.4%), with a mean age of 57.2±8.0 years (Table 1). Ineligible participants were mainly

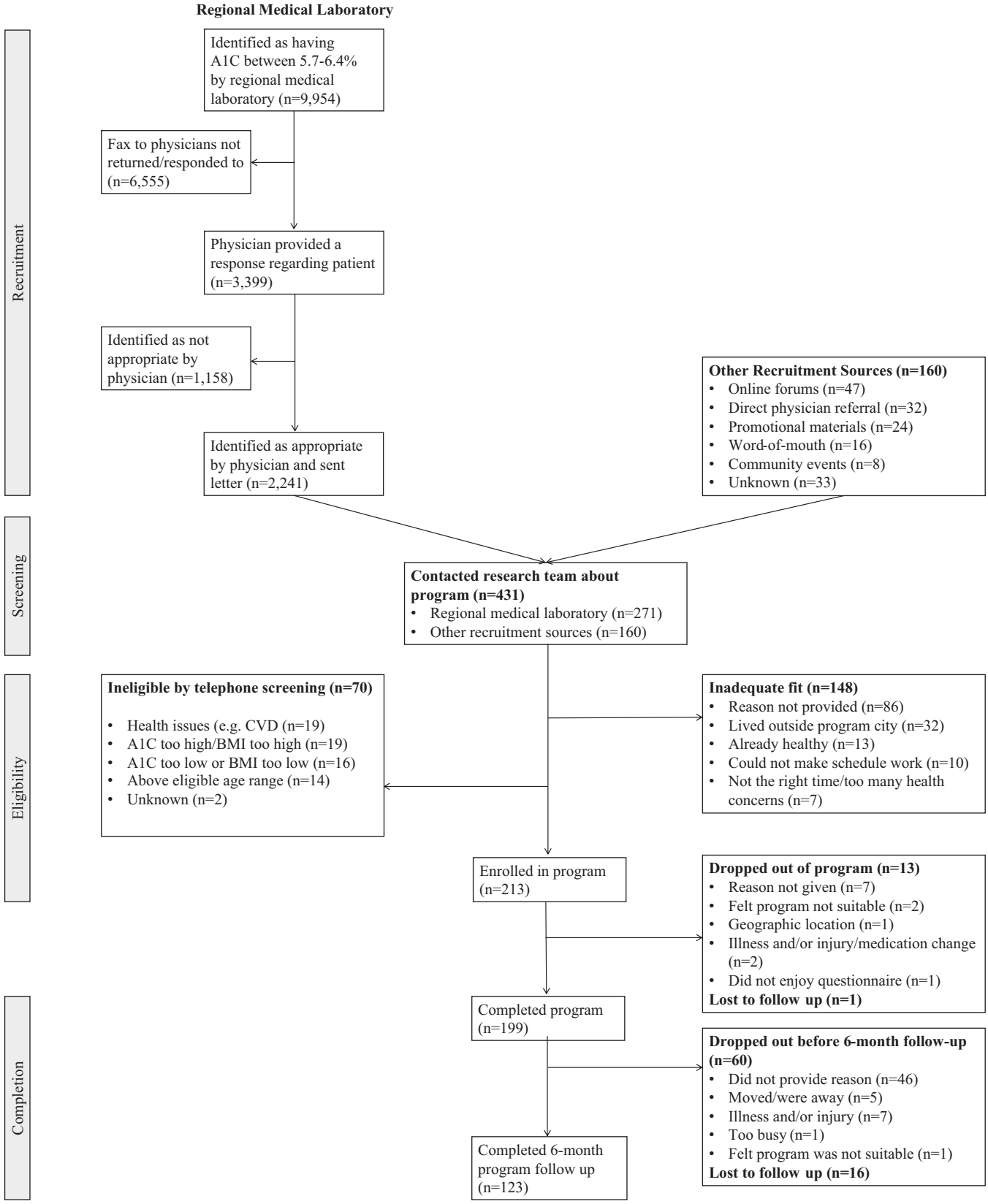


Figure 1. Overview of program recruitment, screening, eligibility and completion.

excluded due to existing health conditions (27%; e.g. cardiovascular disease) or having A1C or BMI levels that exceeded eligibility criteria (27%; e.g. living with T2D). Two hundred thirteen (59%) consented and enrolled in the program during this project's study timeframe (May 2017 to April 2019). Program completion rates were high (95%), whereas completion of a 6-month follow up was lower (69.8%).

The third research question was investigated by comparing demographic variables across 3 participant groups (completed, did not complete and ineligible; Table 1). Differences emerged for age, A1C, smoking and the requirement for medical clearance. Participants who were ineligible were, on average, older (mean [M] = 69.6) compared with those who completed (M=57.1) and did not complete the program (M=55.7 [$p<0.05$]). It should be noted that all participants who were deemed ineligible based on age (≥65 years) came from recruitment sources besides the laboratory, as the laboratory used the aforementioned eligibility criteria. Post hoc analyses indicated a significant difference in mean age between noncompleters and those who were ineligible ($p<0.05$). For A1C, significant differences were present across groups; participants who were ineligible had higher mean A1C (6.1) compared with those who completed (M=5.9) and did not complete SSBC (M=5.9; $p<0.01$). Post hoc analyses indicated a significant difference between completers and those who were ineligible ($p<0.01$) and no significant difference between noncompleters and those who were ineligible ($p=0.07$). Smoking status was also different between completers and participants who were deemed ineligible, with more than expected completers identifying as a nonsmoker and more than expected participants who were ineligible identifying as a smoker ($p<0.01$). Finally, more completers than expected passed the Physical Activity Readiness Questionnaire and did not require clearance, whereas more than expected noncompleters and participants deemed ineligible required additional medical clearance before program enrolment ($p<0.001$).

To address the fourth research question, representativeness was assessed by comparing eligible participants' demographic information to adults with prediabetes and T2D within Kelowna and across Canada based on available data. This comparison provided an approximation of how closely individuals who were interested in (N=431) and completed SSBC (N=203) were representative of the Canadian prediabetes and T2D population (minimal data are available for solely individuals with prediabetes). The mean age of interested individuals (57.2±8.0 years) and individuals who completed SSBC (57.1±6.9 years) was similar to those identified in a national sample of individuals with prediabetes (52.85) (6). In SSBC, there was a higher representation of females expressing interest and engaging compared to those who are at risk for developing prediabetes within (city) and Canada. Within Kelowna, 5.6% of the population have been identified as having diabetes, with a higher proportion of females (6.6%) than males (4.6%) (26). Comparatively, 6.8% of males and 5.9% of females have diabetes in Canada. SSBC is reaching a predominantly Caucasian population, which is in line with the demographic makeup of Kelowna, where just over 6% of the population is a visible minority (27). However, knowing that people of certain ethnic backgrounds (e.g. African, Arab, Asian, Hispanic, Indigenous and South Asian descent) are at greater risk of developing prediabetes and T2D (28), SSBC is not reaching those most at risk (27).

Effectiveness

Of the 199 individuals who completed the program, 69.8% completed the 6-month follow up. An analysis was conducted on the remaining subsample who completed SSBC and 6-month follow up (N=123; M_{age}=43.16±6.12; range=23 to 59; 57.9% women; 86.8% Caucasian) to examine preliminary program effectiveness (Table 2 [reported for entire sample and by sex]). Significant main effects of time were found in the hypothesized directions for weight, waist circumference and 6MWT. Planned contrasts revealed significant improvements in all 3 outcomes from pre- to post- and from pre- to 6 months. Regarding change through the study from the pre- to 6-month follow up, weight decreased by 3.35 kg (Δ3.90%), waist circumference decreased by 4.16 cm (Δ3.97%) and 6MWT distance increased by 31.9 m (Δ6.00%). There were significant changes in the hypothesized direction from pre- to 6-month follow up for self-reported physical activity and all food frequency items. The effects observed from pre- to 6-month follow up were small to moderate (d=0.21 to 0.49).

Discussion

This study provides insight on the reach and effectiveness of a DPP housed in a community site, the findings of which can help inform recruitment and implementation of prevention services. To reach those at risk, a partnership with a local laboratory was developed to support recruitment by identifying individuals at risk, informing physicians and subsequently mailing information letters to potential participants. Similar forms of recruitment have been suggested as a main DPP recruitment strategy (e.g. mass mail-outs through a government agency) (29). Tailoring recruitment strategies (e.g. mode and venue of delivery and resources) and use of external organizations have been shown to positively influence sustainability through recruitment, promotion and administration of DPP interventions (30).

Despite a large potential reach (N=9,954) through the laboratory, poor referral rates were observed. Diabetes Canada recommends that individuals living with prediabetes or at risk for T2D engage in regular physical activity and consume a healthy diet (31). Within this study, only 23% of individuals with an A1C between 5.7% and 6.4% received physician approval to be informed of SSBC, and 11% were deemed not appropriate, leaving 66% of potential participants without an opportunity to learn about SSBC due to physician nonresponse. Similar research found that physicians referred fewer than 5% of eligible patients to a DPP, despite more than 25% of Americans living with prediabetes who expressed interest in joining such a program (32). A bottleneck in reaching potential patients rests with physicians, which is a common challenge in diabetes prevention referral schemes (33). To increase local physician awareness about prediabetes and SSBC, lunch-and-learns between the research team and physicians in Kelowna have been implemented. During these events, information on the referral process, the program and associated outcomes were discussed. Such an approach is in line with research that has documented providing such feedback to physicians was beneficial (33). During informal discussions throughout the lunch-and-learns, physicians outlined that a perceived lack of time was a key barrier to returning the faxes, feeling that they did not have the time to complete the extra paperwork required to approve patients, who would then receive a program information letter via mail. A national dissemination strategy to increase physician knowledge and attitudes towards prediabetes, including Diabetes Canada guidelines for T2D risk reduction strategies, might result in increased physician referrals to health behaviour change programs, such as SSBC.

Incorporating recruitment strategies (e.g. online forums and promotional materials) that are not reliant on regular physician visits and/or physician referral might increase program reach for at-risk individuals (30). Thirty-seven percent of participants were reached through these other recruitment strategies. However, for these strategies to be effective, individuals must first be aware of

Table 2
Descriptive and multivariate statistics for the 6-month main adherence outcomes (N = 123)

Measure	Preprogram M (SD)	Postprogram M (SD)	6-month postprogram M (SD)	Significance tests (t or F)	Pre-to-post Δ (d)	Pre-to-6-month Δ (d)
Weight (kg) – All	86.83 (20.65)	85.17 (20.31)	83.48 (20.49)	F=58.82, $p\eta^2$= 0.50***	0.47	0.47
Females	80.53 (18.72)	79.10 (18.21)	76.68 (17.27)			
Males	101.61 (17.55)	99.59 (17.79)	99.39 (18.73)			
Waist circumference (cm) – All	104.87 (15.21)	103.20 (14.94)	100.71 (15.03)	F=48.81, $p\eta^2$ = 0.46***	0.37	0.68
Females	101.85 (14.54)	100.33 (14.31)	97.33 (13.51)			
Males	112.27 (14.38)	110.31 (14.17)	108.52 (15.61)			
6MWT: distance travelled (m) – All	532.44 (69.84)	557.44 (70.43)	564.38 (78.31)	F=29.94, $p\eta^2$ = 0.36***	0.60	0.63
Females	525.78 (69.89)	550.70 (77.62)	555.64 (86.83)			
Males	545.18 (67.90)	569.95 (55.06)	581.26 (53.38)			
FFM: Fruit – All	3.85 (1.42)	-	4.10 (1.40)	t=2.15*		0.21
Females	3.92 (1.38)	-	4.06 (1.38)			
Males	3.64 (1.48)	-	4.18 (1.49)			
FFM: Vegetable – All	4.41 (1.12)	-	4.67 (1.17)	t=2.52*		0.26
Females	4.55 (1.04)	-	4.72 (1.07)			
Males	4.09 (1.25)	-	4.56 (1.39)			
FFM: Sweets – All	3.21 (1.36)	-	2.63 (1.36)	t=4.60***		0.45
Females	3.19 (1.35)	-	2.72 (1.34)			
Males	3.24 (1.42)	-	2.42 (1.48)			
FFM: Bread – All	3.87 (1.42)	-	3.39 (1.48)	t=3.47***		0.34
Females	3.81 (1.36)	-	3.29 (1.43)			
Males	4.03 (1.55)	-	3.58 (1.60)			
FFM: White rice, pasta –All	2.43 (1.11)	-	2.09 (1.02)	t=3.46***		0.34
Females	2.40 (1.15)	-	2.07 (1.04)			
Males	2.44 (1.01)	-	2.13 (1.01)			
FFM: Refined carbs – All	8.57 (4.14)	-	7.11 (3.53)	t=3.41***		0.36
Females	8.46 (4.58)	-	6.71 (3.12)			
Males	8.60 (3.24)	-	7.73 (4.14)			
GLTEQ score – All	21.77 (21.46)	-	35.47 (25.48)	t=5.03***		0.49
Females	21.59 (20.20)	-	35.13 (28.22)			
Males	24.19 (24.13)	-	35.75 (19.53)			

6MWT, 6-minute walking test; *d*, Cohen's *d*; *FFM*, food frequency measure; *GLTEQ*, Godin Leisure-Time Exercise Questionnaire; *M*, median; *SD*, standard deviation.
*p<0.05, **p< 0.01, ***p<0.001. Statistical tests and effects reported for entire sample.

their risk status. Regardless of the recruitment method (laboratory recruitment strategy or other), only 4% of individuals in the local region with a confirmed A1C in the program eligibility range (5.7% to 6.4%) contacted the program, indicating poor overall reach. Although local efforts to increase prediabetes and program awareness have been implemented (e.g. local health assessment days within community organizations), additional large-scale public health promotion strategies might further increase awareness of T2D risks within the general population. In an American report, 88% of individuals living with prediabetes, confirmed through a blood test, were unaware that they were living with prediabetes (35). Furthermore, results from a national poll commissioned by Diabetes Canada demonstrated that Canadians tend to underestimate the severity of diabetes and the likelihood of being diagnosed within their lifetime (34). Future research is needed to examine how to elicit greater physician response to increase prediabetes and program awareness and increase individual risk perceptions of T2D. Enhanced dissemination of prediabetes awareness nationally might facilitate prediabetes awareness to support physician referrals and self-referrals to DPPs.

Although physicians have a responsibility to refer participants to such a DPP, the onus lies with participants to contact the research team about SSBC. Study findings indicated that only 12% of potential participants who received an information letter contacted the research team about program participation. This number might be a conservative estimate based on self-reporting, and some individuals might have initially received a letter but contacted the program later through a secondary form of recruitment (e.g. after discussing the program with a physician [direct referral], the participant read more information online [online forum]). In a national study in the United States, between 33% and 40% of individuals at risk of T2D who were advised about or referred to a formal program attended (8). Although this number is higher than the present study's findings, it indicates overall low engagement in DPPs.

Similar to previous research (12), intention does not always predict action, as 34% of prospective participants who contacted the research team did not enrol. Reasons for nonenrolment after expressing interest were not formally collected and warrant further investigation. Some potential participants who received information letters outlined that it was owing to geographic location (e.g. living outside the city where (PN) was offered). There are interests and needs beyond the immediate city where the program was offered, which speaks to the importance of program scale-out (36). These study findings encourage the digitization of diabetes prevention programs to aid in scale-up and expand reach. Digital approaches can enhance reach because of accessibility, availability and on-demand capability (10). This approach seems viable for successful uptake and would enable program expansion to underserved communities, where prediabetes rates are high (37).

Representativeness data are limited and often not reported, as it can be challenging to attain a valid denominator (14) because many cases of prediabetes are undiagnosed (38). This study contributed to filling this gap. To assess representativeness, demographic information is required from nonparticipants, raising ethical concerns because nonparticipants have not consented to study involvement (39). Investigation of program representativeness compared to municipal, provincial and federal populations allows for a holistic assessment of reach by investigating the disparity of socioeconomic status on health effects, as sample selection is also influenced by access to health care and healthy equity (40).

A homogeneous sample was reached for those who both contacted and completed SSBC: predominantly female, Caucasian and middle socioeconomic status. Specific to the demographic makeup of Kelowna where the program was offered, participants were of similar makeup yet were less aligned with the Canadian population. Such representation is similar in age and sex makeup to other similar studies (9,30) and is consistent, whereby more females than males tend to enrol in diet and exercise modification interventions (41). Conducting targeted recruitment and/or program tailoring could help to engage more males. For example, a scoping review identified program-specific factors (e.g. competition) and participation facilitators (e.g. personal concern for health status) to engage more males (42). Future research should examine the use of these identified strategies, along with participant advisory committee feedback to adapt the program information letter. Finally, although program representation closely matches Kelowna demographics (43), the sample was not representative of the larger national population with prediabetes; the program is reaching limited ethnic groups (27). To reach those who are most at risk, offering SSBC in regions that are more ethnically diverse can help with diabetes prevention.

Exploring differences between the 3 study groups revealed differences in age, A1C, smoking and medical clearance requirement. In general, individuals deemed ineligible were older and had an A1C within the T2D range (>6.5%), which is consistent with program ineligibility criteria (>65 years old) and increases in T2D risk as individuals age (27). Similar to past literature, where younger participants (i.e. 18 to 44 years old) had lower overall attendance and duration of participation in a DPP (9), noncompleters were the youngest cohort in the study sample. A larger number of participants who were ineligible smoked more than expected, which has been associated with an increased risk for developing T2D (44). Finally, more noncompleters and individuals who were ineligible reported a greater number of comorbidities and required medical clearance to participate. Together, these 4 criteria represent a higher biological risk for developing T2D and indicate that the program is not reaching individuals at the highest risk for developing T2D (older, higher A1C, history of smoking and requiring medical clearance). These individuals should not be left without support but, rather, might require more supervision, such as involvement in a clinical program, than what would be offered in a community program (i.e. SSBC).

Preliminary evaluation of effectiveness in this community-based trial in changing short- and medium-term outcomes provides a metric of whether it is accomplishing its health promotion objectives. The overarching objective of SSBC is to provide an accessible program to change diet and exercise behaviours in individuals at risk of T2D. Six months after SSBC completion, participants were adhering to improved dietary and exercise routines. Sugar and carbohydrate intake are critical dietary components to monitor and reduce for the prevention and management of diabetes (45) and are key components of the program. Reductions in refined carbohydrates in combination with increased vegetable intake suggests that participants are adhering to key program objectives for diabetes risk reduction. Beyond changes in these health behaviours, modest improvements to participants' body composition and fitness levels were observed. The observed improvements are in line with those observed by community translations of the more intensive diabetes prevention program: Katula et al (46) observed an average weight reduction of 3.2 kg; Wilson et al (47) observed a 2.1-kg weight reduction; and Nilsen et al (48) observed a 1.9-kg weight reduction. Despite being much shorter in duration, SSBC resulted in similar weight loss compared to much more intensive DPP translations, suggesting that adherence to exercise and dietary changes are possible after a brief 3-week program.

Study limitations

First, the use of a pragmatic design limits the generalizability beyond study context. Second, the use of self-reported health behaviours to assess program effectiveness can be susceptible to social desirability bias. Third, this study was limited by missing demographic data (range/variable=0.5% to 52%), mainly from individuals not interested in or deemed ineligible not being willing to provide such data. To address the potential limitations of self-report and missing data, qualitative methods might be valuable to explore the reach and effectiveness of DPPs in the community, which is an important approach that is lacking in the field (14). Fourth, the study design did not involve random sampling. Findings might be susceptible to self-selection bias and, therefore, be less generalizable to the broader population. Finally, reach was estimated based on the proportion of sample recruited via laboratory results due to the unknown denominators of other recruitment methods used. Future qualitative research could be valuable in understanding why such a low physician referral rate exists, which could inform future implementation research and physician education regarding diabetes prevention.

Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Diabetes* at www.canadianjournalofdiabetes.com.

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Author Disclosures

The authors declare that they have no conflicts of interest. All procedures performed in this study were in accordance with the ethical standards of the institution's institutional review board, and informed consent was obtained from all individual participants in the study.

Author Contributions

C.B., T.D., S.R.L. and M.E.J. substantially contributed to the conception and design of the project. C.B., T.D. and S.R.L. were involved in the acquisition of, analysis and interpretation of the data. All authors drafted the article, and all authors revised it critically for important intellectual content and provided their approval on the final version of the manuscript.

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