Application of Teleophthalmology in Screening and Monitoring of Elderly Population in Rural Areas in Lithuania

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Abstract A small regional telenetwork has been established in Lithuania and used for piloting homecare and remote care health care service delivery models on the grounds of the work of the Telemedicine Centre of the Lithuanian University of Health Sciences (formerly Kaunas University of Medicine) and private initiative of clinicians and researchers with the aim to promote bottom-up, self-sustainable telemedicine development and to increase accessibility to, and quality of, healthcare especially in rural or underserved areas. Stratelus, a small medical company, together with several family clinics in the rural areas of Lithuania and with support of the Family Medicine Centre of the Kaunas University of Medicine

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started screening and monitoring of elderly population for diabetic retinopathy, aging macular degeneration, optic nerve head evaluation, and glaucoma in their homes and near-home locations, in a mobile telenetwork mode, bringing the access point to the patient. The project demonstrated innovation in terms of the methodology (telehomecare), organization (small bottom-up structure), and technology (high quality handheld fundus camera). The argument behind this project was to test the viability of homecare and remote care service delivery in a small/medium scale, bottom-up organisational setting. This is important for elderly population with limited mobility in rural or remote areas.

Keywords Telemedicine · Ophthalmology · Screening · Monitoring · Rural areas · Homecare · Telenetwork

Population groups included healthy people and patients clinical symptoms. Focus was on 3 clinical conditions at this stage—diabetic retinopathy, age-related macula degeneration and glaucoma.

Patient eye fundus images acquired while visiting them at home or seeing at near-home locations (virtually at home considering the distance) were sent by local family physicians/general practitioners to the competence center of Stratelus where they are being evaluated by tertiary level specialist physicians and evaluation results with clinical recommendations are sent back to the local family physicians. This project has improved accessibility to advanced diagnostics and timely healthcare for a number of rural elderly population who otherwise would often choose not, or could not to, travel to tertiary level healthcare providers for advanced diagnostics until late stage of symptoms. The overall outcome of the project is that initiation and delivery of small/medium telehomecare projects is possible, it can produce good clinical results, and they can be well received by all involved (patients, local physicians, tertiary level physicians), run on small budgets and have good chance to be self-sustainable in long-term.

1 Project Description

Access to health care is generally perceived as a right in many communities, especially in Europe. One of the priorities highlighted by the European Commission is ensuring that the results of biomedical research will ultimately reach the citizens. However, current demographic, economic, and social conditions are challenging effective and efficient delivery of health care services. Lithuania, as many other countries, has seen a combination of stress in public finance, ageing population, decrease of access to health care services in rural areas [1–6]. On the other hand, we have seen rapid growth of technologies, both imported and locally grown, and ICT boom. That prompts to explore possibilities of telemedicine [7–10].

The project "Application of Teleophthalmology in Screening and Monitoring of Elderly Population in Rural Areas in Lithuania" focused on

using the telehomecare model in delivering services to patients in rural communities.

Telehomecare is a developing area of healthcare services that will provide significant benefits to the care providers their patients. Telehomecare is defined as "the use of communications and information technology to deliver health services and exchange health information to and from the home (or community) when distance separates the participants". Telehomecare in ophthalmology brings some real challenges, because in order to make correct ophthalmological diagnosis, a physician needs to evaluate relevant images which requires availability of a high quality equipment which up until recently was rather expensive [11–14]. Digital handheld equipment for ophthalmology was recently introduced to the market which helps to overcome some of these challenges. It can be used not only in general practitioner's office, but can be used for patients homecare as well.

In countries like Lithuania where large hospitals dominate the health services providers market seeing large centrally initiated projects is the norm. However, as primary care provision is continuously moving toward smaller physician offices and family clinics, smaller projects coming from local initiative are becoming increasingly important and they may have large impact for local communities. However, they need access to technologies, cooperation of various stakeholders local, primary care and tertiary level physicians), and some support and encouragement to stay motivated. To try address these issues and bring services closer to the patients, a small telenetwork has been established in Lithuania on the grounds of the work of the Telemedicine Centre of the of Lithuanian University of Health Sciences and private initiative of clinicians and researchers with the aim to promote bottom-up, self-sustainable telemedicine development and to increasing accessibility to, and quality of, healthcare especially in rural or underserved areas. Stratelus, a small company which is also the coordinator of the EU-supported Eurostars project, together with several family clinics in the rural areas of Lithuania and with support of the Family Medicine Centre of the of Lithuanian University of Health Sciences started screening and monitoring of elderly population for diabetic retinopathy, aging macular degeneration, and optic nerve head evaluation in remote family clinics and their homes, in a mobile telenetwork mode, bringing the access point to the patient's home. This is important for elderly population with limited mobility in rural areas.

Telehomecare has proven to be a good model for our project. In rural communities, the demand for tertiary level health care services is high, while patient and physician contact is still very personal and home visits are still often a form of health care services delivery. Telehomecare extended the existing primary care services to a higher specialist level. In terms of the end-user, the project was a combination of homecare and "near-homecare" i.e., provision of care within the community, at a primary care clinic at a proximity so close to home (within 10 min travel time) as compared with the tertiary healthcare centre, that it could virtually be considered homecare.

2 Development of the Project

2.1 Arguments for Initiating the Project

The overall argument for initiating this project was to test the viability of homecare and remote care service delivery in a small/medium scale, bottom-up organisational setting. All the ophthalmologists participating in the project have long experience working in the tertiary level healthcare institutions such as the Eye Clinic of the Lithuanian University of Health Sciences (formerly Kaunas University of Medicine) Hospital and currently hold their main clinical appointment there. Their observation was that patients who don't need tertiary level care are often referred to the tertiary level. Another group of patient is those who come to the tertiary level at a very late stage. As most of the participating ophthalmologists have also been active in the activities of the Telemedicine Centre of the Lithuanian University of Health Sciences, an initiative developed to use the expertise in developing a regional telenetwork and offering services closer to the patients, at home or near home (at local primary care clinics). On the other hand, for Stratelus, as a company, this offered an opportunity for offering new services as well (although financial gains were not a factor as services were generally provided at cost and with some sponsors' help). For patients though, the services offered economic benefits as discussed in Sect. 5.1.

2.2 Clinical Goals and Expectations

Our aim was to establish and develop telenetwork for homecare and remote care in ophthalmology in selected locations in Lithuania and test the viability of bringing the services and diagnostics closer and faster to the patients via telehomecare.

Objective 1. To provide infrastructure (mobile digital medical diagnostic systems—fundus camera and camera for anterior segment).
Objective 2. To train the primary care medical personnel on new telemedicine diagnostic equipment and technologies.
Objective 3. To perform preventive eye disease screenings and early diagnostics.
Objective 4. To perform monitoring of chronic diseases seeking minimization of complications.

This chapter presents the results of 4 establishments of teleophthalmological services in 4 rural or remote areas of Lithuania (Vilkaviskis, Karmelava, Kaltinenai, Klaipeda).

2.3 Innovative Elements

There were 3 kinds of innovative elements in the context of this project—methodological, organisational, and technological. In terms of the methodology of healthcare services delivery via telemedicine or telehomecare, although these methods have been implemented in some specific areas (emergencies; military), it has not become part of routine delivery in Lithuania yet, so the mode itself was an innovative element to the end-users. Organisationally, an innovative element was that this project emerged as a small project driven by bottom-up initiative. Technologically, and in the context of the clinical specialty (ophthalmology), the use of a handheld digital fundus camera for patient examination and data acquisition was an enabling factor to carry out this project.

3 Outcome of the Project

The project reached the aim as the viability of bringing the services and diagnostics via telehomecare was shown to be possible, and services were made available closer and faster to the patients. Factors of success were active involvement of the project participants, including primary care physicians at service locations, patient demand in services, technology that enabled delivery of services at acceptable quality, and good clinical methodology.

3.1 Clinical Methods

Functionally, telehomecare in ophthalmology is comprised of the following service levels:

- Patient evaluation and remote diagnostic services.
- Consultation leading to treatment.
- Continuous virtual medical supervision/monitoring.
- Clinical decision support, including automated diagnostics, computer technologies such as artificial intelligence.

The main ophthalmic diseases (from presbyopic correction till cataract, glaucoma, and AMD) correlate to patients age, and the main changes developing blindness manifests in elderly people. Furthermore, the hardest changes frequently develop in patients with hard general condition, unable to move to the ophthalmologist.

Fig. 1 Service locations

3.2 Project Participants

Stratelus, a small enterprise, a telenetwork coordinator, and service provider (competence center) has partnered with the Telemedicine Center, the Family Clinic, and the Department of Ophthalmology of Institute for Biomedical Research of the Lithuanian University of Health Sciences; Optomed OY, Oulu, Finland; and Remote Analysis OY, Helsinki, Finland in development of the telenetwork and service offering. The participants in remote areas whose patients were served were the Primary Health Care Center of Klasco (Klaipedos juru kroviniu kompanija—Klaipeda Stevedoring Company), Family Health Care Center of Vilkaviskis; Primary Health Care Center of Kaltinenai; Primary Health Care Center of JSC Elinta (Karmelava).

There were no specific requirements for the project participants—general requirements being interested and committed in participating in the project and telenetwork and willingness to learn using new technologies such as digital fundus camera and on-line data transmission.

3.3 Population Groups and Beneficiaries

The telenetwork was established in 4 remote areas with different distances from the Stratelus competence center which is based in Kaunas: Karmelava (20 km from Kaunas), Vilkaviskis (70 km), Kaltinenai (123 km), Klaipeda (205 km) (Fig. 1). Selection of the patients was done by family doctors and paramedics. Part of the selected patients was served at their home, part—in family clinic near their home (within local community).

Population groups have been selected in a number of rural areas in Lithuania. Among them, there were 2 groups—healthy people, who were subjected to

screening, or preventive health check-up, and patients—people with clinical symptoms, who were subjected to monitoring. Focus was on 3 clinical conditions at this stage—diabetic retinopathy and age-related macula degeneration and glaucoma.

The project had not received any public funding. Some donations and in-kind contribution was received from several healthcare/pharmaceutical companies. The reasons of participants' interest in this project were ability to expand their services to their patients (their access to high competence diagnostics); by providing their patients with better and more timely diagnostics, decrease possibility of acute diseases or complications when treatment can be more complicated and more costly; develop their competence in ophthalmology. The ultimate beneficiary is the patient—it can be noted that accessibility of patients in remote locations to high competence diagnostics is constrained by such factors as distance to competence centre; wait time; travel time and resources; patient mobility; determination. Bringing service and experts to patients' home or to a distance minimal to their home (most of patients that were served in family clinics live within 10 min) from their home or work place.

3.4 Methodology and Implementation

The methodology of screening was based on the need for collecting the data and information needed for patient evaluation.

Screening was performed by tertiary level specialists. They made the choice on which tertiary level tests that are not available at primary level are necessary. This choice could not be made by a primary level physician. Thus, there was a selection of patients made at the screening—those who need to travel to a competence centre for more complex tests and evaluation and/or for surgery, and those who can be diagnosed locally. In addition, tertiary level specialists-ophthalmologists trained primary care/family physicians on working with the digital diagnostic handheld equipment suitable for telemedicine, acquisition and transmission of data to the competence centre for consultation and evaluation. With active involvement and relevant training of primary care physicians, remote diagnostics will enable diagnosis be made remotely for a large proportion of patient population.

3.5 Technological Innovative Elements

The most recent version of a Smartscope digital handheld eye fundus camera was used (Fig. 3), and a specialized software was used for online data transmission which was enabled by availability of fast data networks.

3.6 Patient Recruitment, Dissemination, and Screening Process

Patients for screening at remote locations were identified, selected, and recruited by participating primary care/family physicians or paramedics. The information dissemination about the project to the patients was based on direct contacts between the local medical staff and patients. Most of the primary care physicians, nurses have lived in the area for a long time and know their location and people very well. This also helped to maintain trust between patients and physicians in offering new service. Based on multiple factors including patient condition, some of the patients were assigned consultation at home, some—in the near proximity to home, or at their workplace.

Though physically screening was performed at primary level facility, methodology, and technology used included tertiary level such as ultrasound which was performed by tertiary level ophthalmologists. Our findings were that in homecare environment, a combination of trained primary care/family physicians or nurses and innovative telemedicine diagnostic technologies, such as handheld ophthalmoscopes, and transmitting the data for evaluation to competence centre, it is possible to provide sufficiently precise diagnosis without having a patient to travel to a tertiary level medical facility. Thus, homecare can effectively bring high quality healthcare closer to a patient and decrease the time to diagnosis.

There were 2 groups of patients:

- Patients who arrived for evaluation to a clinic near their home (within 10 min travel) or at their workplace.
- Patients located beyond 10 min from a clinic, or patients with impaired mobility were evaluated at home.

Evaluation at a primary care clinic was performed by physicians-ophthalmologists who arrived from a competence centre. Their aim was to perform the first screenings and train local medical personnel, including the use of handheld equipment for ophthalmology. The investigation included basic ophthalmological examination, measurement of intraocular pressure, biomicroscopy by a slit lamp and eye fundus photography by handheld digital fundus camera. Some of the tests were performed by a family doctor or nurse with participation and observation of an ophthalmologist from the competence centre.

Evaluation at the patient's home was performed by a family doctor or nurse with participation and observation of an ophthalmologist from the competence centre using the handheld camera Smartscope with add-ons for fundus photography and anterior eye segment investigation. Investigation included measurement of visual acuity, tonometry, slit lamp examination, Schirmer's test, dilation of the pupil, and eye fundus examination with Volk 90D lens, eye fundus photography (digital handheld eye fundus camera Smartscope, Figs. 2 (right picture) and 3) and data transmitting. Cup disk ratio of the optic nerve head was also evaluated. The data obtained—visual materials i.e., pictures and patient data—were transmitted to the Stratelus competence centre for processing and evaluation by highly skilled

Fig. 2 Patient screening at the Kaltinenai primary care center. Digital eye fundus camera use is shown on the *right* picture

Fig. 3 Handheld digital eye fundus camera (Courtesy of Optomed OY)

ophthalmologist. The focus of diagnostics in home and primary care environment was preliminary diagnosis and identification of the need for further action. Technical aspects are covered in the chapter below.

3.7 Patient—Competence Centre Interface: Data Transmission, Remote Analysis

The equipment used was a digital handheld eye fundus camera together with specialized software for telenetworking and image exchange. Patient fundus images acquired while visiting them at home or at a participating family clinic were sent by local family physicians/general practitioners to the competence center of Stratelus where they were evaluated by tertiary level specialist physicians and evaluation results with clinical recommendations were sent back to the local family physicians. The data processing, transmitting and evaluation process and tools are shown in Figs. 3, 4, 5, 6 and 7.

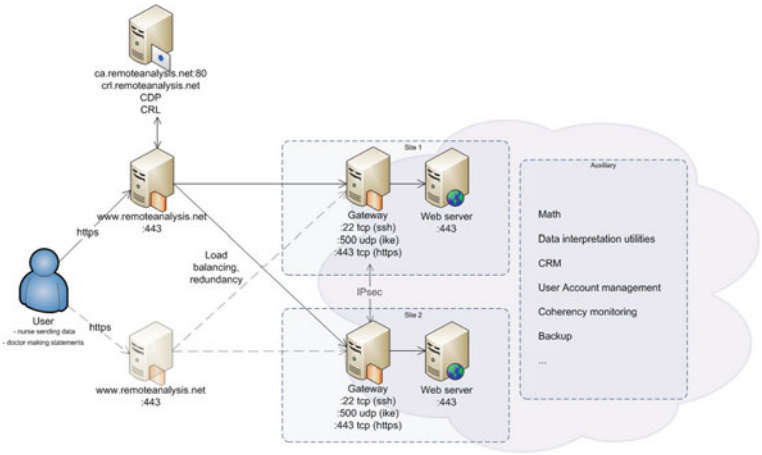

Fig. 4 Data processing (Courtesy of Remote Analysis)

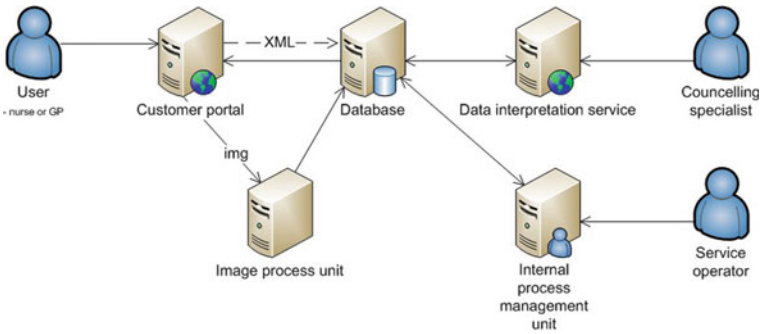

Fig. 5 Data transmitting

3.8 Clinical Findings

The main result of the screenings was provision of timely and high competence diagnostics that was enabled by competence of the physicians (experienced ophthalmologists from the Lithuanian University of Health Sciences), high quality portable equipment, and local cooperation.

The screenings provided with valuable clinical and organizational experience. We noticed direct relationship between remoteness (distance from competence centre) and health condition (occurrence and complexity of diseases) which we believe to a large extent is caused by time, resource and mobility constraints.

Another relationship was age-based: elderly population which is more prevalent in remote rural areas is more likely to show age related diseases, their complications, such as blood vessels blockage, retinal detachment, age-related macula

Fig. 6 Screen (display) of transmission from patients' end to competence center via remote analysis software. The second picture of four pictures sent is enlarged

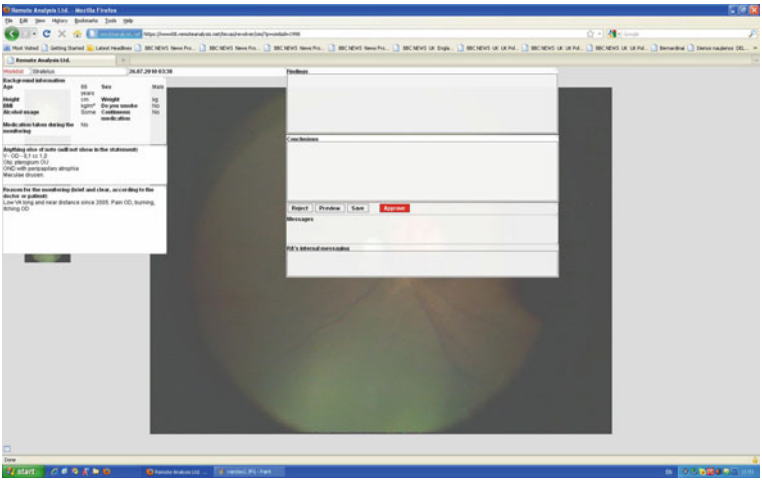

Fig. 7 Screen (display) at the competence center prepared for expert decision to send. Patient data field is visible on the *left side*; field for expert's response/evaluation is visible in the middle of the screen

degeneration. This, in turn, further decreases patients' mobility which makes accessibility to health care even more constrained. High patient turnout at the locations involved demonstrated that homecare or near-homecare is in high demand and can significantly increase patients' accessibility to health services. Patients' distribution by age and gender are shown in Table 1. There was no

Table 1 Patients' distribution by location, age, and gender

Áge group	Location				Total
	Klaipėda	Karmėlava	Vilkaviškis	Kaltinėnai	
15–20	2/1 (3)	0/0 (0)	0/0 (0)	2/1 (3)	4/2 (6)
21–30	2/2 (4)	6/5 (11)	2/0 (2)	2/0 (2)	12/7 (19)
31–40	3/5 (8)	9/15 (24)	1/1 (2)	2/0 (2)	15/21 (36)
41–50	6/4 (10)	16/11 (27)	2/1 (3)	4/5 (9)	28/21 (49)
51–60	5/4 (9)	8/3	3/2	6/6	22/15 (37)
61–70	1/0 (1)	1/1	2/2	4/8	8/11 (19)
>70	0/1 (1)	1/0	0/2	3/4	4/7 (11)
Total	19/17 (36)	41/35 (76)	10/8 (18)	23/24 (47)	93/84 (177)

significant differentiation by gender and the patient population generally corresponded with the general population trends.

Table 2 shows patient distribution by disease. We could not compare frequency of diseases with the statistical average frequency of diseases of Lithuania because patients were chosen selectively and reflect the spectrum of diseases that telehomecare could potentially address. Furthermore, some patients had 2 or 3 diseases such as Cataract, Glaucoma, and dacryocystitis. This was in line with our aim to pilot and utilize telehomecare opportunities. There was a significant number of patients with refractive errors (Myopia, Hyperopia, Astigmatism) which we did not address within the scope of telehomecare.

3.9 Clinical Conditions Investigated

Glaucoma is one of the main ophthalmological problems in the elderly population in Lithuania. There are about 10–12% of all patients suffering from glaucoma and many people with suspected glaucoma. Most important diagnostic sign of glaucoma is evaluation of optic nerve head cupping and it's dynamics. Traditionally, it is a complicated test, which needs to be performed correctly in an ophthalmologists office, at least equipped with slit lamp and 90D fundus lens, and dilated pupil, what sometimes is contraindicated for glaucoma patients. For the evaluation of the optic nerve head cupping as a homecare procedure, we used non-mydriatic (narrow pupil) digital eye fundus camera, operated by nurse together with rutin tonometry at patients home, and transmitted the image to teleophthalmology competence center for processing and evaluation.

Diabetic retinopathy was the second focal clinical condition. On average, out of 10 patients with diabetic retinopathy, 2 were seen at home, eye fundus images of 2 patients were sent to the competence centre for consultation regarding laser treatment. Diabetic retinopathy is another disease that poses considerable challenges to ophthalmologists and general practitioners. It is the second most prevalent cause of blindness in Lithuania. Its diagnostics and treatment is

Table 2 Clinical findings of screening

Diagnosis	Location				Total
	Klaipėda	Karmėlava	Vilkaviškis	Kaltinėnai	
Cataract (beginning)	11	18	8	27	64
Cataract (surgical)	1	2	3	6	12
Glaucoma compensated	5	2	2	4	13
Glaucoma subcompensated	0	0	2	3	5
Glaucoma suspected	3	2	2	3	10
Glaucoma secondary traumatic				1	1
Dry eye	0	12	4	8	24
AMD (dry)	6	8	6	12	32
AMD (wet)	0	0	1	3	4
Diabetic retinopathy	1	3	2	4	10
Corneal opacities (leucoma)	0	0	1	2	2
Anterior uveitis	0	0	1	2	3
Keratitis e lagophthalmo	0	0	1	0	1
Conjunctivitis	0	1	0	1	2
Chalazion	0	0	1	0	1
Refraction error	15	23	6	12	56
High complicated myopia	0	2	0	1	3
Optic nerve disease	1				1
Retinal peripheral degeneration	0	1	2	1	4
Preretinal fibrosis			1	1	2
Dacryocystitis	0	0	0	1	1
Healthy	0	11	0	1	12

concentrated at the 5 largest cities of Lithuania and patients are supposed to go there. However, the number of patients coming for regular evaluation to one of those 5 centers is significantly decreasing with the increase of distance to the center. It is related to the mobility of patients and accessibility to local public transportation. Homecare is a solution that could potentially avert this trend and improve clinical outcomes.

Age related macular degeneration—third target in our screening. It's frequency correlates with age. However, it was observed to appear at a younger age as well. There were 36 such patients at the screening. For most of them, dry form was diagnosed, which requires follow-up—but the good news is that it can be performed remotely. Only 2 wet forms were diagnosed—those patients had to be referred to the tertiary centre for treatment.

3.10 Images Processing and Assessment

The assessment of digital pictures of eye fundus is one the most relevant and frequently used methods for diagnosis of glaucoma, diabetic retinopathy, and age related macular degeneration. It is more easily mastered, accessible, and

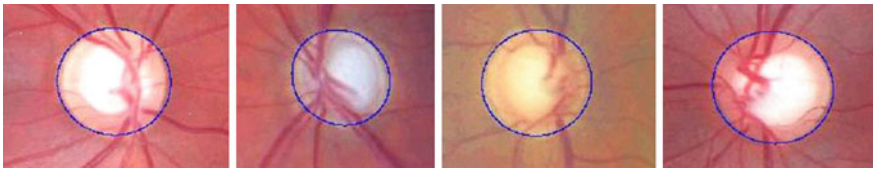

Fig. 8 Images of optical nerve heads with elliptical approximation (gold standard)

inexpensive compared with laser methods (HRT and OCT). For diagnosis and evaluation of glaucoma changes the ONH digital pictures still stay as golden standard [15–17].

Screenings usually result in a high quantity of eye fundus images and their evaluation sometimes becomes complex purely because of the volume, when healthy images have to be distinguished from unhealthy—which have to be evaluated by an experienced expert-physician.

In order to increase efficiency and enable processing of high volume of clinical information, together with the Vilnius Mathematics and Informatics Institute, we started development of automatic eye fundus parametrisation methods. The first one we chose for parametrisation was optic nerve head and its cupping [18–21].

The main advantage of the proposed automatic optical nerve disk localization and approximation method is that the location of the optical nerve head is found automatically without involvement of the physician. Below is a brief scheme of the elliptical automatic optical nerve head localization and approximation. The method consists of the following steps:

- Step 1. Initial image processing.
- Step 2. Localisation of the optical nerve head. Identification of margins.
- Step 3. Elliptical automatic optical nerve head approximation.
- Step 4. Optic nerve head cupping approximation.

Samples of elliptical automatic optical nerve head approximation are shown in Fig. 8, cupping approximation—Fig. 9.

Although the image quality of the handheld camera is lower than taken with professional stationary camera (gold standard), it was sufficient to recognize optic nerve cupping in glaucoma (Fig. 8), hard exudates and hemmorages in nonproliferative diabetic retinopathy. A shortcoming of the version of the camera used was in recognition of early stages of age related degeneration when only small macular edema can persist. The comparison of the output by the handheld camera and gold standard (stationary camera) resulted in giving the handheld camera a score of 7 as compared to score of 10 for the gold standard (Fig. 10). As in the methodology that was used, this camera was used especially to help general practitioners in screening and selecting patients for ophthalmologist's consultation, the quality of image was found to be sufficient for this purpose. The overall clinical advantages in providing patients with better and faster access to services were significant.

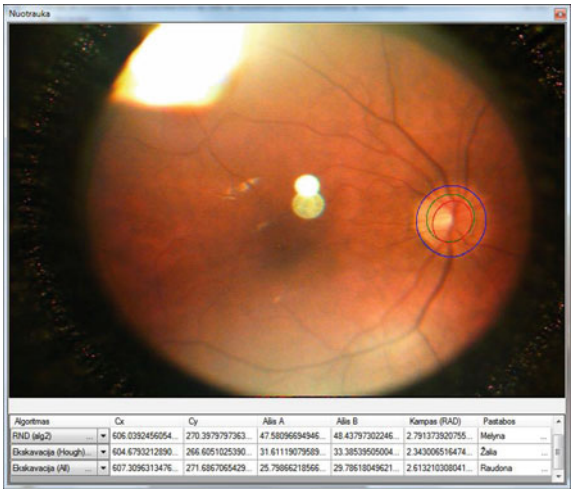

Fig. 9 Optic nerve head and cupping automatic approximation and parameterization (image made with digital handheld eye fundus camera)

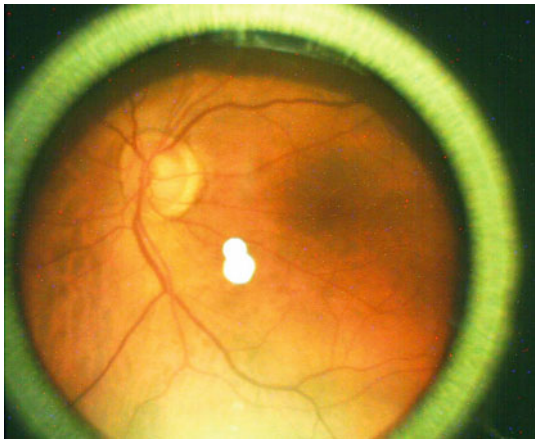

Fig. 10 Eye fundus image taken with the handheld fundus camera

4 Internal Influences on Development and Outcome

As we noted, factors of project success were active involvement of the project participants, including primary care physicians at service locations, patient demand in services, technology that enabled delivery of services at acceptable quality, and good clinical methodology. Active participants of the project were local/primary care physicians, tertiary level physicians, project leader and coordinator, and patients. Motivation of all the participants was maintained by expected outcome of the project, successful offering of health care services delivery in a home environment. In terms of the number of project participants, the project was small (in the range of 15–20 physicians and in the range of 200 patients) which made project management and coordination and interaction between the physicians simple and effective. Project participants were required to

Table 3 Comparison of costs between telehomecare and visit to tertiary healthcare facility

Average service cost at remote location, LTL/EUR	Remote location	Distance to competence centre, km	Average patient travel time, h	Average patient travel cost, LTL/EUR single	Average patient transportation cost, return ticket, and accompanying person LTL/EUR	Average service cost at competence centre, LTL/EUR[a]
70/20	Kaltinenai	123	3	29.5/9	118/34	72/20
70/20	Vilkaviskis	70	2	24/7	96/28	72/20
70/20	Karmelava, Elinta	20	1	3.5/1	14/4	72/20
70/20	Klaipeda	205	4	53/15	212/61	72/20

[a] Average wait for in-person consultation at the Eye Clinic of the Lithuanian University of Health Sciences is 1 month

keep their commitment—local/primary care physicians, learn the technology, interact with their patients, explain, make appointments, participate in clinical decision making; tertiary level physicians—to keep commitment provide with clinical support, evaluate images, consult. We found high enthusiasm of especially rural physicians who were motivated also by learning and using new technologies which are often limited to urban clinics or hospitals are not always reach the periphery. The tertiary level physicians found it motivating to diagnose patients earlier than they would be if they had to come for a live visit to a tertiary level hospital, however their time availability needs to be well considered when planning as they often have busy agendas in academic and clinical activities.

5 External Influences on Development and Outcome

5.1 Economic Aspects

We found that there was an economic benefit of providing care at home or next to home. We saw that physician's time can be used very efficiently when performing screening and seeing high number of patients per hour. Efficient distribution of roles and tasks and inclusion of local primary care physicians and nursing staff for some parts of the process adds up to the efficiency.

Significant advantage to a patient comes from travel time and cost savings. As can be seen from Table 3, average service cost when providing serviced at home or near home is 20 EUR/patient, while an option of traveling to the tertiary centre, depending on distance, may reach up to 81 EUR. Even in case of the closest location, there is some cost advantage (4 EUR/patient) and definitely time advantage. When estimating average travel time and cost, we assumed public transportation is used and we took into consideration wait times for public transportation.

Table 4 Kaiser Permanente study (1997) [22, 23]

Variable	In person	Telehealth[a]
Number of visits/day	5.2	15–20
Time of visit (min)	45	18
Travel	Yes	No
Reimbursement for travel	Yes	No
Time from triage to when patient is seen	24–48 h	Few minutes

Savings of 33–50% were noted

[a] Researchers noted that with telehealth the patient could be seen many times in 1 day if needed

Economic benefit for a participating local primary care clinic comes in the form of extended services to their patients and, by potentially decreasing occurrence of late or complicated diagnosis (although we haven't had sufficient statistical data to prove it), costs of care may be saved as well. In our screenings, we saw trends generally similar to the ones shown in other sources [22–24] (Table 4).

5.2 The Impact of Project Outcome on Project Partners

The positive impact of the project and its viability provided all project participants with motivation to continue the project. Although there was a role of economic benefits in this, interest to continue was driven by clinical and learning reasons—the project helped to meet patient demand in services at rural and remote locations and it provided the participating physicians with opportunities to learn, clinically and use of new method and technologies.

6 User Aspects

(a) *Synergies and efficiency*: Several synergies evolved in the course of the project: local/primary care physicians—tertiary level physicians; local physicians—patients; local physicians—residents practicing in family clinics—the university residents belong to. All these synergies have positive impact on the idea, structure, and outcome of the project. Likewise, motivation and involvement of all these parties is important to keep such a project going. From an organizational point of view, the project demonstrated improvement of efficiency as there was considerable preparation for the screening visits at remote locations, good sharing of functions between the medical staff participating in patient visits, which resulted into a higher number of patients seen per hour than in a normal office visit setting. Synergies that developed via close cooperation between the team of the tertiary level physicians and local primary care physicians also contributed to increased

efficiency and clinical quality. By participating in the project and in patient encounters, competence of local primary care physicians has been steadily increasing which helped to strengthen cooperation and professional ties between project participants and achieve a high level of understanding and integration. This will be used for further improvements and project expansion.

(b) *Education*: Training of the primary care physicians on innovative diagnostic medical technologies and equipment and using it in remote locations can decrease the number of unnecessary referrals to the tertiary level facilities, and to make diagnostics sooner and avoid complications. Training and involvement of the primary level physicians in telehealthcare also increases their professional competence which is an important benefit to the healthcare system. Another component is use of telehomecare in training the residents practicing in family clinics, that is an additional educational tool helping to develop their clinical competence, and also a tool to train use new technologies. In the long term, they will more likely adopt telemedicine in their practice.

(c) *Challenges*: Both the ultimate users—the patients, and primary care clinics as intermediary service users demonstrated high level of satisfaction in the outcomes of the project. There were several challenges that we experienced:

- Appropriate training had to be provided to the participating primary care physicians and nursing staff, such as use of Smartscope for acquiring eye fundus images, online data transmission. Specifically, obtaining the highest quality eye fundus images takes not only high quality equipment, but also training and experience of an investigator, and training is still ongoing for most of the participating primary care physicians. The training is provided by the tertiary level ophthalmologists.
- Seeing patients at home was some organizational and psychological, to a patient, challenge—tertiary level physicians are generally not visiting patients at home often so it required a little different organizational approach, and also, in a screening setting, going to see patients from home to home involves some extra time spent for travel. On the other hand, not all patients felt comfortable by receiving a team of physicians at home for screenings rather than emergency visits, although they were happy with the service they received.

User satisfaction and user-friendliness were important factor in project success. The service was accepted by patients and physicians and demonstrated high satisfaction. Looking to the future, however, training and experience of participating primary care physicians will be an essential factor in ensuring the data transmitted to the tertiary level has good quality, therefore they need to receive appropriate training on using the technologies that are used in the project.

(d) *Legal Aspects*: There were no legal aspects in the course of this project as in all occasions there was a live presence of a physician at a patient encounter. However, moving forward, when technology and training allows trained nurses or paramedics to acquire and transmit eye images to the tertiary level for evaluation, legal aspects of responsibility and liability insurance as well as service reimbursement will become critical and may become an impediment, if not addressed.

7 General Aspects

Implementation of the project and its continuation will contribute to the quality of life of communities in rural and remote areas. Mobility of patients in those locations are often limited by physical and sometimes behavioral, psychological reasons and providing them with better access to healthcare is a step ahead not only making those areas more livable to elderly population but also more attractive for younger generation. As telehomecare is not a mandated service and has not yet become a prevailing or even significant mode of health care services delivery yet, initiative and willingness cooperate is crucial for the model to work. Resolution of legal (including the aspects of physicians' liability), quality of services, and financial aspects is important if we want this model to be sustainable. Local communities will be interested in receiving better services closer to patients, but it is important to assure quality and maintain trust in this model. Patient/community outreach was mainly based on direct contacts by local physicians who usually know their community very well, and to some extent, local press.

8 Conclusion

The aim of our project was to test and pilot the ways and methods of improving accessibility of population in rural and remote locations to high quality and timely healthcare in a real clinical setting. Population in those locations (in terms of accessibility of their population to high quality health care services) is often underserved by modern diagnostic services, largely due to the travel time, cost and wait time constraints. Bringing the service closer to the patients, their home or near home serves as an equivalent of virtually providing tertiary level service at a primary level physical location. This project has improved accessibility to advanced diagnostics and timely healthcare for a number of rural population who otherwise would often choose not, or could not to, travel to tertiary level health-care providers for advanced diagnostics until late stage of symptoms. By using telehomecare, we did not completely replace the need for some patients to visit the tertiary clinic in person—it complemented each other, allowed to eliminate some unnecessary visits to the tertiary level clinic, and in some cases, encouraged patients to visit the tertiary level clinic and address their health condition sooner.

The available technology represents the strength of this type of service, and in the light of general technology trends, further improvements in deliverables (e.g., image quality) and cost should be expected in near term. The opportunity is represented by demand in access to health care services at acceptable costs which would improve the quality of life in rural or remote communities not only for the prevailing elderly population but to younger generation as well. The challenges and threats that we identified were—conservative approach to new modes in physician–patient interaction such as telemedicine from physicians and from

patients, and legal and financial (payment for service) basis for telemedicine that is lagging behind. Telemedicine is still a new method for the wider public and it also has a psychological aspect of direct physician–patient interaction. Our project has shown many of those telehomecare benefits to a patient, health professional, and healthcare payer that were already shown by other studies and sources, such as, improved access to health professional, patients can be seen quicker, be seen more often, stay home longer before becoming institutionalized, patients can be kept in the community (which can show savings), but specifically, we have shown that in ophthalmology, big potential in homecare and telemedicine is being opened by introduction of high quality imaging devices such as handheld fundus/anterior segment cameras because quality if image is the essential factor in making ophthalmological diagnosis.

The overall result of the project was success and it showed that initiation and delivery of small/medium telehomecare projects is possible, it can produce good clinical results, and they can be well received by all involved (patients, local physicians, tertiary level physicians), run on small budgets and have good chance to be self-sustainable in long-term. This will make this project into a continuous activity which we expect to expand significantly. There was a patient cost savings benefit demonstrated which would also translate into cost savings to the healthcare system in general, especially when telemedicine/telehomecare expands to more communities, runs on continuous basis, and addresses preventive screenings and chronic disease treatment to large part of a population. Factors contributing to project success were active involvement of the project participants, including primary care physicians at service locations, patient demand in services, technology that enabled delivery of services at acceptable quality, and good clinical methodology.

The lessons learned were: necessity of having a high quality, portable, relatively low-cost equipment suitable for telemedicine applications; necessity of generating interest of such projects among local family physicians; necessity of proper training of local family physicians in using the equipment and telemedicine applications; self-sustainability is not easy in the times of economic–financial stress but on a broad-scale, it is beneficial both for the family physicians and patients.

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