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Self-monitoring induced savings on type 2 diabetes patients' travel and healthcare costs

Aapeli Leminen[a,*], Markku Tykkyläinen[a], Tiina Laatikainen[b,c,d]

[a] Department of Geographical and Historical Studies, University of Eastern Finland, P.O. Box 111, 80101 Joensuu, Finland
[b] Institute of Public Health and Clinical Nutrition, University of Eastern Finland, Kuopio, Finland
[c] Joint Municipal Authority for North Karelia Social and Health Services, Joensuu, Finland
[d] Department of Public Health Solutions, National Institute for Health and Welfare (THL), Helsinki, Finland

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ABSTRACT

Background: Type 2 diabetes (T2DM) is a major health concern in most regions. In addition to direct healthcare costs, diabetes causes many indirect costs that are often ignored in economic analyses. Patients' travel and time costs associated with the follow-up of T2DM patients have not been previously calculated systematically over an entire healthcare district. The aim of the study was to develop a georeferenced cost model that could be used to measure healthcare accessibility and patient travel and time costs in a sparsely populated healthcare district in Finland. Additionally, the model was used to test whether savings in the total costs of follow-up of T2DM patients are achieved by increasing self-monitoring and implementing electronic feedback practices between healthcare staff and patients.

Methods: Patient data for this study was obtained from the regional electronic patient database Mediatri. A georeferenced cost model of linear equations was developed with ESRI ArcGIS 10.3 software and ModelBuilder tool. The Model utilizes OD Cost Matrix method of network analysis to calculate optimal routes for primary-care follow-up visits.

Results: In the study region of North Karelia, the average annual total costs of T2DM follow-up screening of HbA1c (9070 patients) conforming to the national clinical guidelines are 280 EUR/297 USD per patient. Combined travel and time costs are 21 percent of the total costs. Implementing self-monitoring for a half of the follow-up still within the guidelines, the average annual total costs of HbA1c screening could be reduced by 57 percent from 280 EUR/297 USD to 121 EUR/129 USD per patient.

Conclusions: Travel costs related to HbA1c screening of T2DM patients constitute a substantial cost item, the consideration of which in healthcare planning would enable the societal cost-efficiency of T2DM care to be improved. Even more savings in both travel costs and healthcare costs of T2DM can be achieved by utilizing more self-monitoring and electronic feedback practices. Additionally, the cost model composed in the study can be developed and expanded further to address other healthcare processes and patient groups.

1. Introduction

1.1. Background

Diabetes is one of the fastest growing diseases in the world and it causes annually 673 billion USD healthcare costs [1]. The majority of studies of the cost of healthcare focus on the direct monetary costs of care [2,3]. However, several studies show that additional costs, such as patient time and traveling costs associated with receiving healthcare services may be considerable to both the patient and society as a whole [4–6]. Jowett et al. [3] point out that patients incur substantial time and traveling costs especially when therapy or intervention requires regular monitoring. This is the case in type 2 diabetes since good care outcomes can be achieved only with regular monitoring and measurements [7].

A widely used follow-up indicator for the outcome of T2DM is the hemoglobin A1c (HbA1c) level that provides long-term blood sugar levels [7,8]. Finnish Current Care Guidelines for diabetes recommends that the HbA1c level should be measured every 3–6 months in diabetes patients [8]. Monitoring requires traveling because the follow-up is organized mainly in public healthcare center (PHCC) premises in Finland. Alternatively, part of the follow-up could be carried out with

* Corresponding author.
E-mail address: aleminen@uef.fi (A. Leminen).

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patient self-measurements. In Finland, such self-management has so far only been piloted in small trials with varying results [9].

To date, patients' travel costs and time costs associated with T2DM follow-up and HbA1c screening have not been assessed systematically at the level of healthcare district. To fill this research gap, the aim of this study was to develop a georeferenced cost model that can be used to measure healthcare accessibility and patient travel costs in a region, taking North Karelia as an example. The second objective was to find out whether savings in the total costs of T2DM follow-up are achieved by utilizing a self-monitoring system and replacing a part of the primary-care follow-up visits with patient self-measurements and electronic feedback between PHCC and patients. Data for the study consists of individual georeferenced T2DM patient record data, zip code area-level income, employment and car ownership variables and digital road data.

1.2. Accessibility of healthcare services and travel costs

Accessibility is essentially a construct of two functions: activities or opportunities to be reached and the effort, time, distance or cost needed to reach them [10]. Accessibility is affected by the locations of potential destinations and starting points as well as the performance of the transportation system and the socioeconomic capacities of the individual in connecting these locations [11]. Geurs and Wee [12] have identified four types of components from the different definitions and practical measures of accessibility: land-use (the location of jobs, shops, health, social and recreational facilities etc.); transportation (time, cost and effort when traveling from origin to destination); temporal (temporal constraints in the availability of opportunities); and individual (needs, abilities and opportunities of individuals).

The challenge in the accessibility of healthcare is the mismatch of the geographical distribution of healthcare services and the population needing them. Diseases such as type 2 diabetes currently require regular healthcare visits, whereupon the hindrance of distance and travel time should be considered in healthcare planning as a social cost [13]. Previous research in our study region has revealed that accessibility does not directly affect the treatment results of type 2 diabetes presumably because of travel cost compensations [14].

Peters et al. [15] define the access to health services with a conceptual framework that builds on four dimensions: geographic accessibility (distance or travel time); availability (appropriate type of services to fulfill customer demand); financial accessibility (the price of services and the willingness and ability of users to pay for the services); and acceptability (responsiveness to social and cultural expectations).

The combination of availability and geographical accessibility is commonly called spatial accessibility of healthcare services and it can be measured most accurately with GIS methods [16–18]. Furthermore, spatial accessibility can be seen as the revealed or potential accessibility [16,19,20]. Revealed accessibility focuses on the actual use of healthcare services, whereas potential accessibility means the potential entry into the system without the assumption of the automatic utilization of the offered services [21]. When studying the anticipated real traveling pattern of patients, revealed accessibility is most relevant to specify travel behavior and travel costs.

People tend to use different travel modes with different travel costs, the estimation of which can be a challenge when measuring expected travel behavior [13]. Many studies of the travel mode choice have focused on socioeconomic and demographic variables like age, gender, income, education, employment, family size, the number of children and car ownership [22–24]. According to Rodrigue et al. [25], monetary costs are one of the most important criteria when choosing a travel mode. In passenger transport, these costs can be either distance-related direct costs or travel time-related indirect costs, or their combinations.

Private car is the most common travel mode for short-distance trips in developed countries. In Finland 58 percent of all trips are made by passenger car [26]. However, patient travel behavior differs slightly due to the possibility of being entitled to travel cost reimbursements in the study region. Travel expenditures are usually compensated by the Social Insurance Institution for the least expensive travel modes, but travel by taxi is accepted for health reasons or because of the unavailability of public transport.

1.3. Measuring accessibility and costs of travel, healthcare and self-monitoring with GIS

The concept of accessibility is spatial by nature and it is closely related to distance, whereupon the measuring of it is usually done using GIS statistics. Accessibility is most commonly measured by distance measures, travel time or monetary costs and this can be done either with vector- or raster-based analysis [27]. The availability of high-quality information of a transport network and the development of methods have led to an increasing use of the vector-based network analysis [18]. Compared with the simplest measure of accessibility, straight-line distance, network analysis by road yields more accurate results [28].

In the context of accessibility to healthcare, the WHO [29] suggests to use travel time rather than metric distance as geographical features and transportation facilities in different areas vary so much that relying on the metric distance to health facilities in a route choice would give invalid results. Additionally, the choice between different transportation modes can be considered by travel time. According to Ray and Ebener [27], people more easily pay attention to travel time rather than to distance when making decisions on seeking care. Thus, the selection of the shortest routes of the primary-care follow-up visits in this study is also based on travel time.

Here T2DM follow-up is an event where a patient travels to a public healthcare center for an HbA1c test and for a consultation. This event causes direct costs from both travel and treatment but also indirect costs from the time loss associated with the visit. Scrutinizing the patient data of the study region revealed that part of the follow-up visits could be replaced with patient self-monitoring. In this study, the costs of self-monitoring are included in the analysis when investigating potential savings. All cost factors in the analysis are expressed as monetary costs and the total costs of T2DM follow-up in this case means the sum of travel costs and healthcare costs of the HbA1c screening.

As in Ford et al.'s [30] study, the developed cost model consists of a set of equations that calculate the costs of T2DM follow-up. Travel costs originate differently from the four travel modes selected for the study. Walking and cycling (C_{WC}), private car (C_{PVT}), bus (C_{BUS}) and taxi (C_T) are expressed with the following equations:

$$C_{WC} = T*VOT*P \tag{1a}$$

$$C_{PVT} = (T + T_p)*VOT*P + D*VOC \tag{1b}$$

$$C_{BUS} = (T + T_a)*VOT*P + F \tag{1c}$$

$$C_T = (T + T_a)*VOT*P + F + D*VOC \tag{1d}$$

where T is the journey time of transport, VOT (value of time) is the gross wage coefficient of the patient's zip area, P is the patient's productivity coefficient (weighted for working time and leisure), T_p is the parking time, D is the road distance in km, VOC is the vehicle operating cost per km, T_a is the access time to the network (walk time to bus stop or from bus stop to the health center, waiting time in the bus stop or service time in taxi), F is the fare paid for the journey. Further explanation and coefficient values used for the modeling are given in Table 1.

Similarly to Hanly et al. [31], walkers and cyclists (1a) are assumed to incur zero direct travel costs. The other Eqs. (1b)–(1d) consist of both time costs and direct monetary costs. VOT is based on an average hourly gross wage that is the mean income of the patient's zip area. P is used for weighting the productivity of active and retired patients. In this case Jowett et al.'s [3] division between working time and leisure time is