Self-Management of Diabetes Mellitus with Remote Monitoring:
A Retrospective Review of 214 Cases

Hayat Mushcab, Ulster University, Newtownabbey, UK

William George Kernohan, Ulster University, Newtownabbey, UK

Jonathan Wallace, Ulster University, Newtownabbey, UK

Roy Harper, Ulster Hospital, Belfast, UK

Suzanne Martin, Ulster University, Newtownabbey, UK

ABSTRACT

Purpose: The efficacy of one remote monitoring system was reviewed in order to explore if optimal self-management of diabetes was achieved. Methods: Medical records of 214 patients with diabetes were reviewed from seven diabetes clinics within a single Health & Social Care trust using a remote monitoring solution to help patients self-manage their condition. Data on HbA1c, blood glucose, blood pressure and body mass index were obtained from the patient's medical record, before and after using the remote monitoring solution. Results: The average age of users was 61 years: 60% of the sample were male. The average time living with diabetes was 14 years; the mean duration with remote telemonitoring was 147 days. A greater reduction in HbA1c was seen with female users compared to males 2.37% and 0.87%, respectively. Conclusion: Remote telemonitoring provided the opportunity to collect comprehensive data, allowing patients to be maintained at home, while showing significant improvement in their HbA1c and better overall management of their diabetes

KEYWORDS

Connected Health, Diabetes Mellitus, Self-Management, Self-Monitoring of Blood Glucose, Telemonitoring

INTRODUCTION

Globally, diabetes mellitus is considered to be an epidemic and a growing burden on public health (Matuleviciene, et al., 2014). It is associated with a significant morbidity and mortality (Schwartz & Scheiner, 2012). It has been estimated that 385 million people worldwide live with Diabetes and the number is predicted to rise to 500 million in 2030 (Matuleviciene, et al., 2014). In the UK, there are some four million people diagnosed with diabetes and an estimated additional 590,000 that are not yet diagnosed (Diabetes UK, 2015). The costs associated with diabetes account for almost 10% of the NHS primary care budget with a daily average expenditure of £2.2m on prescriptions for managing the condition (Matuleviciene, et al., 2014) (Lacobucci, 2014).

The key to good self-management of diabetes is to understand the importance of regular blood glucose measurement and the need for good blood glucose control together with a strong belief in one's ability to achieve target levels. Levels of blood glucose vary dynamically from one individual to another and a recommended target range for blood glucose is determined by the healthcare team (Diabetes.co.uk, Blood Sugar Level Ranges). The target is individualised and based on the duration of

diabetes, age, comorbid conditions, micro/ macrovascular diseases, hypo/ hyperglycaemia awareness and other individual considerations such as patient's lifestyle and dietary habits (ADA, Checking Your Blood Glucose, 2015).

The American Diabetes Association suggests the blood glucose target in those with diabetes should be 4.4 to 7.2 mmol/L (80 to 130 mg/dL) before meals and under 9.0 mmol/L (162 mg/dL) for people with type 1 diabetes (T1DM) and under 8.5 mmol/L (153 mg/dL) for people with type 2 diabetes (T2DM) after meals (Diabetes.co.uk, Blood Sugar Level Ranges) (ADA, Checking Your Blood Glucose, 2015). These equate to glycated haemoglobin (HbA1c) levels of less than 7% or 48 mmol/L for people with diabetes (ADA, Checking Your Blood Glucose, 2015) (Diabetes.co.uk, Guide to HbA1c). The healthcare team can get an overall idea of the average blood glucose levels over a period of time –usually every three months- by regular measurement of HbA1c (Matuleviciene, et al., 2014) (Diabetes.co.uk, Guide to HbA1c). HbA1c is the gold standard marker for assessing long-term glycaemic control; however, it does not reveal the immediate hour-to-hour blood glucose levels like self-monitoring of blood glucose does and it does not provide detailed information about individual hyperglycaemic or hypoglycaemic excursions (Boutati & Raptis, 2009).

It has been established that a significant reduction in long-term diabetes-related complications is associated with tight glycaemic control (Boutati & Raptis, 2009) (Association, 2004). Self-monitoring of blood glucose (SMBG) is the process of collecting regular blood glucose information, often up to three to four times daily, to aid maintaining a constant stable glucose level (Diabetes.co.uk, Guide to HbA1c). SMBG is an important component of diabetes treatment and self-management. Results of monitoring are used to assess the efficacy of the therapy, while enabling people with diabetes to make appropriate day-to-day therapeutic choices in insulin dosage as well as to see the effect of diet and physical activities (Diabetes.co.uk, Guide to HbA1c) (Boutati & Raptis, 2009) (Association, 2004) (Benjamin, 2002). SMBG is a widely recommended daily routine as part of good self-management among people with T1DM or insulin-treated T2DM (Boutati & Raptis, 2009). However, it is still unclear as to what extent SMBG is useful and accepted in patients with non-insulin-treated T2DM (Boutati & Raptis, 2009) (Association, 2004) (Martin, et al., 2005). Self-management programs can empower patients by increasing confidence in their abilities, by teaching them skills and techniques to better self-manage their condition, and how to improve their interaction with the healthcare system – all of which can lead to better management of chronic conditions like diabetes (Jaglal, et al., 2014). Within a few years, SMBG by patients has revolutionised management of diabetes but not without barriers including: the costs of SMBG, lack of understanding from patients about the health benefits and proper use of SMBG results, patient psychological and physical discomfort associated with finger-pricking for blood testing, the time consuming nature and inconvenience of testing, and for some the complexity of the technique (Association, 2004).

Through recent advances in technology, blood glucose monitors have been equipped with wireless technology to enable transmission of self-measured blood glucose readings to the healthcare team in real-time or when needed, via communication networks such as the internet or phone line (Medical Advisory Secretariat, 2009). The aims of such developments are to promote, empower and facilitate health and wellbeing within individuals, families and communities; to enhance professional practice through the use of information management and information and communication technology; and to reduce unnecessary hospitalisation (International, 2012). Recently, the term Connected Health Technology has been introduced in the UK (Roberts, et al., 2010) encouraging organisations to share information across boundaries and enable healthcare providers to extend their care to patients' homes, helping them to relieve the increasing burden of chronic diseases including diabetes (AHRQ, 2014). Monitoring patients remotely while supporting the transmission and interpretation of data may help patients' better control their blood glucose levels. Evidence indicates that intensive glucose monitoring

may reduce the likelihood of complications associated with diabetes as outlined in Jaana and Pare's comprehensive systematic assessment of observed effects of 17 home telemonitoring solutions with automated transmission of data on patients' health status from home to the respective healthcare setting (M & G, 2007). At the clinical level, the close management and monitoring of diabetes patients have resulted in significant decreases in HbA1c, which suggests improved management of the medical condition. Nevertheless, the mainstream use of such technology is not fully supported (Macginnis, 2012). Cochrane reviews on the use of technology within healthcare have identified the need for more robust evidence within this domain (Martin, Kelly, Kernohan, McCreight, & Nugent, 2008).

Given the importance of SMBG to diabetes care, the Health Service in Northern Ireland introduced an innovative telemonitoring service aiming to enable patients to control their diabetes and reduce the risk of serious complications (HSC, 2015). "Remote Telemonitoring Northern Ireland" (RT-NI) is a large-scale, clinically-led, managed monitoring service that was launched in 2011, aiming to improve health outcomes for people with chronic illness through better engagement with clinicians while enhancing the self-management process.

RT-NI is a system designed by a group of companies with complimentary expertise known as TF3[1] (NI, 2015). The patient is provided with a computerised hub – a small unit installed in the patient's home along with linked ancillary equipment – a scale, a blood pressure monitor and a glucometer for SMBG. This provides a capability to measure various parameters such as weight, blood pressure, blood glucose, temperature, and oxygen levels in the body. The patient is invited to take measurements using a range of appropriate equipment. The unit is programed to ask a pre-set of "yes or no" questions determined by the healthcare provider. These measurements are checked regularly and if the readings are abnormal, the patients receive a phone call from the nurse to elicit further information. The nurse would assess the situation and if necessary, the physician would be consulted on the matter.

A systematic review by Mushcab (2015) on the impact of web-based remote monitoring on improving HbA1c of insulin-treated T2DM patients concluded that research on web-based telemonitoring solutions for self-management T2DM confirms that the use of telemonitoring systems is a viable approach to the management of T2DM and it effectively improves HbA1c levels (Mushcab, Kernohan, Wallace, & Martin, 2015). However, it also concludes that the understanding of how, why, and when technology can improve clinical care and quality of life for people with T2DM require further intensive and comprehensive investigation as well as the barriers to implementation and the impact and long-term sustainability of outcomes. In this paper we aim to establish the impact of RT-NI on HbA1c levels among users with diabetes. Analysis of existing data will help to identify candidate causal factors contributing to any observed change in patients living with diabetes.

In this paper, the aim is to evaluate the impact of using RT-NI had in self-managing diabetes mellitus by exploring existing records of RT-NI users, comparing the overall change in HbA1c levels in people with different types of diabetes mellitus. The findings of this evaluation present promising results and pronounced confidence in using remote monitoring in self-management of diabetes mellitus.

Methods

Study Design

This was a retrospective cohort study with data analysis from the records of people using RT-NI for self-managing diabetes looking principally for any change in HbA1c levels. Data were available for each participant prior to initiation of RT-NI within one large combined health and social care provider, serving 345,000 people with a budget of almost £500 million per year, collected from one location – Ulster hospital- it is a teaching hospital that provides acute services 250,000 people in Northern Ireland (Wikipedia, Ulster Hospital, 2016). Data were available for people with T1DM, T2DM, Latent Autoimmune Diabetes of Adulthood (LADA) and Impaired Glucose Tolerance (IGT) and who were receiving insulin or oral agents as treatment for their condition. Women with gestational diabetes, people with diabetes who did not need medication and/or people with complex or multiple morbidity conditions were excluded to avoid confounding results. Data were gathered from previous

Figure 1. Flowchart demonstrating the process of patient recruitment onto RT-NI and data retrieval for inclusion in retrospective review
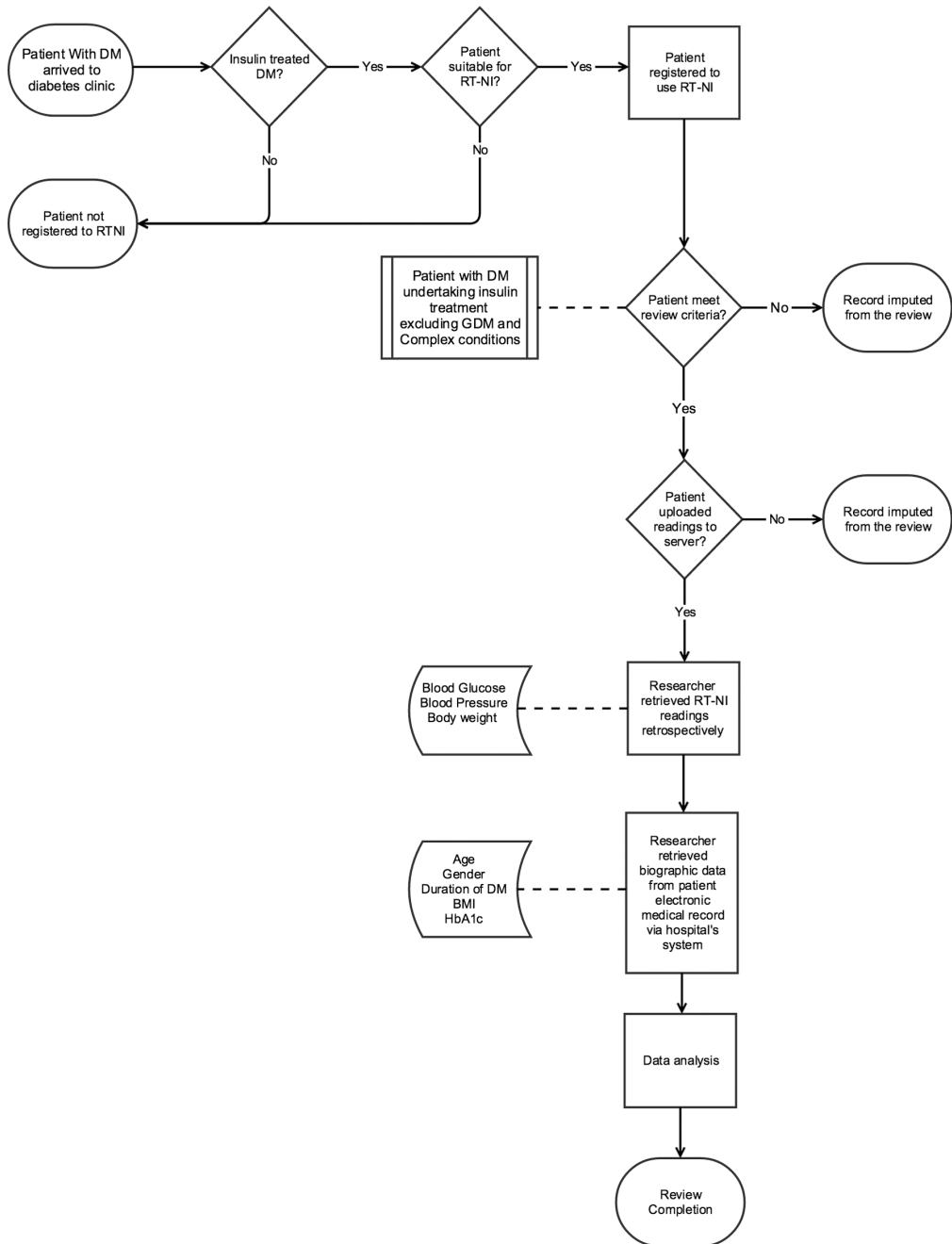
and current users of RT-NI within seven diabetes clinics. The RT-NI database held data on blood glucose, blood pressure and body weight. Data related to patient's age, gender, duration of diabetes, body mass index (BMI) and HbA1c levels were extracted from the electronic medical records at the hospital. Some items were incomplete: missing data were imputed using mean values (see Figure 1).

Data Analysis

Descriptive analysis was carried out to both interrogate and provide summaries of the data sets exploring the sample and measures forming the basis of quantitative analysis of data, which includes Central Tendency measures (mean), Dispersion (Standard Deviation and range), variation with time (to show improvement over time), variation by gender and a paired sample t-test to compare means of measurements before and after provision of remote telemonitoring and SMBG. The usual 5% threshold of p values were used to test for significance.

Results

In total, 214 adult patients were recruited onto the RT-NI service from October 2011 to July 2015. The great majority were T2DM patients with 83.4% or T1DM patients 14.1%. Most 94% of the patients were insulin treated (see Table 1).

The average age of male users (n=134) was 63 ($\pm$13) years forming 60% of the sample; compared to the average age of 59 years ($\pm$14) for female users (n=91) (see Table 2). The average duration of RT-NI utilisation was 212 and 82 days, respectively. A paired sample t-test was performed using (SPSS version 20) to compare the before and after means of BMI, BG and HbA1c (see Table 3). There was a statistically significant improvement in blood glucose and HbA1c levels after using RT-NI for both female and male users.

For male users, the paired samples t-test revealed a statistical difference between the mean of BG (M=13.1 $\pm$4.8) before using RT-NI and after (M=11.6 $\pm$4.0) with t(134)=3.03, degree of freedom=133 and p=0.003. The test also revealed a statistically significant improvement in HbA1c before (M=9.47 $\pm$ 2.09) and after using RT-NI (M=8.59 $\pm$1.92), t(134)=4.94, degree of freedom=133 and p<0.001. However, the test failed to reveal a statistically reliable difference between the BMI mean before using RT-NI (M=33.6 $\pm$6.7) and after (M=34.0 $\pm$6.5), t(134)= -1.67 and a non-significant p value.

Slightly better results were achieved by the female users, the paired samples t-test has revealed a statistically reliable difference between the mean of BG (M=13.4 $\pm$4.5) before using RT-NI and after (M=11.2 $\pm$3.2) with t(91)=4.28, degree of freedom=90 and p<0.001. The test also revealed a statistically significant improvement in HbA1c before (M=10.8 $\pm$ 9.1) and after using RT-NI (M=8.5 $\pm$1.3), t(91)=2.5, degree of freedom=90 and p=0.014. The test also failed to reveal a statistically reliable difference between the BMI mean before using RT-NI (M=34.6 $\pm$9.2) and after (M=34.6 $\pm$7.9), t(91)= 0.005 and a non-significant p value.

DISCUSSION

RT-NI is a mature technology and established service encompassing several diabetes clinics within Northern Ireland. However, there has been no in-depth evaluation of the technology and impact of service on diabetic control; therefore, this review provides useful evidence of its efficacy in improving glycaemic control and in supporting self-management in those with diabetes.

It is known that SMBG and BG data transmission play an important role in improving diabetes control. Indeed, it is highly recommended for insulin-treated patients (Mushcab, Kernohan, Wallace, & Martin, 2015). By remotely monitoring the patient, the clinical team was able to improve the patient's result and help them achieve desired goals. Mainly users used RT-NI to transmit BG data, however, 73 users out of 214 used it to also transmit blood pressure and/or weight data as well. RT-NI was well accepted by the users and 95% of them showed improvements in the long-term. Most patients accepted the technology and used it effectively and showed them improvement. Though, a

Table 1. Showing the number of RT-NI users, presented according to their gender and their diabetes type with the average duration of diabetes since diagnosis in years. It also shows the number of insulin and non-insulin treated users of both genders

Diabetes Type	Male		Avg Diabetes Duration in years (SD)	Female		Avg Diabetes Duration in years (SD)	Overall Average
T1DM	20	15%	22 (±17)	12	13%	25.42 (±17.40)	14.1%
T2DM	110	82%	14 (±7)	77	85%	13.5 (±7.25)	83.4%
LADA	1	1%	-	1	1%	-	0.9%
Secondary	2	1%	7 (±2)	1	1%	-	1.3%
IGT	1	1%	-	0	0%	0	0.4%
Total	134	100%	15 (±8)	91	100%	13 (±12.33)	100%
Treatment							
Insulin treated	124	93%		86	95%		94%
Non-insulin Treated (All T2DM)	10	7%		5	5%		6%

Table 2. The average age, the total number of RT-NI users and returning users from October 2011 to July 2015

	Users		Returning Users		Ave Age
Male	134	60%	8	4%	63 (± 13.12)
Female	91	40%	3	1%	59 (±13.98)
Total	225	100%	11	5%	61 (±13.55)

Table 3. results of paired samples t-tests performed to compare results of BMI (kg/m2), blood glucose (mmol/L) and HbA1c (DCCT-%) by gender

		Paired Differences					95% Confidence Interval		t	df	Sig. (2-tailed)
		Before	After	Mean	SD	Std. Error Mean	Lower	Upper			
BMI Kg/m^2	Female	34.58	34.58	.003	6.47	.68	-1.34	1.35	.005	90	.996
	Male	33.55	34.04	-.494	3.42	.30	-1.08	.09	-1.67	133	.097
BG mmol/L	Female	13.36	11.24	2.114	4.71	.49	1.13	3.09	4.29	90	.000
	Male	13.05	11.58	1.461	5.57	.48	.51	2.41	3.04	133	.003
HbA1c DCCT-%	Female	10.48	8.46	2.375	9.05	.95	.49	4.26	2.51	90	.014
	Male	9.47	8.59	.875	2.05	.18	.53	1.23	4.95	133	.000

small number (N=11) did not cope well with RT-NI and stopped using the technology shortly after starting to use it. In spite of the slight difference in the average results of HbA1c between male and female users, both showed significant improvement in glycaemic control with a fall in HbA1c of .0.9% and 2.4%, respectively. However, the difference in the BMI results was minor and insignificant.

Remote telemonitoring is still considered a novel intervention and still in the development stage but with potential to enhance outcomes (Meystre, 2005). There is a considerable value of remote telemonitoring even when using minimum amount of data such as (high/low) alerts can make the patient avoid hypo/hyperglycaemia episodes enabling the patients to self-manage their diabetes.

Technology advancements have proven their positive impact within time. The past couple of years the diabetes care witnessed a new technology developed by Abbott[1] that exhibited great self-management of T1DM without pricking fingers for blood testing. The Freestyle® Libre System allows the patient to scan his BG level using a reader and a wearable sensor (Assardo, 2016). The results of the clinical trial done using this technology presented promising results with 50 per cent reduction in serious hypoglycaemia and no increase in HbA1c levels in six months. However, where there is new advanced technology there is always the limitation of cost and funding especially in the less developed countries (Assardo, 2016).

CONCLUSION

Diabetes is a global epidemic, challenging many countries on how to provide large-scale effective support services to help individuals self-manage their condition well. Remote telemonitoring of blood glucose can be an effective tool to manage diabetes, allowing patients to be monitored and supported while maintained in their homes. RT-NI provides accurate and comprehensive data in improving clinical outcomes. With 95 per cent long-term improvement in HbA1c levels amongst users, these encouraging results indicate that clinical care can be provided remotely for day-to-day self-management of diabetes and it may offer target for improving complications observed for patients with diabetes mellitus. In conclusion, the possibilities of data sharing towards telemedicine will be crucially beneficial and beyond expectations in managing diabetes and other chronic illnesses.

Competing Interests

Dr. Roy Harper is a physician in the study site.

ACKNOWLEDGMENT

REFERENCES

AHRQ Agency for Healthcare Research and Quality. (2014). Health IT for improved Chronic Disease Management. Retrieved from https://healthit.ahrq.gov/ahrq-funded-projects/emerging-lessons/health-it-improved-chronic-disease-management

American Diabetes Association. (2004). Tests of Glycemia in Diabetes. *Diabetes Care*, *27*(Suppl. 1), S91–S93. doi:10.2337/diacare.27.2007.S91 PMID:14693937

American Diabetes Association. (2015). Checking Your Blood Glucose. Retrieved from http://www.diabetes.org/living-with-diabetes/treatment-and-care/blood-glucose-control/checking-your-blood-glucose.html

Assardo, V. (2016). Abbott Announces Positive Results from Groundbreaking Study of FreeStyle® Libre System for People with Type 1 Diabetes. Retrieved from http://abbott.mediaroom.com/2016-06-13-Abbott-Announces-Positive-Results-from-Groundbreaking-Study-of-FreeStyle-Libre-System-for-People-with-Type-1-Diabetes

Benjamin, E. M. (2002). Self-Monitoring of Blood Glucose: The Basics. *Clinical Diabetes*, *20*(1), 45–47. doi:10.2337/diaclin.20.1.45

Boutati, E. I., & Raptis, S. A. (2009). Self-Monitoring of Blood Glucose as Part of the Integral Care of Type 2 Diabetes. *Diabetes Care*, *32*(Suppl. 2), S205–S210. doi:10.2337/dc09-S312 PMID:19875553

Diabetes, U. K. (2015). *Diabetes: Facts and Stats*. Diabetes, UK: Diabetes UK.

Diabetes.co.uk. (2015). *Blood Sugar Level Ranges*. (Diabetes.co.uk the global diabetes community) Retrieved from http://www.diabetes.co.uk/diabetes_care/blood-sugar-level-ranges.html

Diabetes.co.uk. (2015). *Guide to HbA1c*. (Diabetes.co.uk the global diabetes community) Retrieved from http://www.diabetes.co.uk/what-is-hba1c.html

Diabetes.co.uk. (n. d.). *Blood Sugar Level Ranges*. (Diabetes.co.uk the global diabetes community) Retrieved from http://www.diabetes.co.uk/diabetes_care/blood-sugar-level-ranges.html

Diabetes.co.uk. (n. d.). *Guide to HbA1c*. (Diabetes.co.uk the global diabetes community) Retrieved from http://www.diabetes.co.uk/what-is-hba1c.html

HSC. (2015). *Telemonitoring service allows patients to better control their diabetes*. (Northern Health and Social Care Trust) Retrieved from http://www.northerntrust.hscni.net/about/2559.htm

Jaana, M., & Paré, G. (2007). Home telemonitoring of patients with diabetes: A systematic assessment of observed effects. *Journal of Evaluation in Clinical Practice*, *13*(2), 242–253. doi:10.1111/j.1365-2753.2006.00686.x PMID:17378871

Jaglal, S., Guilcher, S., Hawker, G., Lou, W., Salbach, N., Manno, M., & Zwarenstein, M. (2014). Impact of a Chronic Disease Self-Management Program on health Care Utilization in Rural Communities: A Retrospective Cohort Study Using Linked Administrative Data. *BMC Health Services Research*, *14*(1), 198. doi:10.1186/1472-6963-14-198 PMID:24885135

KPMG. (2012). *Accelerating innovation: the power of the crowd. KPMG International*. Switzerland: KPMG International.

Lacobucci, G. (2014). *Diabetes Prescribing in England Consumes Nearly 10% of Primary Care Budget.* The BMJ.

Macginnis, G. (2012). The National Health Service in England – Moving to Mainstream Use of Ambient Assisted Living Technology. In Handbook of Ambient Assisted Living (pp. 37-66). IOS Press.

Martin, S., Kelly, G., Kernohan, W., McCreight, B., & Nugent, C. (2008). Smart Home Technologies For Health and Social Care Support. *Cochrane Database of Systematic Reviews*, *4*. PMID:18843715

Martin, S., Schneider, B., Heinemann, L., Lodwig, V., Kurth, H.-J., Kolb, H., et al. (2005). Self-Monitoring of Blood Glucose in Type 2 Diabetes and Long-Term Outcome: and Epidemiological Cohort Study. *Diabetologia*.

Matuleviciene, V., Attvall, S., Ekelund, M., Clements, M., Dahlqvist, S., & Fahlén, M. et al.. (2014). A Retrospective Study in 5,989 Patients with Type 1 Diabetes in 10 Outpatient Diabetes Clinics in Sweden of the Frequency of Measuring HbA1c in Clinical Practice. *Diabetes & Metabolism*, *5*(5).

Meystre, S. (2005). The Current State of Telemonitoring: A Comment on the Literature. *Telemedicine Journal and e-Health*, *11*(1), 63–69. doi:10.1089/tmj.2005.11.63 PMID:15785222

Mushcab, H., Kernohan, G., Wallace, J., & Martin, S. (2015). Web-Based Remote Monitoring Systems for Self-Managing Type 2 Diabetes: A Systematic Review. *Diabetes Technology & Therapeutics*, *17*(7), 498–509. doi:10.1089/dia.2014.0296 PMID:25830528

Roberts, A., Reponen, J., Pesola, U.-M., Waterworth, E., Larsen, F., Mäkiniemi, M., & Christensen, B. et al. (2010). Transnational Comparison: A Retrospective Study on e-Health in Sparsely Populated Areas of the Northern Periphery. *Telemedicine Journal and e-Health*, *16*(10), 1053–1059. doi:10.1089/tmj.2010.0075 PMID:21087121

Schwartz, S., & Scheiner, G. (2012). The Role of Continuous Glucose Monitoring in the Management of Type-1 and Type-2 Diabetes. In *Evidence Based Management of Diabetes*. TFM Publishing Ltd.

Medical Advisory Secretariat, M. A. (2009). *Home Telemonitoring for Type 2 Diabetes: an Evidence-Based Analysis*. Toronto, Ontario: Ontario Health Technology Assessment Series.

Telemonitoring, N. I. (2015). *Partners*. (Telemonitoring NI) Retrieved from http://www.telemonitoringni.info/index.php/partners/who-is-tf3/

(2004). Tests of Glycemia in Diabetes. *Diabetes Care*, *27*(Suppl. 1), S91–S93. doi:10.2337/diacare.27.2007.S91 PMID:14693937

UK. D. (2015). Diabetes: Facts and Stats. Diabetes UK.

Wikipedia. (2015). Ulster Hospital. Retrieved from https://en.wikipedia.org/wiki/Ulster_Hospital

Wikipedia. (2016). Ulster Hospital. Retrieved from https://en.wikipedia.org/wiki/Ulster_Hospital

ENDNOTES

[1]   http://www.abbott.com/

Hayat Mushcab has graduated from Ulster University with a PhD degree in Life and Health Sciences. Her main focus is management of chronic illnesses such as diabetes, cancer and obesity. She has experience in quality management and quality control. Her main strengths lie in quantitative methods for service evaluation, health technology assessment and telemedicine implementation.

George Kernohan provides methodology, design, ethics and analytical support at the Institute of Nursing and Health Research at Ulster. He is co-chair of the palliative care research committee with the Northern Ireland Hospice and chair of the Research Governance ethics committee. George has led on several health research projects at national level. He also works as an 'expert' for evaluation of EU research. Working across a range of clinical areas in various contexts, his recent work is in chronic illness care in COPD, heart failure and Parkinson's disease. His main strengths lie in quantitative methods for service evaluation and health technology assessment.

Jonathan Wallace is Professor of Innovation at Ulster University. His excellence in both Knowledge & Technology Transfer and lecturing has been recognised by his being awarded both a Distinguished Business Fellowship and Distinguished Teaching Fellowship. He has for the last 14 years been Director of Knowledge and Technology Transfer for the Faculty of Computing and Engineering, with direct responsibility for the commercialisation of the Faculty's research knowledge, industrial collaboration and consultancy provision. Wallace chairs the Institution of Engineering and Technology Policy Group for Northern Ireland and is a member of the All-Party Advisory Group on Science, Engineering, Technology and Maths for the NI Assembly. He has a significant track record in the field of Connected Health and is recognised as an innovator in the co-creation of user-centred Connected Health product and service solutions. He is a consultant to and sits on the Innovation Groups of a number of Health Trusts. Jonathan is one of the national judges for the annual Telecare Services Association Crystal Awards for Excellence in Telehealth and Telecare, as well as a judge for the annual national eHealth Insider awards. He is currently involved in a number of regional, national and international Connected Health research projects where he is particularly applying his expertise in Usability, UX / Human Computer Interaction and Business Model Development.

Roy Harper has worked for the South Eastern Trust as a Consultant Physician and Endocrinologist from 1999. He has an honours degree in biochemistry (1984), an honours degree in medicine (1987) and obtained a Doctor of Medicine (MD) by thesis (1994) from Queen's University Belfast. He was elected as a Fellow of the Royal College of Physicians in 2000. He is an experienced clinician and researcher and has a particular interest and considerable expertise in harnessing information and communication technologies to successfully enhance clinical care services for patients with diabetes and other chronic diseases. He has helped develop award-winning innovative remote monitoring technologies to support patients at home, along with multimedia educational materials to support patient education and has developed strong collaborative and productive links with the University of Ulster and was awarded a Visiting Professorship within the Faculty of Engineering (School of Mathematics and Computing) in 2006. He is an e-Health clinical advisor for the region and sits on the Northern Ireland HSC ICT Programme Board. He remains a strong advocate and clinical champion for the Northern Ireland Electronic Care Record. He has helped develop innovative patient monitoring systems to enhance the care of hospital inpatients and to improve patient safety. He is a champion for effective ICT developments within healthcare being involved in major system deployments and in testing hardware and software solutions.

Suzanne Martin (PhD) is Professor of Occupational Therapy at Ulster University Northern Ireland. She is a member of the Institute of Nursing and Health Research, exploring new and emerging technologies within Health and Social Care. Suzanne is a trainer and contributor to the Cochrane Library and member of the Office of Research Ethics Northern Ireland.