

A Nurse-Led Telemonitoring Approach in Diabetes: A Prospective Cohort Study and Lessons from the COVID-19 Environment

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Table of Contents

Original Manuscript.....	5
Supplementary Files.....	24
Figures	25
Figure 1.....	26
Figure 2.....	27
Multimedia Appendixes	28
Multimedia Appendix 1.....	29
Multimedia Appendix 2.....	29
Multimedia Appendix 3.....	29
Multimedia Appendix 4.....	29
Related publication(s) - for reviewers eyes onlies	30
Related publication(s) - for reviewers eyes only 0.....	30

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Abstract

Background: The utility of a nurse-led telemonitoring approach (NLTA) is yet to be firmly established in diabetes management.

Objective: To examine the effect of a 12-month proactive NLTA on metabolic and psychological health-indices in individuals with diabetes during the COVID-19 pandemic, and as a new diabetes model-of-care.

Methods: The telemonitoring study-group (TSG n=91) comprised adults who had initially attended a tertiary hospital Australian Diabetes Centre between January 2019-March 2020. Telehealth surveillance contact with a diabetes nurse educator was subsequently maintained at ~3 monthly intervals during the pandemic response period; surveillance measures included HbA1c%, weight, adherence to healthy-behaviours and patient-reported outcomes of distress, anxiety and depression using validated instruments. Metabolic changes were compared retrospectively with a comparison-group (non-TSG n=115) who had not received contemporaneous telemonitoring contact.

Results: At the end of the 12-month study, the relative percentage reduction in unadjusted HbA1c% for the TSG cohort was significantly greater than the non-TSG cohort (3.8% vs 1.2%; $p = .043$) by between group analysis of covariance (ANCOVA). Further adjusting for pre-pandemic HbA1c% for each cohort separately across time, there was an overall significant improvement in HbA1c% for the TSG ($p = .048$) dissimilar to the non-TSG ($p = .61$). TSG participants were 40% less likely (OR: 0.6, 95% CI: 0.5–0.7) to experience an unfavourable rise in HbA1c% compared to the non-TSG participants after adjusting for sex, age, pre-pandemic HbA1c%, ethnicity, diabetes type, and diabetes duration. The NLTA facilitated assessments of psychological risk, with elevated depression scores significantly increased in women and in youth < 30 years-of-age ($p < .001$). Increasing anxiety-measures were observed in those with high baseline anxiety scores ($p < .001$).

Conclusions: A proactive diabetes NLTA is feasible with positive effects on glycemia and the potential to identify those at psychological risk for targeted intervention. In the context of increasing diabetes-resource demand, further study of a NLTA model of care is warranted. Clinical Trial: This study was approved by the Ethics Review Committee (HREC/X20/RPAH/0206) of the Sydney Local Health District.

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Original Manuscript

A Nurse-Led Telemonitoring Approach in Diabetes: A Prospective Cohort Study and Lessons from the COVID-19 Environment

Short title: Nurse-led telemonitoring as a new diabetes model of care

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Abstract

Background: The utility of a nurse-led telemonitoring approach (NLTA) is yet to be firmly

established in diabetes management.

Objectives: To examine the effect of a 12-month proactive NLTA on metabolic and psychological health-indices in individuals with diabetes during the COVID-19 pandemic, and as a new diabetes model-of-care.

Methods: The telemonitoring study-group (TSG n=91) comprised adults who had attended an Australian tertiary hospital Diabetes Centre between January 2019-March 2020. Telehealth surveillance contact with a diabetes nurse educator was subsequently maintained at ~3 monthly intervals over 12 months; prospective surveillance measures included HbA1c%, weight, adherence to healthy-behaviours and patient-reported outcomes of distress, anxiety and depression using validated instruments. Metabolic changes were compared retrospectively with a comparison-group who had not received telemonitoring contact during the study period, (non-TSG n=115).

Results: The average participant age was 57.2 (SD 15) years, 63% (129/206) were male, 48% (99/206) with type 1 diabetes, 50% (104/206) with type 2 diabetes, and baseline glycated haemoglobin A1c percent (HbA1c%) was 8.1% (SD 1.4%). At the end of the 12-month study, the relative percentage reduction in unadjusted HbA1c% for the TSG cohort was significantly greater than observed in the non-TSG cohort (4% vs 1%; $p = .043$). Following adjustments for baseline HbA1c%, we observed a significant improvement in HbA1c% for the TSG ($p = .048$) but not in the non-TSG ($p = .61$). TSG participants were 40% less likely (odds ratio [OR] 0.6, 95% CI: 0.5–0.7) to experience an unfavourable rise in HbA1c% compared to the non-TSG participants after adjusting for sex, age, pre-pandemic HbA1c%, ethnicity, diabetes type, and diabetes duration. The NLTA facilitated assessments of psychological risk, with elevated depression scores significantly increased in women and in youth < 30 years-of-age ($p < .001$). Increasing anxiety-measures were observed in those with high baseline anxiety scores ($p < .001$).

Conclusion: A proactive diabetes NLTA is feasible with positive effects on glycemia and the potential to identify those at psychological risk for targeted intervention. In the context of increasing diabetes-resource demand, further study of a NLTA model of care is warranted.

Introduction

The prevalence of type 1 diabetes (T1DM) and type 2 diabetes (T2DM) mellitus is expected to increase by 46% globally with diabetes predicted to affect approximately 1 in 8 adults by 2045 (~783 million people) [1, 2]. Traditional doctor-led care models delivered via ongoing interval assessments now place unsustainable demands on existing health care systems, so that new sustainable and scalable models of care are needed.

In the post COVID-19 pandemic era there is increasing interest in telehealth for ongoing health care delivery, with a generally high level of patient acceptance [3-8]. In this context, telemonitoring is a relatively new approach in chronic disease management with recognised ability to overcome geographical and transport challenges, to provide greater efficiency and potentially earlier intervention together with cost savings in the context of limited health care resources [9-16]. As well, face to face nurse-led models of care have been shown to be effective in the management of both T1DM, T2DM and allow for the efficient individualised triage of cases to more or less intensive care as required [17, 18]. On this background, we hypothesised that a combined nurse-led telemonitoring approach (NLTA) could have clinical utility within a multidisciplinary diabetes chronic care model. Despite theoretical advantages, there are limited data on the utility of a NLTA in T1DM and T2DM, particularly in an Australian context. We aimed to describe a pragmatic 12-month prospective cohort surveillance study, utilising a NLTA, to examine the trajectory of metabolic and psychological health, and health care utilisation in patients with diabetes (the telemonitoring study group, TSG), in the context of the COVID-19 pandemic environment. A retrospective contemporary clinic cohort, who did not receive regular telemonitoring contact (the non-TSG) was established as a comparator for metabolic indices. We also aimed to examine the clinical features associated with deterioration in psychological and metabolic parameters during telemonitoring, to inform future strategies for surveillance and early intervention.

Methods

Recruitment

The Australian New South Wales COVID-19 pandemic response beginning in March 2020, included strict lockdowns and restrictions to gathering and movement throughout the state resulting in changes to access for ambulatory care services, including a pivot towards telehealth. Eligible participants were non-pregnant adults aged 18 years and above with a diagnosis of Diabetes Mellitus, who had attended the Diabetes Centre at Royal Prince Alfred Hospital (RPAH) in Sydney, Australia, in the immediate pre-pandemic time-period between January 2019-March 2020. They were invited to participate in a NLTA as a health surveillance strategy with the specific aim of monitoring well-being over a 12-month period. The intervention comprised 3-monthly telehealth contacts until 6 months, then again at 12 months post-enrolment. Contact was made via phone or video with a Diabetes Nurse Educator. Baseline data included participant demography, self-reported medication and medical history, and collection of comprehensive blood and urine biomarkers including haemoglobin A1c

percent (HbA1c%) by standard pathology laboratory protocols. At each subsequent assessment, demographic data, self-reported anthropometric measurements and medication regimen were gathered, results of recent (i.e. within 3 months) blood and urine biomarkers were collected and discussed. A main aim in the nurse consultations was to help avoid deterioration in glycaemia, through maintenance in self-care and optimising adherence to lifestyle and medication prescribed. Bespoke health and well-being questionnaires, as well validated psychological screening tools were administered including the Euro Quality-Visual Analogue Scale (EQ-VAS), Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder 7-item scale (GAD)-7 tool and Problem Areas in Diabetes scale (PAID-5) [19-22]. In accordance with best clinical practice and as recommended by the institution HREC, if psychological inventories revealed concern for the presence of major depression including self-harm, the participant's general practitioner (GP) and/or community health team were to be contacted. The participant was encouraged to keep in usual contact with their health care team, in addition to telehealth surveillance visits.

Time periods for analysis were defined as follows: Pre-pandemic (pre-enrolment) data were captured between January 2019-February 2020 (T0). Enrolment data (T1) were obtained during the enrolment period beginning from March 2020 onwards. Follow-up data were collected at ~3 months (T2), ~6 months (T3), and ~12 months post-enrolment (T4). Final follow-up visits finished in January 2022.

A retrospective, non-intervention comparison cohort was established using data collected in the RPAH Diabetes Centre electronic medical record. Criteria for inclusion in the comparison cohort required the participant to have received 4 or more clinical services delivered between 2019-2021, aligned with the TSG participants. Assessment time points were equivalent to that of the intervention group.

All TSG participants consented to deidentified data being used for research purposes. This study was approved by the Ethics Review Committee (HREC/X20/RPAH/0206) of the Sydney Local Health District.

Statistical Analysis

To assess the unadjusted effect of independent variables across metabolic outcomes between the intervention and comparison groups, we employed non-parametric analysis of variance for continuous variables and chi-square tests for categorical variables, along with descriptive statistics over time. Fisher's exact tests were applied when expected cell frequencies were less than 5. Due to the non-normal distribution of the outcome variables, Wilcoxon rank-sum tests were conducted at

each time point (T0, T1, T2, T3, T4) to compare metabolic indices.

A stepwise regression approach was employed to identify potential covariates, excluding interaction terms and independent variables that lacked association, that introduced model skewness, or were deemed clinically irrelevant. To assess differences in effects across time points specifically between the pre-pandemic period (T0) and subsequent assessments, linear regression models were applied, adjusting for key factors such as time, age, sex, diabetes type and duration, ethnicity, perceived personal risk of COVID-19 infection and food stock-piling. For the regression analyses, the very few individuals with maturity-onset diabetes of the young (MODY), pancreatogenic diabetes, or atypical type 1 diabetes were classified as either T1DM if on an insulin regimen or T2DM if on an oral hypoglycaemic regimen.

For the psychological outcome measures (PHQ-9, GAD-7, and PAID-5), regression models were restricted to the TSG group, as these measures were not applicable to the non-TSG group. Results were reported as odds ratios (ORs) with 95% confidence intervals (CIs) and corresponding p-values. Statistical significance was defined as $p < 0.05$. All analyses were conducted using SAS 9.4.

Results

Baseline demographic/clinical characteristics for the TSG and non-TSG comparison group

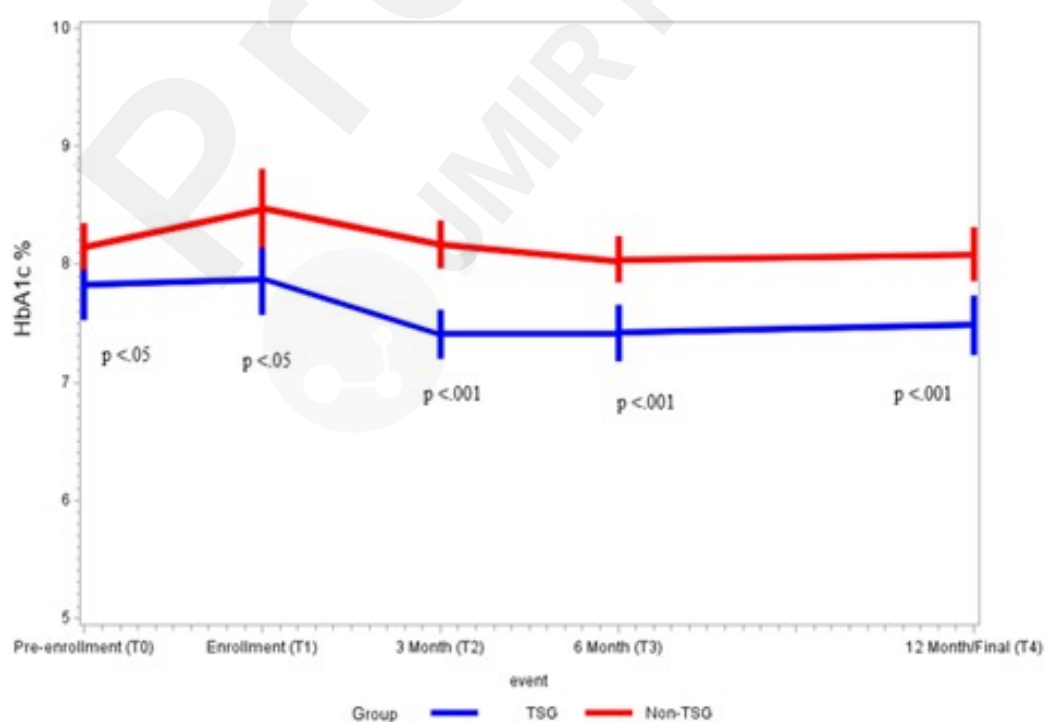
Table 1: Baseline demographic variables for the TSG and non-TSG (n= 206)

Characteristic	Values		P value
	TSG (n=91)	Non-TSG (n=115)	
Male gender, n (%)	52 (57)	77 (67)	.19
Age (years), mean (SD)	53.8 (15.7)	60 (14)	.004
≥ 30 years of age n (%)	80 (88)	113 (98)	.003
Ethnicity, n (%)			
Caucasian	57 (63)	49 (43)	.01
Type of diabetes, n (%)			
T1DM	44 (48)	55 (48)	.93
T2DM	46 (51)	58 (50)	
Other	1 (1)	2 (2)	
Age of onset of Diabetes, mean (SD)	37.1 (16.7)	34.1 (16.4)	.19
Duration of diabetes (years) mean (SD)	16.7 (11.2)	25.8 (10.9)	<.001
Insulin use n (%)	67 (74)	101 (88)	.010
Anti-hypertensives n (%)	46 (51)	49 (43)	1.00

Glycaemic control in the TSG and non-TSG comparison group

Over the pandemic period, there were different trajectories of glycaemia observed in the TSG and non-TSG comparator cohort; more favourable blood glucose levels were maintained in the TSG cohort throughout the study period (**Figure 1**). We note an absolute reduction in HbA1c% from pre-enrolment (T0) to 12-months for the TSG of 0.3% and 0.1% for the non-TSG; the percentage reduction in HbA1c% over 12 months was significantly greater for the TSG compared to the non-TSG (4% vs 1%, respectively; $p = 0.043$). It is notable, however that the pre-pandemic HbA1c% for the non-TSG was higher, at $8.2 \pm 1.2\%$ compared to the TSG HbA1c% of $7.8 \pm 1.5\%$ (**Table 2**, $p = .04$). After adjusting for pre-pandemic HbA1c% for each cohort separately across all the time points, we observed an overall significant improvement in HbA1c% for the TSG particularly at 3 months (T2) ($p = .02$) and 6 months (T3) ($p = .047$) ($p = 0.048$ across all time points). In contrast, there was no significant change in HbA1c% across any of the time points for the non-TSG ($p = .61$). Between group differences were significant between the TSG and non-TSG at each individual time point (**Table 2 and Figure 1**). Notably, the final regression model showed that TSG participants were 40% less likely (adjusted OR: 0.6, 95% CI: 0.5–0.7, $p < .001$) to experience an unfavourable rise in HbA1c% compared to the non-TSG participants, adjusting for sex, age, pre-pandemic HbA1c%, ethnicity, diabetes type, and duration (**Table 3**).

Figure 1: Mean HbA1c% over study period for TSG and non-TSG cohorts.



BMI and CVD risk factors in the TSG and non-TSG comparison group

For the data points available, we observed stability in body mass index (BMI) of $\sim 29.4 \text{ kg/m}^2$ over the 12 months for both the TSG and non-TSG. Mean blood pressure at enrolment compared to the final visit was similar for the TSG and non-TSG. Lipid levels showed similar stability over the pandemic period for both groups. Albuminuria status was progressively more unfavourable in the non-TSG; however, there was more non-TSG data missing for this variable including cardiac, renal and liver disease status (**Table 2 and Multimedia Appendix 1 [Table S1]**).

Table 2: Mean ($\pm$ SD) values of HbA1c% and BMI over 12 months for the TSG and non-TSG cohorts.

Metabolic Index	TSG		Non-TSG		
	Mean (SD)	Total, n	Mean (SD)	Total, n	P value
HbA1c%					
T0 (Pre-enrolment)	7.8 (1.5)	90	8.2 (1.2)	113	.043
T1 (Enrolment)	7.8 (1.5)	91	8.3 (1.2)	54	.04
T2 (3M)	7.4 (1.0)	90	8.1 (1.0)	101	<.001
T3 (6M)	7.4 (1.1)	90	8.0 (1.1)	106	<.001
T4 (12M)	7.5 (1.2)	89	8.1 (1.3)	106	<.001
BMI (kg/m^2)					
T0 (Pre-enrolment)	29.4 (7.1)	38	29.2 (5.2)	103	.86
T1 (Enrolment)	29.4 (6.1)	88	29.2 (4.8)	35	.83
T2 (3M)	29.4 (6.2)	84	29.5 (5.3)	79	.92
T3 (6M)	29.4 (6.2)	91	29.3 (5.7)	75	.91
T4 (12M)	29.3 (6.2)	89	28.9 (5.8)	55	.70

Table 3: Adjusted regression model for change in HbA1c%

Outcome	Variable	Adjusted Odds Ratio (95% CI)	P value
HbA1c% unfavourable rise			
	TSG (non-TSG ^a)	0.6 (0.5, 0.7)	<.001
	Time (T0 ^a)		
	-T1 (Enrolment)	1.1 (0.8, 1.4)	.52
	-T2 (3M)	0.8 (0.6, 1.0)	.05
	-T3 (6M)	0.8 (0.6, 1.0)	.03
	-T4 (12M)	0.8 (0.7, 1.1)	.14
	Female (male ^a)	1.1 (1.0, 1.4)	.11
	Age <30 yrs (>=30 yrs ^a)	0.7 (0.5, 1.0)	.08
	Type 2 diabetes (Type 1 ^a)	1.3 (1.1, 1.5)	.01
	Caucasian (non-Caucasian ^a)	1.2 (1.0, 1.4)	.02

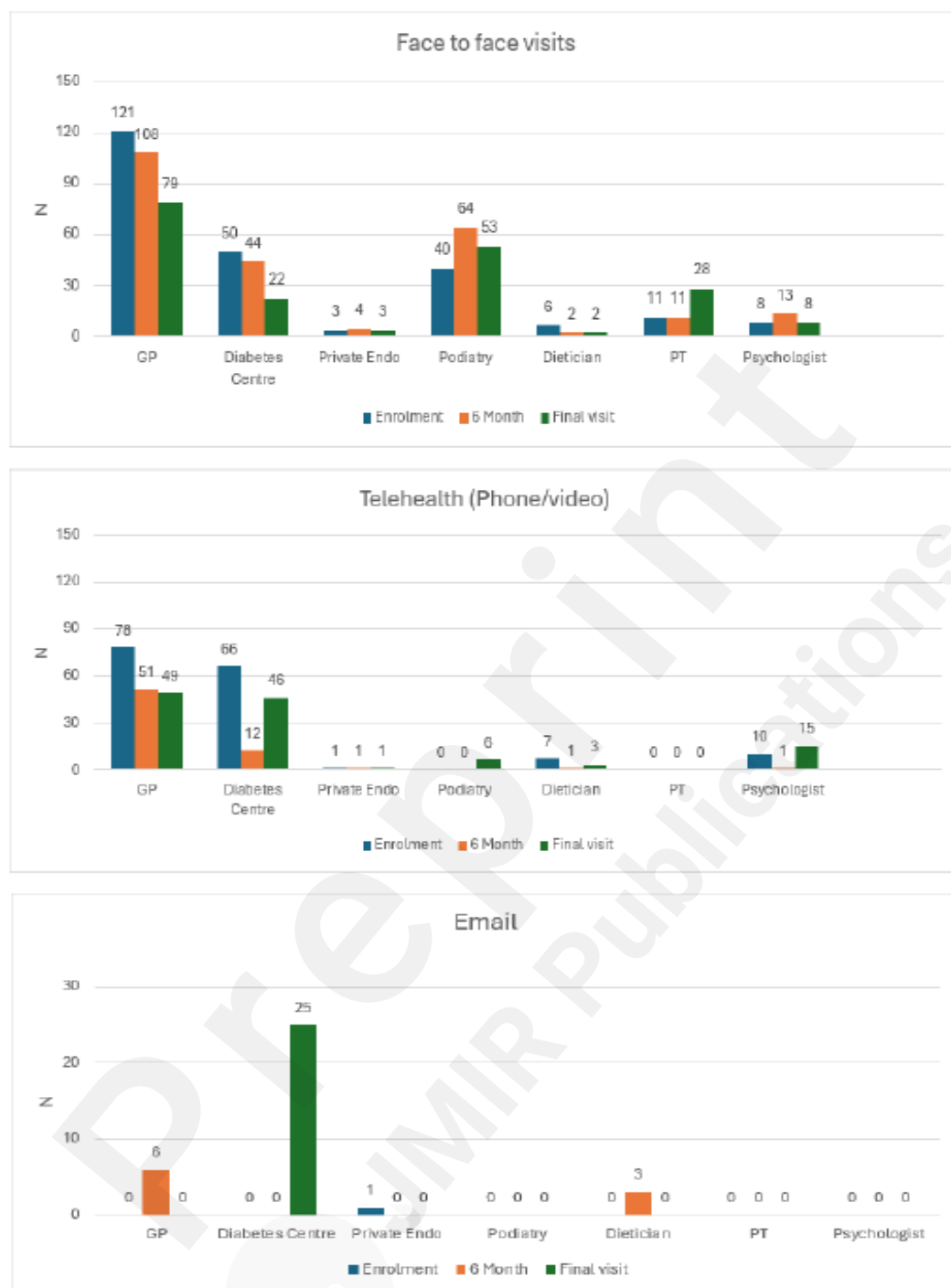
	Duration of diabetes	1.00 (1.0,1.0)	.70
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^a Reference group

Health care utilisation: TSG specific

In the TSG alone, we observed a decline in participants reporting having seen their GP or Endocrinologist over the observation period (**Figure 2**). Specifically, we observed a significant decline in diabetes service attendance over time (**Multimedia Appendix 2 [Table S2]**), $p < .001$. This was true for both face-to-face and telehealth visits over the 12 months. In contrast, we observed an increase in email contact with the Diabetes Centre over twelve months. Visits to allied health practitioners remained low throughout the study period. At enrolment (T1) 13% (12/91) of TSG participants had been to hospital in the prior 3 months, 5.5% (5/91) had visited the Emergency Department (ED) while equally 5.5% (5/91) were hospital inpatient admissions. We did not observe any changes in the number of hospital visits including ED, hospital admissions or day procedures over the observation period. Eighteen percent (16/91) of participants reported that they had specifically avoided or delayed a diabetes-related health care service, and this remained steady throughout the study period (**Multimedia Appendix 2 [Table S2]**).

Figure 2: Changes in number of healthcare visits during the COVID-19 pandemic.



Psychosocial factors: TSG specific

At enrolment (T1), the median EQ-VAS to assess participants' health on a scale from 0-100 was relatively high at 80. Also, at T1, 20% (18/91) of participants reported scores indicative of moderate to moderately severe depression (PHQ-9), while 3.3% (3/91) reported scores consistent with severe depression. Twelve percent (11/91) reported moderate to severe anxiety (GAD-7) and 21% (19/91) reported scores suggesting significant diabetes-related emotional distress at T1. All mental health indices in general over the 12-month period remained consistent. An exception was the observation

of anxiety scores worsening over the 12-month study only in those with an enrolment GAD-7 score ≥ 10 ($P < .001$) (**Multimedia Appendix 3 [Table S3]**).

In the TSG we observed significant differences over the study period in pandemic related beliefs and behaviours including perceived personal risk of clinically contracting COVID-19, stockpiling additional food (**Multimedia Appendix 4 [Table S4]**) and these were adjusted for in the final mental health regression models using backward stepwise elimination (**Table 4**).

Table 4: Adjusted regression models for change in measures of psychological health.

Outcome	Variable	Adjusted Odds Ratio (95% CI)	P value
PHQ-9 unfavourable rise			
	Time (T1-Enrolment ^a)		
	-T3 (6M)	1.8 (0.4, 8.0)	.45
	-T4 (12M)	1.1 (0.2, 4.8)	.92
	Female (male ^a)	9.0 (2.6, 30)	<.001
	Age <30 yrs (>=30 yrs ^a)	42 (5.7, 302)	<.001
	Type 2 diabetes (Type 1 ^a)	8.2 (2.0, 33)	<.001
	Caucasian (non-Caucasian ^a)	5.9 (1.5, 23)	.01
	Duration of diabetes	1.1 (1, 1.1)	.07
	Stocking food (those who do not ^a)	4.8 (1.2, 20)	.03
	COVID personal risk (those with perceived greatly reduced risk ^a)		
	-Slightly reduced risk	2.6 (0.4, 16.4)	.31
	-The same risk	1.5 (0.2, 9.2)	.67
	-Slightly increased risk	10 (1.4, 72)	.02
	-Greatly increased risk	112 (10, 1310)	<.001
GAD-7 unfavourable rise			
	Time (T1-Enrolment ^a)		
	-T3 (6M)	3.2 (0.9, 12)	.08
	-T4 (12M)	1.1 (0.3, 4.0)	.90
	Female (male ^a)	10.3 (3.5, 30.1)	<.001
	Age <30 yrs (>=30 yrs ^a)	93 (16.1, 533)	<.001
	Type 2 diabetes (Type 1 ^a)	5.9 (1.7, 20.1)	.005
	Caucasian (non-Caucasian ^a)	3.3 (1.0, 11.1)	.05
	Duration of diabetes	1.0 (1.0, 1.1)	.57
	Stocking food (those who do not ^a)	2.6 (0.8, 9.2)	.13

	COVID personal risk (those with perceived greatly reduced risk ^a)		
	-Slightly reduced risk	1.5 (0.3, 7.6)	.63
	-The same risk	1.0 (0.2, 5.1)	.97
	-Slightly increased risk	4.4 (0.8, 25.2)	.1
	-Greatly increased risk	21.9 (2.5, 192)	.005
PAID-5 unfavourable rise			
	Time (T1-Enrolment ^a)		
	-T3 (6M)	0.4 (0.1, 1.3)	0.13
	-T4 (12M)	0.4 (0.1, 1.2)	0.09
	Female (male ^a)	4.1 (1.6, 11)	0.004
	Age <30 yrs (>=30 yrs ^a)	12.8 (3, 62)	0.002
	Type 2 diabetes (Type 1 ^a)	1.3 (0.4, 3.8)	0.67
	Caucasian (non-Caucasian ^a)	0.7 (0.2, 2.1)	0.52
	Duration of diabetes	1.0 (1.0, 1.1)	0.66
	Stocking food (those who do not ^a)	6.4 (2.1, 19.4)	0.001

^a Reference group

In the final model for PHQ-9 outcomes adjusting for time, age, sex, type of diabetes, and significant covariates included in the univariate analyses (**Table 4**) compared to males, females were 9 times ($p < .001$) and those less than 30 years of age were 42 times ($p < .001$) more likely, respectively, to experience an unfavourable rise in depression score. Similarly in the GAD-7 outcome model, females and those less than 30 years of age were 10.3 times ($p < .001$) and 93 times ($p < .001$) more likely, respectively, to experience an unfavourable rise in anxiety score. Lastly in the PAID-5 model, females and those less than 30 years of age were 4.1 times ($p < .001$) and 12.8 times ($p < .001$) more likely, respectively, to experience an unfavourable rise in diabetes-related distress score. An adverse increase in PHQ-9 and GAD-7 score was significantly greater for those with T2DM.

Discussion

Principal results

Although the COVID-19 pandemic resulted in overall reduced access to usual health services [23], our study observed a more favourable HbA1c% trajectory over 12 months in the NLTA group, which differed from the comparison, usual care group. This was achieved in the context of fewer medical physician encounters. The NLTA was effective in monitoring psychological health in diabetes and allowed the identification of psychologically vulnerable participants. We observed that the most vulnerable demographic in this cohort are women and young people and those with high baseline GAD-7 scores, with potential implications for future pandemic planning. Perhaps more significantly,

this study highlights the feasibility and positive potential for a nurse-led telehealth surveillance model to support traditional doctor-led models of care in diabetes management. Our results suggest that a nurse-led telemonitoring service is also acceptable to patients with diabetes as evidenced by high participation rates at 12 months.

Comparison with prior work

Our observation that the NLTA achieved stability in glycaemic control during the challenging early stages of the COVID-19 pandemic is similar to other studies, including those in Australia, that involved telehealth use [24-28]. These findings are also in contrast to data highlighting deterioration of glycaemic control in diabetes cohorts during the COVID-19 pandemic [29, 30]. In addition, the intervention cohort achieved glycaemic stability despite a significant decline in contact with their usual endocrinologist and/or usual diabetes educator via face-to-face or telehealth consultations. Contact with primary care providers within the TSG remained consistently unchanged over this period. One might speculate that nurse-led telemonitoring facilitated less frequent endocrinology/diabetes educator contact, in the context of relatively stable glycaemic control in the TSG, reserving targeted contact for those at higher risk and with complications [31-33]. We also observed stability of cardiovascular risk factors over the twelve months in the nurse-led telemonitoring group, again in contrast to other global reports of deterioration in control and despite reduced contact with auxiliary services [34, 35]. Similarly, there was no increase in unplanned hospital attendance throughout the intervention period. Regular nurse-led telehealth surveillance was associated with stability in the overall rates of medication-taking and glucose self-monitoring throughout the pandemic period.

Whilst we did not aim to, nor did we undertake, formal cost-effectiveness comparisons of health care delivery models, based on the NLTA model and reduction in GP/medical specialist consultations, we speculate that the NLTA model would not be more financially costly than the traditional non-TSG model comparator and yet it delivered arguably better metabolic outcomes for the study cohort. The potential cost-effectiveness of the NLTA is supported by prior studies. A review paper examining the cost effectiveness of telehealth for diabetes management, found that despite using different methodologies in varied healthcare settings, the majority of studies found telehealth to be cost-effective, citing direct costs-per patient. The authors concluded that telehealth solutions have vast potential for cost-effective diabetes care [36]. Separately, there is a small body of literature to support the cost effectiveness of nurse-led services in diabetes. In a study from the Netherlands, diabetes nurse specialists provided care comparable to physicians, with similar health-related quality of life

measures and favourable costs per QALY gained [37]. Few contemporary studies exist on the cost-effectiveness of the combined approach of nurse-led telemedicine in diabetes. However, a modelling study on heart failure patients found that nurse-led telephone support improved survival and was cost-effective in comparison with usual care [38]. A 2016 Belgian study reported that a nurse-led tele-coaching program for T2DM compared to usual GP care, was highly cost-effective with a reported incremental cost-effectiveness ratio well below suggested thresholds for the country [39]. Taken together in the context of our findings, these data support the likely cost benefits of the NLTA but underscore the need for additional cost-effectiveness analysis of this model of care, within a robust study design.

By means of regular contact and the administration of validated psychological inventories we were able to capture and track changes in COVID belief factors and any deterioration in psychological health over the study period. We observed high levels of vaccine acceptance, low COVID infection rates and postulate that provision of education through regular and reassuring health check-ins may have contributed to pandemic-safe appropriate behaviours. In addition, with utilisation of validated standardized screening instruments as a component of the surveillance model we were able to identify individuals with high levels of anxiety, depression and diabetes distress-particularly prevalent amongst women and <30 years of age. Our study findings align with the increasing pandemic related-distress observed in the general UK population that included such appear to be driven primarily by changes in younger people and in women [40, 41]. The PREDICT RCT and other studies also observed a similar increased risk of adverse psychological health in younger people with diabetes, over the same period [42, 43]. The reasons behind the increased psychological vulnerability for these groups are not clear but it would be reasonable to speculate that high baseline mental health issues in youth and adverse social determinants of health may play a role, as observed in previous studies [44]. Regardless of aetiology, this model of care may help to identify at-risk young people with diabetes who may benefit from targeted evidence-based intervention, such as an enhanced SMS support program [45]. The alignment of our findings with larger robust studies suggests that a nurse-led telehealth surveillance model of care was able to accurately identify those vulnerable and at risk. Beyond psychological health, physical activity and sedentary behaviour showed modest changes, and self-care behaviours remained unchanged.

Optimal chronic management of diabetes involves monitoring and ongoing support to facilitate self-management and often behaviour change with a significant time and health resource burden. The COVID 19 pandemic has led to innovation in the care of patients and the widespread application of health care delivery via virtual means. A global study has found that 80% of providers from many

countries have adapted to new virtual healthcare via telephonic or video technology [46]. Nurses in particular have embraced such technological advances, often with higher levels of acceptance than primary care providers [46]. A Canadian national survey found a ninefold increase in nurse involvement in virtual care from pre pandemic levels [47]. In the context of the rapid expansion of technologies to deliver healthcare virtually, there is potential for a new nurse-led diabetes surveillance model of care to be scalable, accessible and provide economic benefits in the post pandemic era.

Limitations and Future Work

The limitations of this study include its observational and non-randomised design with the inherent potential bias. It is important to recognise that the baseline differences in age, HbA1c% and diabetes duration between the TSG and non-TSG cohorts could still have influenced our results, despite appropriate statistical adjustments, rendering the glycaemic benefits observed less significant. We also note that data beyond metabolic indices were not available for the comparator group. In addition, this was a single centre study of predominantly white, English-speaking participants in the context of the Australian Medicare funded health systems. Thus, our results may not be entirely generalisable to the wider patient population, nor to other healthcare systems. Our results however do support the need for further study in a larger cohort using a robust randomised and controlled framework in the context of the prevailing health infrastructure. Furthermore, successful implementation of the NLTA would depend on an adequate technological infrastructure, funding and reimbursement for nurse-led encounters as well as workforce training.

Conclusion

Our data suggest that a NLTA in diabetes care is feasible, acceptable and could have utility in the monitoring of metabolic indices and psychological wellbeing in people living with diabetes, allowing for appropriate triage and intensification of management especially in the context of limitations of access to primary or specialist care. With this in mind, we believe further studies of a diabetes nurse-led telemonitoring model of care are warranted.

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Conflicts of Interest

None declared.

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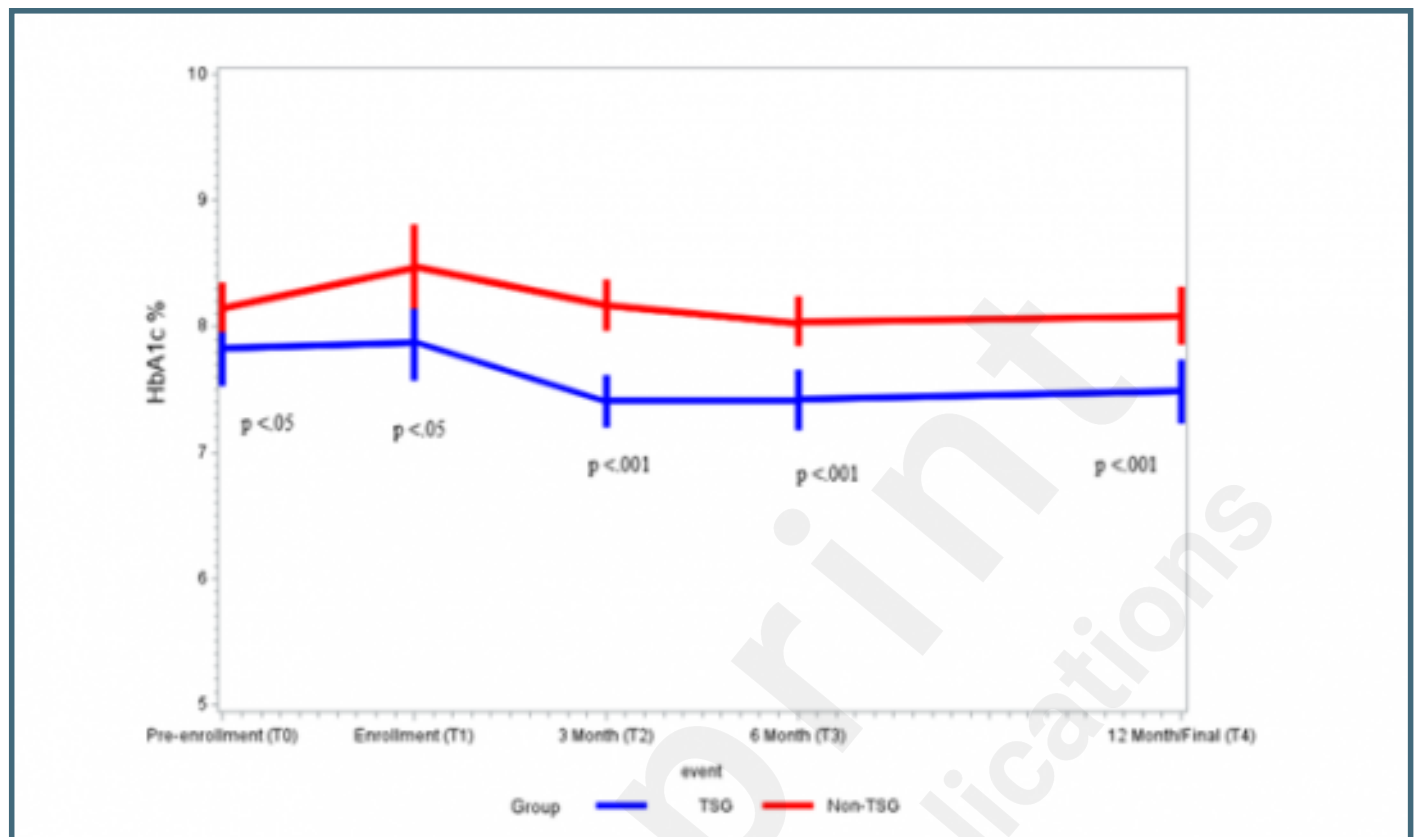
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Supplementary Files

Figures

Mean HbA1c% over study period for TSG and non-TSG cohorts.



Changes in number of healthcare visits during the COVID-19 pandemic.



Multimedia Appendixes

Manuscript_68214 Multimedia Appendix (Table S1).

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