Web-Based Software Applications for Frailty Assessment in Older Adults: Current Status and Insights Into Future Development

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Abstract

Background: A crucial aspect of continued senior care is the early detection and management of frailty. Developing reliable and secure electronic frailty assessment tools can benefit virtual appointments, a need especially apparent since the COVID-19 pandemic. An emerging effort has targeted web-based software applications to improve accessibility and usage.

Methods: We conducted an environmental scan through MEDLINE and Google searches (last updated on June 1st, 2021) to identify currently available web applications, each of which was evaluated and assigned a rating score based on eight featured categories.

Results: Twelve web-based frailty assessment applications were found, chiefly provided by the USA (50%) or European countries (42%) and focused on frailty grading and outcome prediction for specific patient groups (58%). The categories that scored well among the applications included the User Interface (2.67/3) and the Cost (2.75/3). Other categories had a mean score of 1.5 or lower. The least developed features in the existing web applications included Data Saving.

Conclusions: This is the first study that has compiled a comprehensive list of frailty assessments available online, described their usage and evaluated their advantages and limitations. The study emphasized several essential features with future web application development to support early detection and management of frailty with virtual care.

Background

Frailty is a state of increased vulnerability, reflected by the accumulation of deficits in health with age due to declines in resilience [1, 2]. Frailty can lead to increased risks of adverse outcomes, including hospitalization and mortality [3–5]. The Frailty Index (FI) has been used to assess the level of frailty, calculated as the proportion of health deficits that a person has over the total number of health deficits under consideration [1, 2].

Emerging data have highlighted the relationship between frailty and the COVID-19 deaths and other adverse effects in older adults, who are more likely to have accumulated more deficits of multiple organ systems [6–8]. Following the physical distancing guidelines, virtualized approaches are being increasingly adopted to continue senior care and frailty management while reducing in-person appointments [9, 10]. Besides the pandemic, the older adult demographic is already beset by transportation related issues that prevent easy access to primary care (e.g. mobility problems, lack of caregiver ability to drive, no drivers license, remote area) [11, 12], increasing the need for reliable virtual care.

Web-based health assessments have potential to aid in virtual healthcare. In general, web-based assessments are easy to access, available for free or at a minimal cost, more time efficient, and can allow automatic calculations leading to immediate results [13–16]. With a pressing demand for maintaining physical distancing guidelines, reliable web-based assessments may be especially helpful for the future of frailty assessments.

Frailty assessments have traditionally relied on manual data entry and processing, which can be time-consuming and error-prone [16, 17]. Recent research has enabled an electronic FI calculation in the Electronic Medical Records (EMR) system, which has allowed for frailty measures in primary care for millions of older patients in the UK and several other European countries [18, 19]. More recently, an eFI was constructed based on the electronic Comprehensive Geriatric Assessment (eCGA, a multidisciplinary diagnostic assessment that evaluates many domains of older adults' health and care needs) [20, 21]. Being available in EMR systems and as standalone software that runs on personal computers [20], the eFI-CGA is time-efficient and cost-effective. Even so, accessing the EMR from home can be infeasible, and downloading/installing the standalone version upgrades can be inconvenient.

Motivated to develop a web-based software tool, we conducted a thorough search and evaluation of the currently available web applications for frailty assessment. The purpose of this study is to provide insights to guide future web-based frailty assessment software development, including the web-based eFI-CGA. Our specific objectives were to: 1) understand what web applications exist for frailty assessment; 2) describe the usability of these applications; and 3) evaluate the challenges and opportunities of future web-based frailty assessments.

Methods

Search Terms

We conducted an environmental scan to collect and organize information [22, 23] pertaining to web-based frailty assessments. Google search was chosen as our first source of information, given the focus of the search and the known coverage of Google on online resources. An independent MEDLINE database search was also employed to extract information from peer-reviewed research literature. Two independent researchers (RC and HL) conducted each search (Fig. 1), and last updated the information on June 1st 2021.

The initial searches were performed utilizing three sets of keywords: Set 1: "online" or "web-based" or "website-based"; Set 2: "geriatric" or "frailty"; and Set 3: "assessment" or "software tool" or "application" or "calculator". For the Google search, each individual term in sets 1 through 3 were combined, creating 24 unique search inputs (Appendix 1). For the MEDLINE search, the three sets of search terms were combined to create the search string: ("online" OR "web-based" OR "website-based") AND ("geriatric" OR "frailty") AND ("assessment" OR "software tool" OR "application" OR "calculator"). A "*" sign was used to represent different suffixes of the same word in the search inputs/string where applicable.

Search Methods

Google search: All personal Google accounts were logged out of, and the history, cookies, and cache were reset before each search to minimize the effects of Google search customization. The first 50 results (which was found to be sufficient to cover all relevant material) for each Google search using a unique input term (excluding advertisements) were retrieved. This yielded a total of 1200 initial results (Fig. 1). All the resulted website titles and previews were sequentially screened to include websites related to frailty assessment. The selected websites were then fully scanned to ensure they either hosted a web-based frailty assessment or included a direct external link to a web-based frailty assessment meeting our criteria (Fig. 1).

MEDLINE search: Article titles and abstracts were screened to include the publications discussing frailty assessment. Names of specific frailty related web-based assessments were then extracted from these relevant articles. Using this information, an additional Google search of each of the individual web application names was conducted to ensure the assessment remains available online and meets the selection criteria described below (Fig. 1).

Finally, the results from the Google and MEDLINE searches were combined, yielding a final list of web applications for further evaluation and analysis (Fig. 1).

Selection Criteria

Web-based frailty assessments were considered if they met the following inclusion criteria: (1) related to frailty, (2) had a fillable form for data collection, (3) hosted on a web domain, and (4) interfaced in English. The exclusion criteria were: (1) not available online, (2) only showed a non-fillable PDF version, and (3) not accessible for research or use.

Evaluation and Analysis

Considering the common features of web applications, each application was evaluated applying IEEE recommendations for scoring that consisted of a comprehensive list of criteria [24–30]. The criteria of the evaluation included a total of 13 categories of software features (Table 2). These included user friendly interface, effective data saving, completeness of health domain inclusion, completeness of health item inclusion, completion the cost of usage, results interpretation availability, instructions and training availability, remote access and conductance possibility (Table 2, top panel); and time efficiency of assessment, algorithm efficiency, security, environmental requirements, and browser requirements (Table 2, bottom panel). The categories were relevant to frailty and widespread application potential (e.g. promoting digital health and benefiting virtual care).

For each web application identified, an assessment score was assigned using a rating grade ranging from 0 to 3 for a given category, with higher scores meaning better (Table 2). For a category that could not be adequately evaluated (i.e. missed being reported most websites), scoring of the category was not included in the sum up score, but was still discussed. The evaluation and scorings were conducted independently by two researchers (RC and HL). Any discrepancies were resolved through

discussions between the researchers and consensus were achieved upon the majority vote involving additional researchers (e.g., AM, XS).

Results

The final set of results consisted of twelve web-based frailty assessment applications, all of which were developed over the past five years (2015 – 2020). The majority of the web applications were provided by the USA (50%) and UK or European countries (42%), with a focus on frailty grading and outcome prediction for specific patient groups (58%). The basic information for each of the applications is summarized below and described in Table 1.

Released in 2015, the *Edmonton Frail Scale* consists of 11 assessment items. It provides a simple way to assess frailty in older adults and can be completed in 5 minutes on average.

Also released in 2015, the *Myeloma Frailty Score Calculator* aids in the prognosis of elderly myeloma patients. It assesses 31 items, which can be saved in a PDF document along with the calculated score.

In the following year, the *Johns Hopkins Frailty Assessment Calculator* was released to assess the five-item frailty phenotype [31]. A free trial is limited to 5 calculations; unlimited calculations and guidebook and database access can be obtained with an annual subscription.

The *Geriatric 8 (G8) Health Status Screening Tool* was recently updated in 2017, for used to identify older cancer patients who may benefit from a CGA. Free accounts can download a PDF assessment; a subscription leads to unlimited downloads and the ability to add notes to the PDF.

The *Liver Frailty Index* was also released in 2017 to assess physical frailty in patients with chronic liver disease and/or cirrhosis. It assesses three performance-based items: grip strength, chair stands, and balance, with detailed instructions including diagrams for use.

Also released in 2017, the *QFrailty Risk Calculator* assesses older adults' risk of developing frailty involving over 40 items of 10 health domains. The software estimates the frailty degrees (e.g. "mild" or "severe"), and the two-year hospitalization and death risks.

The *Frailty Risk Calculator* was released in 2018 and estimates the probability of hospitalization or death within the next year.

Also released in 2018, the *Senior Health Calculator* uses the CGA items to produce a FI. Fifty items on medical history, functional status, performance tests, and nutritional status are assessed, and FI calculation can be based only on the first two domains. The input data, FI, and summary may be saved or printed as PDF.

The *Modified Frailty Index* was recently updated in 2019 and assesses the morbidity and mortality risks in older general surgery patients. Free accounts can download a PDF of the assessment; a subscription leads to unlimited downloads and adding notes to the PDF.

The *Frailty Index Calculator*, a simple calculator developed in 2020, allows users to enter the number of health deficits present in a patient and the total number of deficits measured, and gets an FI score using the formula $FI = \text{No. deficits present} / \text{No. deficits measured}$. Users need to have the input numbers ready somewhere else first.

The *Myelodysplastic syndromes (MDS) Specific Frailty Index* was released in 2020 and evaluates frailty in patients with myelodysplastic syndrome. Seventeen items are included to calculate a frailty scale ratio, composite score, and estimated survival outcome. Users may manually copy/paste the input and output to the local computer.

The *Cumulative Illness Rating Scale-Geriatric (CIRS-G)* is a brief assessment that quantifies the disease burden in older adults. The Assessment uses 14 multiple-choice items to produce a frailty score. With a free account, users can copy assessment inputs and results to the local computer.

Eight feature categories could be applied to scoring these web applications (i.e., assigning a 0 through 3 to each category), making 24 the highest possible sum-up score that a web application could receive (Table 2). Figure 2 shows the sum-up scores of these web applications. The two categories that scored with high values among the applications were User Interface and Cost (2.67/3 and 2.75/3, respectively), whereas the other categories had a mean score of 1.5 or lower (Figure 2). The category with the lowest score was Data Saving, with only 4 assessments not scoring a 0, as most of the web applications permitted no or very primitive data saving.

Discussion

We conducted this study to understand what frailty assessment tools are available online and to evaluate their usability considering a large number of feature categories. To the best of our knowledge, this is the first attempt to systematically identify and summarize web-based frailty assessment applications. This is also the first known study that comprehensively evaluates the applicability and limitations of the web applications. The research has allowed us to generate important insights into successful future development of online software tools in support of early detection and management of frailty.

The assessments under evaluation showed several essential merits and have multiple advantages. For example, most applications have developed a highly friendly user interface. One crucial benefit of having a web-based assessment is the convenience and ease of completing the assessment with simple selections and mouse clicks [15, 18]. Assessments realized the functionality through employing radio button selection for “yes or no” questions where appropriate, rather than using the more time-consuming drop-down menus or text boxes. Most applications also appeared to be highly cost efficient. Making assessments available for free will maximize the potential for adoption and impact. Having accessible frailty assessments widely available will encourage use and support for frailty management.

Despite these beneficial qualities, several important areas may be improved in future development of web-based frailty tools. For example, the assessment pages often lacked clear and comprehensive instructions or training materials. Including these is helpful for potential users to accurately and effectively complete the assessment, especially regarding the specifics of some performance items (e.g. specific version of the sit to stand test). Similar arguments can apply to including helpful materials for results interpretation. Even though an assessment produced a score or frailty rating, the number often lacked context for clear meaning without interpretation. Adding this can help make appropriate patient care planning.

It is also worth noting that the existing web applications commonly included limited options for data saving and retrieval. Although copying of the completed assessment might be allowed by some, working with the data or even reloading the saved assessments for processing/editing were typically unmanageable. This feature is needed in scenarios where an assessment must be completed over more than one session due to time restrictions, interrupted internet connections, and other disruptions that patients may experience with virtual care [32].

Further, a majority of the assessments considered only a limited number of health domains and/or total items. Because frailty is a multidimensional syndrome characterized by the loss of physiological reserve in multiple health systems [1, 2] frailty assessments can have improved precision relating the outcomes when a wide range of health domains and items are considered, for a comprehensive overview of patients’ health. In fact, it has been recommended that deficit accumulation based frailty index to include no less than 30 individual items when possible [33, 34].

Our study has several limitations. Our search was limited to Google and MEDLINE. While this is a widely accepted approach, it is still possible that some existing tools only available from less prominent resources may have been overlooked. Additional, focusing on the functionality and usability, the content validity of the web applications is beyond the scope of the current investigation, as each assessment warrants a focused separate study [35]. Also, several categories in the evaluation criteria (time efficiency, security, algorithm efficiency, environmental requirements, and browser requirements) were not assessable due to the lack of data provided by the web applications under evaluation. Information on these aspects can be fundamental in software appraisal [20, 24, 27–30]; future developments are encouraged to take into account these into the implement and report how these aspects are addressed.

Despite these limitations, our study is contributable to the research field and is meaningful to advancing early detection and management of frailty. We have applied the established software evaluation approaches [24–30] for insightful understanding of the applications, highlighting the important features for inclusion in the future development, including our ongoing effort in advancing a fully functional web-based eFI-CGA (<https://efi-cga.ca/>). It is seen that having reliable and effective web-based health assessments will enable virtual care via digital health as a common practice in the future.

This study is also relevant to the COVID-19 pandemic and its prevailing consequences and the upcoming new norms, as it has been established that healthcare providers need flexible health assessments to accommodate physical distancing restrictions [10]. This has been reflected by the rapidly increase number of requests, since the beginning of the pandemic, for obtaining a copy of the standalone eFI-CGA software tool [20]. A more widespread uptake of web-based frailty assessments is anticipated, as they can allow for frailty management to continue throughout times of limited contact, as they are not limited by the need to access and download software. These remarks are amongst the situation that transportation-related issues that prevent easy access to primary care already disadvantage older adults. Given the many reasons why virtual care is useful for seniors and their general positive perspectives towards virtual care and tele-technologies [36], this timely study highlights the currently available web-based assessments and provides insights on developing web applications for use in virtual assessments.

Conclusions

The present study contributes to the literature through informing what web software tools are currently available, what gaps and challenges are present, how they are identified, and can be addressed with future research and development, in meeting the needs of virtual care.

Abbreviations

COVID-19: Coronavirus disease 2019

eCGA: electronic comprehensive geriatric assessment

FI: frailty index

eFI-CGA: electronic frailty index comprehensive geriatric assessment

EMR: electronic medical record

G8: Geriatric 8

MDS: Myelodysplastic syndromes (MDS)

CIRS-G: Cumulative Illness Rating Scale-Geriatric

Declarations

Ethics approval and consent to participate: The study received approval from the Fraser Health Research Ethics Board (FHREB2018-080). This study was an analysis of public websites which involved no human participant enrolment or human data use, and thus consent from participants was inapplicable.

Consent for publication: Not applicable.

Availability of data and materials: All data (i.e., the websites) analysed during this study are included in this published article (Table 1). An additional data file listing the original data (i.e., the websites) and the associated scores assigned for the analysis is also provided (Appendix 2).

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: RC conducted the literature search, review, and evaluation, analyzed the data and summarized the results, and drafted the initial version of the manuscript. HL and AM helped with the literature search and evaluation, results summary and presentation, and the manuscript preparation. GP enabled the funding support, provided medical consultations, review the results, and edited the manuscript. XS enabled research funding, conceptualized the study, reviewed the analysis and result presentation, and co-drafted the manuscript. All authors participated in the result interpretation and manuscript revisions and have read and approved the final manuscript.

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Tables

Table 1. Web-based frailty assessments

Web-based Frailty Assessment Tool	Year¹	Provided by²	Purpose of Tool³	Website URL⁴
Edmonton Frail Scale	2015	QxMD, USA	"A simple tool to assess frailty in older patients"	https://qxmd.com/calculate/calculator_595/edmonton-frail-scale
Myeloma Frailty Score Calculator	2015*	International Myeloma Working Group, collaborative effort involving USA, Canada, and European countries	"Predicts mortality and the risk of toxicity in elderly myeloma patients"	http://www.myelomafrailityscorecalculator.net/Geriatric.aspx
Johns Hopkins Frailty Assessment Calculator	2016	Johns Hopkins, USA	"A standardized, evidenced-based method to assess frailty across clinical and research settings"	https://www.johnshopkinssolutions.com/solution/frailty/
G8 Health Status Screening Tool	2017**	Evidencio, Netherlands	"Identifies elderly cancer patients who would benefit from comprehensive geriatric assessment (CGA)"	https://www.evidencio.com/models/show/1045
Liver Frailty Index	2017*	University of California San Francisco, USA	"A tool specifically developed to objectively measure physical function in patients with cirrhosis"	https://liverfrailtyindex.ucsf.edu/
QFrailty Risk Calculator	2017	ClinRisk Ltd., England	"Works out your risk of developing Frailty"	https://qfrailty.org/
Frailty Risk Calculator	2018*	SmartData, University of Bologna, Italy	"Evaluates the probability of being either hospitalized or dying within next year for over 65 population living in Bologna"	http://smartdata.cs.unibo.it/frailtycalc/
Senior Health Calculator	2018	Beth Israel Deaconess Medical Center, USA	"Collects items of a comprehensive geriatric assessment (CGA) to calculate a frailty index (FI)"	https://www.bidmc.org/research/research-by-department/medicine/gerontology/calculator
Modified Frailty	2019**	Evidencio, Netherlands	"Evaluates risk of both	https://www.evidencio.com/models/show/1777

Index			morbidity and mortality in general surgery patients older than 60 years"	
Frailty Index Calculator	2020	MDApp, England	"Measures health status in elderly people and vulnerability to adverse outcomes"	https://www.mdapp.co/frailty-index-calculator-393/
MDS Specific Frailty Index	2020	QxMD, USA	"Frailty scale specific to those patients with myelodysplastic syndrome that improves prognostication."	https://qxmd.com/calculate/calculator_696/mds-specific-frailty-scale
CIRS-G	Not available from the original source	MDCalc, USA	"Quantifies the burden of disease in elderly patients (comorbidity scale)"	https://www.mdcalc.com/cumulative-illness-rating-scale-geriatric-cirs-g#use-cases

¹ Year the tool was created, unless otherwise indicated below

² Organization/company provided the web application, regardless the original assessment.

³ As described in the tool

⁴ The webpage under the present evaluation

* Publication date of the corresponding article

** Date of last revision

Table 2. Evaluation categories and criteria

* The scoring was based on the top portion of the categories above the bolded line.

Figures

Score	0	1	2	3
Category*				
User Interface	Unreadable or unfillable	Poor readability, poor selection choices	Good readability, poor selection choices OR poor readability, good selection choices	Good readability, good selection choices
Data Saving	Unable to save filled assessment form or results	Able to save assessment results only	Able to save filled assessment form and results	Able to save filled assessment form and results, and reload assessments for edits
Number of Health Domains	< 3 health domains included	3-6 health domains included	7-10 health domains included	>10 health domains included
Number of Assessment Items	< 14 items included	14-25 items included	26-37 items included	>37 items included
Cost	Available for a fee / with subscription purchase	Available with a free trial	Available for free but payment required to access certain features	Available for free or with a free account
Results Interpretation	No interpretation or explanation of results provided	Brief interpretation of results provided (< 5 words)	Sufficient interpretation	Detailed interpretation and/or additional information provided
Instructions and Training	No instructions or training provided	Minimal instructions provided within assessment	Instruction manual or other training resources provided (e.g., video tutorial)	Instructions provided within assessment along with additional training or instructional resources
Remote Conductance	Cannot be completed virtually (i.e. includes mandatory items that cannot be completed remotely)	Can be completed virtually with alterations (i.e. items that cannot be completed remotely are not mandatory)	Can be completed virtually through video call (i.e. assessment includes items that require a video call)	Can be completed virtually through phone call (i.e. assessment does not include items that require a video call)
Time Efficiency	Not reported	>30 minutes on average	20-30 minutes on average	<20 minutes on average
Algorithm Efficiency	Not reported	Polynomial runtime complexity ($O(N^3)$, $O(N^4)$, etc.)	Quadratic runtime complexity ($O(N^2)$)	Linear or logarithmic runtime complexity ($O(N)$ or $O(\log N)$)
Security	No login/account security, data access security, or server security	Includes one of: login/account security, data access security, or server security	Includes two of: login/account security, data access security, or server security	Includes login/account security, data access security, and server security
Environmental Requirements	Dependant on multiple third-party applications;	Few (<3) external third-party applications are	External software dependencies are packaged	No external software

	sophisticated hardware/software tools required to use the application (e.g. latest model of iPhone/iPad, minimum 8 GB of RAM)	required for the tool operate; software is platform specific (e.g. only works on Windows/MAC/iOS/etc.)	and installed with the assessment tool; software runs on all desktop operating systems or all smartphones (e.g. is available on Android and iOS)	dependencies exist for the software; software can be accessed and operated on all digital platforms.
Browser Requirements	Compatible with minimum browsers (1).	Compatible with limited browsers (2)	Compatible with more browsers. (3-4)	Compatible with most major browsers (≥ 5)

Figure 1

Flow diagram showing searches on Google and MEDLINE

Figure 2

Graph comparing the total scores of each assessment. * The scoring was based on the categories as given in the legends. Additional categories (time efficiency, security, algorithm efficiency, environmental and browser requirements) could not be scored due to limited information from the applications under evaluation.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryMaterial.docx](#)