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Original Article

Cost-Comparison Analysis of a Physician-Delivered Step-Count Prescription Strategy

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ABSTRACT

Background: Increments of 1000 steps/d predict cardiovascular disease (CVD) event reductions. In adults with type 2 diabetes and/or hypertension, our Step Monitoring to Improve Arterial Health (SMARTER) trial demonstrated a physician-delivered step-count prescription strategy to increase steps by more than this amount over 1 year, compared to usual care. In the present analysis, we aimed to determine the costs of the intervention compared to usual care, incorporating 1-year intervention costs and projected savings from lower CVD hospitalizations over the subsequent 5 years.

Methods: We considered Canadians aged 55 to 74 years with type 2 diabetes and/or hypertension. Using time estimates from our trial, we computed nursing costs corresponding to patient support time over 1 year, and pedometer costs for an anticipated 50% of patients without a smartphone. We estimated the number of CVD hospitalizations, the reduction expected with a mean 1000 steps/d increase, and the associated savings. We calculated the net cost (savings), the proportion of patients with their own device required for cost neutrality, and costs (savings) if all patients needed to be provided with a device.

Results: At an average intervention cost of $51.28/patient, the total cost would be $168 million. With an estimated 8875 CVD events

RÉSUMÉ

Contexte : Une augmentation de 1000 pas par jour est un facteur prédictif de la réduction des événements attribuables à une maladie cardiovasculaire (MCV). Chez des adultes atteints de diabète de type 2 et/ou d'hypertension, l'essai SMARTER (*Step Monitoring to Improve Arterial Health*) que nous avons réalisé a démontré qu'une stratégie de prescription par un médecin d'un nombre quotidien de pas à effectuer permettait d'obtenir une augmentation du nombre de pas supérieure à cette valeur sur une période de un an, comparativement aux soins habituels. Dans la présente analyse, notre objectif était de déterminer les coûts de cette intervention par rapport à ceux des interventions habituelles, en incluant les coûts de l'intervention sur un an et une projection des économies que permettrait une baisse des hospitalisations pour cause de MCV au cours des cinq années subséquentes.

Méthodologie : Nous avons pris en considération des Canadiens âgés de 55 à 74 ans atteints de diabète de type 2 et/ou d'hypertension. À partir des estimations de temps effectuées dans notre essai, nous avons calculé les coûts correspondant au temps consacré par le personnel infirmier au soutien des patients pendant une année et le coût d'un pédomètre pour les patients n'ayant pas de téléphone intelligent,

In 2016, an estimated 17.9 million people died from cardiovascular disease (CVD) globally, accounting for one-third of deaths. Approximately 85% were due to myocardial infarction and stroke.[1] The comorbidity associated with these events is substantial, as are the costs of CVD management.[2] A large body of evidence demonstrates that greater amounts of walking are associated with reduced CVD rates in diabetes and hypertension,[3-5] 2 critical and prevalent CVD risk factors.[1,6,7] There is a need for cost-effective strategies to increase walking in adults with diabetes and/or hypertension, to prevent CVD.

A variety of step-counting devices and apps are available to capture steps per day. A recent systematic review reported that increasing steps by 1000 steps/d reduces both all-cause mortality and CVD events.[8] We demonstrated that a physician-delivered step-count prescription strategy (**S**tep **M**onitoring to Improve **Arter**ial Health [SMARTER]) increases steps by 1200/d over 1 year, compared to usual advice to be active, in adults with type 2 diabetes and/or hypertension.[9] The American Heart Association highlighted this as an evidence-based approach to technology integration into clinical care,[10] and our strategy was adopted into the Diabetes Canada Clinical Practice Guidelines.[3]

The aim of the current study was to examine the net costs (savings) of the strategy, accounting for intervention costs over 1 year and projected savings from reduced hospitalization with fewer CVD events over the subsequent 5 years. Demonstration of benefit could support efforts to integrate step-count prescription into clinical care pathways for type 2 diabetes and hypertension.

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prevented, $208 million would be saved. This savings would result in ~ $40 million in net savings with 50% device ownership, cost neutrality with 25% device ownership, and ~$42 million in net costs if all patients required the healthcare system to provide a device.

Conclusions: At current levels of smartphone ownership, adoption of the SMARTER strategy is cost-saving to cost-neutral from the healthcare system perspective.

dont nous avons estimé la proportion à 50 %. Nous avons estimé le nombre d'hospitalisations pour cause de MCV, la réduction attendue de ce nombre après une augmentation moyenne de 1 000 pas/jour et les économies ainsi engendrées. Nous avons calculé le coût net (économies), la proportion de patients possédant leur propre appareil requise pour atteindre un coût nul, et les coûts (économies) si tous les patients avaient besoin qu'on leur fournisse un appareil.

Résultats : À un coût moyen d'intervention de 51,28 $/patient, le coût total serait de 168 millions de dollars. En estimant à 8 875 le nombre d'événements attribuables à une MCV ainsi prévenus, on économiserait 208 millions de dollars. Une telle stratégie se traduirait par une économie nette d'environ 40 millions de dollars si 50 % des patients possédaient leur appareil, par un coût nul si 25 % des patients en possédaient un, et par un coût net d'environ 42 millions de dollars si le système de santé devait fournir un appareil à tous les patients.

Conclusions : Compte tenu du pourcentage actuel de personnes qui possèdent un téléphone intelligent, l'adoption de la stratégie SMARTER représente soit une économie, soit un coût nul pour le système de santé.

Methods

We adopted the perspective of the publicly funded Canadian healthcare system. We used trial procedures and materials and costed these in terms of real-world settings to estimate per patient intervention costs over 1 year. We multiplied this by the total number of adults with type 2 diabetes and/or hypertension in Canada. We estimated CVD events in this population over the next 5 years and the expected reductions with a mean step-count increase similar to that achieved with our strategy. We calculated the savings that would result from the corresponding reduction in CVD hospitalizations. We then calculated the net cost (savings). We provide details below.

SMARTER trial summary and costs of step-count prescription

All participants in the SMARTER trial were adults who had type 2 diabetes and/or hypertension, a body mass index of 25 to 40 kg/m^2, and were walking < 10,000 steps/d at baseline.[11] Among 347 randomized, 174 were in the step-count prescription arm; they received a Yamax SW-701 pedometer, a validated step-counting device,[12] and maintained a step log. At clinic visits over 1 year, they reviewed their logs with their physician and received a written step prescription. Steps per day targets were increased more progressively in participants with lower baseline step counts.[11] Control arm participants were advised to engage in 30 to 60 minutes of activity daily. Both active arm and control arm participants wore a sealed pedometer (Yamax SW-701) for 1 week at baseline and 1 week at the end of the intervention period, for estimation of changes in steps over the trial period. These were mailed back to the study centre in the stamped envelopes provided. Control arm participants were not provided with a pedometer for use during the trial intervention period, but they received one at the end of the trial in acknowledgement of their participation. There was a median of 3 visits over 1 year in both trial arms, consistent with recommended care.[13] As noted, compared to the control arm, active arm participants achieved a net increase of 1200 steps/d.[9]

During the actual trial, research assistants demonstrated device use and provided support as needed. In the present analysis, we therefore incorporated nursing time costs for each visit as an additional cost, assuming that clinic nurses would provide support. We calculated costs for 20 minutes of nursing time during the patient's first visit and 10 minutes at each of the remaining 2 visits over 1 year, applying the median hourly wage of a nurse at a primary care clinic.

Physicians are remunerated by Medicare, and 3 visits per year are guideline concordant,[13] so clinical visit remuneration was not included as a specific intervention cost. However, we incorporated 3 hours of physician training time for reading about the strategy and/or viewing an online module, applying the higher medical specialist vs family physician remuneration rates for professional development in Quebec. Given that a trained physician would be caring for multiple participants, the training cost was converted to a per-patient cost; we estimated at least 350 patients with diabetes and/or hypertension per physician, representing 20% of patients in a practice of 1750 patients,[14] roughly the size of an average primary care practice in Canada.

The step-counting device was a key component of the active arm intervention. Given that an increasing number of persons own their own smartphone with step-counting functions, we incorporated this into our analysis. Per a survey conducted by the Pew Research Center, 59% of adults in the United States (US) aged 65 to 69 years, and 49% of US adults aged 70 to 74 years own a smartphone.[15] Similarly, 60% of internet users aged over 65 years in Canada own a smartphone.[16] In our main analysis, we assumed that 50% of our intervention population would own their own device and thus had access to a step-counting app. For the patients without their own step-counting device, in the interest of equity, we considered the cost of obtaining a step-counting device as a healthcare-level cost. We ascertained costs of commercially available devices and selected a price within this range.

Search strategies

We conducted literature searches to identify studies examining associations between steps per day and CVD event rates (PubMed citation index; from inception to September 7, 2020; keyword search string 'steps' AND ('pedometer' OR 'accelerometer') AND ('myocardial infarction' OR 'stroke' OR 'cardiovascular disease')), with an emphasis on identifying relevant systematic reviews. We used *WorldCat*, a search tool that includes books and reports that record statistics from provincial and federal governments of Canada, to ascertain the CVD event rate in Canada (key words 'Canada' AND 'Cardiovascular disease' AND 'Statistics' AND 'Stroke' AND ('heart disease' OR 'myocardial infarction')) and the costs of hospitalization for myocardial infarctions and ischemic strokes (key words 'Canada'

AND 'direct health care costs' AND 'ischemic stroke' and then 'Canada' AND 'direct health care costs' AND 'myocardial infarction'). A filter was applied to narrow the search to publications from within the past 10 years.

Main analysis

Computations were performed in Microsoft Excel 2016 (Microsoft Corporation, Redmond, WA). Given that SMARTER trial participants averaged age 60 years (standard deviation [SD] 11.2),[9] we estimated the number of Canadians aged 55 to 74 years with type 2 diabetes and/or hypertension, using data sources identified through the literature searches described. We applied the estimated per-patient intervention cost to this total number, accounting for 50% of the cohort owning their own step-counting device. We calculated the expected number of CVD events over a 5-year horizon in this cohort and the reduction that would be realized by the intervention, assuming that an average increase of 1000 steps/d was achieved in the year prior. We calculated the savings obtained through this reduction in CVD events. We then computed the net cost (savings) over a 6-year period, with the implementation of the step-count prescription strategy during the first year. This particular 5-year follow-up period was selected based on the results of our review of associations between change in steps and CVD events, as described under Results (CVD events prevented with a step-count increase). A discounting rate of 1.5% was applied as recommended by the Canadian Agency for Drugs and Technologies in Health (CADTH).[17]

Sensitivity analyses

Given the inherent parameter uncertainty in an economic evaluation, we conducted several sensitivity analyses. First, we varied nurse support time and remuneration across a range of estimates, to examine the impact of both of these simultaneously on costs, using a 2-by-2 matrix. Second, we varied device costs across the range of prices for pedometers in Canada. Third, we conducted an analysis to estimate the proportion of the population that would have to have their own pedometer device for the strategy to be cost neutral, and another analysis in which none of the patients already owned a device. Fourth, we varied estimates of the increased rate of CVD events in patients with diabetes and/or hypertension. Finally, we varied the estimates of reductions in CVD events associated with higher step counts.

Results

Costs of 1-year step-count prescription strategy

The median Canadian wage of a nurse was determined to be $37.60/hour.[18] Assuming that the nurse spends 40 minutes yearly, per participant, providing support, the cost of nursing support per patient is $25.07. For 3 hours of training, medical specialists in Quebec are reimbursed a maximum of $422.00[19] and family physicians $354.50.[20] Applying the higher specialist reimbursement rate translates to a per-patient cost of $1.21, assuming that each physician follows at least 350 patients. The cost of the Yamax SW-701 pedometer used in the SMARTER trial was $18.48, but pedometer costs vary based on the brand, number of pedometers ordered, step-count accuracy, and extra features. We identified pedometer unit costs (pre-tax) varying from $14.99 for a Sportline 340 Step & Distance Pedometer (Running Room, Edmonton, AB) to $129.95 for a Fitbit Inspire 2 (Fitbit Inc, San Francisco, CA). We elected to incorporate a $50.00 cost in our main analysis, which we believe is a fair estimate for a good-quality pedometer purchased in bulk. As half of the patients would have their own device, we divided the pedometer cost in half to attain our per-patient device cost. Therefore, the total per-patient cost of the 1-year step-count prescription strategy is $51.28 (Table 1).

Table 1. Cost of the physician-delivered step-count prescription strategy from a healthcare system perspective

Item	Study value	Sensitivity-analysis values
Cost of nursing support per patient	$25.07	$12.04-$90.44
Canadian wage of a nurse, $/h	$37.60[18]	$24.08-$45.22[33]
Time per patient for support, min	40	30-120
Cost of physician training per patient	$1.21	$1.21
Cost of remuneration for training	$422.00[19]	$422.00[19]
Number of patients treated/ physician	350[14]	350[14]
Device cost per patient	$25.00	$0.00-$130.00
Proportion of patients with their own device, %	50[15,16]	0-100
Cost of pedometer*	$50.00	$10.00-$130.00
Average per-patient cost for physician-delivered step-count prescription strategy	51.28	$13.25-$221.65

*Sportline 340 Step & Distance Pedometer (Running Room, Edmonton, AB) and Fitbit Inspire 2 (Fitbit Inc, San Francisco, CA).

Estimated CVD event rates

The search string to identify yearly CVD events in Canada yielded 2203 results. The most relevant was a publication by the Public Health Agency of Canada that reported the 2005 and 2006 incidences of myocardial infarction and stroke hospitalizations in the group aged 55-64 years in Canada to be 343 and 143.8 per 100,000 persons, respectively. For the group aged 65-74 years, the rates were higher—590.7 and 365 per 100,000 persons, respectively.[21] Summing these rates yields an average of 721.25 total hospitalizations per 100,000 persons for myocardial infarction or stroke. In patients with diabetes, the incidence of cardiovascular events increases by 2-3 times.[22] Given that the myocardial infarction and stroke rates reported in Canada include those with diabetes or hypertension, we estimated that the rates in a population of only those with diabetes or hypertension would be 50% higher (ie, rather than threefold higher) compared to general population estimates. The result was an estimated 1082 total events per 100,000 persons per year.

CVD events prevented with a step-count increase

We identified 265 studies reporting associations between steps and CVD events, including a recent and relevant systematic review that captured all pertinent studies. The review reported that increasing steps by 1000/d from baseline reduced all-cause mortality by 6%-36%, and CVD events by 5%-21%.[8] There were 4 studies addressing CVD morbidity and mortality,[23-26] of which 2 were of high quality and reported CVD event rates.[24,25] Of these 2, one included individuals with an average age of 78 years, a higher mean age than that in our trial, with a 14% reduction in events per 1000 steps/d.[24] The other studied individuals with an average age of 60 years, similar to the average in our trial, and reported a 5% reduction over 5 years per 1000-steps/d increment in the year prior to a 5-year follow-up.[25] This method aligned well with our approach of costing the SMARTER intervention over 1 year and then examining savings related to reduced hospitalizations over the next 5 years. We adopted this 5% estimate over a 5-year time horizon for initial calculation, and also performed sensitivity analyses as shown below (in Sensitivity Analyses section).

Costs of hospitalization for CVD events

The search string to identify the cost of myocardial infarction and stroke hospitalizations in Canada on *WorldCat* yielded 258 and 144 results, respectively. The 2 most pertinent studies were selected.[27,28] It was estimated[27] that the average cost of hospitalization for a myocardial infarction was $16,462.21. For stroke (disabling and non-disabling), the average cost for hospitalization and rehabilitation (for the first 3 months) was $40,624.[28] Per the myocardial infarction and stroke hospitalizations rates above, the proportions of myocardial infarction and stroke were 65% and 35%, respectively. Using these proportions, the cost of a CVD event hospitalization was calculated to be $24,919.

Theoretical cohort

Our theoretical cohort was all Canadians aged 55 to 74 years with type 2 diabetes and/or hypertension. In 2014, the general Canadian population aged 55 to 74 years was 3,856,110 men and 4,008,408 women.[29] The prevalence of hypertension in this time period was 32.5% and 27.3% in men and women aged 55 to 64 years, respectively, and 43.9% and 44.9% in men and women aged 65 to 74 years, respectively.[30] The prevalence of diabetes in 2014 in men aged 55 to 59 years, 60 to 64 years, 65 to 69 years, and 70 to 74 years was 14.4%, 19.8%, 25.4%, and 29.8%, respectively. In women, it was 11.1%, 15.1%, 19.1%, and 22.6%, respectively.[31] Therefore, approximately 1,425,313 men and 1,378,906 women had hypertension, and 806,403 men and 642,286 women had diabetes in Canada in 2014. A study showed that 67.1% of Canadians with diabetes also had hypertension.[32] Therefore, of the 806,403 men and 642,286 women who had diabetes, 541,096 men and 430,974 women also had hypertension. In order to avoid double-counting, we subtracted these values from the above estimates of Canadians aged 55 to 74 years with hypertension, to determine the number of Canadians with hypertension alone (884,217 men and 947,932 women). By summing the estimate of the population with diabetes, which also includes people with diabetes and hypertension, and the estimate of the population with hypertension alone, we estimated that the Canadian population aged 55 to 74 years with diabetes and/or hypertension is 3,280,838.

Cost-comparison analysis results

As noted above, in a group of 100,000 patients with diabetes and/or hypertension, there would be an estimated 1082 CVD events per year. Therefore, in the 3,280,838 Canadians aged 55 to 74 years with diabetes and/or hypertension, there would be 35,499 total CVD events per year. A 5% reduction in events in this group translates to 1775 CVD events prevented yearly, or 8875 CVD events prevented over the 5 years following the 1-year intervention. With a discounting rate of 1.5%, the total savings associated with this change would be $208,416,006.

Our analysis above demonstrated that the 1-year step-count prescription strategy resulted in an average per-patient cost of $51.28 if half of the intervention population owned their own device. Therefore, implementation of the strategy for all Canadians aged 55 to 74 years with diabetes and/or hypertension would be $168,241,373. Therefore, in the case of 8875 CVD events prevented over 5 years, there would be a net savings of $40,174,633 with the strategy (Table 2).

Sensitivity analyses

According to the Interprofessional Health Federation of Quebec, the wage of a nurse may vary from $24.08/hour to $45.22/hour, depending on education level and work

Table 2. Cost-comparison results of the physician-delivered step-count prescription strategy from a healthcare system perception

Item	Study value	Sensitivity-analysis values
Costs		
Average cost of implementing SMARTER strategy (per patient)	$51.28	$13.25-$221.65
Canadians aged 55 to 74 years with diabetes and/or hypertension	$3,280,838[29-32]	$3,280,838[29-32]
Total cost	$168,241,373	$43-$727 million
Savings		
Yearly number of CVD events/ 100,000 Canadians with diabetes and/or hypertension	1082	721-2164[21,22]
Total annual number of CVD events among Canadians aged 55 to 74 years with diabetes and/or hypertension	35,495	23,663-70,989
Percent reduction in CVD events yearly	5[25]	0-5
Estimated yearly decrease in number of events	1775	0-3549
Number of years	5	5
Cost of a cardiovascular event, $	$24,919[27,28]	$24,919[27,28]
Discount rate (applied to savings occurring over 5 years following a 1-year intervention), %	1.50[17]	1.50[17]
Total savings	$208,416,006	$0-$417 million
Net cost (savings)		
Total cost of implementing SMARTER strategy	$168,241,373	$43-$727 million
Total savings from potential CVD event prevention	$208,416,006	$0-$417 million
Net cost (savings)	($40,174,633)	($373)-$727 million

CVD, cardiovascular disease; SMARTER, **S**tep **M**onitoring to Improve **Arter**ial Health.

experience.[33] Simultaneously varying the nursing cost from $24.08/hour to $45.22/hour, and the yearly amount of nursing time per patient between 30 minutes and 2 hours, while keeping the per-patient physician training cost of $1.21 and the device cost of $25.00 constant, resulted in per-patient costs ranging from $38.25 to $116.65 (Supplemental Table S1).

When the pedometer cost was varied from $10.00 (bulk order) to $130.00, with the nursing costs, physician training costs, and proportion of patients with their own device held constant, the per-patient cost of the strategy varied between $31.28 and $91.28. Varying all 3 factors (pedometer cost, nursing wage, and yearly nursing time per patient), while keeping physician training costs and proportion of patients with their own device constant at $1.21 and 50%, respectively, resulted in costs ranging between $18.25 and $156.65.

If the healthcare system had to provide a pedometer to the entire intervention population, and we assumed a pedometer cost of $50, the per-patient cost of intervention would be $76.28. Similar variations in nursing hourly wage, time spent in nursing support per patient, and pedometer cost as above would result in per-patient costs ranging between $23.25 and $221.65. On the other hand, if the entire population owned or procured their own device, the per-patient cost incurred by the healthcare system to deliver the SMARTER strategy over 1 year would decrease to $26.28. Variations would result in per-patient costs ranging from $13.25 to $91.65.

Therefore, the average per-patient cost of implementing the step-count prescription strategy can range to anywhere between $13.25 and $221.65. This large range is mainly due to the large variation in the device cost.

Assuming the cost of the intervention to be $26.28 for patients with their own pedometer, and $76.28 for patients without their own device, we estimated that approximately 25% of the population would need to own a pedometer for the net cost (savings) of the strategy to be zero.

To estimate the incidence of CVD events in patients with diabetes and/or hypertension, we assumed a 1.5-fold increase of the incidence rate compared to that in the general population. If the incidence rate ranged from that of the general population to a 3-fold increase, then the number of CVD events prevented from the SMARTER intervention over a 5-year period would range from 5915 to 17,745. Therefore, implementation of the strategy (average per-patient cost of $51.28) would vary from a net cost of $29,336,508 to a net savings of $248,473,221.

Furthermore, we adopted a 5% reduction in CVD events over a 5-year time horizon for our intervention. If there was no reduction obtained, the healthcare system would incur the entire $168,241,373 cost of the intervention without any benefits. If there was only a 2.5% reduction in CVD events over a 5-year period, then only 4435 CVD events would be prevented and implementation of the strategy would have a net cost of $64,092,079. Therefore, if the reduction in CVD events over a 5-year period ranged from 0% to 5%, the net cost (savings) of the intervention would vary between a cost of $168,241,373 and a savings of $40,174,633.

Varying the total number of CVD events from that of the general population to a 3-fold increase and the percent reduction due to the intervention from 0% to 5%, while keeping the average per-patient cost of the strategy constant at $51.28, would result in the net cost (savings) of the intervention ranging between a cost of $168,241,373 and a savings of $248,473,221. Simultaneously varying the average per-patient cost of the strategy from $13.25 to $221.65 would result in the net cost (savings) of the intervention ranging between a cost of $727,197,743 (if no reduction in CVD events were attained) and a savings of $373,243,490.

Discussion

The SMARTER intervention achieved a net increase of 1200 steps per day from baseline,[9] which we have estimated would reduce the number of cardiovascular events by 8875 over 5 years in Canadians aged 55 to 74 years with type 2 diabetes and/or hypertension. We estimate that implementation of the strategy could lead to a net savings of $40,174,633 if half of the cohort owns their own device. If the device had to be provided to all patients, the strategy would have a net cost of $41,846,317 for the same 8875 CVD events prevented over 5 years. This translates to a cost of $12.75 per patient or $4715 per CVD event prevented. If approximately 25% of this population owned their own device, the strategy would be cost neutral. These findings clearly support the integration of step-count prescription delivery, training, and monitoring into clinical services for adults with type 2 diabetes and/or hypertension.

There are benefits that we did not capture in the present analysis, including mental health benefits[34,35] and osteoarthritis symptom relief.[36] Additionally, there are benefits such as years of life gained and morbidity reductions resulting from CVD prevention. Step count increments of 1000 steps/d are associated with reductions in mortality rates of 6%-36%.[8,25,37] In 2007, a total of 43.5% of Canadians who reported having heart disease, and 57.2% of Canadians who reported living with effects post-stroke, rated their health as being fair or poor, compared to only 6.1% of Canadians without chronic conditions. Among Canadians who reported having heart disease and living with effects post-stroke, 30.3% and 59.5%, respectively, reported needing help with their daily activities of living, compared to 7.4% of Canadians without heart disease or stroke. Furthermore, 68.8% and 83.6%, respectively, reported having limitations doing activities they enjoyed, compared to 29.3% of Canadians without heart disease or stroke.[21] These activity limitations have cost implications in terms of productivity loss and healthcare expenditures. We did not integrate these, as this would have required a wider set of assumptions; however, the prevention of mortality and morbidity is clearly valuable to society.

A key attraction of the SMARTER strategy is its simplicity and its structural similarity to other aspects of diabetes and hypertension care. Just as healthcare professionals provide self-management support with measuring and reviewing home blood pressure and glucose values, the SMARTER strategy involves self-management support for step counting. Our in-depth interviews with physicians and patients indicate high enthusiasm for the strategy but a need for support from other clinic staff, similar to that provided by the coordinator in our original trial.[38] In the present analysis, we demonstrate that integrating such support into clinical practice is a worthwhile investment, translating into overall cost savings in certain situations.

In our study, we estimated that half of our intervention population owned their own step-count measuring device, such as a smartphone with a step-counting app. Given that with time the proportion of the population with a suitable device will continue to grow, the per-patient cost to the healthcare system could become lower than estimated. In addition, bulk purchase by the healthcare system could reduce costs further. Some private medical insurance plans have incorporated physical activity monitoring into plans, providing potential for discounted rates if certain activity thresholds are achieved.[42] This stream of funding for devices could thus lower costs further. Moreover, as technology evolves, these devices may become less expensive.

In the present analysis, we compared the cost of implementing the SMARTER intervention over one single year with the savings associated with the CVD events prevented in the subsequent 5 years. Ideally, we hope that participants would continue to monitor their step counts, either daily or intermittently as a check, and that their physicians would continue to support and motivate them to incrementally further increase or maintain their daily step count. Moreover, as participants continue beyond 1 year, physical activity may become a habit.[38] The pedometer cost and the cost associated with physician training are one-time costs incurred at the onset of the strategy. The nursing time costs are arguably most relevant in the first year, for instruction on step monitoring and pedometer or app use and troubleshooting; thereafter, the patient would be expected to be sufficiently experienced. Therefore, given that the physician visit is covered by Medicare, and additional nursing support beyond 1 year is less likely to be needed, we believe it is reasonable to estimate intervention-related costs beyond 1 year as being zero from a healthcare system perspective.

There are limitations to our analysis. Our original trial was not large or long enough to provide all relevant information within a single study. We therefore had to rely on a combination of data sources, including our trial, observational studies of steps/day and long-term impact on CVD, and published estimates of hospitalization costs. The observational study examining associations of step-count changes over 1 year to subsequent reductions in 5-year CVD events[25] was well suited to our purpose and included nearly 10,000 participants; however, as for all observational studies, reverse causality cannot be excluded, despite prospective follow-up. Furthermore, as discussed, it was beyond the scope of our study to integrate considerations of quality-adjusted life years. Despite these limitations, we believe that by combining various data sources, we have derived reasonable estimates of savings and costs associated with implementing a physician-delivered step-count prescription strategy.

Walking is a form of physical activity that is feasible for many people and is often endorsed as a preferred form of exercise by persons with diabetes and/or hypertension.[39,40] Nonetheless, there are environmental factors that may be limiting for outdoor walking, including cold temperatures and precipitation, and “walkability” of neighbourhoods in terms of sidewalks, green spaces, variety and proximity of points of interest, intersection density, safety, and other factors, as we and others have described.[41-45] However, accumulation of steps may also be achieved indoors, walking up and down stairs and hallways, and even stepping in place. The use of a pedometer to achieve targets, indoors or outdoors, renders the SMARTER intervention appealing to patients and physicians.[38]

Conclusions

Our cost-comparison analysis demonstrates that at current levels of smartphone ownership, adoption of the SMARTER strategy in adults with type 2 diabetes and/or hypertension is cost saving to cost neutral from the healthcare system perspective. The cost to implement the strategy and prevent cardiovascular disease events would arguably remain reasonable if the device was provided to all participants.

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Disclosures

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References

1. World Health Organization. Cardiovascular diseases (CVDs). Available at: https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds). Accessed August 19, 2020.
2. Tarride J-E, Lim M, DesMeules M, et al. A review of the cost of cardiovascular disease. Can J Cardiol 2009;25:e195–202.
3. Sigal RJ, Armstrong MJ, Canada Clinical Practice Guidelines Expert Committee, et al. Physical activity and diabetes. Can J Diabetes 2018;42 (suppl 1):S54-S63.
4. Hamasaki H. Daily physical activity and type 2 diabetes: a review. World J Diabetes 2016;7:243–51.
5. Rossi A, Dikareva A, Bacon SL, Daskalopoulou SS. The impact of physical activity on mortality in patients with high blood pressure: a systematic review. J Hypertens 2012;30:1277–88.
6. Patel SA, Winkel M, Ali MK, Narayan KM, Mehta NK. Cardiovascular mortality associated with 5 leading risk factors: national and state preventable fractions estimated from survey data. Ann Intern Med 2015;163:245–53.
7. World Heart Federation. Risk factors. Available at: https://www.world-heart-federation.org/resources/risk-factors/. Accessed August 19, 2020.

8. Hall KS, Hyde ET, Bassett DR, et al. Systematic review of the prospective association of daily step counts with risk of mortality, cardiovascular disease, and dysglycemia. Int J Behav Nutr Phys Act 2020;17:78.

9. Dasgupta K, Rosenberg E, Joseph L, et al. Physician step prescription and monitoring to improve ARTERial health (SMARTER): a randomized controlled trial in patients with type 2 diabetes and hypertension. Diabetes Obes Metab 2017;19:695–704.

10. Bhavnani SP, Parakh K, Atreja A, et al. 2017 roadmap for innovation—ACC health policy statement on healthcare transformation in the era of digital health, big data, and precision health: a report of the American College of Cardiology Task Force on Health Policy Statements and Systems of Care. J Am Coll Cardiol 2017;70:2696–718.

11. Dasgupta K, Daskalopoulou S, Rosenberg E. Step monitoring to improve ARTERial health (SMARTER) through step count prescription in type 2 diabetes and hypertension: trial design and methods. Cardiovasc Diabetol 2014;13:1–8.

12. Tudor-Locke C, Sisson SB, Lee SM, et al. Evaluation of quality of commercial pedometers. Can J Public Health 2006;97(suppl 1):S10–5. S10-6.

13. Berard LD, Siemens R, Woo V. Monitoring glycemic control. Can J Diabetes 2018;42:S47–53.

14. McLeod L, Buckley G, Sweetman A. Ontario primary care models: a descriptive study. CMAJ Open 2016;4:E679–88.

15. Anderson M, Perrin A. Technology Use Among Seniors. Washington, DC: Pew Research Center for Internet & Technology; 2017.

16. Statistics Canada. Table 22-10-0115-01: Smartphone use and smartphone habits by gender and age group. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2210011501. Accessed March 26, 2021.

17. Guidelines for the economic evaluation of health technologies: Canada. 4th ed. Ottawa: CADTH; 2017. Available at: https://www.cadth.ca/sites/default/files/pdf/guidelines_for_the_economic_evaluation_of_health_technologies_canada_4th_ed.pdf. Accessed February 23, 2021.

18. Government of Canada Job Bank. Primary care nurse in Canada. Available at: https://www.jobbank.gc.ca/marketreport/summary-occupation/687/ca. Accessed July 30, 2020.

19. Régie de l'assurance maladie Québec. Ressourcement, développement professionnel et maintien des compétences. Available at: http://www.ramq.gouv.qc.ca/fr/professionnels/medecins-specialistes/facturation/Pages/ressourcement-developpement-competences.aspx. Accessed July 30, 2020.

20. La Fédération des médecins omnipraticiens du Québec. Allocations et ressourcement. Available at: https://www.fmoq.org/formation/politiques/allocations-et-ressourcement/. Accessed July 30, 2020.

21. Public Health Agency of Canada (PHAC). 2009 Tracking Heart Disease and Stroke in Canada. Ottawa: PHAC; 2009.

22. Booth GL, Kapral MK, Fung K, Tu JV. Recent trends in cardiovascular complications among men and women with and without diabetes. Diabetes Care 2006;29:32–7.

23. Cochrane SK, Chen S-H, Fitzgerald JD, et al. Association of accelerometry-measured physical activity and cardiovascular events in mobility-limited older adults: the LIFE (Lifestyle Interventions and Independence for Elders) Study. J Am Heart Assoc 2017;6:e007215.

24. Jefferis BJ, Parsons TJ, Sartini C, et al. Does total volume of physical activity matter more than pattern for onset of CVD? A prospective cohort study of older British men. Int J Cardiol 2019;278:267–72.

25. Yates T, Haffner SN, Schulte PJ, et al. Association between change in daily ambulatory activity and cardiovascular events in people with impaired glucose tolerance (NAVIGATOR trial): a cohort analysis. Lancet 2014;383:1059–66.

26. Huffman KM, Sun J-L, Thomas L, et al. Impact of baseline physical activity and diet behavior on metabolic syndrome in a pharmaceutical trial: results from NAVIGATOR. Metabolism 2014;63:554–61.

27. Cohen D, Manuel DG, Tugwell P, Sanmartin C, Ramsay T. Direct healthcare costs of acute myocardial infarction in Canada's elderly across the continuum of care. J Econ Ageing 2014;3:44–9.

28. Mittmann N, Seung SJ, Hill MD, et al. Impact of disability status on ischemic stroke costs in Canada in the first year. Can J Neurol Sci 2012;39:793–800.

29. Statistics Canada. Table 17-10-0005-01 Population estimates on July 1st, by age and sex. Available at: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000501&pickMembers%5B0%5D=1.1&pickMembers%5B1%5D=2.3&cubeTimeFrame.startYear=2014&cubeTimeFrame.endYear=2014&referencePeriods=20140101%2C20140101. Accessed October 25, 2020.

30. Statistics Canada. High blood pressure, 2014. Available at: https://www150.statcan.gc.ca/n1/pub/82-625-x/2015001/article/14184-eng.htm. Accessed October 25, 2020.

31. Public Health Agency of Canada. Diabetes in Canada. Available at: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/diabetes-canada-highlights-chronic-disease-surveillance-system.html#shr-pg0. Accessed October 25, 2020.

32. Padwal RS, Bienek A, McAlister FA, Campbell NRC. Outcomes Research Task Force of the Canadian Hypertension Education Program. Epidemiology of hypertension in Canada: an update. Can J Cardiol 2016;32:687–94.

33. Interprofessional Health Federation of Quebec. Salary scales and list of job titles. Available at: http://www.fiqsante.qc.ca/wp-content/uploads/2016/10/Echelles_salariales_Web_2016-2020_ANG.pdf?download=1. Accessed December 11, 2018.

34. Mammen G, Faulkner G. Physical activity and the prevention of depression: a systematic review of prospective studies. Am J Prev Med 2013;45:649–57.

35. Stanton R, Reaburn P. Exercise and the treatment of depression: a review of the exercise program variables. J Sci Med Sport 2014;17:177–82.

36. Kraus VB, Sprow K, Powell KE, et al. Effects of physical activity in knee and hip osteoarthritis: a systematic umbrella review. Med Sci Sports Exerc 2019;51:1324–39.

37. Dwyer T, Pezic A, Sun C, et al. Objectively measured daily steps and subsequent long term all-cause mortality: the Tasped prospective cohort study. PloS One 2015;10:e0141274.

38. Cooke AB, Pace R, Chan D, et al. A qualitative evaluation of a physician-delivered pedometer-based step count prescription strategy with insight from participants and treating physicians. Diabetes ResClin Pract 2018;139:314–22.

39. Casey D, De Civita M, Dasgupta K. Understanding physical activity facilitators and barriers during and following a supervised exercise programme in type 2 diabetes: a qualitative study. Diabetic Med 2010;27:79–84.

40. Ford ES, Herman WH. Leisure-time physical activity patterns in the US diabetic population: findings from the 1990 National Health Interview

Survey—Health Promotion and Disease Prevention Supplement. Diabetes Care 1995;18:27–33.

41. Mah SM, Sanmartin C, Riva M, Dasgupta K, Ross NA. Active living environments, physical activity and premature cardiometabolic mortality in Canada: a nationwide cohort study. BMJ Open 2020;10:e035942.

42. John Hancock Vitality. John Hancock Vitality program. [cited 2018 October 1]. Available at: https://www.johnhancockinsurance.com/vitality-program.html. Accessed October 1, 2018.

43. Hajna S, Kestens Y, Daskalopoulou SS, et al. Neighbourhood walkability and home neighbourhood-based physical activity: an observational study of adults with type 2 diabetes. BMC Public Health 2016;16:957.

44. Hajna S, Ross NA, Brazeau A-S, et al. Associations between neighbourhood walkability and daily steps in adults: a systematic review and meta-analysis. BMC Public Health 2015;15:768.

45. Kaberi D, Joseph L, Pilote L, et al. Daily steps are low year-round and dip lower in fall/winter: findings from a longitudinal diabetes cohort. Cardiovasc Diabetol 2010;9:81.

Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at https://www.cjcopen.ca/ and at doi:10.1016/j.cjco.2021.04.009.