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ORIGINAL ARTICLE/REMOTE MONITORING

# Remote monitoring for diabetes disorder: Pilot study using InDiaTel prototype



*La télésurveillance pour les troubles du diabète : une étude pilote utilisant le prototype InDiaTel*

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## KEYWORDS

Remote monitoring;  
Diabetes;  
Non-invasive sensors;  
ZigBee;  
GSM

## Summary

**Background.** – Diabetes, which has been jeopardizing human health over the past few years, can be vanquished by improving glycemic control. This paper reports the findings of the pilot study, which employed InDiaTel, a remote monitoring system for diabetic patients. This concept was supported by the Department of Science and Technology (Government of India), and the results were validated by the MedZon Diabetes Centre (Vellore, India).

**Methods.** – The primary objective of InDiaTel is to monitor glucose and other vital signs continuously. It has been designed using a PIC microcontroller through multichannel data acquisition. Serial communication is established between the patient unit and the nursing and doctor units, which are in remote areas.

**Results.** – For clinical evaluation, the system's output was compared with the MedZon Diabetes Centre report in which a non-invasive glucose sensor showed a deviation of 15% with glucose tolerance test (G.T.T.). Other vital signs showed good accuracy of about 95% with the commercial device. The prototype was analyzed for usability, and was accepted by more than 80% of study subjects.

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**MOTS CLÉS**

Télésurveillance ;  
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GSM

*Conclusion.* – The positive finding of this system improved glycemic control and confirmed the feasibility of efficient health care management. The novelty can be attributed to non-invasive measurement, multichannel data acquisition and serial communication.

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**Résumé**

*Introduction.* – Le diabète, qui est responsable de la mise en péril de la santé depuis plusieurs années, peut être vaincu par l'amélioration du contrôle de la glycémie. Le présent document fait état des constatations de l'étude pilote qui employait InDiaTel, un système de télésurveillance de patients diabétiques. Ce concept a été subventionné par le ministère de la Science et de la Technologie du gouvernement indien, et les résultats ont été validés par le centre du diabète MedZon (MedZon Diabetes Center, Vellore, Inde).

*Méthodes.* – L'objectif principal d'InDiaTel était de surveiller en permanence le glucose et d'autres signes vitaux. Il a été conçu à l'aide de microcontrôleurs PIC via l'acquisition de données multicanaux. Une communication série est établie entre l'unité patient et les unités infirmier et médecin qui sont dans des régions éloignées.

*Résultats.* – Pour l'évaluation clinique, la sortie du système a été comparée avec le rapport du centre du diabète MedZon dans lequel un capteur de glucose non invasif a montré un écart de 15% avec le test de tolérance au glucose (G.T.T.). D'autres signes vitaux ont montré une bonne précision d'environ 95% avec l'appareil commercial. Le prototype a été analysé pour sa fonctionnalité et a été accepté par plus de 80% des sujets de l'étude.

*Conclusions.* – Les résultats positifs de ce système ont donné lieu à un meilleur contrôle de la glycémie et ont confirmé la faisabilité d'une gestion de soins de santé efficace. La nouveauté peut être attribuée à la mesure non invasive, à l'acquisition des données multicanaux et à la communication série.

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**Introduction**

According to the International Diabetes Federation, nearly 591 million people may have diabetes by 2025 [1]. The fact that currently 65.1 million patients have diabetes, when compared to 50.8 million in 2010, alarms the Indian medical community as a result [2]. Dr. V. Mohan, President of the Madras Diabetes Research Foundation has found that 25% of Tamil Nadu residents have diabetes, a high percentage in India [3]. Improper health care may lead to other medical complications such as cardiovascular disease, stroke, kidney failure, vision loss, etc. Neuropathy is a disorder which mostly occurs in 50% of diabetic cases at chronic stages [4]. Many bedridden and normal individuals living in remote places are in need of routine health check-ups, a daunting and expensive task, demanding a real-time and continuous monitoring system.

Telemedicine holds a great potential for improving clinical management and health care delivery in remote places using information and communication technologies for diagnosis, treatment and prevention. Furthermore, it provides benefits such as international consultations for patients, reductions in travel cost, time, stress, etc. A report claims that the number of patients using this service will rise from 350,000 in 2013 to 7 million in 2018 [5].

Gomez et al. have developed a tool (DIABTel) and proved that glucose can be maintained below the hyperglycemia level due to efficient insulin management [6]. Shea et al. have proposed a system (IDEATel) that facilitates decision-making for health care providers [7]. Mohammadi et al. have evaluated near-infrared (NIR) sensors for continuous glucose monitoring and stated that blood sugar concentration can be predicted if proper calibration and signal drift correction is applied [8]. Despite the contribution of numerous techniques for diabetes monitoring by many researchers, there is no wide utilization due to challenges in implementation, owing to high cost, need for high-speed internet connectivity and complex networking architecture, which have hindered the diffusion of telemedicine technology to the wider population.

This paper proposes a low-cost telemedicine system (InDiaTel) that monitors diabetic patients in synchronous mode. The novelty lies in the design, development and packaging of a body sensor network module with a multichannel data acquisition system. This system provides comprehensive and continuous monitoring using serial communication protocols to link multiple sub-modules and GSM connectivity, significantly reducing costs as a result. The conventional continuous blood glucose monitoring devices are invasive and costlier. Hence, a novel design for

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