

A Collective Intelligence Framework for Lifestyle Management pro Mental Health Systems

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Abstract— Health Information Management Systems are becoming a central fixture in healthcare settings, but only a few frameworks exist to provide guidelines for the development of an innovative and sustainable system. This study employs a collective intelligence approach by corroborating knowledge, skills and contributions of various stakeholders to develop a Framework for Lifestyle Management pro Mental Health Management Systems (FLMMHS). A mixed-methods approach was employed and covered in two principal phases namely; document analysis (analysis of existing facts about mental health in the body of knowledge) and empirical analysis (experts' validation using four core parameters namely; efficacy, effectiveness, simplicity and flexibility). FLMMHS' components are apportioned into three core layers namely; Research Design Evaluation (RDE wrapper), Guidelines and Requirements (G&R), and Diagnosis Prevention Alleviation (DPA). While these components are flexibly designed to allow seamless system integration, its comprehensive representation serves as an implementation platform for the development of mental health systems. Although the suitability of FLMMHS for system development is based on the premise of lifestyle management for mental health, successful evaluation following qualitative and quantitative measures by expert judges impresses its aptness for the development mental health management systems.

Keywords- *mental health systems; lifestyle management; collective intelligence; Diagnosis Prevention and Alleviation; framework; standards; Guidelines and Requirements; barriers and facilitators; mental health support; FLMMHS.*

I. INTRODUCTION

This work extends our existing research [1], which contends that lifestyle management approach as an effectual management practice for mental health disorders. A subsequent failing of aspects of human health such as intelligence, imagination and thought is considered a mental health disorder [2]. Globally, this health phenomenon is increasingly becoming popular with notable consumption of various aspects of human resources. Currently, a significant proportion of adult's population now suffers a form of mental health disorder with a record of about 26.2% of US adult population suffering a form 'serious' mental illness and 27% in the EU having mental issues [3]. Contemporary, records show that the gap between mental health treatment and its accessibility is increasingly becoming wider, currently estimated between 35% and 50% [4]. This gap is

often widened by known factors including; stigma associated with mental health candidates, ineffective therapies, lack of adequate and awareness of mental health resources among other factors. Consequently, a significant proportion of mental health disorder candidates are left undiagnosed or diagnosed with no adequate attention or treatment.

Even more prominent is the traditional approach of dealing with these disorders (i.e., the process of Diagnosis, Prevention and Alleviation - DPA) also contributes to these noted shortcomings thus, aiding this increase perhaps, exponentially. Effectively, common DPA practice involves consultation with healthcare professionals, such as a General Practitioner (GP) or psychiatrist, who utilises standard tools such as, Hospital Anxiety and Depression Scale (HADS) [5], the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [6] and International Classification of Diseases (ICD) criteria [7], Generalized Anxiety Disorder (GAD-7) [8] among other appropriate tools to examine the candidate's situation. Nonetheless, almost half of the world's population lives in countries with fewer than two psychiatrists per a hundred thousand (100,000) people [9], therefore, optimal access to these practitioners is becoming highly impossible. Arguably, occurrences of prominent mental health disorders such as depression, bipolar affective disorder, anxiety, schizophrenia and dementia are rather deteriorative of one's health rather than instantaneous. Hence, on many occasions, appropriate lifestyle management may be better suited to avert the occurrence, or/and perhaps, manage these disorders effectively. Nevertheless, appropriate lifestyle management could be effectively accomplished with utmost acceptance of the life owner.

Mentioned earlier that traditional diagnosis and subsequent treatment of mental disorder conditions require the expertise of skilled medical practitioners who often are not readily available, recorded advances in technology can support bridging this gap. Not only are the advances of technology necessitating its prominences in various aspects of human lives including education, business and health, but the availability, size and power of hardware components and sensors are significantly aiding its presence. Besides, the existence of concepts such as artificial intelligence (Machine Learning, Natural Language Processing and Analytics) combined with the power of internet reinforces technology's importance in different areas of life, particularly health. For instance, in health, smartphone technology, which combines the communication and computation of a handheld device is

used to facilitate point of care services using mobile computing [10]. Also, computer-based cognitive behavioural therapy (CBT) has proven to be clinically effective similar to a face-to-face treatment of various mental disorder [4].

Although technology-based approaches of health treatment and management have been characterised by low-cost and ability to reach a larger audience, the lack of traceable standards for many of these tools raises potent questions perhaps, in terms of their efficacy, effectiveness and acceptability. For instance, an online mental health diagnostic tool is prone to contests such as inaccuracies, exaggerations or misrepresentations that may influence accurate diagnosis thus, constituting false or negative effects. This work aims to curtail these aforementioned problems by presenting a research-oriented Framework for Lifestyle Management pro Mental Health Systems, FLMMHS. The framework adopts a collective intelligence approach by utilising the knowledge of literature, various stakeholders, existing systems and other sourced components among others.

The rest of the paper is structured as follows; Section II explores some existing mental health systems and the importance of a standard framework; Section III discusses existing mental health frameworks and Section IV explains the methodology comprising of empirical and document analysis. Section V discusses the barriers and facilitators of implementing mental health systems while Section VI describes the components of FLMMHS and its evaluation. Finally, conclusions and future work were presented in Section VII.

II. CURRENT MENTAL HEALTH SYSTEMS AND FRAMEWORK IMPORTANCE

Health information systems are becoming a central fixture in the healthcare settings, but only a few standards are currently associated with the implementation and adaptation of these system solutions. The integration of mental health information systems into primary care is increasingly growing popularity as an effective means of treating mental health conditions and depression has been a good case example [11]. While benefits like lower healthcare costs, improved medication adherence, early diagnosis, and better patient/treatment follow-ups have been associated, healthcare system developments rely on suitable infrastructures, effective policies and perhaps cutting-edge technologies. More so, the acceptance of newer technologies for diagnosis, prevention and alleviation by major stakeholders is still very feeble for several reasons.

With technological advancements such as fast internet and 5G network, patients are now able to remotely receive real-time support/treatment for conditions that do not necessarily require the physical presence of physicians. For example, in recent times, the delivery of cognitive behavioural therapies (CBT) over the internet has been proven effective [12] and such internet-based protocols have been widely adopted to date [13]. Besides, numerous behavioural intervention technologies (BIT) - a technological application of behavioural and psychological intervention to

address behavioural, cognitive and affective targets – are currently being adopted to treat or support physical and behavioural mental health disorders [14]. More recently, further advancements are being recorded in the areas of mobile hardware and sensor infrastructure. For instance, the traditional method of examining blood alcohol, nicotine and vitamin D levels are being substituted with technological hardware. Such advancements have been further magnified by organisations such as Samsung who recently released a smartwatch device for blood pressure measurements [15]. Additionally, other advancements that have been recently presented include devices such as BACtrack, Digital Health Age and others that have been mentioned in different studies [16] [17] [18] for carrying out vitamin D and other physiological measurements.

The readiness of smartphones and other handheld devices for e-health has severally been explored with no exception to its utilisations for the management of mental health situations. For example, face-to-face therapy presented in [4] adopts this technique for DPA activities. Additionally, momentary and intervention triggered configurable commonly utilised for assisting distressed patients, in remote locations further justifies the importance of technology for the attainment of urgent treatment particularly, in areas such as mental health. In recent times, numerous mobile applications have been available for mental health management (i.e., diagnosis, prevention and alleviation) however, many of these applications are prone to risks including mismanagement, misinterpretation, misdiagnosis or recommendation of unsuitable alleviation techniques. Not only could these risks worsen the situation of vulnerable users, but they could lead to potential health relapse.

Google Play and Apple Store play host platforms for numerous mental health apps analysed by Shelton, Psycom (top 25 mental health apps in 2018) in 2018 [19]. These mental health apps were categorised into general mental health, addiction, anxiety, suicide prevention, depression, bipolar disorder and obsessive-compulsive disorder apps among other categories. In these categories are apps such as Self-help for Anxiety Management (SAM), CBT Thought Record Diary, MoodKit, IMoodJournal and Talkspace Online Therapy among others [19]. Although some of these apps are accessible to users at a cost, others are available for free to improve mood, life-quality and user's mood among other activities. For example, "Depression CBT Self Guide" is a pocket guide that helps users to learn about CBT and how to cope with depression; it also allows users to measure the severity of depression, develop positive thoughts and encourages meditation practice. Other highly rated apps in Google store [20] include "Positive Thinking" or "Operation Reach Out" which provides support via different resources such as hotlines, videos to military personnel and veteran who suffer depression. Also "Moodkit" in Apple Store provides over two hundred mood improvement activities to support distressing thoughts.

Apart from the aforementioned apps, other mental health mobile apps that present users-functionalities such as, diagnosis and progress tracking include Moodtrack diary [21] and depression screening test [22], which tracks activity

progression and diagnosis respectively. Pacifica [23] and Relieve depression PRO [24] provide prevention and alleviation functionalities, although without diagnosis or personalisation functionalities. While many of these apps support users via a variety of techniques, there is no known standards or framework typical to these systems. Moreover, more profound information about their implementations or policies adopted for deployment are not generally publicised to the best of our knowledge.

III. EXISTING MENTAL HEALTH FRAMEWORKS

Several service-oriented frameworks provide guidance and coordination supports for mental health care delivery to enhance patient experience and service quality. Numerously, different health bodies have developed various service-oriented frameworks, which cater for different mental health aspects. For example, the Organisation for Economic Co-operation and Development (OECD) in the United Kingdom concentrates on diagnosis and assessment, access to mental health services, personal well-being and care programmes, and treatment of patients according to defined standards [25] [26].

Occasionally are these frameworks revised to satisfy the ever-evolving stakeholders' requirements. For instance, a recent review of the Department of Health service framework for mental health [25] aided the updates, which include (i) deepening the health and social care services integration; (ii) health and social well-being improvements; (iii) promote evidence-based practices and (iv) multidisciplinary and intersectoral workings enhancement [25]. Although the framework builds on the 2010 version, it offers a more streamlined approach to include service and experience indicators. Also, the values and principles of the revised framework are based on the recommendation of National Institute for Health and Care Excellence (NICE), which focuses on safe and effective care, patient's experience and recovery principles.

Another example of existing frameworks is the Community Mental Health Framework for Adults by the National Health Service [27]. Its implementation breaks down the current barriers as follows: (i) mental health and physical health, (ii) health, social care, voluntary, community, social enterprise organisations and local communities, and (iii) primary and secondary care in order to provide an integrated, and personalised service. Other positives aimed at this framework is enabling candidates with mental health complications: have unhindered access to mental health care, manage their conditions, move to individualised treatment plans, and contribute to the local community. The goal of the framework is similar to the Service-based Framework focusing on local communities' needs.

Besides, in the United States, mental health services follow the Donabedian framework model - a quality assurance-based framework, which considers the

organisation and structure of the health care system delivery with the aims of providing better health care outcomes [28] [29]. The National Institute of Mental Health (NIMH)'s Research Domain Criteria (RDoC) framework is not only considered as a diagnostic tool for mental health problems but also serves as a basis of understanding the biological, social, developmental and environmental factors that may affect individual psychological functions. Often, is it used alongside other models such as, the International Classification of Diseases (ICD) [7] or the Diagnostic and Statistical Manual of Mental Disorders (DSM) [30].

While many of these frameworks are commonly considered to play effective roles in mental health service, management and delivery; their deployments for system development have not considered or published to the best knowledge of the authors. For example, technological factors such as interoperability, usability, technology acceptance or scalability are not explicitly reflective in most of these frameworks. Hence, this study bridges the identified gap by combining service and technical oriented requirements (incorporating medical and technical principles) to develop a system deployable framework for system developers. Taking a collective intelligence approach, the framework proposes to serve as a standard for mental health management system development following a lifestyle management approach. The following section illustrates the adopted methodology and the role of collective intelligence in the development and evaluation of FLMMHS.

IV. METHODOLOGY

Different study methods may be adopted at various stage of a research life cycle. For this work, a multifaceted mixed-methods approach was adopted, albeit, classified into two main phases namely; 1) documentary analysis and 2) empirical analysis. While the phase of documentary-study involved the analysis of existing body of facts in the knowledgebase, the empirical analysis phase involved qualitative and quantitative evaluation of derived facts from documentary analysis and the developed framework. Therefore, the Framework for Lifestyle Management pro Mental Health System is developed following a concept of collective intelligence i.e., combining the knowledge, skills and collaborative outputs of diverse sources and stakeholders.

A. Document Analysis

Enhanced methodical approach of literature analysis, PRISMA [31] was utilised to collect intended relevant contents. The principles of PRISMA was adopted in four cardinal stages that include identification, screening, eligibility and inclusion. As these cardinal stages were carried out iteratively, varying keywords were employed at different stages to distinctly improve robustness of document inclusion. Key terms including collective intelligence, barriers, facilitators diagnostic, prevention and alleviation

approaches about mental health were utilised for extracting facts from reputable platforms. Employed platforms include British Library [32], German National Library of Science and Technology [33], Google scholar [34] among others. Documents such as white papers, journal and conference articles were examined to elicit mental health efforts. These efforts were further analysed in order to classify key mental health concepts and principles. In addition to general mental health efforts and concepts, specific common mental health disorders such as depression, bipolar-disorder, sleeping-disorder, and schizophrenia, among other conditions were singularly and commonly evaluated. Key concepts including definitions, symptoms, impacts, methods of diagnosis, prevention and alleviation were also intensely examined. In additions, standards and policies of health system development, system design methods, guidelines and system requirements were appraised and suitably categorised in line with mental health system development as framework components. Separate from the efforts of the framework development was a further scientific appraisal of the framework's suitability and reliability as explained in the empirical analysis section.

B. Empirical Analysis

To validate framework rigor, multiple empirical methods (qualitative and quantitative) including survey, discussion groups and data triangulation were applied. Also, qualitative and quantitative validity criteria that include face and content validity index were adopted. A thematic survey was utilised primarily to gather regular user's perspectives and their understanding of technology adoption for managing mental health and its disorders. While there are no general exclusion criteria for the survey participants, associated limitations of online survey limit the survey respondents to technological informed candidates with basic knowhow of electronic system operation (i.e., basic understanding of mobile or Web technologies). The outputs of the survey and documentary analysis did not only aid the development process of the framework, further were the utilised empirical methods (secondary survey, discussion group and data analysis) to strengthen its evaluation. Twenty-six expert judges (software engineers and developers of varying level of expertise) completed a validation survey followed by three discussion groups of distinct expert judges (with varying level of expertise). Although the outputs of the survey and discussion groups were later triangulated to justify the validity of the adopted instruments, the reliability of questions was subsequently measured using Cronbach's alpha technique. The following section considers collective intelligence and its significance as a tool for the framework development.

C. Collective Intelligence

The concept of Collective Intelligence embraces the utilisation of skills, knowledge, sources and collaboration of multiple stakeholders to solve a problem. Although the concept has existed for decades, the recent conception of its combination with machine learning principles has been

catalytical for the generation of newer and more interesting facts. Nowadays, advances recorded in technological visions, computing powers and machine learning abilities (collecting/analysing data from millions of records over the cloud) has opened up new possibilities of finding solutions to modern-day problems [35]. Interestingly, the health domain has been one of the various domains that benefits from technological sophistications particularly, through collaborative measures between individuals and companies leading to the development of smart algorithms. For example, health organisations now uses machine learning concepts to predict disease and symptom deterioration, hence, preventive measures are taken to reduce hospitalisation and mortality rates. Taking to these benefits, the use of machine learning techniques on collectively gathered facts will not only aid the accumulation of newer knowledge yet, exponentially.

Considerably, this work considers the five factors of collective intelligence (Autonomous Commons, Balance, Focus, Reflexive and Integrate for action) highlighted crucial to solving problems by Mulgan [36] as imperative for the development of effective mental health system. Accordingly, an intricate collection and analyses of existing mental health data was utilised to accomplish a rich background for developing a framework, which a robust mental health management system can be based.

Indicative barrier from literature evidenced that mentally disordered candidates tend not to seek support when experiencing emotional or mental health difficulty. This barrier is decidedly prompted by stigma, negative perceptions, self-reliance, and lack of awareness as triggering factors [37]. Collectively embracing gathered facts for the development of health management systems notably englobes factors including human resources, finance, medicines, technology, service infrastructure. Also included are intangible assets of ideas and interests, relationships, policies, values and people-centered norms as identified by Glenn [38]. This encirclement can further unveil the benefits and limitations of electronic health care systems, and thus, barriers and facilitators between the users and the systems are farther acknowledged. This work combines concepts from Glenn and Mulgan's five factors of collective intelligence, to analyse mental health care services and system to derive combining factors shown in Figure 1. Furthermore, barriers and facilitators of mental health and disorder management system development are highlighted in the following section.

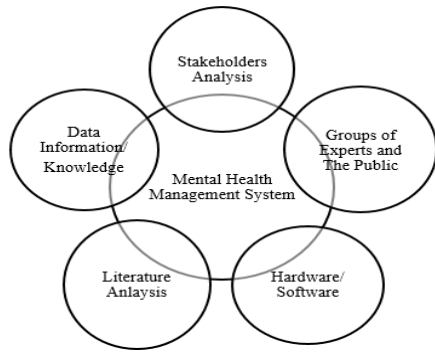


Figure 1: Englobed Factors of Collective Intelligence

V. BARRIERS AND FACILITATORS

Human’s mental health is considered a vital aspect of general health yet, robust measures to cope with the existing burden of mental health disorders are not currently possessed by health care providers. Since mental health conditions range in a spectrum of mild to extremely severe states, different conditions require distinct management plans i.e., diagnosis and treatment plans, hence, the seamless integration of mental health services into primary care to bridge treatment gaps is necessitated [39]. For instance, the National Health Service (NHS) in the United Kingdom, UK provides mental health services (including dealing with problems such as drug, alcohol addiction and psychological therapies - IAPT) for patients, but accesses to most of these services are through local General Practitioner, GP referral [40]. Conversely, effective management of contemporary mental health burdens necessitates seamless user-treatments interface, powered by advanced technology sophistication to handle with distinct requirements robustly. While technology can facilitate seamless management of mental health conditions, some barriers are identified to hinder diagnostic and treatment procedures. Normally, these barriers and facilitators are identified using the Supporting the Use of Research Evidence (SURE) framework. The framework aims to support mental health system design through the involvement of a wide range of stakeholders [41] and was mainly developed for implementing health system changes and support policymaking in Africa [39]. Highlights in Table 1 are various barriers and facilitators for implementing mental health care systems. Among these factors are segregated care, lack of finance and resources, policymakers, privacy and acceptance among other issues are identified hindering factors (barriers). However, data access, end-user’s motivation, infrastructure sophistications and effective collaboration between medical and IT professionals could facilitate a successful implementation of a mental health management system. Collectively, knowledge accrues from document analysis and the evaluation of barriers and facilitators are considered for the derivation of the components of Framework for Lifestyle Management pro Mental Health Systems (FLMMHS) as described in the result section.

Table 1: Barriers and Facilitators of Mental Health Systems

| Barriers | Evaluation from Research Work |
|--------------------------------------|--|
| Segregated Healthcare | The perception that mental health is separated from mental health systems informs the lack of integration of both concepts [11], [42] |
| Financial Resources | The limitation in budget leads to the lack of developing integrated mental health care systems. [11] |
| Bureaucracy (Policy makers/planners) | High cost of medical care attributed some policies procedures and decision making makes the implementation of mental health systems harder [43] |
| Norms and Standards (HL7) | There are certain norms and standards that need to be followed when implementing mental health system for system interoperability which can be implemented with the right experts’ skills. [39] [44] (World Health Organization., 2012) |
| Privacy and Security | There are concerns about the privacy and the security of the systems that deal with confidential and personal information. [46] |
| Technology Acceptance/ Change | There are usually mixed views about the use of new information systems i.e., organisation staff very often show unwillingness to adapt to changes or lack of time/interests.[46] |
| Credibility/Appro priateness | The appropriateness of technology needs to be assessed in order to solve particular problems faced by mental health professionals. There is little evidence that supports the efficiency of tools used to support patients suffering from mental health issues.[46] [47] |
| Facilitators | Evaluation from Research Work |
| Technological Infrastructure | Mental health systems can be integrated with other sub-systems through the exploitation of technology such as IoT, cloud and 4G. [48] |
| Knowledge/ Skills | The knowledge and skills of different experts such as Psychologists, Physiotherapist, GPs, Nurses, Patients and Software Companies can help to design mental health system to suit the needs of patients. (World Health Organization, 2012) |
| Motivation | Current healthcare professionals should be able to understand the benefits of using such a system to be motivated to use it. [49] |
| Data Access | Integrated mental health care systems may facilitate access of patients’ data [48] at any time and from anywhere as far as there is an internet connection. |
| Training | Training can facilitate the knowledge exchange and helps motivate staff to use the new system. [50] |
| Collaboration | The collaboration of different stakeholders such as pharmacists, psychologist, nutritionists, GPs, designers, programmers, can facilitate the implementation of a mental care system. [45][50][51] [48] |
| Resources/ Government Strategies | With a time frame and appropriate resource allocation, strategic plan with clear objectives can facilitate the implementation of mental health system. [52] |

VI. RESULTS

The outcomes of this work are perceived in two perspectives namely; FLMMHS (mental health system development framework) and its evaluation. The framework section explains the core components of FLMMHS including the Research Design Evaluation (RDE) wrapper, Guidelines and Requirement (G&R), and the Diagnosis Prevention Alleviation (DPA) layers. Subsequently, the evaluation section uncovered the rigour of framework through analysis of expert judges' submissions on the framework's suitability.

A. Framework for Lifestyle Management pro Mental Health System (FLMMHS)

An iterative document analysis of mental health literature, concepts of system development and the derivation of facilitators and barriers in conjunctions with the findings of the user survey aided the development of a Framework for Lifestyle Management pro Mental Health Systems (FLMMHS). Not only do these factors collectively derived the framework's composition, but also aided the components' classification into layers to improve the robust implementation of a mental health management system. Although FLMMHS's components are apportioned into three layers namely; RDE wrapper, Guides and Requirements (G&R), and DPA layers, the layers are flexibly integrated to encourage seamless deployment for system development. The following section describes FLMMHS's components (as depicted in Figure 2) according to their corresponding layers.

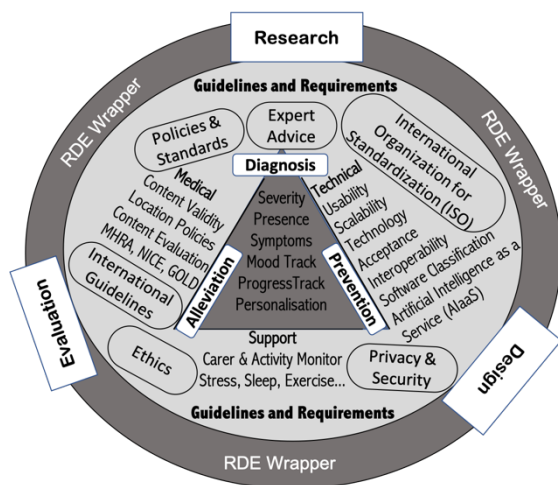


Figure 2: Framework for Lifestyle Management pro Mental Health Systems

- RDE Wrapper
The RDE wrapper is the outermost layer shielding all components of the framework. The wrapper consists of three basic features namely; Research, Design and Evaluation. Fundamentally, developers

are expected to consider the wrapper layer as a development navigator of a lifestyle management system, irrespective of the type of mental health disorder or system. The **Research** component considers the aspect of mental health (i.e., states, disorders and types among others), users (patients, practitioners and other stakeholders) and the systems. Considering the dissimilarity in the types of mental health disorders and the heterogeneity of the stakeholders (candidates, users, medical practitioners etc.), developers are obligated to conduct intense research about specifics of mental health i.e., in terms of system requirements and the needs of the potential system users. Whereas, the **Design** component guides the process of system development in aiming that a mental health management system is extensively supportive such that they are less demanding perhaps, moderately automated. For example, the user interface of a mental health management system should be undoubtedly simple, intuitive and usable to avoid any aggravation of the user's states. Concepts such as colour impacts, fonts, navigation, perception and overall comprehension of the system are comprehensively thought through, mostly in-line with the requirements of the intended users, i.e., significant depth of design is considered. Finally, the **Evaluation** components is an appraisal mechanism for the **Research** and **Design** elements, which ensures system's suitability for the intended users. The RDE wrapper is considered a kernel for developers of mental health management systems, irrespective of the disorder or intention.

- Guidelines and Requirements (G&R)
The G&R tier is an intermediate layer that binds the RDE and DPA layers of the framework. It considers technical and medical requirements of mental health management system development by employing major components namely; Policies & Standards, Experts Advice, Ethics, and Security & Privacy. The layer permits seamless integration of support, medical and technical requirements as a single module for mental health state management.
Taking that standards and medical guidelines vary by country or region [53], medical requirements of the intended location (country or region) of deployment must be appropriately implemented. For example, in the United Kingdom, the National Institute for Health Care [54] recommends that healthcare professionals provide information, advice, diagnosis and treatment for patients, while Mental Health in America (MHA) develops guidelines to identify mental health measures [55]. Also, the APA provides evidence-based recommendations regarding psychiatric disorders assessments [56] and the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) to diagnose and/or classify mental health disorders. Therefore, the G&R sector

considers medical tools and contents as stringent suited for intending location.

Similarly, technical requirements of the system are considered in terms of generics and specifics. Further considered are standards in terms of software and hardware requirements, system accessibility, scalability, interoperability and technology acceptance are to be rigorously considered; and similarly, the Security & Privacy of the system users. Also, the sensitivity of mental health conditions demands robust Ethics and Security architecture for FLMMHS based management systems. Therefore, the data handling process of the system should aim user's data privacy, encryption algorithms and access level functionalities amongst other features.

Finally, developers need understand that mental health systems are not purposed to displace practitioners but to play enhanced role in handling this health situation, therefore easier communication mechanism between stakeholders, i.e., practitioner (GP, psychiatrist, career) and patients should be stringently facilitated within the system. Other support features include automatic sleep management, diet, exercise and other lifestyle factors management. The following section expands the DPA layer, its components and roles in supporting the framework particularly, in accomplishing lifestyle management for mental health conditions.

- **Diagnosis Prevention Alleviation (DPA) Layer**
Lastly, innermost layer of FLMMHS', DPA, consists of three foremost components namely; **Diagnosis, Prevention & Alleviation**. These components consist of other sub-components including tools for determining the presence of mental health disorder, its severity, corresponding symptoms, prevention and progress managements. Also, these subcomponents embodied the traditional process of examining symptoms and severity of mental health disorders. Therefore, mental health management systems considering diagnosis should incorporate a means of deducing mental health symptoms and corresponding severity. Furthermore, the framework embraces flexible techniques to allow developers adopt a preferred standard diagnostic tool such as DSM-5 [6], ICD-10 [57], the Beck Depression Inventory, BDI [58], PHQ-9 [59] and GAD-7 [8], among other tools. To maintain the flexibility of FLMMHS, the **Diagnosis** component connects the prevention and alleviation components. Taking that the framework focuses on lifestyle management approach of mental health disorders, emphases are laid on prevention and alleviation methods through lifestyle management, therefore factors such as nutrition, exercise and sleep rate among other factors are considered core for system based on this framework. These core factors are associated with several studies and scientific findings, hence, are deemed important constituents

for lifestyle approach of management. For example, the study conducted by Jacka et al, reflected significant association between diets and mental health management [60]. Similarly, Tanaka [61] and Freeman [62] found correlations between sleep rate and mental health state. Although cues are taken from these studies, the framework flexibility allows the inclusion of further elements to the DPA component. Finally, personalisation and progress tracking are considered for all DPA components i.e., the process of diagnosis, prevention and alleviation are personified, therefore, FLMMHS based system mandates progress-track functionality to manage associated lifestyle activities, perhaps, in correlation with the user's mental health state. The following section discusses FLMMHS' evaluation to ensure its robustness for mental health system development.

B. FLMMHS Evaluation

To determine the framework's robustness for system development, a holistic face validity evaluation was conducted using expert judges' submissions. The evaluation adopts mixed methods (qualitative and quantitative techniques) following four key parameters namely; efficacy, effectiveness, simplicity and flexibility. Explicitly, survey and focus group instruments were independently employed, and the outcomes of both methods were triangulated to improve the confidence of the derived results. The survey procedure and results were discussed in the survey section as follows.

- **Survey**
Twenty-two expert-judges (software developers with varying level of expertise) participated in a validation survey comprising of a derived 22 item-question. A significant proportion of the questions are multidimensional that transcend multiple evaluating parameters, but a few were unidimensional. Table 2 illustrates the item-questions and corresponding parameters intended to evaluate. For example, the 'knowledge and expertise' dimension aims to identify the level of expertise and knowledge of expert judges through questions 1, 2, 3 and 5, while question 4 primarily focused on measuring participants' perception of the framework and its suitability. Twenty-one participants completed their evaluation by providing answers to all item-question, but one participant did not complete the item-question and thus, was excluded from the data analysis. Although some questions are multidimensional, the questions are validated to be internally consistent and reliable as Cronbach's alpha score of 0.95 was recorded. Figure 3a and 3b depict the overall perception's rating (Question 4 only) and evaluation of parameter rating respectively. The average perception rating of 0.61 was recorded to evidence judges' satisfaction. Also, correlation analysis was conducted to understand the

judges' bias in terms of knowledge and understanding of mental health and software and system development.

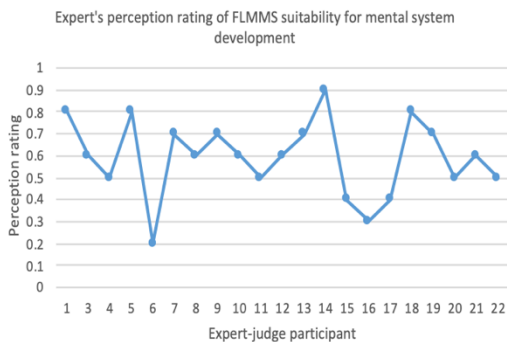


Figure 3a: Experts' Perception of FLMMHS

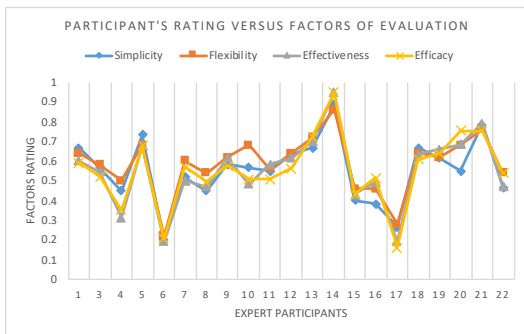


Figure 3b: Experts' Rating of Evaluation Factors

The Pearson correlation coefficient of the overall perceptions and combination of evaluating parameters (i.e., rating in flexibility, simplicity, effectiveness and efficacy) is 0.79, indicating a high positive correlation [63]. Not only does the high correlation recorded signifies robust suitability of the framework for mental health system development, but it also strengthens the success of the evaluating parameters. Figure 3c represents the correlation between the perceptions and evaluating factors, while Figure 3d represents the correlation between participant's knowledge & expertise and their perceptions.

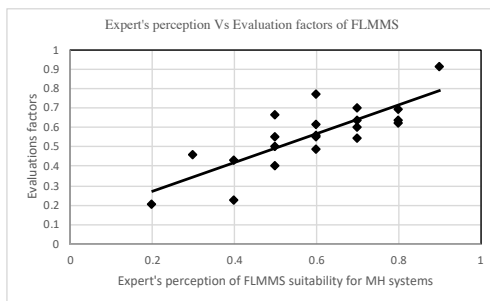


Figure 3c: Correlation Analysis of Perception

A positive correlation coefficient of 0.23 is computed for experts' knowledge/expertise versus their perceptions, indicating low or perhaps, a negligible correlation between the expert's rating of the framework's suitability for development and their knowledge/expertise. Also, this represents a positive reflection of the suitability of adopting the framework for mental health system development, irrespective of the level of expertise whether basic, intermediate or advanced.

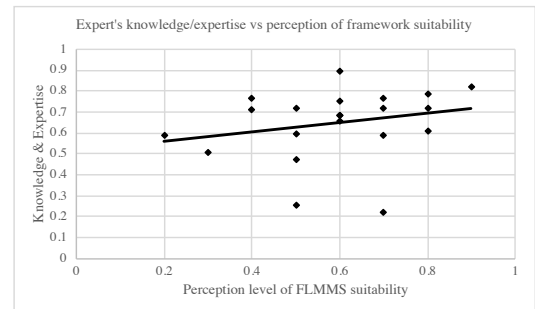


Figure 3d: Perception of FLMMHS' Suitability

Overall, the face validity of the framework is good with an acceptability index of 0.61. Besides, supplementary focus group sessions were conducted to examine the recorded results of the survey on the acceptance of the framework as discussed in the following section.

- Focus group
Following, the survey analysis, a supplementary qualitative analysis was conducted to improve evaluation confidence of FLMMHS. Three discussion-group sessions were carried out with expert-judges in groups of five, eight and seven. These sessions lasted an average of 11 minutes 46 seconds and the data was transcribed using a professional transcriber. The transcribed data was processed using NVivo software [64] for coding and thematic analysis. Firstly, the first hundred frequent words of the transcript data were deduced by taking out the sight or joining words such as *the*, *and*, *this* and *is* among others. (See Figure 4 for a cloud representation of contents) to enhance content analysis.



Figure 4: Cloud Representation of Content Analysis

Subsequently, a thematic analysis was conducted by coding the data in themes similar to the survey's key themes i.e., knowledge & expertise, flexibility, simplicity, effectiveness and efficacy. Additionally, two newly themes were derived namely; expert's perceptions and other factors, which were classified by related texts, accordingly. For example, key texts such as; think, ideal, quality and suitability relate to the perception's context thus, corresponding references were clustered appropriately for the perception of each participant group. Appendix I, Table 3 indicates the number of coding terms per participant group for each theme.

Table 2: Thematic representation of codes for each focus group

| Evaluating Criteria | Group One | Group Two | Group Three |
|---------------------|-----------|-----------|-------------|
| Flexibility | 8 | 7 | 4 |
| Simplicity | 7 | 8 | 5 |
| Efficacy | 11 | 7 | 12 |
| Effectiveness | 19 | 10 | 21 |
| Expert_MH_Knowledge | 8 | 6 | 1 |
| Expert_Expertise | 21 | 19 | 22 |
| Expert_Perception | 14 | 21 | 15 |
| Other_Factors | 8 | 8 | 6 |

Another meaningful observation is the derived correlation between the key themes. While efficacy of the framework is regarded the most important theme based on experts' submissions. Although all themes are intertwined through shared key terms, the efficacy term appeared connected with all themes as noted with tree representation of the content in Figure 5.

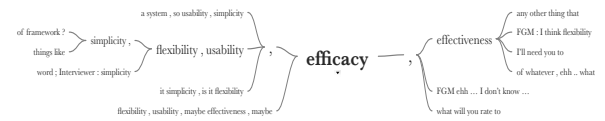


Figure 5: Tree Representation of Content Analysis

Finally, a matrix representation of the coded data shown in Appendix I, Table 4 indicates a high relationship between effectiveness and efficacy, simplicity, expertise and level of perception. There is quite low association between expertise and mental health knowledge, which further justifies easier deployment of the framework, irrespective of mental health practicing knowledge.

Overall, the results from both qualitative and quantitative evaluations indicate the suitability of the framework for mental health system deployment pro lifestyle management. The framework's robustness is further evidenced through expert judges' review on fundamental features of system development (i.e., simplicity, usability, flexibility, efficacy and effectiveness) with no preference to their level of expertise. Following is an insight on the practical deployment of FLMMHS for mental health system development.

C. Practical deployment of FLMMHS

Mobile systems offer a range of self-management apps, digital consultations and digital-enabled models of therapy for patients suffering from mental health conditions, but these systems often segregated from other services. FLMMHS is expected to be deployed by software engineers or Web developers working closely with healthcare or health-related professionals. The conceptual model can easily be translated to a more practical integrated solution as a software library or Web service or complete system solution. Barriers previously identified in Table 1 have thus been considered when designing the framework to include major factors such as HL7 standards for storing data. Other factors considered include privacy and security of patients' confidential information and evaluation of the system expert stakeholders to understand the deployment acceptance.

Healthcare services looking at mental health care delivery systems can adopt FLMMHS concept to implement software solutions. More so, various bodies explications can be integrated to improve the process of strategic design, delivery and development FLMMHS based systems. Systems can be reinforced with digital clinical decision-making tools, which can help healthcare professionals in early diagnosis of mental health-related issue. With an integrated care approach, improving access to psychological therapies or some other supports can be made easier. Knowledge, skills and competences can also be shared across multiple disciplines if the designed system is based on FLMMHS. A comprehensive implementation of FLMMHS

based system is aimed in future work as illustrated in the following section.

VII. CONCLUSION AND FUTURE WORK

Over the years, advancements in technology have led to its substantial deployment of clinical and health management systems. Technology adoption for managing lifestyle in line with human mental health is increasingly becoming popular in modern society. However, several existing mental health systems were developed with no known development reference. This work classifies lifestyle management as a potent approach for mental health management and presents a **Framework for Lifestyle Management pro Mental Health System** based on a collective intelligence approach. Indication from expert judges in terms of holistic perception, i.e., flexibilities, simplicity, efficacy and effectiveness portray a good acceptance index thus, indicating the suitability of the framework for mental health system development. Also, there is negligible correlation between judges' level of expertise and their perception of the framework's efficacy, therefore, mental health management systems' development is made easy via FLMMHS' adoption, irrespective of expert level or mental-health knowledge. Although the framework has been successfully evaluated by experts, future work aims on a comprehensive technical implementation of the framework, which can be deployable as software library, Web service or compact mobile/Web management system. Such implementation permits a further empirical validation of the effectiveness of mental health systems for managing mental health and its disorders.

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APPENDIX I

Table 3: A Recapitulated Survey Questions with Dimensions of Evaluation for FLMMHS

| No | Expert-judge questions | Experts’ knowledge & expertise | Evaluation parameters pro questions correspondence | | | |
|----|--|--------------------------------|--|---------------|-------------|------------|
| | | | Efficacy | Effectiveness | Flexibility | Simplicity |
| 1 | Expert’s level of expertise of Web/Software/System development | √ | | | | |
| 2 | Expert’s experience of clinical & MH system development | √ | | | | |
| 3 | Expert’s knowledge of MH disorders, characteristics & symptoms | √ | | | | |
| 4 | Expert’s perception of utilising the framework for developing MH management system | - | - | - | - | - |
| 5 | Expert’s knowledge of MH Standards and its availability | √ | | | | |
| 6 | Technology acceptance & change within the framework | | √ | √ | | |
| 7 | Acceptability of the framework by system developers for MH system development | | √ | √ | | |
| 8 | Credibility of Framework for MH system development | | √ | √ | | |
| 9 | Framework acceptability (Question ‘g’ repeated) | | √ | √ | | |
| 10 | User’s privacy consideration for MH system development | | √ | | | |
| 11 | Provisions of guidelines for developers of MH system | | √ | | | |
| 12 | Skill & knowledge enhancement for developers of MH system | | √ | √ | √ | √ |
| 13 | Motivation and support for developer in developing MH management system | | | √ | √ | |
| 14 | Resources consideration for development of MH system | | √ | | | |
| 15 | Guide to MH Policies & Strategies for developing MH system | | √ | √ | √ | √ |
| 16 | Easy of comprehending framework for MH system development | | | | | √ |
| 17 | Expert’s perceived usefulness of the framework for MH system development | | √ | | | |
| 18 | Effectiveness/efficacy of the framework for developing MH Diagnosis | | √ | √ | | |
| 19 | Effectiveness/efficacy of the framework for developing MH Prevention | | √ | √ | | |
| 20 | Effectiveness/efficacy of the framework for developing MH Alleviation | | √ | √ | | |
| 21 | Effectiveness of the framework for developing MH system holistically | | | √ | | |
| 22 | Expert’s ideal characteristics of framework for MH system development | | √ | √ | √ | √ |

Table 4: A Matrix Representation of Themes Association via Coded Data

| | Expertise | MH knowledge | Expert perception | Flexibility | Simplicity | Efficacy | Effectiveness | Other factors |
|--------------------------|------------------|---------------------|--------------------------|--------------------|-------------------|-----------------|----------------------|----------------------|
| Expertise | - | - | - | - | - | - | - | - |
| MH knowledge | 2 | - | - | - | - | - | - | - |
| Expert perception | 16 | 5 | - | - | - | - | - | - |
| Flexibility | 4 | 0 | 10 | - | - | - | - | - |
| Simplicity | 4 | 0 | 11 | 10 | - | - | - | - |
| Efficacy | 7 | 3 | 8 | 5 | 6 | - | - | - |
| Effectiveness | 20 | 4 | 17 | 7 | 12 | 18 | - | - |
| Other factors | 6 | 0 | 6 | 5 | 10 | 8 | 15 | - |