Diabetes risk reduction in primary care: Evaluation of the Ontario Primary Care Diabetes Prevention Program

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ABSTRACT

OBJECTIVES: Lifestyle interventions can reduce type 2 diabetes risk. The Primary Care Diabetes Prevention Program (PCDPP) was implemented by the Government of Ontario to lower diabetes risk. This study first evaluated the program, and second used a validated tool to estimate a potential population impact if the program were implemented more broadly in the province.

METHODS: PCDPP was implemented in six primary care settings serving communities with high mortality risk due to chronic diseases. In total, 1916 adults with prediabetes or metabolic syndrome were enrolled from January 2011 to December 2012. Body weight was the primary outcome variable, and was modeled using four time periods (i.e., baseline, 3rd, 6th and 9th month). The intervention effect was estimated using multilevel mixed-effects linear regression, and was stratified by gender and age. In the population impact analysis, a number needed to treat (NNT) for the intervention to prevent one case of diabetes and an absolute number of diabetes cases averted were estimated.

RESULTS: Weight loss over 9 months was 7.5% (or 6.8 kg), with 7.4% (or 6.4 kg) in females and 8.6% (or 8.6 kg) in males. When modeled, changes in weight were all statistically significant. The models for male participants predicted, however, some gains in weight in the last 3 months of the program. Dropout rates were 26.8%, 46.8% and 63.0% at 3rd, 6th and 9th month respectively. Scaling up the program would produce an NNT of approximately 36 and would avert 6401 cases of diabetes in five years.

CONCLUSION: PCDPP may represent a potentially effective tool for population-level diabetes risk reduction.

KEY WORDS: Type 2 diabetes; primary care; prevention

La traduction du résumé se trouve à la fin de l'article.

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Diabetes is a major and growing health concern internationally.¹ Its prevalence in the province of Ontario (Canada) has risen dramatically in recent years.^{2,3} Diabetes and its complications cause extensive morbidity, mortality, and health system costs.^{4–6} Type 2 diabetes, which accounts for approximately 90% of diabetes cases in Ontario, often stems from potentially modifiable lifestyle factors (e.g., obesity and physical inactivity).^{7,8}

Prediabetes (i.e., impaired fasting glucose) is a type 2 diabetes precursor.^{9,10} Individuals with prediabetes have been estimated to have a 23% risk of developing diabetes over four years.⁸ Multiple trials show the risk of progression from prediabetes to diabetes can be reduced through lifestyle interventions focused on weight reduction, dietary change and physical activity.^{10–14} Both the landmark US Diabetes Prevention Program (DPP) and the Finnish Diabetes Prevention studies achieved an initial diabetes risk reduction of up to 58% compared to control.^{12,15} Follow-up studies show this risk reduction can be sustained. The Finnish follow-up risk reduction was 43% after 7 years, and the US DPP follow-up risk reduction was 34% after 10 years.^{13,15} A program modeled after DPP has been tested in a primary care setting. It demonstrated clinically significant improvements to body mass index (BMI), waist circumference, and fasting blood glucose compared to usual care.¹⁶ Several other studies have documented

the feasibility of offering a DPP-style program in community settings.^{17–19}

The Ontario Ministry of Health and Long-Term Care (MOHLTC) launched the Ontario Diabetes Strategy in 2008. The Strategy included a two-year diabetes prevention pilot program called the Primary Care Diabetes Prevention Program (PCDPP), modeled on the DPP. The objective of the current study was to evaluate the real-world effectiveness of the PCDPP, and to use a validated diabetes risk modeling tool to estimate the impact of scaling up the program.

METHODS

The PCDPP demonstration period ran from January 2011 to March 31, 2013 in six Family Health Teams (FHTs), a multidisciplinary primary care setting. The PCDPP utilized a behavioural lifestyle intervention method called Group Lifestyle Balance™ (GLB) Program, adapted from the original US DPP.¹⁹ The Diabetes

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Prevention Support Center (DPSC) of the University of Pittsburgh provided training to all six FHTs to deliver the healthy lifestyle change program.

PCDPP goals were for participants to: 1) achieve a 7% weight loss; 2) engage in ≥ 150 minutes/week of moderate physical activity; and 3) increase and retain knowledge about healthy lifestyle practices. Individuals were eligible if they were at least 18 years of age and had a diagnosis of prediabetes or metabolic syndrome made by physicians from the FHTs. The diagnosis of these conditions followed the GLB program, where some risk factors (e.g., overweight, high blood pressure, cholesterol) and test results (e.g., fasting plasma glucose) are involved in the assessment.¹⁹ Information on individual physician assessment was, however, not available for the purpose of this study.

Exclusion criteria were an existing diabetes diagnosis, pregnancy or planned pregnancy within six months, and any condition preventing the participant from committing to program curriculum (e.g., terminal illness).

Statistics Canada census data were used to generate 118 potential sites that served communities with high mortality risk due to chronic diseases. The approach identified first communities in the highest mortality quintile, and second, within those, communities in the lowest quintile for income, education, and visible minority. The resulting 118 communities do not necessarily share the same risk factors, but rather the great diversity of the Ontario population who are at the highest mortality risk due to chronic diseases. Mapping identified 20 primary care sites with the greatest number of high-risk communities within 20 km². Criteria that considered readiness and capacity to deliver programming reduced this number to 16. They were invited to complete a program application. Finally, 6 sites were chosen due to their experience implementing programs related to health promotion, diabetes, Aboriginal peoples, and/or people with low socio-economic status. Table 1 describes the population served by each primary care site.

Each site employed a lifestyle coach, who was part of the Family Health Team. Lifestyle coaches received standardized training by DPSC. Coaches needed to have some health background or training (e.g., kinesiology, diet and nutrition, health promotion), but no specific profession was required for the purpose of the intervention. Each site was expected to enrol 300 individuals over two years, for an anticipated total program enrolment of 1800. Cohort program length was 9–12 months, divided into a core phase (12 weeks), a transition phase (8–12 weeks) and a maintenance phase (up to 28 weeks).

The core phase featured weekly classes with up to 20 participants. Curriculum focused on healthy behavioural topics (e.g., healthy eating, physical activity, and obesity health risks). Participants were asked to record in logbooks their caloric and fat intake and their physical activity. In all phases, logbooks were shared with lifestyle coaches during one-on-one meetings. These meetings focused on progress towards participant goals, and identification of barriers and solutions to these goals, such as time management, and motivational or behavioural strategies.

The transition phase followed, where meetings occurred first biweekly and then monthly. This phase focused on supporting participants on the self-management and reinforcing of educational content, skills, and strategies learned earlier. Sites were encouraged to offer participants a supervised physical activity session at every gathering. The maintenance phase supported participants as they

Table 1. Description of population served by Family Health Teams (FHTs)

Site	Description
Family Health Team 1	The population served by FHT1 experiences a continuous influx of baby boomers. The area surrounding this site is also known for its "cottage country" setting. Close to 20% of the population within the area served by FHT1 is aged 65 and older.
Family Health Team 2	The catchment population of the area served by FHT2 has one of the highest concentrations of Anabaptist members in Ontario, which brings some cultural and religious barriers to receiving health care. The Anabaptist population also experiences a lower socio-economic status as compared to the general population in Ontario.
Family Health Team 3	The area served by FHT3 includes a large Aboriginal population, which struggles with high rates of heart diseases, diabetes and related complications, as well as respiratory diseases. These conditions, and the resulting burden that they place on community health, are common among many Aboriginal populations in Canada, where the rates of diabetes are often considerably higher than in the general Canadian population.
Family Health Team 4	The catchment area served by FHT4 has the fastest-growing population cohort of pre-seniors in Canada, as well as the second highest level of ethnic diversity in Ontario, with over 50% of residents indicating neither English nor French as the first language.
Family Health Team 5	The population served by FHT5 has a high mortality rate from diseases of the circulatory system, such as stroke and heart diseases.
Family Health Team 6	The population served by FHT6 has high rates of obesity, diabetes, hypertension, and cardiovascular and respiratory diseases.

took an increasingly independent role in self-managing their behavioural changes, and meetings with lifestyle coaches occurred on a monthly basis.

Lifestyle coaches collected baseline demographic data from each participant. Participant weight was recorded weekly in the core phase. Daily caloric intake, fat intake, and duration of independent physical activity performed were taken directly from participant logbooks. A Microsoft Access database tool was developed to collect participant data throughout the program. Information on participant age and gender was almost complete (97% and 99% respectively) in the database. However, some socio-demographic data (e.g., education, employment status) were poorly recorded in the database (i.e., >50% missing values). To compensate, participants were assigned to a census subdivision using their postal code recorded in the database, and Statistic Canada's 2006 Profile Census Subdivision data were used instead for information on income, education and ethnicity.

Data from 1916 participants enrolled in the program between January 2011 and December 2012 were analyzed. In this study, body weight was the primary dependent outcome variable of interest. Four time periods were used to evaluate PCDPP (intervention) effectiveness: baseline, 3rd, 6th and 9th month. The number of weight measurements decreased in later time periods as a result of participants dropping out in the core phase or enrolling in the program late in 2012. For a small proportion of participants, who may have missed a data point during the program, weight values were replaced with the closest weight value on record (i.e., the week/month before or after). This approach took advantage of data points that were available in the database, and

that were close enough to participant missing values to well represent the actual participant weight trajectories during the program. It was only done in 25% (3rd month), 17% (6th month) and 12% (9th month) of all missing values. For the most part, missing values for dropouts were not replaced. Analysis of Variance (ANOVA) demonstrated no statistical differences in weight distributions before and after replacement ($p > 0.900$).

Physical activity and caloric/fat intake were poorly, and in some instances inconsistently, recorded, and thus were excluded from the analysis. During the core phase, close to 20% of participants reported their physical activity and caloric/fat intake, and at the end of the program, reporting dropped to 10% for physical activity and 6% for caloric/fat intake. To assess goal #3 (knowledge of healthy lifestyle practices), an online survey was conducted at the end of the core and maintenance phases, and 6 and 12 months after completion of the program. Based on the 1916 participants enrolled in the program, response rate was 19.3% after the core phase, 3.4% after the maintenance phase, and less than 2% in the last two surveys. The results section summarizes only responses obtained after the core and maintenance phases.

The survey assessed participant knowledge on healthy eating, weight loss and physical activities. Examples included substituting water for other drinks like juice and soda pop, eating a variety of low-fat foods, incorporating physical activity into daily activities (for example, walking instead of driving), and drinking plenty of water before, during and after being active.

Multilevel mixed-effects linear regression models were used to estimate the effect of the intervention on weight loss, following a similar methodology used by Walsemann et al.²⁰ Analyses stratified participants by gender (male or female) and age (over/under 65 years of age). Weight was modeled as a function of participants' height, age, income, education, ethnicity, program site, and time. Time was modeled linearly (i.e., 0 for baseline, and 1, 2 and 3 for each program phase) and included a squared term to capture typical weight loss trajectories, where participant weight loss may reach a plateau phase or may be reversed to some extent at some point.^{12,15,19} The model included both random intercept and random slopes (coefficients) for time and time squared, and robust standard errors. Statistical analysis was performed using STATA, version IC 12.1 (StataCorp LP, College Station, TX).

The Diabetes Population Risk Tool (DPoRT) was used to estimate the impact of scaling up the PCDPP to the province of Ontario.²¹ DPoRT uses population data on diabetes risk factors to estimate the future burden of diabetes within a population.^{21,22} Predictive factors in the tool, which is gender-specific, include body mass index, age, ethnicity, hypertension, immigrant status, smoking, education status and heart disease.²¹ The tool uses information from the Canadian Community Health Survey (CCHS) to generate a number needed to treat (NNT) for an intervention to prevent one case of diabetes and an absolute number of diabetes cases averted.^{21–23} A representative Ontario population was created with the same demographic and risk profile as the PCDPP participants at enrollment. Population benefit was then defined as the absolute risk reduction (ARR) in 5-year diabetes risk (i.e., absolute difference in diabetes risk before and after the intervention) and the number of diabetes cases prevented.²³

Two scenarios were used to estimate the NNT and cases averted: 1) a change in an individual's risk factor profile due to losing 4.6%

and 7.0% of body mass; 2) a 5-year relative risk reduction of developing diabetes ranging from 30%–60% as observed in the literature.^{12,13,15} The analysis of PCDPP data was approved by the University of Toronto Research Ethics Board in June 2014.

RESULTS

Descriptive statistics of study participants are presented in Table 2, where participant education, income and ethnicity were derived from census data. Most participants were female (70%). Participant average age was 58 years. Average household income in the census-subdivisions where participants lived was CAD\$67,313. An estimated 54% of participants had post-secondary education, and 9.5% were of a visible minority group.

Baseline participant average weight was 91.0 kg. At the end of the core phase, average weight decreased to 87.1 kg (or 4.3%). At 6th and 9th month, the average weight was 6.9% (or 6.3 kg) and 7.5% (or 6.8 kg) lower than baseline respectively. Total weight loss in male participants (8.6%) was statistically higher (ANOVA, $p < 0.05$) than that in female participants (7.4%). Average BMI was 32.9 at baseline and 30.5 at the end of the program.

Across sites, average weight at baseline varied from 88.3 to 97.5 kg, and BMI from 32.1 to 34.4 (Table 3). Except for one site, weight loss across sites ranged from approximately 8.0% to 11.0% during the program. Differences were statistically significant (ANOVA, $p < 0.01$). Participants over 65 years of age (Table 4) experienced a slightly lower weight loss (6.3%) when compared to all participants (7.5%). Total weight loss was higher in male (7.5%) than in female (6.1%) participants, although not statistically different (ANOVA, $p = 0.360$).

On healthy eating, 82.1% of respondents answered correctly 9 or 10 questions (out of 10) at the end of the core phase. At the end of the maintenance phase, this percentage dropped to 68.2%. On weight loss, these percentages on the first two surveys were 84.6% and 86.3% respectively. As for physical activity, knowledge retention appeared somewhat lower (59.1% and 54.5% in the first and second surveys respectively).

Table 5 presents the results of the regression models to predict the effect of the program on weight loss. The effect was captured through the variables time and time squared, which were statistically significant ($p < 0.01$) in all models performed. Predicted average decrease in weight was 3.4 and 5.1 kg in female and male participants respectively at the end of the core phase. At the of the transition phase, additional weight loss was 1.5 and 2.0 kg in females and males respectively. Participants began to gain weight during the maintenance phase (0.3 and 1.1 kg in females and males respectively). Results were similar for participants over 65 years of age (Table 5). Figure 1 shows these trajectories. Age and height were consistently associated with weight. For males over 65 years of age, education was also inversely related to weight.

Table 6 shows the NNT and population impact (cases averted) if the program were scaled up to the province of Ontario under different modeling scenarios and participation rates. Using a 7% weight reduction within 9 months, as seen in this study, the NNT ranges from 28 (average absolute risk reduction (ARR) = 3.57%) to 36 (average ARR = 2.78%) depending on participation rates. Cases averted range from 5669 to 18 666 as the participation rate increases from 30% to 100%. This means that between 28 and 36 people would have to receive the intervention to prevent one case of diabetes in 5 years.

Table 2. Descriptive statistics of study participants, all ages (education, income and visible minority are derived from census data)

Variable	Total (N = 1916)		Female (N = 1338)		Male (N = 566)	
	Mean (SD) or %	n	Mean (SD) or %	n	Mean (SD) or %	n
Weight (baseline, kg)	91.0 (20.7)	1846	87.0 (19.7)	1301	100.1 (20.1)	540
Weight (3 months – core phase, kg)	87.1 (19.7)	1290	83.9 (18.9)	918	94.7 (19.4)	368
Weight (6 months – transition phase, kg)	84.7 (19.0)	867	81.5 (18.1)	619	92.5 (18.9)	246
Weight (9 months – maintenance phase, kg)	84.2 (18.5)	581	80.6 (18.2)	392	91.5 (17.1)	187
Height (cm)	165.8 (9.6)	1596	162.2 (7.4)	1125	174.5 (8.6)	467
BMI (baseline, kg/m ²)	32.9 (6.6)	1590	32.9 (6.9)	1121	32.8 (5.9)	465
BMI (3 months – core phase, kg/m ²)	31.6 (6.5)	1122	31.8 (6.8)	802	31.2 (5.8)	317
BMI (6 months – transition phase, kg/m ²)	30.8 (6.4)	771	30.9 (6.5)	559	30.5 (5.9)	210
BMI (9 months – maintenance phase, kg/m ²)	30.5 (6.3)	514	30.6 (6.6)	354	30.4 (5.3)	158
Family Health Team 1	25.8%	494	27.3%	365	23.2%	129
Family Health Team 2	10.2%	195	8.0%	107	15.6%	87
Family Health Team 3	14.8%	283	16.8%	225	10.1%	56
Family Health Team 4	14.8%	284	11.5%	154	22.5%	125
Family Health Team 5	19.3%	370	24.1%	323	8.3%	46
Family Health Team 6	15.1%	290	12.2%	164	22.1%	123
Age (years)	58.1 (12.4)	1852	56.7 (12.5)	1298	61.2 (11.7)	552
Gender						
Male	29.5%	566				
Female	70.0%	1338				
Missing	0.50%	12				
Visible minority (% in census subdivision [CSD])*	9.5% (20.4%)	1625	7.6% (18.1%)	1132	13.8% (24.4%)	490
Income (average household income, CAN\$ in CSD)	\$67,313 (\$16,324)	1625	\$66,065 (\$14,821)	1132	\$70,163 (\$19,038)	490
Education (% of population with certificate/degree in CSD)†	53.4% (8.5%)	1625	52.7% (8.3%)	1132	55.0% (8.6%)	490

* Defined as the percent of the population in CSD who are Chinese, South Asian, Black, Filipino, Latin American, Southeast Asian, Arab, West Asian, Korean, Japanese, and others not identified elsewhere, and multiple not classified elsewhere.

† Defined as the percent of the population in CSD with a certificate, diploma or degree after high school.

Table 3. Descriptive statistics of study participants across Family Health Teams (FHTs), all ages (education, income and visible minority are derived from census data)

Variable	FHT1 (total N = 494)	FHT2 (total N = 195)	FHT3 (total N = 283)	FHT4 (total N = 284)	FHT5 (total N = 370)	FHT6 (total N = 290)
	Mean (SD), % or n					
Weight (baseline, kg)	88.4 (19.6)	96.7 (22.6)	92.4 (18.5)	88.3 (16.9)	87.5 (21.5)	97.5 (23.4)
Weight (3 months – core phase, kg)	84.7 (19.0)	93.6 (22.6)	88.3 (17.9)	84.5 (14.9)	83.7 (21.0)	92.3 (21.0)
Weight (6 months – transition phase, kg)	82.9 (18.3)	91.2 (21.4)	84.1 (16.9)	80.9 (14.7)	81.7 (20.4)	89.3 (20.2)
Weight (9 months – maintenance phase, kg)	84.4 (18.4)	89.0 (21.4)	82.2 (14.8)	81.6 (15.3)	80.5 (18.3)	88.2 (21.2)
N (baseline)	489	193	275	260	362	267
N (3 months – core phase)	346	145	233	164	246	156
N (6 months – transition phase)	223	107	167	108	134	128
N (9 months – maintenance phase)	123	76	103	80	102	97
Height (cm)	164.9 (9.1)	167.9 (12.8)	165.3 (9.0)	166.0 (9.6)	164.7 (7.6)	168.9 (10.1)
BMI (baseline, kg/m ²)	32.5 (6.5)	34.4 (8.1)	33.5 (5.7)	32.1 (5.0)	32.4 (7.3)	33.6 (7.2)
BMI (3 months – core phase, kg/m ²)	31.3 (6.3)	33.5 (8.4)	32.0 (5.6)	30.7 (4.8)	30.8 (7.1)	32.7 (6.7)
BMI (6 months – transition phase, kg/m ²)	30.8 (6.1)	32.0 (8.3)	30.9 (5.6)	29.8 (4.8)	30.0 (6.7)	31.9 (6.8)
BMI (9 months – maintenance phase, kg/m ²)	31.3 (6.3)	31.4 (7.8)	30.4 (5.4)	29.7 (4.8)	29.7 (6.2)	31.2 (7.1)
Age (years)	58.8 (12.9)	60.6 (12.3)	58.0 (12.8)	58.4 (11.2)	54.1 (12.7)	59.7 (10.9)
Gender						
Male	26.1%	44.6%	19.8%	44.0%	12.4%	42.4%
Female	73.9%	54.9%	79.5%	54.2%	87.3%	56.6%
Missing	0.0%	0.5%	0.7%	1.8%	0.3%	1.0%
Visible minority (% in census subdivision [CSD])*	1.4% (2.6%)	2.1% (1.8%)	0.0% (0.1%)	54.0% (20.9%)	2.2% (0.8%)	2.4% (1.0%)
Income (average household income, CAN\$ in CSD)	\$66,129 (\$7,219)	\$65,439 (\$8,716)	\$55,073 (\$7,305)	\$101,422 (\$6,073)	\$63,324 (\$1,594)	\$56,135 (\$7,599)
Education (% of population with certificate/degree in CSD)†	55.3% (5.1%)	46.1% (7.4%)	56.4% (2.2%)	67.3% (2.1%)	43.6% (1.4%)	53.2% (1.8%)

* Defined as the percent of the population in CSD who are Chinese, South Asian, Black, Filipino, Latin American, Southeast Asian, Arab, West Asian, Korean, Japanese, and others not identified elsewhere, and multiple not classified elsewhere.

† Defined as the percent of the population in CSD with a certificate, diploma or degree after high school.

Table 4. Descriptive statistics of study participants, age ≥ 65 (education, income and visible minority are derived from census data)

Variable	Total (N = 621)		Female (N = 381)		Male (N = 238)	
	Mean (SD) or %	n	Mean (SD) or %	n	Mean (SD) or %	n
Weight (baseline, kg)	87.0 (17.5)	608	81.6 (16.6)	375	95.2 (15.5)	231
Weight (3 months – core phase, kg)	82.7 (16.7)	450	78.0 (16.2)	279	90.5 (14.5)	169
Weight (6 months – transition phase, kg)	81.3 (16.2)	321	77.2 (16.1)	201	88.2 (13.9)	119
Weight (9 months – maintenance phase, kg)	81.5 (15.9)	215	76.6 (16.7)	123	88.1 (11.9)	91
Height (cm)	165.5 (10.5)	529	160.4 (7.6)	325	173.8 (9.0)	202
BMI (baseline, kg/m ²)	31.7 (6.1)	529	31.8 (6.5)	325	31.6 (5.3)	202
BMI (3 months – core phase, kg/m ²)	30.3 (5.9)	389	30.3 (6.2)	241	30.2 (5.1)	146
BMI (6 months – transition phase, kg/m ²)	29.8 (5.7)	283	30.0 (6.0)	178	29.4 (4.8)	104
BMI (9 months – maintenance phase, kg/m ²)	29.6 (5.5)	188	29.6 (5.9)	107	29.4 (4.4)	80
Family Health Team 1	31.4%	195	34.6%	132	26.5%	63
Family Health Team 2	12.4%	77	9.4%	36	16.8%	40
Family Health Team 3	15.1%	94	16.8%	64	12.2%	29
Family Health Team 4	12.9%	80	10.0%	38	17.6%	42
Family Health Team 5	12.6%	78	16.5%	63	6.3%	15
Family Health Team 6	15.6%	97	12.6%	48	20.6%	49
Age (years)	70.9 (4.9)	621	70.5 (4.8)	381	71.5 (4.9)	238
Gender						
Male	38.3%	238				
Female	61.4%	381				
Missing	0.3%	2				
Visible minority (% in census subdivision [CSD])*	9.3% (20.5%)	524	7.9% (18.9%)	315	11.6% (22.6%)	207
Income (average household income, CAN\$ in CSD)	\$67,207 (\$16,563)	524	\$66,372 (\$15,068)	315	\$68,564 (\$18,621)	207
Education (% of population with certificate/degree in CSD) [†]	53.6% (8.3%)	524	53.3% (8.0%)	315	54.1% (8.8%)	207

* Defined as the percent of the population in CSD who are Chinese, South Asian, Black, Filipino, Latin American, Southeast Asian, Arab, West Asian, Korean, Japanese, and others not identified elsewhere, and multiple not classified elsewhere.

[†] Defined as the percent of the population in CSD with a certificate, diploma or degree after high school.

Results from our analysis also demonstrated that, despite the increased risk of diabetes, restricting the program to those over the age of 65 would not change the efficiency (i.e., NNT) but would drastically reduce the population impact because of a smaller eligible population.

Participant dropout rates were estimated using two scenarios: i) all 1916 participants enrolled in the program between January 2011 and December 2012, and ii) all 1293 participants enrolled between January 2011 and March 2012. Since the database used in this study was provided at the end of the two-year pilot program, some participants enrolled near the end of the two-year period may not have had their weights recorded in the database. Limiting the analysis to those enrolled up to March 2012 may provide a more reliable estimate of dropout rates as it allowed enough time for participants to complete the program and have their information recorded in the database.

Using scenario i), dropout rates were 3.4% at baseline, 31.6% at the end of the core phase, 53.4% at the end of the transition phase, and 69.7% at the end of the maintenance phase (i.e., 9th month). Dropouts at baseline represent those who enrolled but never showed up.

Using scenario ii), dropout rates in all four phases were 2.8% (at baseline), 26.8% (at 3rd month), 46.8% (at 6th month) and 63.0% (at 9th month). Across sites, dropout rates varied from 17.5% to 37.7% at the end of the core phase, and from 39.7% to 71.7% at the end of the maintenance phase.

DISCUSSION

The PCDPP appears to be an effective population-level intervention capable of reducing diabetes risk in people with a high risk of

developing type 2 diabetes in Ontario primary care settings. Total average body weight loss over 9 months was 7.4% in females (or 6.4 kg) and 8.6% in males (or 8.6 kg). For females and males over 65 years of age, weight loss was 6.1% (or 5.0 kg) and 7.5% (or 7.1 kg) respectively. When modeled, these changes in weight were all statistically significant.

The study also showed that a proportionally larger number of male participants lost weight with the program compared to female participants. At the end of the program, 91% of male participants lost weight. For female participants, this percentage was 88%. Scaling up the program to an Ontario population with similar demographic and risk profile to those involved in this study would produce an NNT of 36 (average ARR = 2.78%), and would avert 6401 cases of diabetes in 5 years.

Consistent with the DPP and Finnish Diabetes Prevention studies, intensive lifestyle coaching was found to be an effective diabetes prevention intervention in the PCDPP. In comparison to these studies, the PCDPP had a much smaller follow-up period, thus it cannot be confirmed whether diabetes risk reduction was also maintained over the long term. Average weight loss observed in this study (6.8 kg after 9 months) was likely similar to the Finnish Diabetes Prevention study (4.5 kg after 1 year).¹⁵ The NNT value of the PCDPP (NNT: 36) was higher than that observed in the original DPP trial (NNT: 6.9), which is not surprising given the more intensive oversight and follow-up employed in the DPP versus what is feasible in a real-world community setting.¹²

The large number of participants is a key strength of this study, and makes the PCDPP perhaps the largest community adaptation

Table 5. Random-intercept and random-slope (coefficient) model, correlated random effects for program effect by gender and age 65+; dependent variable: weight (in kg)

[illegible]

Note: Income effect represents a change of CAN\$10,000. * $p < 0.01$; ** $p < 0.05$.
SD = standard deviation.

Figure 1. Program effect for an average individual over the 9-month intervention period across gender and gender and age 65+

Table 6. The number needed to treat and the cases averted if the intervention effect observed in the pilot was applied in an Ontario population with the same demographic and risk profile as the PCDPP participants at enrollment, under various coverage scenarios (30%–100%). These numbers were estimated using the Diabetes Population Risk Tool (DPoRT)

Coverage	Impact	Interventions					
		Percent weight loss		Percent 5-year diabetes risk reduction			
		4.6%	7.0%	60%	50%	40%	30%
30%	Number needed to treat (NNT) [†]	42	28	10	12	15	20
40%		48	36	10	12	15	20
50%		39	28	10	12	15	20
75%		40	29	10	12	15	20
100%*		41	29	10	12	15	20
30%	Cases averted [‡]	3756	5669	15 947	13 289	10 631	7974
40%		4765	6401	22 840	19 033	15 226	11 420
50%		7569	10 405	29 725	24 771	19 816	14 682
75%		10 324	14 059	41 165	34 304	27 443	20 582
100%*		13 492	18 666	54 589	45 491	36 392	27 294

* 100% coverage is equivalent to no dropout.

[†] NNT = number needed to treat with the intervention to avoid one case of diabetes.

[‡] Cases averted is the number of cases within the target population that would be averted if the program were scaled up to the Ontario population.

of the DPP to date. Further, the PCDPP utilized multiple sites hundreds of kilometres apart, and worked with quite different populations. With some variation, the intervention was effective in all 6 sites, where total average weight loss varied from 4.5% to 11.1% during the 9-month program. There was no clear relationship, however, between weight loss and differences in participant characteristics across sites. The program was also equally effective across participants with different education and income levels.

Limitations

This study has some limitations. It was not a researcher-led randomized clinical trial, but rather an observational study of a pilot program implemented by the Ontario Ministry of Health and Long-Term Care and primary care providers. Thus, comparison with other programs or public policies on diabetes risk reduction, including cost-effectiveness analysis, was not possible. As a real-world intervention, it was not surprising that data collection and management was an important challenge. This was observed through significant missing data on participant characteristics

and outcomes, and through some inconsistencies in the data recorded in the database.

For some patient characteristic data (e.g., education), census data (i.e., Statistics Canada) could be used. However, for some important outcomes of the program (i.e., physical activity and caloric/fat intake), the lack of data did not allow for further evaluation of the effectiveness of the intervention. Similarly, our analysis did not incorporate other potential impacts caused by participant weight loss, such as avoidance of cardiovascular diseases and other BMI-linked causes of mortality,²⁴ improvements to quality of life,²⁵ and potential health system cost savings.²⁵

Participant dropouts may have biased the effect of the intervention. That is, participants who completed the program may have had some unique characteristics (e.g., motivation) that led them to successful weight loss. However, additional analyses between non-dropouts and dropouts did not show statistically significant differences in, at least, measured characteristics (i.e., gender, income, education and ethnicity, as reported in Table 2). The exception was age (three years difference), but it was not related to weight loss.

Additional analyses including only participants who completed the 9-month program did show, however, some indication of a potential bias that dropout cases may have caused. After the end of the core phase, our complete analysis, that included participants who dropped out at some point, showed an average weight loss of 3.9 kg. When including only those who completed the program, average weight loss at the end of the core phase was higher at 4.7 kg. This difference in weight loss, although not statistically significant (ANOVA, $p = 0.182$), may suggest that dropouts tend to lose less weight than non-dropouts. Had they all completed the 9-month program, the total average weight loss of 6.8 kg (or 7.5%) reported in this study might have been lower.

Participant dropouts may also call into question the implementation of this intervention, as the estimated dropout rate at the end of the 9th month program was 63%. However, the most important phase of the program, where sessions were held on a weekly basis, was the core phase which lasted for 3 months, and where the estimated dropout rate was much lower at 26.8%. At the end of the transition phase (i.e., 6 months into the program), the estimated dropout rate was 46.8%. Given that the goal of 7% was almost achieved at the end of this phase, it is not unreasonable to argue that the program could be shortened to 6 months, as participation rates may be significantly improved without compromising the goal of 7% weight loss.

CONCLUSION

Between 1994/1995 and 2004/2005, adult diabetes prevalence in Ontario grew from 5.2% to 8.8%, a 69% increase in only 10 years.² Currently, more than a million people live with diabetes in Ontario, a number expected to increase.³ Insurers and health systems are increasingly launching diabetes prevention initiatives to address this trend and its associated burden (i.e., costs).^{26,27} Thus, it is necessary to understand how these initiatives work in practice. The PCDPP was implemented in a multidisciplinary primary care practice, and it would be important to assess whether the program's effectiveness differs in other settings such as churches, schools or YMCAs, as has been attempted in other jurisdictions. Experimentation with PCDPP program delivery may prove beneficial at increasing program effectiveness.

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RÉSUMÉ

OBJECTIFS : Les interventions sur le mode de vie peuvent réduire le risque de diabète de type 2. Le Programme de prévention du diabète en soins

primaires (PPDSP) a été mis en œuvre par le gouvernement de l'Ontario pour diminuer le risque de diabète. Premièrement, notre étude a évalué ce programme; deuxièmement, elle a utilisé un outil validé pour estimer l'incidence possible sur la population de l'application du programme à plus grande échelle dans la province.

MÉTHODE : Le PPDSP a été mis en œuvre dans six milieux de soins primaires servant des communautés où le risque de mortalité dû aux maladies chroniques est élevé. En tout, 1 916 adultes atteints de prédiabète ou du syndrome métabolique ont été inscrits entre janvier 2011 et décembre 2012. Le poids était la principale variable de résultat, et nous l'avons modélisé à l'aide de quatre intervalles (base de référence, 3^e, 6^e et 9^e mois). Nous avons estimé l'effet de l'intervention au moyen d'une régression linéaire multiniveau à effets mixtes, et nous l'avons stratifié selon le sexe et l'âge. Dans l'analyse d'incidence sur la population, nous avons

estimé le nombre nécessaire pour traiter (NNT) pour que l'intervention prévienne un cas de diabète et le nombre absolu de cas de diabète évités.

RÉSULTATS : La perte de poids sur 9 mois a été de 7,5 % (ou 6,8 kg), soit 7,4 % (ou 6,4 kg) chez les femmes et 8,6 % (ou 8,6 kg) chez les hommes. Avec la modélisation, les changements du poids étaient tous significatifs. Les modèles pour les participants de sexe masculin ont cependant prédit des gains de poids au cours des 3 derniers mois du programme. Les taux d'abandon ont été de 26,8 %, 46,8 % et 63 % au 3^e, 6^e et 9^e mois, respectivement. La mise à l'échelle du programme produirait un NNT d'environ 36 et éviterait 6 401 cas de diabète sur cinq ans.

CONCLUSION : Le PPDSP est un outil potentiellement efficace pour réduire le risque de diabète dans la population.

MOTS CLÉS : diabète de type 2; soins primaires; prévention