Original Article

Care4Value: measuring value in health in Integrated Continuous Care Units

Care4Value: medição de valor em saúde em Unidades de Cuidados Continuados Integrados
Care4Value: medición del valor en salud en Unidades de Cuidados Continuos Integrados

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Abstract

Objective: To develop a digital platform for optimizing data collection processes with medical scales and monitoring data for measuring value in health.

Method: Using an investigative intervention methodology, a platform was developed including qualitative and quantitative approaches in three phases: focal groups were conducted by a multidisciplinary team of investigators and healthcare providers at the pilot study site, an Integrated Continuous Care Unit (UCCI); data from a sample of 21 UCCI users was analyzed as a pre-test to classify different levels of complexity; UCCI financial data and operational costs were collected and analyzed during the 21 users stay at the UCCI. The platform's iterative and incremental development allowed for the collection of as a form of improvement.

Results: The platform includes three modules: a mobile application; a dashboard; and an import module. Data collected on the platform are centralized and shown on the dashboard. Data are collected using a mobile application and/or an import module to input data from existing medical systems.

Conclusion: The mobile application is ready to be used by healthcare providers and caregivers. The dashboard shows users' clinical follow-up and health gain data for monitoring.

Resumo

Objetivo: Desenvolver uma plataforma digital para a otimização do processo de coleta de dados de escalas clínicas e monitoramento desses dados com vista à medição do valor em saúde.

Métodos: Por meio de uma metodologia de investigação-ação, o desenvolvimento da plataforma incluiu abordagens qualitativas e quantitativas, em três fases: grupos focais com uma equipe multidisciplinar de investigadores e profissionais de saúde da UCCI do estudo-piloto; análise dos dados clínicos em formato de pré-teste de uma amostra de 21 usuários da UCCI para categorizar diferentes graus de complexidade; e, análise de informação financeira, aos custos operacionais da UCCI, relativa ao momento de permanência dos mesmos 21 usuários. O desenvolvimento iterativo e incremental da plataforma permitiu coletar *feedback* dos usuários como forma de melhoria.

Resultados: A plataforma inclui 3 módulos: *aplicativo* móvel; *dashboard*; e módulo de importação. A plataforma centraliza os dados coletados e disponibiliza-os por meio de um *dashboard*. Os dados são coletados por *aplicativo* móvel e/ou por um módulo de importação que consome dados de sistemas clínicos existentes.

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Conclusão: O *aplicativo* móvel está apto a ser utilizado por profissionais de saúde e cuidadores, e o *dashboard* apresenta informações de acompanhamento clínico dos usuários e monitoramento dos seus ganhos em saúde.

Resumen

Objetivo: Desarrollar una plataforma digital para optimizar el proceso de recolección de datos de escalas clínicas y monitoreo de estos datos con el fin de medir el valor en salud.

Métodos: Mediante una metodología de investigación-acción, el desarrollo de la plataforma incluyó enfoques cualitativos y cuantitativos, en tres fases: grupos focales con un equipo multidisciplinario de investigadores y profesionales de la salud de la UCCI del estudio piloto, análisis de los datos clínicos en formato de prueba piloto de una muestra de 21 usuarios de la UCCI para categorizar los diferentes niveles de complejidad, y análisis de la información financiera, costos operativos de la UCCI, relativos al momento de permanencia de los mismos 21 usuarios. El desarrollo repetitivo y progresivo de la plataforma permitió recolectar *feedback* de los usuarios como forma de mejoría.

Resultados: La plataforma incluye tres módulos: aplicación móvil, *dashboard* y módulo de importación. La plataforma centraliza los datos recolectados y los exhibe mediante un *dashboard*. Los datos son recolectados por aplicación móvil o por un módulo de importación que consume datos de sistemas clínicos existentes.

Conclusión: La aplicación móvil es apta para ser utilizada por profesionales de la salud y cuidadores, y el *dashboard* presenta información de seguimiento clínico de los usuarios y monitoreo de sus ganancias en salud.

Introduction

An increasingly aging population associated with rising health costs has become a cause for concern in developed countries, especially in sceneries of prevalent chronic conditions. This is of special relevance for health units that offer care for chronic patients presenting with multipathology-caused multimorbidities, as is the case of Portuguese Integrated Continuous Care Units (UCCI). Thus, it is critical for UCCIs to be able to measure, monitor, and predict health costs and outcomes per user, expanding the required knowledge to actualize the value created for users and caregivers, in terms of both outcomes obtained per monetary cost and improvements in quality of life.[1]

A deeper analysis of health indicators is paramount, especially in users presenting with multimorbidities. Value-based measurement of health outcomes is a user-centric approach that implies defining the set of outcome standards valued by users when seeking healthcare, such as functionality and quality of life.[1,2] Thus, the model developed under this project characterizes the user' medical condition based on assessment scales and classifies it in different levels of complexity. It will then be possible to predict direct impact on care costs and measure individualized outcomes in health. This setting requires:

- an integrated data collection, processing, analysis, comparison, and report model that shows the connection between health costs and outcomes;[2]

- innovative and user- and caregiver-centric tools that facilitate data collection by healthcare providers.

This will support decision making by healthcare administrators and providers focusing on organization quality, efficiency, and sustainability and creating value in health.[2] The authors have insofar verified that value in health is measured only by some acute care institutions, but not by UCCIs.

One of the challenges with health information systems is collecting data in a structured and automatic way.[3] Medical scales consist of instruments of various sources and forms of collecting information, such as assessment and classification scales; medical observation indexes; and screening, observation, and interview tools. Each assessment instrument generates a final numeric score or index that provides additional information about a users' specific state or condition. Medical assessment scales are virtually information collection instruments used to obtain data that connects the user's physical, social, and spiritual state of health. Healthcare providers use these scales to monitor (sometimes daily) various health indicators to understand each user's progression, allowing them to conduct their work more effectively. Currently, certain validated scales are already used in UCCIs, but their daily application is still predominantly manual, both paper-based or on digital tables.[4-16] Even though there are information systems prepared to collect medical scale data, practice suggests that most UCCIs have specific needs that require customizing these sys-

tems by adding parameters for scale selection and scale configuration. On the other hand, assessment instruments and scales are applied daily, but are not used to systematically and regularly assess and monitor users' medical conditions by healthcare providers and administrators, who can also begin using them to determine value in health.

Developing a digital platform to optimize medical scale data collection and monitoring to measure value in health constitutes this study's objective. Data collected via medical scales were used as a basis to reach this objective. In other words, the authors developed a digital platform to optimize and aid in data collection, as well as to monitor and view users' medical data, and calculate value in health.

The Care4Value Platform is a potential solution of relevance for healthcare providers in Portugal, especially those directly involved in proving care at UCCIs. Part of the daily routine at UCCIs stills consists of outdated procedures involving information redundancy. On the long term, tools developed under this study are intended to make healthcare providers' tasks easier, as well as provide information on collected data, allowing them to better plan care, manage available resources, and measure health outcomes per user.

Methods

This is an investigative intervention study integrating the Care4Value Project (Figura 1) conducted between October 2017 and July 2019 in three different phases. The Care4Value Project involved a multidisciplinary team that included Health, Business, and Information Engineering experts from different Central Portugal regions (Leiria, Santarém, and Coimbra). The Care4Value Platform's pilot study site was a prolonged stay UCCI in the District of Leiria that integrates Portugal's National Network for Integrated Continuous Care. Its main patient population are adults presenting with chronic conditions, and it offers services ranging from rehabilitation to prolonged UCCI stay.

In the first phase, three focal groups were conducted by our investigation team to establish what were the relevant health assessment dimensions that affected measuring value associated with care at the UCCIs. Focal groups were conducted between December 2017 and February 2018 with a total of 12 individuals, including: UCCI healthcare providers (doctors, nurses, a social worker, a physiotherapist, a nutritionist) and research team members (economists, information engineers, nurse). Each session lasted 2 hours. Content of group results and consensuses was analyzed to identify these dimensions and the different levels of complexity in users' medical conditions. Concurrently, this analysis revealed the medical scales already in use at the UCCI to measure each these dimensions. The set of assessment scales identified in the pilot study was used by the research team to obtain a numeric score to classify users' medical conditions based on the information gathered on their state of health (Figure 2).
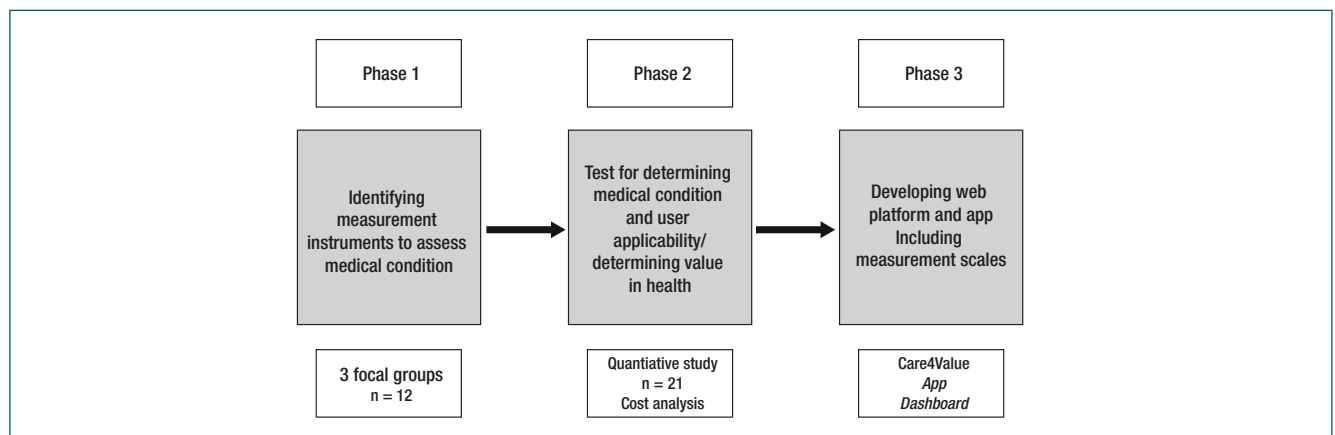
Figure 1. Study design
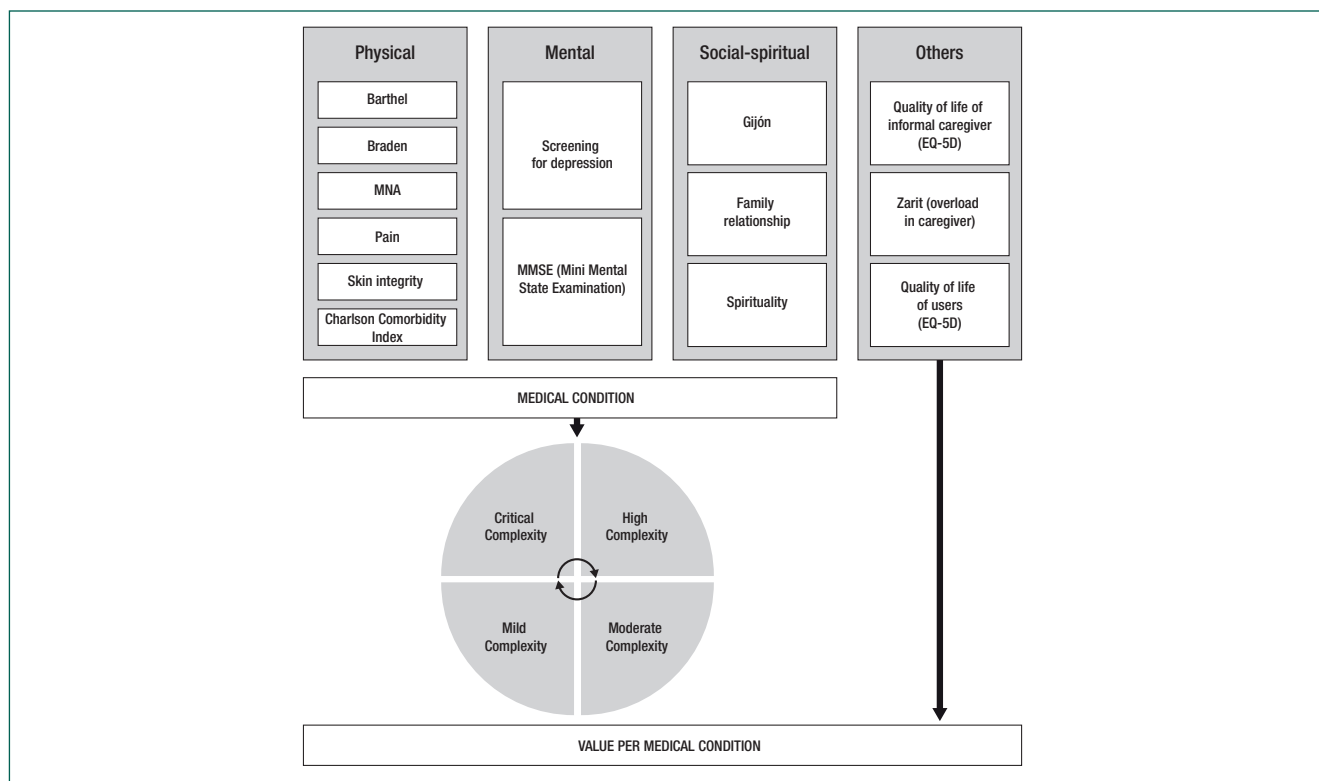
Figure 2. Calculating medical conditions and associated costs

Instruments and medical scales selected for the project's data collection process include: the Barthel Index,[4] the Braden Scale,[5] an assessment tool for skin integrity (as per the NPUAP pressure ulcer classification),[6] the Mini Nutritional Assessment (MNA),[10] the Numeric Pain Rating Scale (NRS-11),[11] Gijón's social-familial evaluation scale (SFES),[7] and the Mini Mental State Examination (MMSE).[12]

Focal groups results also reported that the Charlson Comorbidity Index,[9] a scale for the assessment of spirituality in health settings[13], and a family relationship scale[6] could be used to classify medical conditions more precisely, as these would reflect all dimensions of a holistic view of health.[14]

Additionally, two additional medical scales were used to obtain user experience information: (a) the EQ-5D to measure user/family caregiver quality of life,[8] and (b) the Zarit Burden Interview to assess caregiving burden.[7]

The model for calculating medical conditions attributes each individual scale and axis different weights. The weighting's final result assesses the user's baseline state when admitted to the UCCI, classifying them into medical conditions based on level of complexity (Critical Complexity, High Complexity, Moderate Complexity, and Mild Complexity).

In the second phase, the research team conducted a quantitative analysis of medical data as a pre-test with a sample of 21 users to classify them in the different levels of complexity and define the medical conditions to be shown on the platform. This process allowed for validating the medical scales selected during the focus groups. Process results were validated by the healthcare providers involved.

A concurrent analysis of the UCCI's financial information and operational costs was conducted. The analysis included information about the 21 users' stay at the UCCI. The resulting costs model allows for calculating a cost value per medical condition.[2,17]

Medical scales used in the project measure the user's physical, social, and spiritual condition, the three axis around which medical conditions are structured and calculated (Figura 2).

The resulting models for calculating medical condition and cost (cost value per medical condition) were parametrized on the Care4Value digital platform, which was especially developed under thus study and is described in the following section (third phase, figura 1).

The study was duly submitted to and approved by an Institutional Review Board and by the study site's UCCI. Throughout all research phases the Helsinki Declaration's principles were warranted. Data pertaining to users and their families were collected by the medical team and provided to researchers as raw anonymous data, with no possibilities of linking users and their families to the collected data.

Results

The Care4Value Platform was used by different users divided into three groups: Caregivers, Healthcare Providers, and Investigation Team. Depending on user profile, different resources will be shown to meet the user's needs (Figura 3, left).

The mobile application can be used by caregivers and healthcare providers to collect data on the user's state of health. They are the main persons responsible for monitoring users and adequately answering medical scales. The application allows users to collect and send the required data to a centralized system (the Care4Value server).

The dashboard can be used by healthcare providers and the investigation team. Its main resources are viewing user progress and user classification based on medical condition. This information is collected and centralized on the Care4Value server.

The Care4Value Platform (Figura 3, right) has three main modules: (1) a mobile application; (2) a dashboard; and (3) an import module. The import module is a customized adapter that automatically imports data from existing medical and financial systems (MedicineOne,[18] Primavera Software[19], and the newly developed GUCC[20]), making them available to the other two modules.

The mobile application is mainly for data collection purposes and supports the two most common operating systems, Android and iOS.

The dashboard is a data viewing web application available from the domain: http://care4value.pt.

The import module is the integration component that allows the platform to automatically collect data from existing systems, providing future interoperability between this recently developed platform and the UCCI's previously existing systems. Currently, these systems contain a large data set collected by healthcare providers and ensure clinical follow-up of users, as well as the fulfillment of operational and legal demands. The partnering UCCI's initial medical systems provide an export method to output the desired data at a known or standard format (Excel and/or XML). After changes were made to the existing medical systems, it was also necessary to consider how to support importing data from other systems currently in use (in JSON format).

Mobile application

Health units collect a considerable volume of medical information from its users daily, mainly using the
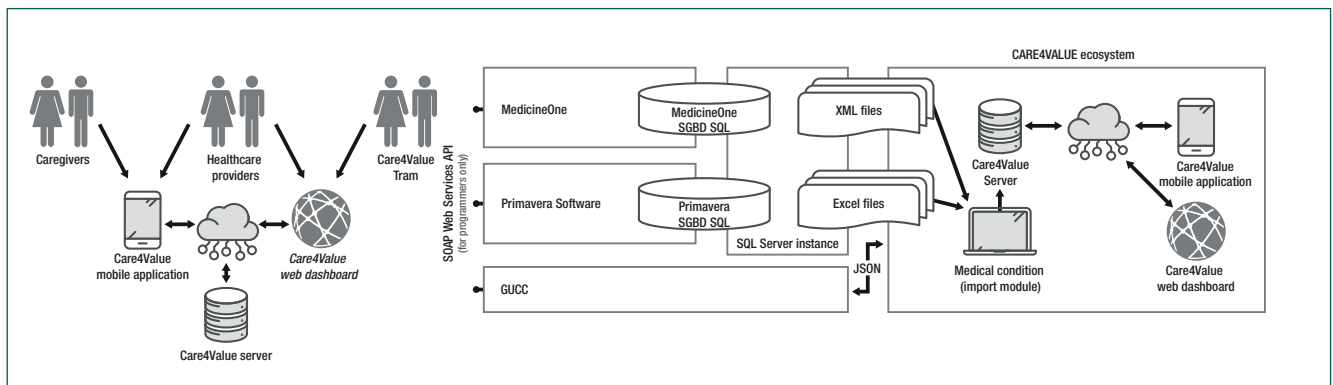

Figure 3. Care4Value Platform user groups and modules

aforementioned medical scales. At this case study's UCCI, data collection is mainly manual. Data are later input into a digital table and replicated to the various information systems in use.

Care4Value is a data collection application that simplifies and centralizes the required user data. Medical scales applied by healthcare providers daily are included in the app, and data can be collected in the user's physical presence (Figura 4 (a)). Each scale briefly summarizes the number of questions and shows a brief description of its objectives. Scales are shown in the mobile application depending on the healthcare provider logged in the application. This setting, as well as each scale's structure, can be parametrized in the dashboard module, ensuring confidentiality of the obtained data according to system access level.

Healthcare providers can then select which scales to fill out for a given user, and data collected are directly synchronized to the centralized server (Figura 4 (b)). This resource provides healthcare providers with an efficient use of time, as the scale can be paused at any given time in the data collection process, and the user can return to it and finish it later — in which case the "Em Progresso" (In Progress) status will be shown. The percentage of data collected with the scale can be viewed at any time. Healthcare providers can see data that have already been filled out and filter it by user, date range, state, and other relevant fields, which contributes to a better perception of each user's progress.

Medical scales available to healthcare providers can be managed on the Platform's dashboard. When scales are created or updated, they are shown in real time on the mobile application. Currently, there are 17 medical scales available for use, but the data available can also be configured to meet healthcare providers' changing needs. Thus, adding a new scale to the mobile application is as simple as creating an entry for this scale on the dashboard.

Likewise, healthcare providers can collect data from several users simultaneously, fill out missing data, and simply synchronize the mobile application to the server when the questionnaire is concluded.

Filling out answers to questions on a medical scale consists of selecting options or values (Figura 4 (c) and (d)). On some scales, this value may influence the final score (Figura 4 (e)) and will be shown as soon as all questions defined as required are filled out.

Another one of the mobile application's relevant aspects is the ability of healthcare providers to collect data offline. Healthcare providers may use the application to fill out scales when and where desired, synchronizing it back with the server when there is access to a network connection (either wireless or 3G/4G networks). Users can then use their mobile devices offline whenever, in poor connection areas or without any access to wireless networks. When offline, all data will be locally stored on their mobile devices.

Lastly, we point out that healthcare providers can have real-time feedback on the results of med-
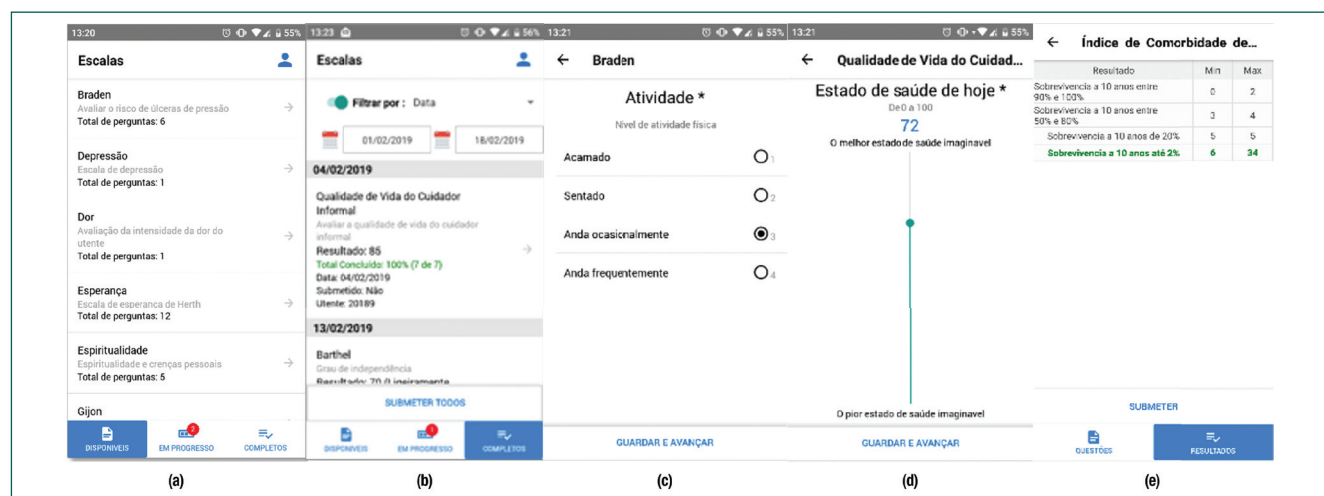
The mobile application is dynamic, as shown in Figure 4 (a) that shows the Herth Hope Index. This Index was later abandoned for the spirituality scale.

Figure 4. Scales, questions, answers, and results on the Care4Value mobile application

ical scales (scores). After answering the scale's required questions, the mobile application provides the user's corresponding score(Figura 4 (e)).

Dashboard

The dashboard allows for viewing data and operates as a backoffice resource. It is essential for data to be collected effectively on the mobile application. The dashboard provides scales with the required structure for data to be collected on the mobile application. It supports the required authentication process and ensures data are persisted in a centralized and structured way. In agreement with recent changes in the European regulation for collection and analysis of data and considering the sensitive data involved in the project, a General Data Protection Regulation (GDPR) Data Processing Agreement was submitted to an Ethics Committee and approved.[21]

The dashboard allows any registered user to be authenticated. The appropriate safety measures were applied to ensure all confidential data were accessed by authorized users only.

One of the application's most important resources is the management of medical scales, namely by configuring questions and response options for each medical scale.

The following resources can be found on the dashboard:

- creating new medical scales and questions, response options, and final score calculation mechanisms;
- updating medical scales;
- managing users on the platform (dashboard and mobile application);
- managing user access to the platform;
- attributing or revoking user access to medical scales;
- exporting existing data to data models that can be easily, visually, and automatically interpreted (Excel and JSON);
- importing, analyzing, and formatting previously obtained data from other platforms (communicating with the import module; Excel and XML).

The dashboard includes a set of visual resources that add value to the system on an information viewing level. It is currently under development, and it is predicted as a value-adding tool for several user profiles.

Discussion

Creating models that measure value in health has been felt as an increasing demand for health systems, as a way to develop an adequate response to its users' needs.[17,18] Current challenges include people-centric strategies for managing care with result monitoring supported by information systems, which need to be both user friendly and able to evidence value in health per unit of cost.[1-3] Insofar as the authors have been able to verify, experiences of creating value in health are mainly set in the context of acute conditions and lack the use of information technology to measure results.[2] Multimorbidity has a high cost, especially in the setting of chronic conditions. Additionally, it is difficult to measure the value health services aggregate to its users, and this is a growing cause for concern for health systems.[2,17] Global metrics are not always focused on what really matters to the user.[1] This study has shown it is possible to create value in care in the setting of chronic conditions and multimorbidity by optimizing data collection and interpretation based on medical condition. This study's main contribution is the creation of a digital platform for collecting medical data consisting of: (a) a model for automatic determination of the multimorbidity user's medical condition due to chronic conditions; and (b) a cost model that can be parametrized.

Given it is essential for unique and replicable models to be created in several settings, the digital Care4Value Platform was shown as a valid response to begin determining value in health in association with chronic conditions. Its use in the pilot-study phase allowed for improvements to be made based on user feedback obtained with an investigative intervention methodology and on a continuous improvement process. This process was supported by a team who collaborated to create a technology tool in service of users, facilitating multidisciplinary data collection by healthcare providers at the time

of care and allowing for optimization of user care and better time management. System interoperability allows for an outcome monitoring curve and the medical condition's consequent progress to be shown on the platform, which allows for care plans to be adjusted to users' needs.[1,2]

This study also contributes to the practice of nursing, once data collected on the digital platform optimize service and improve the quality of care offered to users by involving them in the planning of care. The data collection mobile application can be used by healthcare providers and caregivers and with data from other medical and finance information systems. The dashboard can then show valuable information for clinical follow-up of users and their caregivers, which adds value to monitoring not only user health but also the burden experienced by informal caregivers.

Additionally, it also contributes to management and orchestration functions within health institutions by showing costs and associated value, allowing them to follow up on users' global health progress and eventually even predicting initial costs and value.

This study also presents some limitations. Firstly, it was not possible to move to in-field usability tests that the authors consider essential to identify potential flaws in operation and validate the platform. Viewing user progress and predictive progress models from UCCI admittance also need a deeper study. Platform interoperability needs on a data level generate one of the main safety concerns that we hope to mitigate in the near future, by making data safe and interchangeable. Lastly, this study involved providers and users from a single unit and, for this reason, results obtained cannot be extrapolated to other settings. We predict implementing the project at the study's UCCI may indicate the potential to expand to other UCCIs.

Conclusion

The Care4Value Platform provides a mobile application for healthcare providers that facilitates daily reporting tasks. On the other hand, the Care4Value dashboard provides visualization and data monitoring services for interpreting collected data, in addition to supporting the centralization of collected data. On a strategic and operational level, Care4Value allows for the development and implementation of a model for an information and management control system that maximizes value creation (outcomes in health per Euro spent) based on user information obtained upon their admission to the UCCI, as well as throughout their stay, and upon discharge.

Acknowledgment

Contributions

All authors substantially contributed to the design of the project; analysis and interpretation of data; and contributed to the final version. Reis CI, Maximiano MS, Ferreira PH, and Querido AI drafted the manuscript. Sargento AL, Carvalho HA, Leal SC, and Oliveira SM equally provided critical feedback.

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