

Review Article

Approaching Mental Health Through a Preventive Data Analysis Platform

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Abstract

The rising prevalence of chronic diseases and the aging population globally are diminishing the overall quality of life, especially for those with demanding daily routines. As medical advancements extend lifespans, the proportion of individuals over 60 is set to double by 2050, necessitating societal shifts toward health-responsible citizenship. Despite longer lifespans, evidence suggests that older age often accompanies mental health challenges such as anxiety, depression, and substance misuse. Social isolation and loneliness further compound these issues, affecting both physical and mental well-being. Digital wellness empowers individuals to take charge of their health, promoting proactive care and literacy to foster health-conscious citizenship.

This paper explores the intersection of mental health, aging populations, preventive wellness initiatives, and health literacy, emphasizing their significance within the Health 5.0 framework, especially for older adults. Traditionally, health regulators offer static workflows for adopting standard procedures in health and well-being, reflecting a reactive approach. However, the evolving landscape of wearable and mobile devices connecting to healthcare IT systems through secure online networks necessitates a shift. Technology now facilitates remote patient monitoring and telemedicine service subscriptions and empowers individuals to manage their health proactively.

The BE4YOU project, conducted in Portugal, serves as a case study, facilitating individual maintenance of health and well-being through intelligent and dynamic workflows, which are defined based on analytical models considering each person's risk profile. By facilitating data sharing, promoting healthy lifestyles, and enabling early detection of mental health issues, the project leverages technology to support personalized monitoring and enhance overall health outcomes. Through technology-driven empowerment, individuals and healthcare professionals are better equipped to assess risks and ensure ongoing wellness monitoring, underscoring the role of technology in fostering personal health and supporting healthcare effectiveness.

Introduction

Aging is a global phenomenon in both developed and developing countries. The World Health Organization (WHO) predicts that the global elderly population will exceed 12% to 22% by 2050 [1]. This aging implies the need for society to become more responsible for its health and well-being. As the population ages, especially in Europe, where the proportion of older adults is expected to increase significantly, the prevalence of chronic diseases is also likely to increase. Older individuals often have chronic conditions such as cardiovascular disease, diabetes, and dementia, which can increase feelings of loneliness and social isolation [2,3]. These factors contribute significantly to mental health problems, especially among those with stressful lifestyles. Prevention and treatment of these health issues are fundamental to reducing the need for health services and the costs related to treatment [4].

The concept of active aging is relevant for individuals and populations, as it enables people to achieve their maximum potential for physical, social, and mental well-being throughout their lives. This involves facilitating participation in society according to your needs, desires, and abilities [5,6]. Mental health significantly influences individuals' well-being and quality of life in different societies [7]. Given this growing public health problem, many countries emphasize the importance of improving health literacy and promoting health-conscious behaviors [8]. The link between loneliness, social isolation, and mental health disorders transcends specific age groups, affecting both young people and older adults. While younger individuals may face these problems due to factors such as social media addiction or academic pressure, older adults may face isolation due to retirement, loss of social networks, or physical health limitations. Regardless of age, the impact on mental health can be profound, leading to adverse outcomes if not addressed [9].

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A lack of social connections can lead to feelings of isolation, hampering mental health problems such as anxiety, depression, and substance abuse [10]. Research indicates that individuals who experience loneliness are more likely to develop depressive symptoms, as they do not have the social support necessary to deal with stressors [9,11,12] effectively. Likewise, social isolation can contribute to high levels of anxiety, as individuals may feel disconnected and unable to rely on support or validation from others [13].

In the current technological landscape, personalization and responsible health citizenship are central principles of the Health 5.0 framework [14]. This approach advocates individual engagement in proactive healthcare practices and encourages personalized wellness initiatives while highlighting the importance of promoting community health literacy and social awareness. Creating a sustainable healthcare system depends on creating a generation of health-conscious citizens who are knowledgeable about the factors that influence their health and well-being. By empowering individuals, especially digital natives who rely heavily on technology for information, with the necessary skills and knowledge, they can make informed decisions, adopt preventive measures, and improve their well-being through digital well-being [15].

This paper explores the interplay between mental health domains, active population aging, preventive wellness measures, and health literacy as tools to enhance the quality of life, particularly for senior adults. The BE4YOU project serves as a case study to highlight its primary accomplishments. Conducted in Portugal, the project aims to support individuals in maintaining their health & well-being. This is achieved by collecting individual data, processing analytical data algorithms to determine risk indicators, and involving healthcare professionals from various fields to promote social awareness regarding health & well-being.

The BE4YOU case study provides an example of how a web-based responsive platform can assume a key role in proactively engaging individuals to become health-conscious by delivering educational resources, self-help tools, and follow-up interventions for effective mental health management. Follow-up plans tailored to their health profile and age-related needs, addressing issues like alcohol and drug-related disorders, might also contribute to monitoring aspects related to loneliness and social isolation, fostering the adoption of healthier habits and enhancing well-being [16].

Based on calculated risks, individuals are provided with personalized follow-up plans and informed of the necessary actions to be taken. The presented case study also shows that digital wellness can mitigate the risk of anxiety, depression, and substance abuse, connecting to supportive communities for collaborative sharing and professional support.

The project strives to leverage technology to assist

individuals and healthcare professionals in assessing risks and ensuring ongoing personalized monitoring. By empowering individuals to track their wellness status and progress, the project emphasizes the role of technology in enhancing personal health and the overall effectiveness of healthcare professionals.

Citizenship empowerment in the field of mental health

The contribution of technology to health-accountable citizenship: The integration of technology, particularly mobile solutions interconnected with the Internet of Medical Things (IoMT), holds significant promise in advancing health-conscious citizenship and tackling mental health challenges like anxiety, depression, and substance abuse. Yahara, et al. [17] observed that using immersive virtual reality to induce remote reminiscences can result in reduced anxiety in patients diagnosed with mild cognitive impairment [17].

IoMT technology encompasses a range of wearable and mobile devices designed to support data collection for various healthcare purposes. For instance, Wearable IoMT devices (aka, on-body IoMT) are attached to a person's body to monitor and record multiple medical parameters and health-related data. These devices can be categorized as consumer-grade or medical-grade [18]. Consumer-grade wearable devices, such as smartwatches and fitness trackers, are widely accessible and primarily used to track health metrics like heart rate, physical activity, and sleep patterns. On the other hand, medical-grade wearable IoMT devices are typically used under the supervision of healthcare professionals and are designed to monitor specific medical conditions or deliver medical interventions. Health-conscious citizens can use smartphones to remotely monitor health parameters measured by medical devices such as glucose monitors and blood pressure cuffs. Mobile devices often integrate with cloud platforms, securely storing and analyzing collected data, facilitating data collection automation, personalized healthcare delivery, and triggering health-context awareness for proactive or timely interventions [18].

Mobile solutions integrated with IoMT facilitate real-time monitoring and collection of health data. Through mobile devices, individuals can track vital signs, activity levels, and other metrics, gaining valuable insights into their well-being and identifying potential risk factors for mental health issues. This proactive approach empowers individuals to take control of their health, making informed decisions to prevent health deterioration. Moreover, digital natives, accustomed to technology, are more likely to engage with mobile health solutions, creating opportunities for healthcare providers to deliver personalized interventions tailored to their preferences and needs. Additionally, IoMT-connected mobile solutions facilitate access to supportive communities and resources, fostering peer support, shared experiences, and encouragement for effective mental health management [19].



By leveraging technology, individuals can enhance their overall well-being and create a more health-conscious society prioritizing proactive health management and community support. It also facilitates communication and collaboration between individuals and healthcare professionals (e.g., enabling remote consultations with mental health professionals), offers convenient expert guidance, and provides access to online support.

Aging and mental health: As individuals age, embracing healthy behaviors can lead to a more active and higher quality of life. “Active aging” enables older adults to live healthily, engaging in various physical, mental health, and risk-related aspects [7]. In this domain, mental health-related issues, including alcohol and drug-related disorders, significantly impact the quality of life for senior adults in Europe [20,21]. Portugal, in particular, had the highest prevalence of mental diseases in the European Union, affecting 19.3% of its population, and when considering alcohol and drug-related disorders, it rises to 23.2% [22]. Depression and anxiety are among the most common mental health problems, affecting more than 20% of elderly individuals, with depression symptoms increasing after age 55 [21]. Such conditions can significantly reduce the quality of life and increase dependency on others [1].

Behavioral factors and exposure to health risks, including smoking, alcohol consumption, and physical inactivity, can significantly impact older adults’ health in the long term [20]. Despite a slight decline in alcohol intake during adulthood, Portugal maintains one of the highest rates in the EU. Over half of the country’s residents reported daily (21%) or regular (37%) alcohol consumption in the past year, with higher daily rates among men aged 55 - 74 [23]. These findings underscore the impact of such behaviors on mental health and the urgency of promoting healthier lifestyles among older adults for overall well-being. Furthermore, Portugal remains notable in the OECD for its high consumption of hypnotic, sedative, and anxiolytic drugs, particularly benzodiazepines, attributed to urban living and persistent stress [24]. While there has been a reduction in consumption, over 85% of benzodiazepines/anxiolytics are still used, with a rising trend observed among older individuals and females.

While tobacco consumption has gradually declined recently [25], approximately 17% of the population aged 15 or over still reported smoking, with 14.2% being daily smokers, according to the 2019 National Health Survey. Tobacco use is linked to several health problems, including cardiovascular disease, cancer, and respiratory issues. Encouraging smoking cessation or preventing its initiation is a vital and health-beneficial decision [20,26].

Health platforms offer opportunities for individuals to identify their specific needs and tailor lifestyles conducive to their well-being. BE4YOU’s personalized follow-up plans exemplify how technology can promote mental health

literacy, enabling citizens to make informed choices about adopting more impactful health practices aligned with their preferences and needs.

Materials and methods

The development of the BE4YOU platform, aligned with Health 5.0, transcends the conventional focus of treating illnesses and encompasses a holistic approach to promoting health, namely mental health and general well-being. In the context of the Be4You case study, data governance focuses on managing data related to Mental Health, including awareness of modifiable factors that affect the quality of life, especially for adults over 45 years of age.

First, individual data is collected and technologically processed using analytical algorithms and artificial intelligence to determine each person’s health risk indicators. Individuals receive personalized monitoring plans based on these risks and are informed about the necessary actions. Risk levels concerning stress, depression, anxiety, and substance use are assessed by the Anxiety, Depression, and Stress Scale (EADS-21) [27] and by the Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST) [28].

Instruments

Anxiety and Depression Stress Scale (DASS-21) [27] to track and monitor stress, anxiety, and depression. Composed of 21 statements, it assesses the intensity of significant symptoms in clinical and non-clinical groups, using a four-point Likert scale that ranges from 0 (did not apply at all) to 3 (applied a lot or most of the time). Before interpreting the scores, the numbers for each subscale are multiplied by two. The version for Portugal was validated by Pais Ribeiro, et al. [27], and the detailed items for each DASS-21 subscale are presented in Table 1.

In Table 2, we find DASS Severity Ratings. Before interpreting the scores, the summed numbers on each subscale need to be multiplied by two. If the person scores high on any problems, it may be necessary to consider seeing a specialist who can conduct a clinical interview.

The Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST) [28] is utilized to detect alcohol, caffeine, tobacco, or anxiolytic/sedative consumption. The instrument is adapted through a cultural adaptation process outlined by the WHO (2010). It consists of 8 questions related to the use of psychoactive substances, covering tobacco, alcohol, cannabis, cocaine, stimulants, sedatives, inhalants, hallucinogens, and opiates or other substances. The ASSIST is user-friendly, enabling easy application, measurement, and interpretation of results. Table 3 presents the scores, risk levels, and corresponding interventions.

We may conclude that early detection of mental health problems and guidance on follow-up plans is crucial for developing empowerment concerning mental health.



Table 1: DASS-21 subscales, items, and definition.

Subscales	Stress	Anxiety	Depression
Items	1, 6, 8, 11, 12, 14, 18	2, 4, 7, 9, 15, 19, 20	3, 5, 10, 13, 16, 17, 21
Definition	difficulty relaxing, nervous tension, irritability, and restlessness	physiological overarousal, fears, and situational anxiety	unhappy mood, lack of self-confidence, hopelessness, worthlessness, lack of interest in involvement in love affairs, lack of enjoyment in life, and lack of energy and strength

Table 2: DASS Severity Ratings and actions recommended in the follow-up plan.

Subscales	Stress	Anxiety	Depression	Actions
Normal	0-14	0-7	0-9	Recommendations* to prevent stress, anxiety, and/or depression*
Light	15-18	8-9	10-13	Recommendations to prevent stress, anxiety, and/or depression*; Monitoring whenever you feel the need
Moderate	19-25	10-14	14-20	Recommendations to prevent stress, anxiety, and/or depression*; Suggestion to consult a health professional
Severe	26-33	15-19	21-27	Recommendations to prevent stress, anxiety, and/or depression*; Suggestion Specialised services
Very severe	≥ 34	≥ 20	≥ 28	Recommendations to prevent stress, anxiety, and/or depression*; Suggestion Specialised services

* Healthy lifestyles (food; physical exercise; coffee consumption; sleep; socialization) and relaxation techniques.

Table 3: ASSIST, List of Results, Risk Levels, and Respective Interventions.

Level of Risk	Alcohol	Other Substances	Problem	Actions
Low	0-10	0-3	Abstinence or risky consumption	Information; Education
Moderate	11-26	4-26	Risk consumption	Information; Guidance on actions to reduce risk; Monitoring
High		27 ou +	Probable dependence	Information; Specialised healthcare referral

Adapted from WHO (2003).

Results and discussion

Data governance for mental health monitoring plans

In the digital wellness paradigm, data governance is essential, orchestrating business processes and maximizing data use for informed decisions. This entails a comprehensive framework, policies, and procedures for ethical data management. In BE4YOU, data governance centers on managing Mental Health data, especially for senior adults, considering modifiable factors affecting quality of life. BE4YOU employs data governance to empower individuals, providing tools for accessing and understanding health information, enhancing health literacy, and improving communication with healthcare providers. Emphasizing responsible citizenship, BE4YOU safeguards data privacy, security, and ethical use, establishing policies for sensitive information protection.

The framework ensures proper data handling, forming the basis for health literacy initiatives. Specific questionnaires, activated based on user risk levels by the Risk Assessment System (RAS), identify associated risk levels for various pathologies. The system prevents worsening conditions by proactively monitoring health parameters and managing modifiable factors. Figure 1 illustrates the BPMN¹ diagram, depicting the sequence flow and complexities in determining user risk levels across Mental Health domains.

The sub-process “A8: Update user risk profile” encapsulates the complexity of how newly collected data concerning the user’s health and wellness is stored in the user’s record. This data integration is facilitated through the execution of the following sub-processes”

- “A3: Activate data collection forms” - This is triggered when new data related to the user’s risk level in specific domains need to be gathered. The Data Governance component, guided by the Business Rules Manager, initiates workflows for users to periodically report additional parameters closely linked to follow-up plans.
- “A4: Activate follow-up plans” - Initiated when BE4YOU identifies a moderate or high-risk level in one of the covered Mental Health domains. Users receive specific forms to report health & well-being parameters, and the follow-up plan’s duration is based on their risk profile calculated by the BE4YOU Risk Assessment System (RAS) based on demographic parameters and other factors.
- “A7: Activate dashboard viewer” - Handles complex computations when new measurements are reported, ensuring the user’s dashboard remains up to date. Clicking the Dashboard ribbon triggers the system to check for new values and update scorecard values in real time.

The designed questionnaires in BE4YOU are intended to collect new parameters and elucidate their significance in maintaining optimal or acceptable thresholds. Users receive notifications about the consequences of unhealthy lifestyles and are encouraged to take personal responsibility for safeguarding their health and well-being. Follow-up plans facilitate data collection with a significant impact on calculating risk levels within the BE4YOU community.

Figure 2 presents the workflow associated with “A4: Activate follow-up plans.” Users may have multiple prescribed forms to choose from when reporting new measurements, and specific parameters may be requested in different forms

¹Business Process Model and Notation (BPMN) provides a standard graphical notation for representing information workflows, facilitating communication of internal business procedures and collaborations among organizations (source: www.bpmn.org).

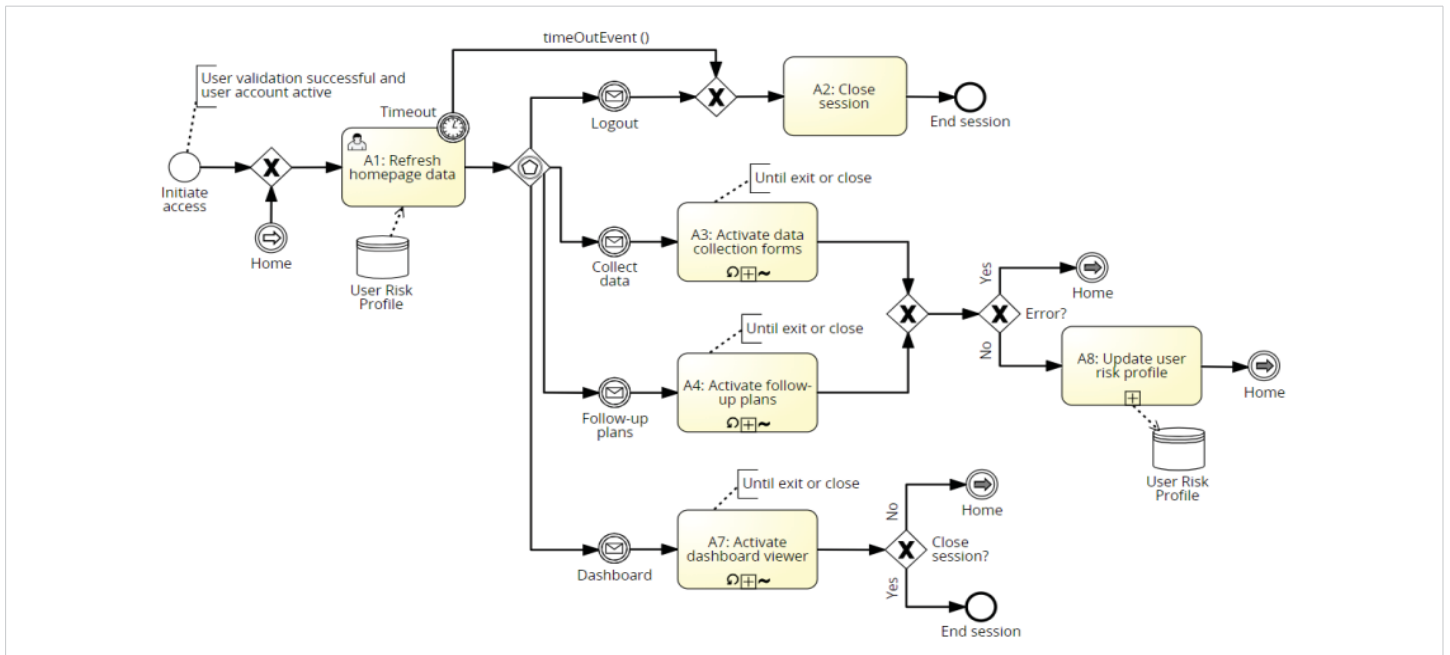


Figure 1: Global overview of the BE4YOU data governance workflow.

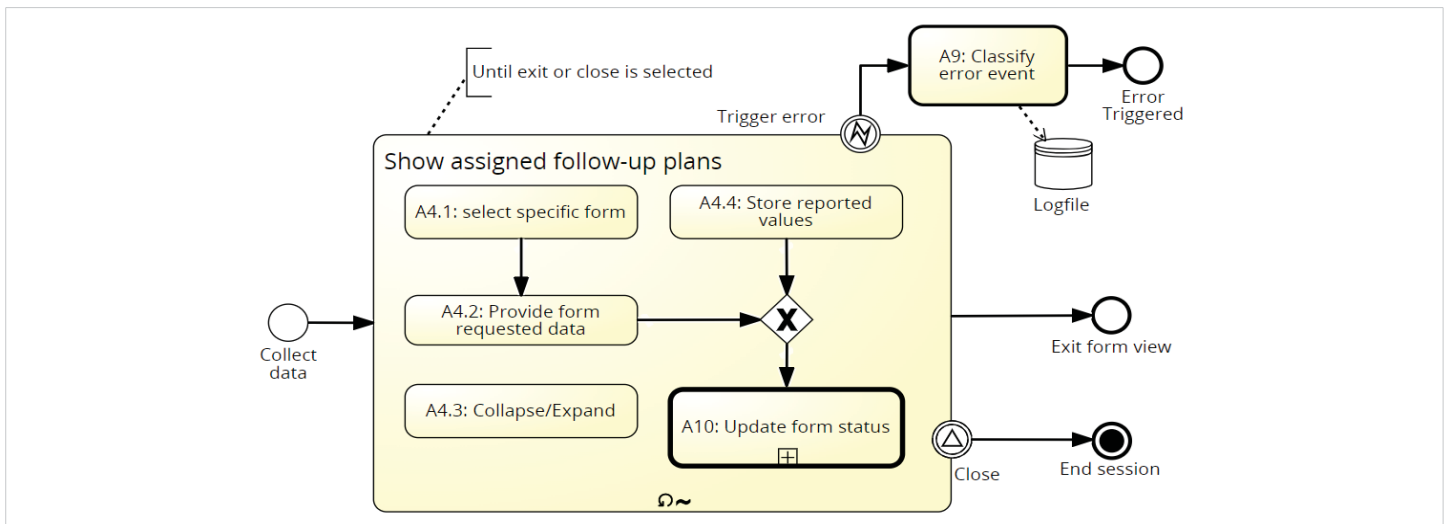


Figure 2: Drill-down to the subprocess A4: Activate follow-up plans.

if they are relevant across different Mental Health domains. While this aspect will be improved in future releases, it was retained for analysis purposes. The subprocess includes an ad-hoc loop, allowing users to expand or collapse forms for a visual overview of requirements. Once a form is selected, users are guided through informative sections for health literacy and report sections to enter data. The activity “A10: Update form status” stores reported data in the user profile, functioning as a Call activity that other processes can invoke. Figure 2 also illustrates two interrupting boundary events that terminate associated activities when triggered, allowing automation for timely user awareness. For instance, if a user takes too long to answer or an unexpected error occurs, the intermediate timer and error events attached to the activity will trigger a notification.

Data governance is a foundational pillar in pro-health literacy and responsible citizenship within the context of digital wellness. Through effective data governance, business processes can be orchestrated to leverage data-driven insights, leading to healthier communities and improved global health outcomes.

Mental health empowerment in the era of digitalization

In today’s technology-driven world, data analysis platforms have become vital tools for empowering citizens, especially in the field of Mental Health. These platforms address diverse mental health aspects like addictive substance consumption, stress, depression, and anxiety, providing accessible and reliable information for informed decision-making and self-management [29]. Studies reveal that 88.2%



of Portuguese families had internet access in 2022 [30], amplifying digital wellness's impact in offering educational information and health monitoring in a more holistic perspective. With increasing internet connectivity, digital wellness gains momentum through Mental health literacy and citizen empowerment, fostering a more responsible society, especially among older adults [16].

This approach supports active aging through health literacy and proactive self-care. Digital wellness empowers individuals to effectively self-manage their health and well-being, promoting lifelong learning opportunities and a better understanding of personal health [15].

BE4YOU's follow-up plans, grounded in mental health literacy, enable senior adults to understand mental health issues better, recognize risky behaviors and proactively care for their mental well-being by adopting healthier habits. By actively engaging and positively influencing their behavior and society, older adults contribute to the common good. This empowerment fosters active participation in decision-making and advocacy for their rights and interests, including matters about mental health [29].

The BE4YOU platform addresses these challenges by providing individual risk assessments conducive to conscious, participatory, and informed decisions. It fosters global collective well-being with personalized follow-up plans within the Be4you community. The platform's main objective is to raise awareness and mobilize people toward prevention, emphasizing the importance of a responsible health culture. Through health literacy, individuals can monitor their well-being and make informed decisions, aligning with the National Health Plan's focus on prevention, promotion, and early intervention in Mental Health [26].

The BE4YOU platform offers free access to evidence-based content presented in simple language, encouraging health surveillance and positive behaviors. User risk levels are assessed using established models like DASS-21 and ASSIST, enabling personalized follow-up plans for healthier habits. Be4You addresses addictive substance consumption, such as alcohol, tobacco, and drugs, allowing users to track consumption within safe thresholds and receive alerts for risky behaviors. Customized follow-up plans are triggered based on users' risk levels, providing practical strategies to adopt healthier behaviors. The platform also addresses symptoms of stress, anxiety, and depression, offering self-assessment tools and convenient follow-up plans to improve mental well-being.

Personalized follow-up plans promote healthy and active aging, positively impacting senior adults' mental health. The platform includes tasks and resources to help individuals better understand their emotions, cope with adversity, and develop resilience. Guided sessions for stress reduction

techniques, healthy lifestyle practices, and coping strategies are readily accessible. It is important to remember that while digital wellness can be a valuable tool for empowerment, professional assistance remains essential in addressing mental health issues effectively.

Conclusion

Stress, anxiety, depression, and substance use are complex public health problems with far-reaching implications on physical, social, and psychological dimensions for individuals and their families. Given the growing elderly population in Portugal and their mental health challenges, promoting active aging, empowerment, preventive health strategies, health literacy, and responsible citizenship becomes urgent.

Social connections can also impact our mental and physical health and well-being. Social isolation and loneliness are essential yet neglected social determinants for people of all ages. Adopting mobile solutions interconnected with IoMT offers a promising avenue for promoting Health-accountable citizenship and addressing mental health issues among digital natives. By leveraging technology to monitor health parameters, connect individuals to supportive communities, and facilitate access to healthcare resources, mobile solutions empower individuals to take proactive steps to safeguard their mental well-being and reduce the risk of developing dependencies or unhealthy behaviors.

In this context, digital health solutions present valuable tools to promote, prevent, and support those dealing with mental health challenges. These technologies can potentially empower citizens to actively engage in their health and decision-making processes, enhancing their overall well-being and quality of life. Through digital wellness, individuals can track their wellness status and take proactive steps to improve their health, fostering a greater sense of control and empowerment in managing their overall well-being.

Individualized follow-up plans, tailored to health profiles, enhance the adoption of effective health practices, addressing alcohol and drug-related disorders, crucial for improving quality of life. It is also essential to monitor loneliness and social isolation, common contributors to mental health issues, which is particularly vital among those with stressful lifestyles. Digital wellness shows promise in mitigating conditions like anxiety, depression, and substance abuse, potentially preventing dependencies or unhealthy behaviors. Recognizing digital natives' familiarity with technology and easy access to information, these resources can serve to raise awareness and connect them with supportive communities, facilitating collaborative sharing of experiences and professional support if needed.

Improving health literacy empowers individuals to actively engage in behaviors promoting well-being and preventing mental health issues. This empowerment fosters



effective communication with healthcare professionals and facilitates proactive health maintenance, contributing to a more informed and responsible society amidst advancing technological trends.

BE4YOU, a platform dedicated to disease screening, prevention, and health promotion, intertwines mental health and empowerment, granting individuals the autonomy to assess and monitor their health independently, thus enabling early detection and prevention of exacerbation. Specifically targeting mental health, BE4YOU evaluates stress, anxiety, depression, and addictive substance consumption, encouraging active involvement in decision-making for personalized follow-up plans.

Through digital wellness facilitated by BE4YOU, a culture of enlightened and participatory citizenship is fostered, promoting individual agency in well-being management and contributing to improved mental health outcomes. To further advance research in this domain, several promising paths merit exploration. These include broadening and diversifying participant demographics to gain a comprehensive understanding of user perceptions, delving into detailed analyses of inclusion issues, and applying Health 5.0 principles to ensure equitable access to health services. Additionally, research efforts could focus on identifying the training needs of healthcare professionals and developing tailored training programs. Emphasizing client-centered care, future endeavors will seek to capture healthcare users' evolving experiences, expectations, and satisfaction levels within the dynamic landscape of Health 5.0.

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