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Furthering the reliable and valid measurement of mental health screening, diagnoses, treatment and outcomes through health information technology ☆

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ABSTRACT

Introduction: Measurement of mental health is challenging; however, many solutions may be found through the use of health information technology.
Method: This article reviews current approaches to measuring mental health, focusing on screening, diagnosis, treatment, and outcomes. It then identifies several key areas in which health information technology may advance the field and provide reliable and valid measurements that are readily available to and manageable for providers, as well as acceptable, feasible, and sustainable for selected populations.
Result and Conclusions: Although new technologies must overcome many challenges, including privacy, efficiency, cost, and scalability, it is an exciting and fast-growing field with many potential applications and clinical benefit.

1. Why is this theme a priority?

Health information technology (IT) may hold the key to overcoming many of the challenges in measurement of mental health. Current measures for screening, diagnosis, treatment and clinical outcome assessment rely primarily on traditional models of care delivery involving face-to-face (synchronous) interactions between provider and patient (for example, clinic visits). Relying on synchronous interactions means that measurement is likely to take place on an irregular and infrequent basis, reducing the potential effectiveness of measurement-based care. Effective use of health IT can extend care into asynchronous spaces, broaden the populations reached, expand information exchange between provider and patient, and thereby increase the effectiveness and efficiency of mental health care. Fertile areas for research in this area include the invention of new measurement technologies, as well as more effective implementation of existing technologies to serve diverse settings, populations and health care infrastructures.

2. What has been done in this area?

Mental health care has historically relied on subjective measurement, typically structured patient interview or self-report linked to a direct clinical encounter. For instance, an individual may report depression symptoms on a self-report scale while waiting to see her physician or report on the mental health of others, such as a parent reporting on the behavior of a child. Subjective measurement is appealing in that it is inexpensive, fast and easy to implement, but it can underestimate socially unacceptable behavior (for example alcohol consumption) and overestimate socially desirable behavior (for example medication adherence) [1]. It is also inherently limited by its dependence on accurate memory and correct attribution of ambiguous symptoms. Individuals may have difficulty recalling events that took place more than a few days ago, especially if cognitive impairment is a factor, and most self-report measures specify longer recall periods on patterns of behavior [2].

Objective measurement has had a less prominent role in behavioral health measurement to date; however, passive methods (such as biosensors to record sympathetic nervous system activity) and active methods (such as blood samples to measure serum drug levels) are now available. Compared to subjective measures, objective methods have higher correlation with biological and clinical markers [3,4]. However, they tend to be expensive and resource intensive, and measurable behaviors or outcomes may not directly correlate with the mental health issue being investigated [5–7].

The reliability and validity of measures can be established through psychometric testing of subjective scales or measures, or formal biologic assay development for serum drug levels, measurement must also be affordable, feasible and acceptable to clinicians and patients to achieve widespread use. This is a difficult balance. For example, medication adherence can be assessed through self-report or through any of several objective measures (such as pharmacy refill data or electronic monitors that record when a medication cap has been removed). While self-report

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may overestimate adherence [8,9], objective measures also present problems: pharmacy data can only record whether pills have been obtained, not taken; and an electronic medication bottle may be only be opened once in a week, when the patient fills a weekly pill box.

2.1. Mental health screening

Screening or case-finding for mental health problems has traditionally involved questionnaire and scale administration in formal settings, such as a primary care doctor's office or an educational institution. Several reliable and valid self-report questionnaires have been effectively employed in these settings; current examples include the Generalized Anxiety Disorder (GAD)-7 [10,11], the CAGE alcohol screen [12], the Patient Health Questionnaire (PHQ)-2 and PHQ-9 [13,14], the Quick Inventory of Depressive Symptomatology Self-Report [15], the Edinburg Perinatal Depression Scale [16], the Geriatric Depression Scale [17] and many others. However, this approach only reaches individuals who are actively engaged in health care.

Some innovative technological approaches have been developed to cast a wider net in mental health screening. Internet Web sites now offer mental health screening for adults [18] and youth [19], and outreach can be enhanced through mobile phone applications [20] and online communities [21]. These approaches may be useful for specific groups who frequent the Internet, such as men who have sex with men [22] or adolescents and young adults [23,24]. Clinicians or programs may direct individuals to complete screening questionnaires online, or the Web sites may be available to all users (for example, www.mentalhealthscreening.org and http://doyouneedtherapy.com). Similar mass screening can be conducted offline through computerized forms [25] and may involve novel technologies, such as interactive voice response [26–28]. This approach to screening can be advantageous in that the questionnaires are completed privately or anonymously, thus potentially decreasing social desirability bias [29]; however, individuals must be adept at using technology [30].

Expanded screening has the potential to bring many more individuals into care; however, the reliability and validity of technologically based screening remains unclear, and we do not yet know if online screening leads to increased rates of treatment. The US Preventive Services Task Force underscores the importance of linking mental health screening to systems of care in recommending screening for depression only when depression care supports are in place [31].

2.2. Mental health diagnosis

The standard for mental health diagnosis has long required in-person clinical assessment. In recent years, this scenario has been expanded through new technologies including telemedicine [32–35] and computerized questionnaires, some of which implement computerized adaptive testing methodologies [36–40]. In this latter approach, assessments are tailored to the individual through the use of interactive response technology or branching logic based on specific responses to questions or characteristics (for example age, gender), thus leading to diagnostic efficiency. These technologies offer a promising option for reaching rural populations where mental health care resources are extremely limited [32,34]. Preliminary evidence suggests that the reliability and validity of diagnoses made through the assistance of technology are acceptable when compared to in-person assessment [33,38,40,41].

2.3. Mental health treatment — quantity, quality and adherence

Current approaches to measuring the quantity or quality of treatment vary by type of treatment. Provision of counseling or behavioral therapy can be measured by number of sessions attended or modules completed, and care quality can be assessed through direct observation and critique, by measured adherence to a protocol or by general measures of provider "quality." To date, measurement criteria for nonpharmacologic treatment have been largely subjective and based on self-report or clinician judgment [42,43].

Quality assessment of providers has been rare outside the training setting, and attention to decision-making ability has often been lacking [44]. Technology-based approaches are now beginning to overcome these limitations. Improved functionality and more widespread implementation of electronic health records (EHRs) have enabled tracking of engagement in care [45], and virtual human agents have been used to assess provider skills [46–48]. Further research on reliability and validity of these new approaches to measurement is needed.

Medication adherence is perhaps the best-studied and best-implemented category of mental health treatment measurement. As described above, both subjective and objective measures are available, but all measures are subject to imprecision and bias. Recent efforts have focused on technologic enhancements in assessing individual patient medication adherence, such as wireless medication devices [49], frequent self-report through mobile phones [50–52] and Web-based portals [53], with varying levels of success. One novel approach employing mobile phone-based context-sensing to monitor and enhance self-management for depression has just been tested [54].

2.4. Mental health outcomes

Incremental changes in behavior or symptom severity over time are routinely assessed through subjective clinical opinion, as well as through scores on validated self-report questionnaires and scales. While an individual's progress during treatment can be tracked using pen-and-paper methods, technology-based approaches to outcome monitoring can greatly enhance the integration of outcome measurement into clinical care. Outcome measurement can be in turn linked to clinical decision support tools at the point of care to improve routine practice; this general approach has been given the term "measurement-based care" [55–57]. The literature contains calls for technology to enable rapid development and deployment of various outcome reports, decision support tools and measurement feedback systems [44,58,59]; this work is just now beginning. Outcome measurement instruments have been integrated into EHRs to routinely appear for individual patients who have the diagnosis of a specific mental health problem [60,61]; some work has been done to integrate simple "one-click" decision support protocols or prompts that appear for patients with active diagnosis of depression or bipolar disorder [60,62]. Additionally, mobile devices could allow assessment of actual activity or behavior patterns (for example physical activity, duration, continuity of sleep) or direct assessment of behavioral indicators (for example voice tone, speed of response) [63] (http://www.cogitocorp.com). These tools could help move mental health assessment away from self-report to more objective measures. While these innovations are promising, there is little evidence to date to support their effectiveness.

Technology has also been applied to enhance population-based measurement. Several commercial EHRs and population management software systems now have the capacity to aggregate outcome measurement across all patients with a specific diagnosis to facilitate population management. Another recent initiative is the development of comprehensive behavioral health reporting systems to facilitate clinical and administrative use of evidence-based practices. In support of this initiative, the National Cancer Institute in collaboration with content area experts has begun work to identify or develop consensus standards for assessing and reporting on key behavioral domains [64,65].

The design processes underlying system mapping of decision points and distillation of performance information at the individual, caseload and organizational levels can be implemented to support clinical practice in a wide variety of settings [66,67]. At the individual level, rapid feedback of outcome measure scores to clinicians can inform midcourse corrections in treatment strategies. At the administrative level, outcome data can be aggregated for all patients of individual clinicians and used as one indicator of clinicians' treatment effectiveness. At the population level, time-series measurements can be compared against expectancy curves of improvement based upon aggregated data for predefined target populations. At this stage of development, validity and reliability remain important concerns, as EHRs have been shown to potentially underreport practice performance [68,69].

Finally, standardized outcome measurement can support incentive-based reimbursement models. For instance, payment can be provided to the individual or the provider for successful cessation of substance abuse or improved depression remission rate. These arrangements have been found to have substantial and replicable benefits in adult mental health treatment and are currently being tested in youth mental health practice settings [70,71].

3. What work is needed?

The future of IT for measurement of mental health lies in three key areas: development and adaptation of reliable and valid measures to provide useful just-in-time data; management of high volume data; and determining the acceptability, feasibility and sustainability of measurement technology for target populations.

3.1. Development and adaptation of reliable and valid measures to provide useful just-in-time data

Just-in-time is a concept in which information is made available to those who need it at the moment when they need it, and is greatly facilitated by technology [72]. Data can be transmitted in real time, minimizing recall bias and enabling proactive approaches to disease management. Consider this example;

> Mr. Jones uses his smart phone [or his laptop computer or another personal digital assistant (PDA)] to interact with his primary care practice. The practice identifies him as a "high-risk" patient for onset of depression due to his family history of depression and comorbid medical problems of diabetes and coronary artery disease. On May 10, the practice sends out a PHQ-9 scale to all high-risk patients asking them to respond and post results back to the practice inbox. Mr. Jones does so. His score is recorded at 14, representing moderate depression, and is flagged for follow-up. A staff member calls, confirms his symptoms and then schedules an office visit to review his symptoms to see whether treatment is needed. At his appointment 2 weeks later, he completes another PHQ-9 along with screening items for comorbid mental health problems while waiting to be seen. Data are entered directly into the practice EHR, scored and posted on the front screen of his patient file to be reviewed when his physician opens his record. At the end of the visit, after the diagnosis is confirmed, Mr. Jones agrees to start treatment with a selective serotonin reuptake inhibitor. One week after the visit, the practice EHR pushes an outcome assessment scale including PHQ-9 and items assessing side effects and functional status to his smart phone. He completes the items and sends the scale back to the practice inbox. The EHR compares the PHQ score to previous scores and sends a longitudinal graph back to the smart phone with an explanation of the findings and to his physician's inbox. His physician decides when to schedule the next electronic follow-up and/or next office follow-up based upon these results.
>
> After several weeks, Mr. Jones is doing well, with PHQ score indicating remission of depression. His physician initiates follow-up electronic monitoring, sets the interval for his EHR to push the outcome assessment to Mr. Jones' smart phone at every 2 months and sets the threshold for an immediate physician alert to a score of 8. Mr. Jones is also shown how to access the outcome assessment at a time of his own choosing if he desires more frequent self-monitoring or feels that his symptoms are recurring. Over the next several months, he completes several measures and remains in remission.

Although not specific to mental health, the New York City Department of Health has implemented such an application of PDAs in primary care clinics [73]. Most of the components needed to implement this approach for depression care have already been introduced (see above), but full integration into practice workflow has yet to be accomplished. The potential response burden for patients with comorbid mental health problems (each with their own measurement protocols) and medical problems can be addressed with use of item response theory-derived personalized measurement, such as in the Patient-Reported Outcomes Measurement Information System [36,74]. Considerable investment will be necessary to develop a robust, reliable and efficient interface to support this level of care.

EHRs can also provide just-in-time support to facilitate treatment measurement, such as electronic prompts for obtaining serum drug levels at recommended intervals or when the most recent level is out of a target range. This is becoming standard practice for some medical problems such as anticoagulation management for patients taking warfarin [75,76]; adapting these protocols to support mental health medication management should be relatively easy to accomplish.

3.2. Management of high-volume data

Technology readily enables the collection of vast amounts of data. For example, automated text messages can be used to prompt the collection of symptoms of mental health symptoms on a daily, weekly or random basis from hundreds or thousands of individuals. Similarly, wireless adherence devices can automatically determine if individuals open their medication bottles at recommended times. The number data points quickly add up and can overwhelm a provider, clinic or service agency. Development of data management systems that can accurately sort out meaningful signal (such as missed openings of a medication bottle) from background noise such as (on-time openings of the bottle) will be extremely important for the next generation of mental health IT.

3.3. Determining the acceptability, feasibility and sustainability of measurement technology in selected populations

The advances in health IT described above have the potential to transform mental health care. To fulfill that potential, the next wave of research will need to carefully address the acceptability, feasibility and ease of implementation of proposed new technologies very early in the development process. The majority of primary care practices in the United States have now implemented an EHR [77], and many will be effectively "locked in" to the specific technology embedded in that EHR for years to come [78]. Mental health measurement technologies that cannot be easily grafted on to existing EHRs or that do not fit into the workflow of the developing a Patient-Centered Medical Home [79] may prove very difficult to disseminate to or sustain in community practice settings. In specialty mental health practices, which are traditionally more resistant to adoption of EHRs [80], technology-enabled measurement may be difficult to implement in any form.

In the next wave, it will be important to match technology to the population and setting. Interactive smart phone technology can

enhance measurement in practices with highly optimized EHRs and a large proportion of patients who can make use of that technology, but rural practices serving a high proportion of uninsured and indigent patients would not likely benefit from investing in that technology. The frequency and intensity of data collection must be carefully matched to the needs of patients and practices, given the chronic and comorbid nature of many mental health problems. User interfaces must be tailored to the specific needs of patients, providers and administrators to enable effective use of collected data. Research partnerships that bring together innovative technology developers and investigators in the emerging field of implementation science will be critical to the success of this next wave of research.

4. Challenges

Along with the promises of health IT come significant challenges:

- *Privacy and data transmission* — Privacy is a significant concern, given the stigma associated with mental health conditions, and individuals must give informed consent prior to participating in studies or programs. All transmission of mental health IT data, which often involves multiple parties, must be secure and compliant with the Health Insurance Portability and Accountability Act. Security can be achieved through techniques currently in use, such as data encryption, numeric subject identifiers and personal identification numbers. Alternative methods include voice or voice pattern recognition and biometrics, such as fingerprints and iris scans. Data must also be transmitted and verified in a timely manner.
- *Efficiency of implementation* — Data collection with rapid feedback of results for quality improvement can be accomplished most efficiently with an EHR infrastructure. The widespread use of outcome measures to improve treatment quality, support quality assessment or enhance reimbursement will in the end be somewhat dependent on the (slow-paced) adoption of EHR systems.
- *Cost and scalability* — New technology developments, whether hardware, applications or human oversight, can initially impose significant costs. This barrier can be ameliorated through adaptation of existing technologies and open-source code, as well as collaborations to allow for economies of scale, such as mass production. In resource-limited regions, cost savings, not just cost-effectiveness, may be required for implementation.
- *Expansion of mental health IT to populations without previous exposure to or understanding of technology, such as the elderly or illiterate* — Electronic measurement and Web-based interactions may be impractical or unavailable to these groups. Persons living in remote or rural areas may have more limited access to the Internet or remote measurement technologies. Elderly persons may be less inclined to interact with online mental health interventions or assessment protocols. Persons with more severe or complex emotional disorders may have particular problems in adhering to or following through with on-line protocols. This is an area in which more research is clearly needed.

5. Conclusion

Health IT is a fast-growing field that is infused with an inspiring sense of enthusiasm. New technologies for measurement of mental health are being developed rapidly with many potential applications and clinical benefit; however, scientific rigor is critical for ensuring they have the reliability and validity necessary to effectively support and ideally integrate screening, diagnosis, treatment and outcomes. Key factors for mental health research include development and adaptation of measures to provide useful just-in-time data; management of high volume data; and determining the acceptability, feasibility and sustainability of measurement technology for relevant populations. Researchers and implementers must also consider the challenges associated with developing these technologies: privacy and data transmission, cost and scalability, and expansion to populations without previous exposure to or understanding of technology.

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