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Applying Patient Segmentation Using Primary Care Electronic Medical Records to Develop a Virtual Peer-to-Peer Intervention for Patients with Type 2 Diabetes

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Abstract: The aim of this study was to design a virtual peer-to-peer intervention for patients with type 2 diabetes (T2D) by grouping patients from specific segments using data from primary care electronic medical records (EMRs). Two opposing segments were identified: patients living with diabetes who tend to take several medications ("medication" segment: ~32%) and patients who do not take any diabetes-specific medications ("lifestyle" segment: ~15%). The remaining patients were from two intermediate segments and exhibited medication-taking behavior that placed them midway between the medication and lifestyle segments. Patients were grouped into six workshops (two workshops in each group: medication, lifestyle, and mixed group), including individuals with good and bad control of their disease. Measures of attitudes, learning, and motivation were addressed during and after the workshops. Results showed that patients in the lifestyle segment were more interested in T2D lifestyle control strategies, more satisfied with their in-workshop learning experience, and more motivated to set a goal than those in the medication segment. These results suggest that the proposed intervention may be more viable for patients in the lifestyle segment and that EMR data may be used to tailor behavioral interventions to specific patient groups. Future research is needed to investigate different segmentation approaches (e.g., using data related to smoking, drinking, diet, and physical activity) that could help tailor the intervention more effectively.

Keywords: electronic medical records (EMRs); patient segmentation; peer-to-peer support; positive deviance; type 2 diabetes

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1. Introduction

Type 2 Diabetes (T2D) is a major challenge for health systems, accounting for 90% of diabetes cases worldwide [1]. In 2021, the International Diabetes Federation estimated that around 536.6 million adults were living with diabetes, with 6.7 million deaths attributable to the disease. Diabetes-related healthcare costs are extremely (close to USD one trillion in 2021) [2]. It is widely recognized that prevention is key to reducing the complications of T2D and is extremely important in terms of limiting the socioeconomic impacts of this disease. However, despite well-disseminated, high-quality prevention guidelines, large investment in diabetes self-management education, new and improved treatments and good patient follow-up over the last two decades, many patients with T2D continue to have poor control of their disease and have difficulties in dealing with the related emotional, social, and physical effects [3].

Different peer support models, e.g., face-to-face, telephone-, or web-based programs have been developed so far. The rationale is to let patients talk with each other and address common issues, typically under the supervision of expert moderators or healthcare professionals, outside the patient–physician direct relationship. Studies have shown that peer support intervention can lead to better glycemic control than individual programs, but these programs may fail to achieve wide adoption as a large variability in individual outcomes is observed [4,5]. A minority of patients are able to achieve good control of their disease whereas the majority struggle to do so, despite having access to the same resources. Specifically, depending on patient segment, anywhere from 27 to 55% of patients have poor blood pressure control, 37 to 83% have poor cholesterol control, and 15 to 73% have poor blood sugar control [6,7]. Moreover, the recent COVID-19 pandemic has exacerbated some of the barriers that patients experience in maintaining a healthy lifestyle. Social distancing and preventive measures have limited the frequency of routine primary care encounters, particularly for the elderly [8,9]. In this context, the availability of tailored interventions delivered in a virtual environment may help overcome the challenges related to conventional approaches.

In a preliminary study [7], we demonstrated that patients with T2D enrolled in a virtual peer-to-peer moderated group discussion had a favorable attitude toward the opportunity to share their experiences with peers in a virtual environment, regardless of the patient segment and of their level of control of the disease. Moreover, our preliminary findings suggested differences between patient segments in terms of self-reported learning and preferred topics (i.e., patients interested in preventive measures were more likely to belong to the lifestyle segment whereas patients interested in symptom management were more likely to belong to the medications segment) [7].

The aim of this study was to develop a new, scalable, data-driven approach for patients with T2D in the form of peer-to-peer support in a virtual environment, based on two principles still largely unexplored in healthcare: patient segmentation and positive deviance. Segmentation is widely used in marketing to subdivide populations based on demographics, psychographics, and behaviors [10]. The use of segmentation in healthcare is limited to, e.g., needs evaluation and service design [11,12] and is not usually adopted for the provision of tailored interventions, despite growing evidence that it could support patient self-management [13,14]. Positive deviance is a form of collective intelligence that assumes that solutions can be generated collectively within communities through a process of learning, rather than externally imposed. In healthcare, positive deviance has been used for health services assessment but it has not been used so far for developing group interventions [15–17]. In this study, we applied positive deviance by including one or two patients with good control of their disease in each peer-to-peer group to let patients with bad control learn from successful peers, with a view to intrinsic and socially-driven behavior change. The rationale was to address whether patients with T2D with poor control of their disease can learn from others who are successful in managing their diabetes and whether this kind of intervention can be more effective, in terms of supporting, learning, and motivation for behavior change, if it is tailored to patients with similar characteristics as opposed to current 'one size fits all' approaches. In this first study, patient segmentation is performed based on medication-taking behavior in order to further validate our preliminary findings [7]; however, the overall intervention is model-agnostic and can be adapted to different patient segmentation approaches.

2. Materials and Methods

2.1. Participants

The study population included 825 patients (403 males, 422 females; age: mean 68.6 years; s.d. 11.69; inclusion criteria: age $\geq$ 40 years, diagnosed with T2D for two or more years, and having basic computer and internet skills). Patients were identified from the EMRs of a network of primary care physicians associated with Queen's University Department of Family Medicine. The study protocol was approved by Queen's University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board (5 October 2020, renewed on 5 October 2021 and 23 September 2022) and by Toronto Metropolitan University Research Ethics Board (10 March 2021, renewed on 09 March 2022).

2.2. Patient Segmentation and Characterization

Patients were segmented based on recent medication-taking behavior data extracted from their EMRs from the past two years. Specifically, four binary features were defined based on the presence (value = 1) or absence (value = 0) of medications in each of the following groups of medications, as relevant to T2D: (1) first-line diabetes drugs (e.g., metformin); (2) second-line diabetes drugs (e.g., insulin, sulfonylureas, and other blood glucose-lowering drugs); (3) anti-cholesterol drugs (statins); and (4) anti-hypertensives. Each patient in our sample took medications from at least one of these four groups. On average, the medications taken most frequently in our sample were from group (4), anti-hypertensives, and group (3), anti-cholesterol drugs. We extracted two opposing segments: patients who took medications from each of the four groups ("medication" segment: 261 out of 825 patients, i.e., ~32%), and patients who took medications only from groups (3) and (4) and took no diabetes-specific medications from either group (1) or (2) ("lifestyle" segment: 123 out of 825 patients, i.e., ~15%). The remaining patients were from two intermediate segments, as they took different combinations of medications (i.e., a combination of group (1) with groups (3) and (4); or a combination of group (2) with groups (3) and (4)).

In addition to medication data, the following attributes were extracted from EMRs: age, sex, body mass index (BMI), glycated hemoglobin (HbA1c), low-density lipoprotein (LDL), systolic blood pressure (sBP), and diastolic blood pressure (dBP). The values of BMI, HbA1c, LDL, sBP, and dBP were computed as the average of the measures extracted from EMRs in a time window of two years before the experiment. Patients with good control of T2D were defined as those with HbA1c $\leq$ 7%, LDL $\leq$ 2.6 mmol/L, sBP < 130 mmHg, and dBP < 80 mmHg, in line with the American Diabetes Association guidelines [18], whereas the remaining patients were defined as having poor control of their disease.

2.3. Experiment

Patient recruitment was carried out using an opt-out procedure for primary care providers. Primary care providers sent a letter to patents included in the pool inviting them to participate in the study. The content of the letters was tailored to the patient segment and to the level of control of disease. Patients were contacted by phone 1–2 weeks after the letter of information had been sent to obtain verbal consent.

A total of 6 workshops were performed: 2 with patients from the medication segment (4 and 5 patients, respectively), 2 with patients from the lifestyle segment (4 and 3 patients, respectively), and 2 with a mixed group of patients, including patients from across all segments, including the intermediate segments (6 and 4 patients, respectively). In workshops with up to 4 participants, 1 patient with good control of T2D was involved, whereas in workshops with 5 or more participants, 2 patients with good control were involved. Information about the individual level of control (good/bad) of participants was not disclosed during the workshops. The workshops were held on a widely available video-conference platform and were based on a 90-min discussion guide developed following collective intelligence principles (the discussion guide is reported in detail in Appendix A). The workshops were facilitated by an expert moderator (R.K.). Patients were allowed to join the meeting using their preferred device (e.g., computer or mobile). The patients, the moderator, and a research assistant (R.T.) were in the same virtual room during the session, with the only exception being the 'idea generation' phase (item 6 in the discussion guide) in which patients were subdivided in 2 different groups and moved to 2 separate breakout rooms to share ideas on how to share knowledge about diabetes.

As the aim of this study was to address whether the proposed intervention could help patients learn from each other and support their motivation to behavior change, patients were asked to fill out surveys regarding attitudes, learning, and motivation during and after the workshop. The surveys were developed by a team including medical doctors (D.B., K.K), a market research expert (R.K.), and a data analytics expert (A.P.). To address the perceived usefulness of the workshops in terms of behavior change and improved disease management, the themes addressed by the surveys were related to learning, overall feelings, goal setting, motivation, and self-belief. The surveys were based on simple statements with responses mapped on a 3- or 5-item Likert scale. Patients were given the option to skip questions if they did not feel comfortable. On average, the completion time of the workshop survey and the post-workshop survey was about 10 min. The surveys delivered during the workshops were administered using Microsoft Forms, whereas the post-workshop surveys were administered using REDCap. The post-workshop survey is shown in Appendix B.

3. Results

3.1. Characterization of Patient Segments

Table 1 summarizes the characteristics of patients in the medication segment, in the lifestyle segment and in the whole sample of 825 patients with T2D. As outlined in Section 2.2., patients in the medication segment took medications from each of the 4 medication groups here considered (i.e., first-line and second-line diabetes drugs, anti-cholesterol drugs, and anti-hypertensives), whereas patients in the lifestyle segment took only drugs to keep cholesterol and blood pressure under control (i.e., anti-cholesterol and anti-hypertensives medications), and no diabetes drugs.

Table 1. Characteristics of medication and lifestyle patient segments.

	Medication	**Lifestyle**	**Whole Sample**
N. (%) of patients	261 (31.6%)	123 (14.9%)	825 (100%)
% male	48.3%	49.6%	48.8%
n. of comorbidities: mean (±s.d.)	1.5 (±1.08)	1.5 (±1.18)	1.4 (±1.09)
Age: mean (±s.d.)	68.7 (±11.62)	69.0 (±12.95)	68.6 (±11.69)
BMI: mean (±s.d.)	31.8 (±6.88)	31.6 (±6.62)	31.8 (±7.18)
HbA1c: mean (±s.d.)	7.2 (±1.41)	7.5 (±1.54)	7.2 (± 1.18)
LDL: mean (±s.d.)	2.1 (±1.02)	2.0 (±1.11)	2.0 (±0.97)
sBP: mean (±s.d.)	130.0 (±13.6)	130.4 (±14.5)	129.8 (±13.3)
dBP: mean (±s.d.)	74.5 (±9.3)	74.8 (±8.5)	74.5 (±8.8)

Table 1 shows that the average values of age, BMI, HbA1c, LDL, sBP, and dBP observed in the two segments and in the whole sample are similar. Moreover, the distribution of sex and average number of comorbidities did not show noticeable differences between the groups. The results in Table 1 suggest that, in spite of patients in different segments having very different medication-taking behavior, the clinical biomarkers of patients in the medication and lifestyle segments are, on average, comparable. Noticeably, patients in the lifestyle segment did not take, by definition, any specific medication for their T2D, but they had average biomarker values similar to those of patients who took diabetes-specific medications.

3.2. Workshop Discussion and Survey

From the six workshops performed, we observed that participants appreciated the value of being with other people with the same disease to share their stories, regardless of the patient segment and of their level of control of disease (good/bad). The virtual environment here used was described by patients as a good opportunity to meet, but some patients expressed a wish for regular in-person meetings in the future (e.g., in the form of ‘walking groups’ or a ‘buddy system’). When patients were offered the opportunity to share thoughts about "how to realize collective intelligence in diabetes management" (item #6 in the discussion guide; see Appendix A), themes such as sharing experiences, engaging primary care clinicians in organizing peer-to-peer groups, and meeting regularly emerged from the discussion.

Table 2 summarizes the main outcomes from the surveys collected during the workshops (item #4 in the discussion guide; see Appendix A). Differences were observed across the groups in terms of measures of learning (question 1), topics of interest (question 2), practical strategies (question 3), and willingness to recommend to others (question 5), whereas a similar distribution of responses was observed in relation to overall feelings (question 4). In response to questions 1 and 3, patients from the mixed and lifestyle groups identified specific solutions to be adopted, e.g., walking, carb control, or using wristbands, apps, or specific exercise machines, whereas patients in the medication group mainly reported sharing of experiences, the effects of T2D, and the challenges of living with the disease, including mental wellbeing and possible practices to deal with stress (e.g., meditation). The distribution of responses to question 3 shows a marked difference between segments. Specifically, the majority of patients in the lifestyle and mixed groups (i.e., 4 out of 7 and 5 out of 9, respectively) reported that they learned something that they were willing to try, compared to only 1 out of 8 patients in the medication group.

Table 2. Results of the workshop survey obtained from six workshops in the three patient groups.

	Medication	Lifestyle	Mixed Group
1. Did you learn something new that you had not heard about before?	1/8: Nothing at all 1/8: Maybe 2/8: A little 3/8: A few things 1/8: A lot	0/7: Nothing at all 0/7: Maybe 1/7: A little 5/7: A few things 1/7: A lot	0/9: Nothing at all 0/9: Maybe 3/9: A little 6/9: A few things 0/9: A lot
2. Which topics were most interesting to you?	2/8: Diet 3/8: Exercise 3/8: Stress management 1/8: Medications 3/8: Management of symptoms 3/8: Other (heart disease, how to keep people on track, mental health components of diabetes)	5/7: Diet 6/7: Exercise 0/7: Stress management 0/7: Medications 3/7: Management of symptoms 1/7: Other (changing of mindset, motivation to change behavior)	6/9: Diet 9/9: Exercise 2/9: Stress management 1/9: Medications 4/9: Management of symptoms
3. Did you hear something you would like to try?	1/8: Yes 3/8: No 4/8: I don't know	4/7: Yes 2/7: No 1/7: I don't know	5/9: Yes 2/9: No 2/9: I don't know
4. How do you feel about your condition, following this conversation?	7/8: I feel better 0/8: I feel worse 1/8: I don't know	6/7: I feel better 0/7: I feel worse 1/7: I don't know	6/9: I feel better 1/9: I feel worse 2/9: I don't know
5. Would you recommend this workshop?	4/8: Yes 3/8: No 1/8: Prefer not to say	7/7: Yes 0/7: No 0/7: Prefer not to say	8/9: Yes 0/9: No 1/9: Prefer not to say

Regarding the distribution of responses to question 2, differences were observed between the three groups. Specifically, the number of patients interested in lifestyle preventive measures such as diet and exercise were higher in the lifestyle and mixed groups compared to the medication group (e.g., for exercise, 6 out of 7 in the lifestyle group, 9 out of 9 in the mixed group, and only 3 out of 8 in the medication group), whereas the number of patients interested in stress management was 3 out of 8 in the medication group, 2 out of 9 in the mixed group, and 0 in the lifestyle group. Noticeably, themes related to behavior change and motivation emerged in the lifestyle group only. Regarding question 4, most of the patients reported that they felt better (i.e., 7 out of 8 in the medication group, 6 out of 7 in the lifestyle group, and 6 out of 9 in the mixed group), whereas only 1 patient (from the mixed group) was feeling worse. It is worth noting that the patient who selected 'I feel worse' in question 4 also reported limited learning in questions 1 and 3.

In response to question 5, some patients provided additional comments, highlighting further differences between the groups. None of the patients in the mixed and lifestyle groups answered 'No' to the question 'Would you recommend this workshop?', whereas 3 out of 8 patients in the medication group answered 'No'. Patients from the mixed and lifestyle groups were satisfied with the format and found the session useful and enjoyable, also providing suggestions for improvement (e.g., increasing the number of sessions, expanding the size of the group to add richness and breadth to the discussion). Patients in the medication group who were not happy with the format complained about the session format and recommended a reduction in duration (e.g., to below 1 h).

3.3. Post-Workshop Survey

Figure 1 shows the distribution of responses collected from the survey delivered after the end of each workshop, in each of the three patient groups (medication, lifestyle, and mixed). The six questions in the survey (see Appendix B) prompted participants to reflect about the following aspects, in relation to the attended workshop: (1) Feeling better about diabetes management; (2) Learning new information; (3) Usefulness of the information; (4) Plans to act based on the information obtained; (5) Self-belief towards achieving individual goals within three months; and (6) Motivation to set a goal.

The distribution of responses shown in Figure 1 suggests differences between the groups. In general, the majority of patients in the lifestyle group tended to agree (from moderately agree to strongly agree) with the feelings and attitudes captured by the proposed statements. Only one patient from the lifestyle segment reported a neutral response (neither agree nor disagree) in one of the questions, and none of the patients in the lifestyle segment disagreed. Noticeably, in three out of six questions all patients in the lifestyle segment strongly agreed with the proposed statement (i.e., Q3: The information and interactions during the workshop were useful to me; Q4: I plan to act on the information I obtained in the workshop; Q6. I am motivated to set a goal for improving my diabetes).

Vice versa, patients in the medication group had varying opinions about the statements presented in the survey. Only the distribution of responses to question Q2 was similar between patients in the lifestyle and medication group, with 50% or more patients reporting that they moderately agreed with the fact that they learned new information, and the remaining participants reporting that they either strongly agreed or that they did neither agreed nor disagreed. Regarding questions Q1, Q3, Q4, Q5, and Q6, patients in the medication group were less optimistic than those in the lifestyle group, particularly in relation to having motivation to set a goal or make plans to act, and having the self-belief to achieve the goal. Overall, the distribution of responses observed in patients in the mixed group shows an intermediate pattern that is between those of patients in the lifestyle and medication segments.

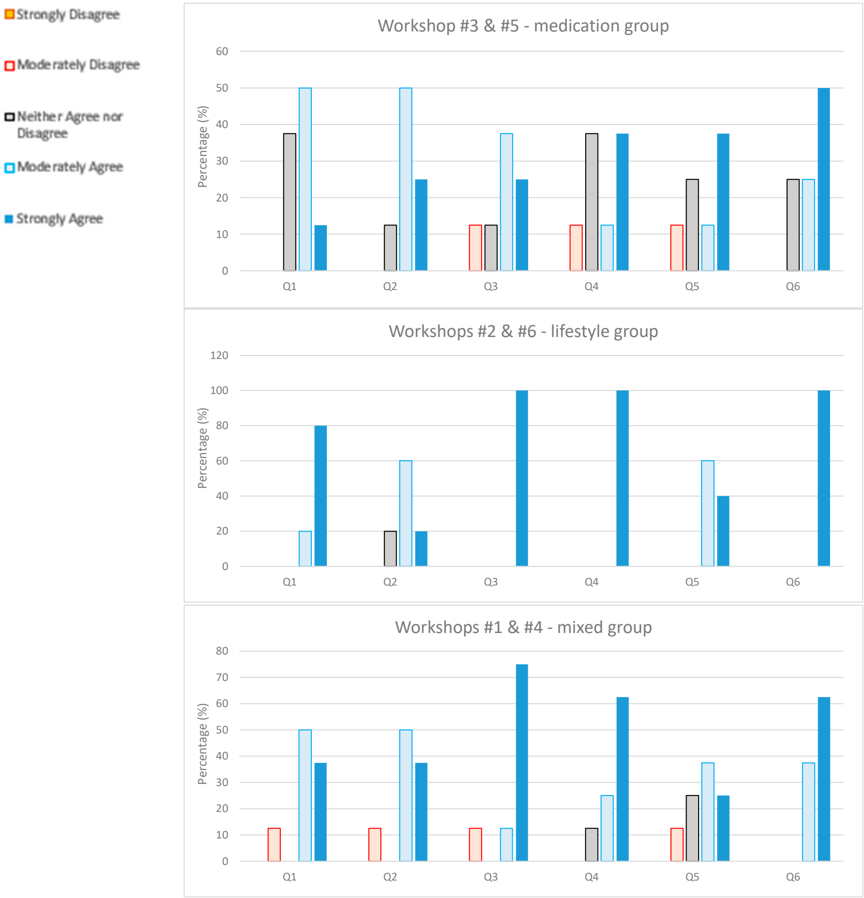

Figure 1. Distribution of responses collected from the post-workshop survey from patients in the medication (**top panel**), lifestyle (**center panel**), and mixed (**bottom panel**) groups. Questions: Q1: After this workshop I feel better about managing my condition; Q2: I learned new information during the workshop; Q3: The information and interactions during the workshop were useful to me; Q4: I plan to act on the information I obtained in the workshop; Q5: I believe I will achieve my goal within the next three months; Q6. I am motivated to set a goal for improving my diabetes.

4. Discussion

The analysis of medication-taking behavior in the tested sample revealed two opposing segments: medication and lifestyle. The former included patients who take several medications (anti-diabetics, anti-hypertensives, and anti-cholesterol), whereas the latter included patients who do not take diabetes-specific medications, only anti-hypertensives and anti-cholesterol drugs. Noticeably, the clinical characteristics of patients in the two segments are similar in terms of mean age, average number of comorbidities, and average values of biomarkers (BMI, HbA1c, LDL, sBP and dBP), as shown in Table 1. The percentage of patients who had good control of HbA1c (i.e., HbA1c $\leq$ 7%) was 42.3% in the lifestyle segment and 43.7% in the medication segment. Stated differently, our results showed that patients from the lifestyle segment may reach a similar level of blood sugar control as patients who take diabetes drugs regularly, suggesting that patients in the lifestyle segment may be managing their blood sugar through lifestyle modifications (e.g., diet, exercise). Noticeably, similar results were obtained from a sample of 34078 patients with T2D extracted with the same inclusion criteria here used from a large Canadian database of EMRs (CPCSSN, Canadian Primary Care Sentinel Surveillance Network) spanning years from 2005 to 2015 [19]. In the CPCSSN sample, the percentage of patients in the medication segment was higher than that observed in this study (i.e., ~37% vs. ~32%) whereas the percentage of patients in the lifestyle segment was lower (i.e., ~7% vs. ~15%). The observed differences between the findings observed in two studies may be related to the different characteristics of patients in the two datasets, with patients in the CPCSSN sample having a higher average number of comorbidities than those in this study (i.e., 1.6 vs. 1.4), and worse average biomarker values (e.g., BMI: 32.7 Kg/m^2 vs. 31.8 Kg/m^2; LDL: 2.3 mmol/L vs. 2.0 mmol/L). For a deeper understanding of the characteristics of the patient segments here identified, further research is needed. For example, it will be important to externally validate these results using different datasets, for example data extracted from the CLSA (Canadian Longitudinal Study of Ageing) or ELSA (English Longitudinal Study of Ageing) databases that include similar data to the CPCSSN but are collected at regular time intervals, in contrast to primary care EMR data, which are collected at routine clinical examinations. Moreover, it will be important to develop and investigate different patient segmentation approaches, for example, by including specific lifestyle-related features (e.g., medication adherence, exercise, diet) and measures collected through ad hoc surveys (e.g., attitudes towards diet, exercise, stress management, sleep management, medications, personal monitoring devices) in addition to features extracted from the EMRs.

Based on the segments identified in this study, a total of six workshops were conducted (two for patients in the medication segment, two for patients in the lifestyle segment, and two gathering a mixture of patients from across segments). In each workshop, patients with good control of the disease were involved, following the principle of positive deviance [15,16]. In general, the feedback collected from patients during the six workshops indicated interest in the proposed virtual peer-to-peer environment and supported sharing of experiences and potential for collective idea generation, regardless of the segment and the level of control.

Although the general feedback about the proposed intervention was, overall, good, the analysis of patients' responses to the proposed surveys (during and after the workshop) revealed differences between the lifestyle and medication groups (Table 2, Figure 1). Regarding learning, most of the patients in each of the three groups reported that they felt better after the conversation and that they had learned something (Table 2). In the medication group, the learning reported was more generally related to sharing of experiences and symptom management (e.g., stress, mental health), possibly due to the fact that patients in the medication segment may tend to rely less on lifestyle and behavior change than those in the lifestyle segment. Patients from the mixed group and from the lifestyle group were interested mainly in preventive measures and identified practical solutions (e.g., diet, exercise, use of apps and wearables). All patients from the mixed and lifestyle groups were willing to recommend the workshop to others whereas patients in the medication group had varying opinions, with some of them (i.e., three out of eight) not satisfied with the workshop content and format (e.g., duration too long).

The results of the post-workshop survey demonstrated a more positive attitude among patients in the lifestyle and mixed groups compared to those in the medication group, particularly in relation to overall experience, usefulness of learning experience, and motivation, attitude, and self-belief for behavior change. Vice versa, patients in the medication segment had varying opinions and has, in general, less favorable attitudes toward behavior change and adoption of practical solutions. The lower interest and motivation exhibited by patients in the medication segment might be related to a more skeptical approach towards behavioral interventions as well as to a lower perceived self-efficacy in relation to behavior change goals. Future research will be needed to address the needs and expectations of patients in the medication segment and develop data-driven approaches tailored to their needs. For example, a different discussion guide could be developed to incorporate themes of interest to patients in the specific segment (e.g., managing the effects of diabetes, improving medication adherence). Moreover, it will be important to analyze in more detail the characteristics of the two intermediate segments (i.e., those including patients who took a combination of diabetes-specific drugs and anti-cholesterol or anti-hypertensive drugs). Specifically, it will be interesting to evaluate whether the clinical characteristics of patients from intermediate segments differ from those in the lifestyle and medication segments, and to understand if the use of more complex segmentation approaches as mentioned above (e.g., based on behaviors and attitudes) can help identify more distinct patient profiles.

The concept of segmentation is not novel in healthcare as recent studies documented varying applications of patient segmentation, for example, in population health, targeted communication, service delivery, and policy making, but limited evidence is available on patient segmentation for group intervention [13,20,21]. Developing personalized interventions for patient segments can offer more success with patient adherence to medical treatments and support patient self-management, particularly if offered through mobile technology [20–22]. This study showed that patient segmentation in peer-to-peer group intervention for T2D management and prevention may offer advantages in terms of tailoring content, supporting sharing of experiences among patients who share similar characteristics, and driving motivation to change in patients with T2D.

It is to note that this study is exploratory by design. It has limitations in terms of small sample size and qualitative nature. The study findings suggest possible differences between the lifestyle and medication groups, but future studies will be necessary to replicate and support the observed findings. Moreover, the study focused only on two opposite segments (medication and lifestyle) but it will be important to address if, and to what extent, the observed findings can be extended to patients from intermediate segments or sub-segments. Specifically, it will be important to conduct further workshops with a more regular composition of patients (e.g., constant number of patients in each workshop, balanced number of males and females). Moreover, it will be useful to address standardized measures before and after the workshops, including follow-up measures at predetermined intervals (e.g., after one week, one month, and three months). Examples of relevant measures include surveys to address health status (e.g., the EuroQol EQ-5D-5L, which includes perceived overall health and dimensions of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression), patient attitudes and behaviors (e.g., the DIAB-Q, Diabetes Intention, Attitude, and Behavior Questionnaire), and individual self-efficacy and disease management (e.g., the DMSES, Diabetes Management Self-Efficacy Scale). The addition of specific measures of perceived health, individual attitudes, and self-efficacy is also important per se to support a better understanding of the specific behavioral characteristics and attitudes of patients in the medication segment and could support future development of interventions tailored to the needs of these patients. In addition, in a follow-up study it will be important to incorporate the proposed peer-to-peer intervention into a clinical prospective study to address the clinical characteristics of patients in the different segments and investigate the changes in biomarker values and the individual control of disease following the intervention.

It is acknowledged that the results of this study are preliminary; nevertheless, they provide interesting insights for the future implementation of peer-to-peer interventions for patients with T2D. Our study indicates that, particularly in patients who are more willing to follow lifestyle-based interventions, evidence from successful strategies within a patient's own segment presented in a positive manner without shaming can help people create their own choice architecture, sparking collective intelligence to foster better health. Moreover, the proposed approach is potentially scalable as it uses a fully virtual process, it does not require healthcare provider supervision, and is based on EMR data that are widely used globally. In the future, ad hoc digital tools could be developed (e.g., a mobile app or web portal) to let people with similar behaviors and attitudes work collectively towards a shared goal.

5. Conclusions

The results of this study showed that a non-negligible proportion of subjects (about 15%) tend to prefer lifestyle modifications to medications for managing their diabetes and that their clinical characteristics might be, on average, similar to those of patients who take diabetes-specific medication and to the average patient with diabetes, in relation to HbA1c control, for example. Overall, findings from the six workshops performed in this study support the proposed approach based on peer-to-peer virtual meetings through a moderated discussion guide that is hinged upon collective intelligence for problem detection and solution identification.

This pilot study provides preliminary evidence that peer-to-peer virtual workshops involving patients with good and bad control of disease may support patient learning and motivation, particularly in patients from the lifestyle segment. Patients in the lifestyle group exhibited a more positive attitude than those in the medication group and may be more likely to share, learn, and find practical disease management strategies. Such intervention could be helpful not only to support disease management in patients with chronic disease but also to aid individuals at risk of developing disease (e.g., individuals with prediabetes) to work together to lower their risk in a preventive manner, therefore helping reduce the burden of chronic disease in a way that is patient-centered, affordable, and sustainable. Future research is needed to investigate different patient segmentation approaches (e.g., based on a combination of clinical data and information about lifestyle, behaviors, and attitudes) and different peer-to-peer approaches tailored to the needs of patients from different segments.

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Appendix A

The discussion guide used in the experiment is reported below.

Introduction:

Good morning everyone, my name is R K. I am here to help guide your conversation today. Rebecca is from Queen's University and will be helping me today.

I have been asked to investigate your thoughts and feelings about your diabetes condition. To do this, first, we are just going to have a discussion amongst ourselves as if we all met in a café for tea or coffee, like friends or neighbors. Afterwards, I have an interesting little creative exercise we can have some fun with.

This discussion is confidential and will not be shared with anybody who is not part of the research team. You are not asked to share personal information except for your first name and some general information. Participation to this workshop is voluntary and you can withdraw or skip a question at any moment.

There are no right or wrong answers here, just your opinions, so feel free to talk amongst yourselves. This discussion works best if you hear my voice as little as possible, so please ask each other questions. But I will be asking for clarification sometimes. We are not videotaping this session, but we are audio recording, so that I do not have to take notes. Rest assured your name will not be made public or associated with what you say. We are interested in your collective thoughts and ideas.

So, let's start by introducing ourselves. I am Robert and I am a professional market researcher specializing in Healthcare. I have been doing this for over thirty years and still enjoy learning from others. I live in Toronto with my wife and two boys. I am working with both, Canadian and European universities on this project.

Now, how about you; ________. Why don't you tell us about yourself. Tell us about your

- background, (e.g., family size, age, time in Canada, etc.) and
- current employment, hobbies, pass times, or other things you are interested at the moment.

1. My Refresher Activity: . . . (Walkabout on first thoughts. List of words participants react to.) (5 min.) Elicit patient responses on key terms related to diabetes to get them warmed up to the workshop.
   Key words: 1. Diabetes, 2. Exercise, 3. Diet, 4. Nutrition, 5. Wellness
2. Storytelling: . . . Everyone tells their story about their condition and actions. (40 min.) PROBE;
   - How did you learn about their diabetes?
   - What were your first thoughts and feelings?
   - How did you handle your diabetes?
   - What worked for you?
   - What are your current goals?
3. Discussion on Issues Identified: . . . Hot topics discussed from storytelling. (20 min.)
   - What topics discussed were most meaningful to you?
   - What were your thoughts and feelings about the topics?
4. QUESTIONNAIRE. Provide questionnaire. We are trying to assess participant learning and engagement with individual assessment using an online survey via Microsoft Forms (see Workshop survey for specific questions). Please complete it now.
5. Discussion of learnings from questionnaire (10 min)
6. IDEA GENERATION: . . . Now, I would like you to help us understand how best to spread this type of "collective intelligence". (20 min). You have learned more about how others handle diabetes, that information may help you in the future. Let's discuss how we can spread this type of knowledge more widely.
   - To do this we will have two brainstorming sessions where 2–3 of you can work together to generate different ideas on how to do this. It is important at this stage that we do not make judgements on these ideas during your session. We will have chance after the session to evaluate and prioritize these ideas. Facilitator asks the participants to form 2 small groups of 3 people each to conduct brainstorming and report back to the group. You will be given a link to a shared mural where you can write down your thoughts. The goal is to identify how average people can share their thoughts, insights, ideas and solutions on how they handle their diabetes. You will have ten minutes to come up with your 5 best ideas. Be creative! Start.
   - After session; Sub-groups present on their ideas (while our research assistant will be sharing the murals on the screen)

7. Problem Detection on best ideas: . . . Problem solve solutions. (10 min)
    - Participants prioritize the most promising ideas
    - Participants then put on their negative hats to identify barriers to implementing their ideas
8. Identify Optimal Solution: . . . Build on optimal solution. (10 min)
    - Participants brainstorm solutions to identified barriers
    - Participants pick 1 or more solutions that seem the most promising
    - Participants define criteria for ideal solutions
9. Reality vs. Ideal: . . . Discussion on ideal vs. current situation. (10 min)
    - Participants discuss feasibility of solutions and why some ideal solutions may not be implementable.
    - Participants discuss likelihood of ideal solutions being implemented
10. What is the 1 thing that we each learned that was most powerful and effective for us as a group? (10 min)
11. Finally, are you comfortable at this point to share a goal that you'd like to achieve in the next 3 months? If you are comfortable, please share with us your goal and how you plan to achieve it. (5 min)
    Thank and Close.

Appendix B

The post-workshop survey included the following questions:

1. After this workshop I feel better about managing my condition
2. I learned new information during the workshop
3. The information and interactions during the workshop were useful to me
4. I plan to act on the information I obtained in the workshop
5. I believe I will achieve my goal within the next three months
6. I am motivated to set a goal for improving my diabetes.

For each question, the following options were provided, on a marked 5-item scale:

- Strongly Disagree
- Moderately Disagree
- Neither Agree nor Disagree
- Moderately Agree
- Strongly Agree

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