

Modelling a web app to facilitate Family Doctors and General Practitioners screen dementia in general and multicultural population

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Received date: June 26, 2022

Accepted date: July 19, 2022

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Citation: Sagiadinou MM, Vlamos P, Exarchos T, Galanis S, Bringiotti PM, Tsitlaidi M. Modelling a web app to facilitate Family Doctors and General Practitioners screen dementia in general and multicultural population. Am J Aging Sci Res. 2022;3(1):6-13.

Abstract

Background: Though dementia has become a world-wide priority, there is a low recognition rate in primary care settings, mostly due to time constraints and lack of suitable, brief and validated measures. In the case of multicultural population, primary care health systems face a variety of challenges during the diagnostic process. However, thanks to technological advantages, dementia early screening is becoming a key element factor of regular health check-ups.

Aim: This study is a part of an ongoing research which aims to design, develop and implement a web-based application for early dementia screening in primary care settings. It focuses on describing the methodology followed for the development of the web application and on presenting the final measures selected.

Methods: After consistent review of literature two advisory groups of experts were set up. First group consisted of clinical and experimental psychologists and its target was to propose adequate, validated, brief cognitive tools for screening early dementia. Second group consisted of general doctors and neurologists and its target was to propose those biomarkers, which have high value concerning the risk factors for dementia and would be most appropriate for primary health care settings. After knowledge extraction a prototype was designed and tested before the final application is ready to assess.

Outcomes: Inclusion criteria for test selection were: brief time of assessment, good psychometric values, availability of norms, restricted bias as for educational/ linguistic/socioeconomic reasons, multiple linguistic translations, no use licence needed and online availability. It was also of great importance the need to select tests which would evaluate both episodic memory and executive functioning. Final tools selected: GPCog, RUDAS, GDS-4, CAIDE Model.

Conclusion: It is possible to create a web-based application through the optimal utilization of computer science advances in the combination of cognitive tests and biomarkers for early screening of dementia.

Keywords: Dementia, Screening models, Cognitive tests, Biomarkers, Web-based applications

Introduction

Dementia has become a world-wide priority for global health organizations, as the impact in patients and their families is huge [1]. Based on estimations of Alzheimer's Diseases International, nowadays 44 million people are affected by dementia worldwide, a number which will double by 2030 and will hyper triple by 2050 [2].

Over the last decade the interest of the scientific community has been focused on primary care and the importance of early screening health issues, before they reach the edge of the deterioration period [3]. Primary care serves as the first point of contact for people with dementia and is, thus, a promising setting for screening, assessing, and initiating dementia-specific treatment and care [4]. Especially in the case of dementia, the majority of the patients conclude to a possible diagnosis only after the establishment of a strong symptomatology or the complaints of family members. It

is a fact that dementia is under recognised in middle age and older adults [5]. Primary care clinicians encounter a variety of obstacles concerning dementia diagnosis, such as patient visit time constraints; reimbursement and follow-up; complexity of diagnostic procedure, lack of an effective treatment; and concern about causing distress in patients and their families [6]. Research shows that primary care settings often fail to diagnose dementia and is possible to miss almost 90% of the cases [7,8], whereas previous research concluded in 66% missed cases of dementia in primary care settings [9]. On the other hand, an exception comes from Irish General Practitioners (GPs), who reported using appropriate tools at a 92% [10].

Concerning the case of immigrants' dementia screening, recent literature underlines the late health specialist diagnosing, as in many cases symptoms of cognitive impairments are accepted as normal memory symptoms or they are perceived as stigma [11]. Also, language or culture barriers make it complicated for GPs to pursue such cases and the assessment of cognitive tools becomes an additional challenge [12]. Another important finding of Sagbakken's study is that one probable reason for the underdiagnosis of minority patients with dementia is the inadequacy of the diagnostic tools administered, such as Mini-Mental State Examination (MMSE), which is the most world widely used assessment tool, although it requires knowledge of language, geography and a general level of education [13]. It is estimated that over 475,000 dementia cases can be estimated among migrants living in Europe [14], whereas in Canevelli's epidemiological study (2020) 686,000 cases of Mild Cognitive Impairment were estimated in the extended European Union [15]. As this specific study refers, in Greece, the estimated cases of MCI reached 194,579 subjects among immigrants from 60 to 89 years old.

Coming from the neuroimaging field, it is already a past proven scientific fact that before symptoms make their appearance there is an underlying long pre-symptomatic and pre-clinical period with pathological events in limbic regions of the brain affecting primary the episodic memory [16,17]. Cognitive assessment can play a significant role facilitating the screening and even the diagnosis of dementia [18,19]. In some cases, cognitive tests can detect cognitive deficits 10 years before clinical diagnosis of dementia, whereas recent research suggests that screening dementia could be preceded even 18 years before clinical diagnosis of Alzheimer' Disease [20].

Although during the past decades, organizations and study groups have developed references and guidelines for detecting dementia patients, there is no one yet available that proposed a holistic approach, which would be user friendly, easy to use, not time consuming for the busy settings of general physicians. As the focus worldwide is guided to provide patient-centered management of dementia and diminishing the negative impact on economical, psychological, ethical aspects for both patients and caregivers, the need for early screening is becoming crucial. Early screening will allow clinicians to offer a wider perspective of pharmacological or non-pharmacological based treatments and help to organize the next steps [21].

Even from the early 2013, Alzheimer's Foundation of America and the Alzheimer's Drug Discovery Foundation convened a workgroup to review evidence for screening implementation. Following the review and discussion of the evidence, the workgroup meeting participants concluded into recommending among others, the need for "cognitive screening facilitated by information technology" [22].

A great number of cognitive tests has been developed based on internet technology and nowadays there has been a shift towards internet application development, as companies tend to create products and screening tools for clinical or non-clinical settings, which could be incorporated into insurance policies [23].

According to Scott Mackin [24], who conducted research with his colleagues on behalf of Brain Health Registry aiming to evaluate performance of an online version of cognitive battery [25], he concluded that an online cognitive test performance significantly improved diagnostic classification. Indeed, there has been a dramatically growth in online tests of cognition and there are over 40 different online cognitive batteries for cognitive assessments [24].

Although detection of cognitive impairment is required as part of the annual wellness visit to clinicians, no specific protocol has been provided to them. It seems like the most common practice that GPs use, concerning dementia screening, is that they ask the patient general questions or they gather information from relatives while the minority of GPs indicated that they utilize cognitive tests and some of them do not perform any examinations at all [26]. Primary care clinicians (PCP) face numerous barriers to dementia screening, including patient visit time constraints; reimbursement and follow-up complexities of diagnosis; and concern about causing distress in patients and their families lack of an effective treatment [6,27].

However, the growth of Informatics and Communication Technology (ICT) has created an opportunity to improve primary health [28], through various e-health interventions by utilizing platforms, such as web-based applications. Studies show that these web-based applications can be effective in changing health behaviors and improving health status, by addressing different health needs, like health screening, health promotion, and health advice [29]. Web-based screening has the additional advantages of being engaging and efficient for primary prevention and health promotion strategy [30].

Objectives

The aim of the specific study was to design, develop and implement a web-based application, which would combine multidomain approach, including cognitive assessment and biomarkers, addressing to primary care settings for screening dementia at early stages to general and multicultural population. Moreover, depending on the outcome, it would provide personalized guidance for next steps, such as referral to a specialist and recommendations for lifestyle changes, which would reduce the risk of developing dementia. In this paper the aim is to present the methodology used to develop the specific web-based application as well as the procedures followed for the selection of specific tools.

Methodology

This study focuses on designing a web-based application which runs inside a web browser. It is client-based, thus, a small part of the program is downloaded to a user's desktop, but processing is done over the internet on an external server. The programming languages used for developing the app were PHP, HTML, CSS, JavaScript and MySQL. The PHP programming language was used for the functionality and capacity of the application. PHP along with MySQL with which they work excellently, are responsible to store, display, edit and delete the data set move in the application.

First a consistent review of the literature was conducted using Google, Android, PubMed and Google Scholar in order to achieve

a dual goal in the search: a) for risk factors associated with early dementia and b) for online/web-based applications screening dementia. Keywords used were: online cognitive assessment, screening early dementia apps, neurocognitive tests, biomarkers. Through thorough study of associated literature, the aim was to develop a first list with all the predictive factors which could potentially be risk factors for developing dementia. However, keeping in mind that these factors should be either readily available for the clinician or easily assessed in primary care settings, we limited the list to specific probable predictors.

Then, a long list of cognitive tools, risk factors, qualitative questions and various biomarkers was developed. As the focus of the study was the development of an easy to use in primary settings screening application, we formed two advisory groups to help us identify those specific, brief and easily obtained cognitive tests and biomarkers, which could be assessed through the specific web application. The first advisory group was coming from the field of psychology with clinical and experimental backgrounds and its main target was to propose specific cognitive tools which assess for early dementia, and would be brief and appropriate to examine episodic and executive memory. The second advisory group consisted of general practitioners and neurologists who practice their specialty either in private or public services settings. The target of the second group was to propose those biomarkers, which have high value concerning the risk factors for dementia and would be most appropriate for primary health care settings either of private or of public character. Both of the advisory groups included six persons: psychologists and doctors respectively.

After knowledge extraction, the recommendations and even the field additions of the advisory groups, a final much smaller and more cohesive list of domains, cognitive tools and biomarkers was formed that led to the development of the web application. When a prototype was ready, the opinion of the second advisory group was once more necessary, in order to provide guidelines for changes or points for optimization of the final product (**Figure 1**).

Outcome

Dementia Assessment

Dementia assessment application includes 5 axes: 1) Demographics, 2) Cognitive Assessment, 3) Biomarkers, 4) Proposals, 5) References.

1) Demographics

The first axe of the dementia screening application consists of the demographic data. The aim of this axe is to gather all the information, which will be necessary for the proceeding statistical analysis and will integrate the risk factor data.

2) Cognitive assessment

The focus of the study was to choose cognitive tests with specific characteristics. The inclusion criteria were: *brief time of assessment, good psychometric values (sensitivity and specificity), availability of norms, restricted bias as for educational, linguistic and socioeconomic reasons, multiple linguistic translations, no use licence needed and online availability*. It was also of great importance the need to select tests which would evaluate both *episodic memory and executive functioning*.

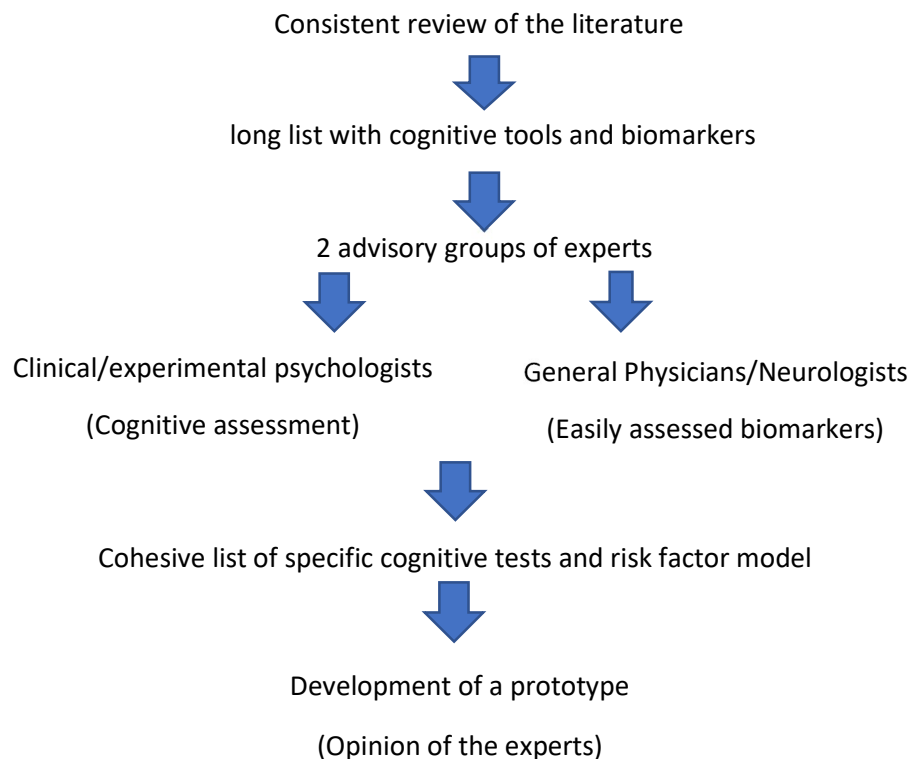


Figure 1: Work flow of Methodology.

We selected tests which could be administered by GPs or other health care professionals with minimal training and appear to be suitable for primary care settings. The aim was to find cognitive tools which would be particularly useful in rural areas where there are limited resources expertise in state-supported primary care systems and accessibility to specialists and various groups of minorities, such as the case in Mediterranean countries with the particular geographic characteristics.

Based on the previous reasoning the study group came to the following tests (**Table 1**):

General Practitioner Assessment of Cognition: The General Practitioner Assessment of Cognition (GPCOG) evaluates time orientation, word recall, recall of recent event and includes a clock drawing test [31]. This tool has the option of an additional 6-questions set addressing the informer (GPCOGI) examining changes that have been noticed lately, but for the sake of time it will not be administered in this study. Sensitivity reaches 82% and specificity 70%. The combined score of the two scales is found to have higher sensitivity (85%) and specificity (86%) than each section separately. Its administration time is less than 4 minutes. GPCOG is validated in primary settings and one of its benefits is that it can be administrated by general physicians and not medical staff like nurses, psychologists, physiotherapists etc.

Rowland Universal Dementia Assessment: Rowland Universal Dementia Assessment (RUDAS) is a validated measure for detecting dementia that is valid across cultures [32]. It was designed as a 6-item multicultural cognitive test which measures memory, gnosis, praxis, visuospatial skills, judgement and language. It lasts about 5 minutes and examines recognition of body parts, visuospatial function, reasoning, memory. Validation showed 89% sensitivity and 98% specificity, while it is unaffected by gender, education and first language. RUDAS is one from of the few cognitive scales, which could facilitate dementia screening for immigrant population, with the assistance of an interpreter. Moreover, there is a complete version of RUDAS for subjects with severe listening problems.

Geriatric Depression Scale: Geriatric Depression Scale (GDS) is a screening tool, which was developed to detect depression in the elderly by distinguishing symptoms of dementia and depression [33]. In the specific study we used the short term GDS, which consists of just 4 rather than 30 questions and makes the assessment brief and easy, while keeping its psychometric values. It is free in multiple versions and in many languages, which are available online at www.Stanford.edu/yesavage/GDS.html. GDS needs about 1-2 minutes to complete it. The GDS short form has been shown to differentiate between depressed and nondepressed elderly primary care patients with a sensitivity of 0.814 and a specificity of 0.754. It is the second

most often used tool to screen depressive symptoms among the elderly and is recommended by the World Health Organization [34].

3) Biomarkers/Caide Model

The Cardiovascular Risk Factors, Aging and Dementia (CAIDE) Risk Score is the first midlife tool, which combines modifiable and nonmodifiable factors and is developed for dementia prediction [35]. It is composed of vascular and sociodemographic risk factors, such as: age, education, blood pressure, cholesterol, body mass index (BMI), and physical activity, and is based on the midlife risk profile, it provides a 20-year dementia risk estimate. The CAIDE model was tested in multiple settings, such as memory and general clinics and is associated with vascular brain pathology at autopsy, cognitive impairment, dementia, neuroimaging measures of grey matter [36]. Body mass index has been proven to associate with dementia, but research indicates that the relationship differs depending on the age when BMI is measured [37]. During midlife high BMI is perceived as risk factor for dementia, whereas high BMI in late life is associated with decrease risk for dementia, creating the so called “obesity paradox”, probably because unintentional weight loss in older people is a risk factor for early dementia [38]. According to a review research body weight starts to decline around 10 years prior to dementia diagnosis, and with a steeper decline in BMI trajectory among those who later develop dementia compared to those who do not [39]. According to Hughes’s meta-analysis of clinical trials, blood pressure lowering was associated with a lower risk of cognitive impairment or incidence of dementia [40], while hypertension in midlife is associated with risk of dementia in later age [41]. Hypertension was defined as receiving medication, systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg [42].

4) Proposals

The researchers based their proposals to the patients on the FINGER study, a 2-year multidomain intervention for preventing dementia and cognitive impairment. The lifestyle interventions, which are proposed, consist of nutritional guidance, exercise, cognitive training, social activity, and management of metabolic and vascular risk factors [35].

5) References

The last axe of the web-based app is the unit “References”, which includes: a) all the scientific resources of each one of the tools proposed, b) the references of the lifestyle proposals based on FINGER study, c) the original answer sheet in pencil, in case someone wishes to print it and check it, both in English and Greek (English version of GPcog is already online- gpcpg.com.au-), d) educational videos, by the researchers, of assessing GPcog and RUDAS to facilitate users in providing the tools.

Table 1: Dementia Assessment.

	SENSITIVITY	SPECIFICITY	TIME	DOMAINS ASSESSED
GPCOG	0.82%	0.70%	3'	time orientation, word recall, recall of recent event and includes a clock drawing test
RUDAS	0.89%	0.98%	5'	memory, gnosis, praxis, visuospatial skills, judgement and language
GDS-4	0.64%	0.87%	1'	Depression
CAIDE MODEL	0.76%	0.68%	4'	Midlife vascular risk factors

Table 2: Procedure of the application.	
How web app works	
1.	Visit: visit the system
2.	Enroll: GP enrolls the patient
3.	Input data: input demographics data, assess cognitive tests, examine biomarkers
4.	Output data: specific scores
5.	Send data: send patient's saved data via e-mail
6.	Set oalert: alert if cognitive tests' scores suggest dementia risk
7.	Alert: alert about risk factors from other domains
8.	Referral: send patient to an expert (neurologist) for further examination
9.	Follow up: follow up in 6 months if referral, or 1 year if referral not proposed
10.	Recommend: give patients options according FINGER study and recommendations to reduce risk factors

All the above axes have strong representation in the web-based app from the beginning till the end (Table 2).

Discussion

Literature reveals that dementia is underrecognized in primary level of health and in emergency departments as well, influencing negatively effective care in both settings [8]. According to Carpenter's survey, dementia is linked with serious consequences, such as increased use of the emergency department, long period of hospitalization, delirium episodes and higher mortality rates [8,9]. Along with the aging of general population comes the aging of immigrants' population, and as findings illustrate serious limitations regarding assessing multicultural population, especially due to lack of knowledge of appropriate diagnostic tools among health professionals, new challenges emerge for primary care physicians [12]. According to a Hungarian study, 91% of GPs participated in the research relied on asking the patients general questions for screening dementia and only a quarter of them (24%) used formal tests [26], while infrequent administration of formal test is also observed in other European studies (85% of French, 79% of Swiss, 53% of Italian and 33% of Scottish) with many GPs preferring to use no-standardized, general questionnaires. Interestingly, half of the French GPs felt that it was not worth making a dementia diagnosis because of the ineffective pharmacological treatment [27].

Studies suggest that almost a decade before the onset of dementia, signs of episodic memory loss are detectable [43]. Psychometric tools are capable of distinguishing cognitive alterations which are due to normal aging in contrast to those which are due to dementia [44]. This case stands also for the brief cognitive tests (BCT), as they seem to be useful tools for screening patients among healthy samples [45]. Brief cognitive tests could play extremely important role in primary care settings, as long as they are quick and easy to administrate and demonstrate good values of specificity and sensitivity, resulting in high positive likelihood to detect probable dementia [46].

As the final goal of the study was to intergrade dementia application screening in the daily GPs' routine examination, we had to overcome the barrier of validated but time-consuming cognitive tests. Although there is no gold standard tool for detecting dementia, the most common cognitive test for cognitive screening is still Mini Mental State Evaluation (MMSE), though misclassifications rates are high for minority, low education people and even for screening early stages of dementia [47].

During the last decades there is a growth of significant development of tests that examine cognitive abilities online, either supervised or unsupervised. However, the majority of them have not

been validated clinically [24]. Efficient dementia screening relies on brief instruments, with good psychometrically values, acknowledged as value-added by health care providers. Tools for cognitive screening in rural primary care must be brief, easily scored and relatively unaffected by sociodemographic factors [48]. The MMSE may yield false positives in lower socioeconomic and limited health literacy populations, while exhibiting false negatives in highly educated group.

The group of experts concluded in specific screening instruments which are characterized by good psychometric properties, are quick to administer, free to use and have been evaluated in clinical trials and in the general population, but mainly at the level of primary health. As far as the cognitive tools are concerned, the final instruments proposed are in accordance with the clinical guidelines for diagnosis and treatment of Alzheimer's Disease and other disorders related with dementia from Ministry of Health, Mental health Directorate [49].

Specifically, GPCOG [31], has good positive predictive value [71.4% (higher than MMSE)], good internal reliability and reliability control and re-control, but at the same time satisfaction is expressed with its use by both general practitioners as well as by the patients themselves. Moreover, GPCOG was clinically validated in Greece's rural primary settings with sensitivity of 86% and specificity 61% [48]. Like our study, Iatraki's survey was conducted on rural Greece where a large part of population has completed fewer than six years of formal education and its capacity to cope with complex instructions and unfamiliar tasks may lead to an overestimation of cognitive impairment risk [5]. GPCOG may be assessed with minimum training and is suitable for primary care settings serving elders with no or minimal formal education [51].

While most GPs and specialists use Mini Mental State Examination (MMSE), RUDAS, which was design for cognitive screening, stands out as a robust test that was designed to minimize the effects of cultural learning and language diversity. Sagbakken et al. [12] in their study with Norwegian immigrants and dementia in primary care settings proposed RUDAS as most suitable when assessing people from different cultural and linguistic environments.

Cardiovascular Risk Factors, Aging, and Incidence of Dementia (CAIDE) risk score is the only currently available midlife risk score for dementia. It is extremely interesting the fact that in contrast with other risk scores for dementia which are based on older population, CAIDE model focuses on midlife risk factors confirming the recent research proving that the pathophysiological process of dementia underlies decades before diagnosis [52].

It has been estimated that up to a third of all Alzheimer's Disease cases can be attributed to common modifiable risk factors, including midlife hypertension and obesity, low educational level, diabetes, low physical activity, depression, and smoking, and a reduction of these risk factors would have a significant impact on the disease prevalence [41]. The multidomain Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER) announced positive results concerning late onset of dementia due to multidomain interventions [35]. FINGER is the first large, long-term randomized controlled trial (RCT) demonstrating that a multidomain lifestyle intervention can improve cognitive function in older adults from the general population who are at elevated risk of developing dementia. The World-Wide FINGERS (WW-FINGERS), launched in 2017 and including over 25 countries, is the first global network of multidomain lifestyle intervention trials for dementia risk reduction and prevention, aiming to reduce risk of cognitive impairment in different geographical, cultural, and economic settings. CAIDE is the risk factor model which was integrated in all the above longitudinal studies and this is why is valuable for our study. Thus, as for our study, the recommendations suggested after the outcome of the risk of developing dementia are based on the FINGER lifestyle interventions.

This study had several strengths, such as the collaboration of multidomain clinical scientists from different scientific fields, psychologists, general physicians, neurologists, computer scientists and each one gave an improved view of the final application on the basis of validity and functionality. Moreover, the selected tests have already the advantage of validation and RUDAS as well as GPCOG are also proposed for administration by the Hellenic Ministry of Greece [49].

This study had also limitations. Though each item separately is accompanied by good grades of psychometric qualities and validity studies, the validation of the application as a whole system is not tested yet. The implementation study is in process and until now statistically significant results are coming up, which are to be announced soon.

Conclusion

We developed a brief to administer multidomain web-based application which combines cognitive tests and biomarkers as a screening tool to predict dementia both in general and multicultural population, for primary care settings. Accordingly, to the outcomes of the tests the patient will receive suitable recommendations concerning changes on lifestyle and wellbeing for minimizing risk of developing dementia and/or referral for further specialised examination for dementia. Further research is needed to validate properly the administration of the specific application. The results from the implementation study and the measurement of satisfaction and usability are to be announced in following study. The implementation study of the specific tool by primary care physicians is still ongoing and the results are to be announced soon. This study is significant not only in that it developed a web-based application that could be integrated in regular GP's wellness visits, but also it combines already reliable and valid weighted measures addressing cognition and biomarkers by utilizing the advances of new technologies. Further research is necessary in the field of early screening dementia based on the best use of technological advantages and robust clinical examination.

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