Mental Health Care Provider’s Perspectives Toward Adopting a Novel Technology to Improve Medication Adherence

Joshua N. Liberman, Ph.D., Tigwa Davis, Ph.D., Dawn Velligan, Ph.D., Delbert Robinson, M.D., William Carpenter, M.D., Chris Jaeger, M.D., Heidi Waters, Ph.D., Charles Ruetsch, Ph.D., Felicia Forma, B.Sc.

Objective: To understand perspectives of mental health care providers regarding barriers and drivers of adopting a medication ingestible event monitoring (IEM) system in clinical practice.

Methods: Between April and October 2019, a cross-sectional, online survey was conducted among 131 prescribing clinicians and 119 non-prescribing clinicians providing care to patients with major depressive disorder, bipolar disorder, and schizophrenia.

Results: Most prescribing clinicians were physicians (79.4%) while most non-prescribing clinicians (52.9%) were licensed clinical social workers, followed by counselors (30.8%), clinical psychologists (13.4%), and case managers (2.5%). Most respondents (93.2%) reported that clinicians can influence adherence, that the IEM technology was in their patients’ best interest (63.6%), and a willingness to beta test the technology (54.8%). Support was positively associated with prescribing clinicians (OR: 2.2; 95% CI: 1.1, 4.5), belief that antipsychotics reduce the health, social, or financial consequences of the condition (OR: 3.8; 95% CI: 1.3, 11.0), concern for patients’ well-being without monitoring (OR: 3.3; 95% CI: 1.2, 8.7), and belief the technology will enhance clinical alliance (OR: 3.1; 95% CI: 1.5, 6.3) or improve patient engagement (OR: 3.0; 95% CI: 1.5, 6.2). Support was inversely related to concerns about appropriate follow-up actions (OR: 0.4; 95% CI: 0.2, 0.9) and responsibilities (OR: 0.3; 95% CI: 0.1, 0.8) when using the technology.

Conclusions: Our results suggest that IEM sensor technology adoption will depend upon additional evidence that patients will actively engage in the use of the technology, will benefit from the technology through improved outcomes, and that the additional burden placed upon providers is minimal compared to the potential benefit.

Affecting nearly one in five US adults (1), serious mental illnesses are diagnosable mental, behavioral, or emotional disorders that include major depressive disorder (MDD), bipolar I disorder, and the schizophrenia spectrum of disorders (1). These disorders can profoundly disrupt personal and family relationships, often lead to lost worktime and reduced productivity, and, if severe, can interfere with basic activities of daily living (1–3).

These disorders are often difficult to treat (4,5), and a major driver of relapse is medication non-adherence (6,7). Because pharmacotherapeutic effectiveness depends upon consistent medication use, an accurate and timely assessment of medication non-adherence is beneficial to clinicians (8). However, the primary method of assessment, patient self-report in combination with observed symptom control, confound the clinician’s ability to discern between medication non-effectiveness and poor medication adherence.

Digital medicine platforms that capture and report real-time medication ingestion data are among the first technologies to make these data available as decision support

KEY POINTS
- Among clinicians with prescribing authority, 91.6% are concerned about the quality of self-reported medication adherence and 75.6% reported that the IEM sensor technology would be in their patients’ “best interest”.
- Most prescribing (85.5%) and non-prescribing (74.0%) clinicians believe that the IEM sensor technology will either improve patient outcomes or practice efficiency.
- A key barrier to adoption appears to be concern about how to incorporate these data into practice.
for prescribers and those in treatment to use in planning treatment modifications (9). Ingestible event monitoring (IEM) systems include a sensor embedded within oral medication that sends a signal upon digestion to a wearable sensor (patch). The sensor, in turn, sends a secure, wireless signal to a smart phone that communicates with a cloud-based application that records the date and time of ingestion. The data are then available for viewing by the prescribing provider and others approved by the patient. In addition, data recording activity, rest, and self-reported mood can also be recorded. The IEM system is safe, effective, accurate, specific, and protects patient confidentiality (10,11).

While use of an IEM technology could be transformational in measuring and reporting adherence, the medical profession, and psychiatry in particular, has historically delayed uptake of digital tools designed to enhance their treatment practices (12,13). As important, patients with chronic mental illness are often supported by both a clinician with medication prescribing authority and an extended care team of allied mental health professionals including social workers, case managers, psychologists, and therapists. These providers are principal points-of-contact for patients, delivering education and encouragement, coordinating care services, and monitoring and managing symptoms and health-related behavior, including medication adherence (14). Little has been reported about the perspectives of extended care team providers for digital health solutions and their willingness and ability to support their use among stakeholders (15). The few insights available suggest these providers recognize the value of digital health solutions in clinical practice but have concerns about the digital divide, ethics including confidentiality and data security, and the impact on care (16,17).

The purpose of this study was to improve understanding of the barriers to and drivers of adoption of this digital medicine technology and to compare the perspectives of prescribing clinicians and non-prescribing care team members regarding the importance of medication adherence, their role in supporting patients’ adherence efforts, and the value of this novel technology.

**METHODS**

The survey research protocol was approved by the Advarra Institutional Review Board.

**Study Design**

The study was a cross-sectional, online survey conducted between April and October 2019, of clinicians with and without medication prescribing authority, licensed in the United States who provide care to patients with serious mental illness.

**Identification and Selection of Study Participants**

Potentially eligible participants were identified from national lists of behavioral healthcare providers and invited to participate by email. Eligible participants provided a valid National Provider Registry (NPI) number; and provided care to more than 10 patients with serious mental illness per month. Prescribing clinicians included board-certified US-licensed Doctor Medicine; board-certified Doctors of Osteopathic Medicine; or Advanced Practice Registered Nurse or nurse practitioner or clinical nurse specialist (NPs). Non-prescribing clinicians held a clinical psychology degree, social work license, or case management certification.

**Questionnaire Design and Development**

The survey questionnaire was developed by a steering committee comprised of experts in psychometrics, psychiatric treatment, psychiatric research and evaluation, and clinical informatics. The following domains were selected for measurement by committee consensus: eligibility, demographics and practice characteristics; beliefs about medication adherence; experience with digital technology in clinical practice; perceived impact of adherence management and technology on practice efficiency; concerns about liability and responsibility; belief about effect of being monitored; and incentives to adoption.

Manifest items for each measurement domain were identified from existing questionnaires and additional items were generated by the steering committee with input from the relevant content expert and the psychometrician. The final list of items was assembled into a pilot questionnaire form with instruction sets and relevant response fields. Endorsement for each driver and barrier to IEM adoption was captured on a four-point Likert scale consisting of “strongly agree”, “somewhat agree”, “somewhat disagree” and “strongly disagree”. For other barriers and drivers, participants rank ordered items based on the importance to their decision making or their possible adoption of the IEM technology. The questionnaire was finalized by the steering committee following pilot tests and cognitive debriefing interviews with five prescribing and five non-prescribing clinicians to assess face validity of instruction sets, items, and responses. Including questions to determine eligibility and to assess provider demographics and practice characteristics, the total questionnaire included 85 items.

**Recruitment and Participation**

Participants were recruited via email invitation. Eligible participants who completed the survey were remunerated: $175 (prescribing clinicians) or $75 (non-prescribing clinicians). A total of 905 prescribing and 11,919 non-prescribing clinicians were invited to participate in the survey, with a 34.1% and 5.9% participation rate,
Statistical Analysis
Support for adoption of the IEM technology (dependent variable) was defined by a “strongly” or “somewhat” agree response to the question, “Using the IEM sensor technology is in my patients’ best interest.” Independent variables including respondent age, gender, level of clinical experience (years), practice type, and degree type were summarized descriptively for the total population and by support for IEM adoption. Four-point Likert scales were converted to a two-point scale consisting of “agree” and “disagree”. Tests of significance for observed differences between groups were conducted using unadjusted Odds Ratios and 95% confidence intervals and confirmed with chi-square tests for categorical variables. Variables identified as significant in the bivariate analysis were added into a backwards elimination stepwise logistic regression model. The threshold for significance was set at 0.05. All analyses were performed with SAS software, v9.4, SAS Institute Inc, Cary, NC, USA.

RESULTS
Respondent Characteristics
A total of 131 psychiatric prescribers participated in the survey (Table 1). The prescribers were 79.4% physicians, 20.6% NPs, 56.5% female, and an average age of 47.5 years. Fifty-eight percent reported working in private or group practice. Prescribers who predominantly treated patients with schizophrenia were significantly more likely (p < 0.01) to practice in hospitals, psychiatric facilities, and settings other than individual or group practice.

A total of 119 non-prescribing clinicians participated (Table 1) and were predominantly female (79.0%), with a mean age of 44.8 years. Most (52.9%) were licensed in social work, followed by licensed counselors (30.8%), clinical psychologists (13.4%), and case managers (2.5%). The most common practice settings were individual or group practice (24.4%), public outpatient clinic (22.7%), and mental health center (17.6%). Respondents who predominantly treated patients with schizophrenia or bipolar disorder worked in mental health centers or clinics (74.3% and 53.9%, respectively) while respondents with a higher proportion of MDD patients worked in office-based practice (61.0%).

| TABLE 1. Demographic and practice characteristics of prescribing and non-prescribing clinicians |
| Prescribing clinicians | Non-prescribing clinicians |
|------------------------|---------------------------|
| Physicians             | Nurses                    | Social work | Counselor | Psychology |
| N = 104                | N = 27                    | N = 66      | N = 37    | N = 16     |
| N %                    | N %                       | N %        | N %       | N %        |
| Gender                 |                           |            |           |            |
| Female                 | 52 50.0%                  | 22 81.5%   | 53 80.3%  | 32 86.5%   | 9 56.3%     |
| Male                   | 50 48.1%                  | 3 11.1%    | 11 16.7%  | 5 13.5%    | 7 43.8%     |
| Other/unknown          | 2 1.9%                    | 2 7.4%     | 2 3.0%    | 0 0.0%     | 0 0.0%      |
| Age (mean)             |                           |            |           |            |
| 18–35                  | 14 13.5%                  | 5 18.5%    | 20 30.3%  | 12 32.4%   | 1 6.3%      |
| 36–55                  | 66 63.5%                  | 8 29.6%    | 31 47.0%  | 16 43.2%   | 9 56.3%     |
| 56+                    | 24 23.1%                  | 14 51.9%   | 15 22.7%  | 9 24.3%    | 6 37.5%     |
| Years practicing       |                           |            |           |            |
| ≤5 years               | 4 3.8%                    | 2 7.4%     | 18 27.3%  | 11 29.7%   | 3 18.8%     |
| 6–10 years             | 26 25.0%                  | 11 40.7%   | 15 22.7%  | 10 27.0%   | 4 25.0%     |
| 11–20 years            | 36 34.6%                  | 9 33.3%    | 15 22.7%  | 11 29.7%   | 4 25.0%     |
| 21+ years              | 38 36.5%                  | 5 18.5%    | 18 27.3%  | 5 13.5%    | 5 31.3%     |
| % Of patients on medicaid |                       |            |           |            |
| ≤25%                   | 57 54.8%                  | 19 70.4%   | 22 33.3%  | 13 35.1%   | 11 68.8%    |
| 26–50%                 | 23 22.1%                  | 5 18.5%    | 10 15.2%  | 5 13.5%    | 2 12.5%     |
| >50%                   | 24 23.1%                  | 3 11.1%    | 34 51.5%  | 19 51.4%   | 3 18.8%     |
| Practice setting       |                           |            |           |            |
| Individual practice    | 39 37.5%                  | 8 29.6%    | 8 12.1%   | 5 13.5%    | 4 25.0%     |
| Group office practice  | 19 18.3%                  | 10 37.0%   | 5 7.6%    | 3 8.1%     | 4 25.0%     |
| Public psychiatric hospital | 11 10.6%               | 2 7.4%    | 4 6.1%    | 1 2.7%     | 1 6.3%      |
| Public clinic or outpatient facility | 9 8.7%          | 2 7.4%    | 18 27.3%  | 8 21.6%    | 1 6.3%      |
| Mental health center   | 7 6.7%                    | 1 3.7%     | 13 19.7%  | 7 18.9%    | 1 6.3%      |
| Private psychiatric hospital | 6 5.8%                | 0 0.0%    | 1 1.5%    | 0 0.0%     | 1 6.3%      |
| Private clinic or outpatient hospital | 4 3.8%         | 2 7.4%    | 4 6.1%    | 0 0.0%     | 1 6.3%      |
| Private, public general hospital | 4 3.8%             | 2 7.4%    | 4 6.1%    | 1 2.7%     | 0 0.0%      |
| Other work setting     | 9 8.7%                    | 2 7.4%     | 9 13.6%   | 12 32.4%   | 3 18.8%     |

* Two social workers identified as neither male or female.
Beliefs About Medication Adherence
When uncertain about a patient’s adherence, most prescribers (93.9%) reported asking patients about adherence directly, followed by assessing symptomatology (63.4%), asking a collateral (relative, caregiver; 61.1%), or contacting a pharmacy (22.9%). Few prescribers reported counting pills (7.6%), requesting use of a daily logbook (0.7%), or using adherence scales (0.7%).

Most prescribers (84.0%) reported adequate time to assess medication adherence, while only 66.2% reported confidence in accurately estimating adherence (Table 2). Most prescribers (91.6%) reported concern about the validity of self-reported adherence, a concern that was more common among those providing care for patients with bipolar disorder and schizophrenia rather than MDD (95.7% and 97.4% vs. 82.2%; \( p < 0.05 \)). More prescribers treating patients with schizophrenia (84.6%) reported concern about their ability to adequately monitor adherence, followed by those treating bipolar disorder (73.9%) and MDD (44.6%; \( p < 0.05 \)). Most non-prescribing clinicians (89.9%) reported that assessing adherence is an important part of the service provided, and that adherence can be influenced by clinicians (91.6%; Table 2).

TABLE 2. Drivers and barriers of technology adoption in clinical practice among prescribing and non-prescribing clinicians

| Question                                                                 | Prescribing clinicians | Non-prescribing clinicians |
|-------------------------------------------------------------------------|------------------------|-----------------------------|
| Drivers of adoption                                                     | \( N = 131 \)          | \( N = 119 \)               | Odds ratio | 95% CI |
| This product is likely to ____ increase efficiency                      | 10 (7.6%)              | 17 (14.3%)                  | 2.1        | (1.1, 3.9) |
| This product is likely to ____ improve outcomes                         | 102 (77.9%)            | 71 (59.7%)                  |            |        |
| This product is likely to ____ have no effect                           | 15 (11.5%)             | 21 (17.6%)                  |            |        |
| This product is likely to ____ decrease efficiency                      | 2 (1.5%)               | 5 (4.2%)                    |            |        |
| This product is likely to ____ decrease outcomes                        | 2 (1.5%)               | 5 (4.2%)                    |            |        |
| Using the ingestible event marker sensor technology is in my patient’s best interest. |                        |                            |            |        |
| Agree                                                                   | 99 (75.6%)             | 60 (50.4%)                  | 3.0        | (1.8, 5.4) |
| Disagree                                                                | 32 (24.4%)             | 59 (49.6%)                  |            |        |
| This product is likely to ____ enhance patient engagement with their treatment |                        |                            |            |        |
| Increase                                                                | 94 (71.8%)             | 59 (49.6%)                  | 2.6        | (1.5, 4.4) |
| Decrease                                                                | 13 (9.9%)              | 28 (23.5%)                  |            |        |
| Have no effect                                                          | 24 (18.3%)             | 32 (26.9%)                  |            |        |
| Using this technology will ____ enhance my clinical alliance with patients |                        |                            | 1.6        | (1.0, 2.7) |
| Enhance                                                                 | 85 (64.9%)             | 63 (52.9%)                  |            |        |
| Erode                                                                   | 46 (35.1%)             | 56 (47.1%)                  |            |        |
| This product is likely to ____ decrease inter-visit contacts with patients |                        |                            |            |        |
| Agree                                                                   | 62 (47.3%)             | 49 (41.2%)                  |            | NS      |
| Disagree                                                                | 69 (52.7%)             | 70 (58.8%)                  |            |        |
| Barriers to adoption                                                     |                        |                            |            |        |
| ‘I Would not adopt this technology because...’                           |                        |                            |            |        |
| It might require 24/7 monitoring                                        |                        |                            |            |        |
| Agree                                                                   | 39 (29.8%)             | 62 (52.1%)                  | 0.4        | (0.2, 0.7) |
| Disagree                                                                | 92 (70.2%)             | 57 (47.9%)                  |            |        |
| I’m unsure of my responsibility when using it                           |                        |                            |            |        |
| Agree                                                                   | 86 (65.6%)             | 89 (74.8%)                  |            | NS      |
| Disagree                                                                | 45 (34.4%)             | 30 (25.2%)                  |            |        |
| It’s data I do not normally collect                                     |                        |                            |            |        |
| Agree                                                                   | 73 (55.7%)             | 78 (65.5%)                  |            | NS      |
| Disagree                                                                | 58 (44.3%)             | 41 (34.5%)                  |            |        |
| I’m unclear on follow-up actions                                        |                        |                            |            |        |
| Agree                                                                   | 57 (43.5%)             | 68 (57.1%)                  | 0.6        | (0.4, 0.9) |
| Disagree                                                                | 74 (56.5%)             | 51 (42.9%)                  |            |        |
| It might make it difficult to accept new patients                        |                        |                            |            |        |
| Agree                                                                   | 58 (29.0%)             | 50 (42.0%)                  | 0.6        | (0.3, 0.9) |
| Disagree                                                                | 93 (71.0%)             | 69 (58.0%)                  |            |        |
| I lack knowledge about adherence drivers                                |                        |                            |            |        |
| Agree                                                                   | 28 (21.4%)             | 49 (41.2%)                  | 0.4        | (0.2, 0.7) |
| Disagree                                                                | 103 (78.6%)            | 70 (58.8%)                  |            |        |
| I would like to be a beta site for this technology                      |                        |                            |            |        |
| Agree                                                                   | 68 (51.9%)             | 59 (49.6%)                  |            |        |
| Disagree                                                                | 63 (48.1%)             | 60 (50.4%)                  |            | NS      |
practitioners and the most likely adherence intervention reported was switching the patient to a long-acting injectable (38.9%), followed by cognitive behavioral therapy/motivational interviewing (33.6%), and adherence education (16.9%).

**Barriers and Drivers of Support for the IEM Technology**

The majority (85.5%) reported having used digital medicine technology with patients and agreed that digital medicine applications improve efficiency (84.0%). Prescribers believed that an IEM solution would be beneficial to their patients: 77.9% agreed that an IEM would improve clinical outcomes and 75.6% agreed that the device was in their patients’ best interest (Table 3). Nearly two-thirds of prescribers (64.9%) reported that an IEM solution would “enhance” their clinical alliance with patients. Overall, 71.8% reported the solution would increase patient engagement with their treatment; fewer (47.3%) agreed that it would decrease inter-visit contacts with their patients.

Most (65.6%) prescribers were unsure of their responsibility when using such a device (Table 4), though this issue was a greater concern among NPs than physicians (85.2% vs. 61.2%; \( p < 0.05 \)). Nearly 56% of respondents expressed concern about collecting data they do not normally collect. Few prescribers (29.8%) expressed concern over potentially new patient monitoring responsibilities or impact to their patient panel (29.0%). Finally, 43.5% were unclear about required follow-up actions if they adopted the system, and 21.4% indicated that a lack of knowledge about drivers of medication adherence was a concern.

Of the 119 non-prescribing respondents, 60 (50.4%) agreed that the use of the IEM technology was in their patients’ best interest. Support for the technology did not vary by provider age, sex, degree/licensure, practice setting, or years in practice; however, it did vary by disorder, with the highest level of support for patients with bipolar disorder (64.1%), followed by schizophrenia.

**TABLE 3. Clinician characteristics and perspectives on medication adherence with whether the ingestible event monitoring technology is in patients best interest, by clinical group**

| Question to prescriber | Prescribing clinicians | Non-prescribing clinicians |
|------------------------|------------------------|----------------------------|
|                        | Best interest | Not best interest | Odds ratio | 95% CI | Best interest | Not best interest | Odds ratio | 95% CI |
| Clinician characteristics |             |                 |           |       |             |                 |           |       |
| Physician              | 82.8%        | 68.8%          | NS        |       | -            | -                |           |       |
| Nurse                  | 17.2%        | 31.3%          |           |       | -            | -                |           |       |
| Psychologist           |              |                 |           |       |              |                  |           |       |
| Social work            |              |                 |           |       |              |                  |           |       |
| Counselor              |              |                 |           |       |              |                  |           |       |
| Clinician sex          |             |                 |           |       |              |                  |           |       |
| Female                 | 55.6%        | 59.4%          | NS        |       | 75.0%        | 86.0%            | NS        |       |
| Male                   | 41.4%        | 37.5%          |           |       | 25.0%        | 14.0%            |           |       |
| Years in practice      |             |                 |           |       |              |                  |           |       |
| 0–5 years              | 4.0%         | 6.3%           | NS        |       | 30.0%        | 23.7%            | NS        |       |
| 6–10 years             | 28.3%        | 28.1%          |           |       | 25.0%        | 23.7%            |           |       |
| 11–20 years            | 34.3%        | 34.4%          |           |       | 26.7%        | 23.7%            |           |       |
| 21+ years              | 33.3%        | 31.3%          |           |       | 18.3%        | 28.8%            |           |       |
| Condition managed      |             |                 |           |       |              |                  |           |       |
| MDD                    | 31.3%        | 46.9%          | 1         | (0.6, 3.4)| 25.00%        | 44.10%         | 1          |       |
| Bipolar I disorder     | 34.3%        | 37.5%          | 1.4       | (0.6, 3.4)| 41.70%        | 23.70%         | 3.1        | (1.2, 7.7)|
| Schizophrenia          | 34.3%        | 15.6%          | 3.3       | (1.1, 10.1)| 33.30%        | 32.20%         | 1.8        | (0.7, 4.5)|
| Perspectives on adherence |             |                 |           |       |              |                  |           |       |
| Clinicians influence adherence to oral antipsychotic medication? | Agree | 96.0% | 93.8% | NS | 93.3% | 88.1% | NS |
| Disagree               | 4.0%         | 6.3%           |           |       | 6.7%         | 10.2%           |           |       |
| Concerned about self-reported adherence | Agree | 93.9% | 84.4% | NS | 93.3% | 79.7% | 3.6 | (1.1, 11.8) |
| Disagree               | 6.1%         | 15.6%          |           |       | 6.7%         | 20.3%           |           |       |
| Adherence reduces consequences of the disorder | Agree | 89.9% | 71.9% | 3.5 (1.3, 9.6) | 96.7% | 79.7% | 7.4 (1.6, 34.7) |
| Disagree               | 10.1%        | 28.1%          |           |       | 3.3%         | 20.3%           |           |       |
| Adequate time to assess medication adherence | Agree | 84.8% | 81.3% | NS | 91.7% | 88.1% | NS |
| Disagree               | 15.2%        | 18.8%          |           |       | 8.3%         | 11.9%           |           |       |
| Assessing adherence important service provided | Agree | 97.2% | 50.0% | 2.7 (1.2, 6.1) | 53.3% | 50.8% | NS |
| Disagree               | 2.8%         | 50.0%          |           |       | 46.7%        | 49.2%           |           |       |
| Concerned about adequately monitor adherence | Agree | 97.2% | 75.0% | 10.7 (2.6, 43.3) | 86.7% | 67.8% | 3.1 (1.2, 7.8) |
| Disagree               | 2.8%         | 25.0%          |           |       | 13.3%        | 32.2%           |           |       |
| Concerned for patients’ well-being without adequate monitoring | Agree | 97.2% | 75.0% | 10.7 (2.6, 43.3) | 86.7% | 67.8% | 3.1 (1.2, 7.8) |
| Disagree               | 2.8%         | 25.0%          |           |       | 13.3%        | 32.2%           |           |       |
| Confident estimating patient’s medication adherence | Agree | 64.6% | 71.9% | NS | 75.0% | 64.4% | NS |
| Disagree               | 35.4%        | 28.1%          |           |       | 25.0%        | 35.6%           |           |       |
Support for the IEM sensor technology was associated with concern about the validity of patient self-reported adherence (OR: 3.6; 95% CI: 1.1–11.8), with the belief that improving adherence with antipsychotics “reduces the health, social, and financial consequences” of their patient’s disorder (OR: 7.4; 95% CI: 1.6–34.7), and with concern for patients’ well-being if adherence not adequately monitored (OR: 3.1; 95% CI: 1.2–7.8) (Table 2).

Non-prescribers (73.9%) expected the technology to either improve outcomes or increase practice efficiency. Fewer (52.9%) expected the technology to enhance the clinical alliance with patients, increase patient engagement with treatment (49.6%), or decrease contacts with patients between visits (31.1%). However, supporting the IEM technology was associated with each of the following beliefs: improved outcomes or practice efficiency (OR: 17.2, 95% CI: 4.8, 61.0), enhanced clinical alliance (OR: 6.8; 95% CI: 3.0, 15.3), and fewer contacts between visits (OR: 2.5; 95% CI: 1.1, 5.9). Providers who expected the technology to increase inter-visit contacts were also more supportive of the technology (OR: 3.6, 95% CI: 1.3, 9.9). The most common barrier was unclear responsibility when using the technology (74.8%), which was also associated with support for adopting the IEM technology (OR: 0.8; 95% CI: 0.1, 0.7) followed by unclear follow-up actions (OR: 0.4; 95% CI: 0.2, 0.8) (Table 3).

Both the belief that the IEM technology was in patients’ best interest and an interest in being a beta test site for the technology were positively associated with a general support for technology to monitor adherence (as measured by support for MEMS), a belief that the IEM technology will increase patient engagement with treatment, and that the technology will enhance the clinical alliance and was inversely associated with concern about clinician responsibility when using the technology (Table 5) Belief

### Table 4: Association of clinical characteristics and perspectives on medication adherence with interest in being a beta test site for ingestible event monitoring technology

| Question to prescriber | Prescribing clinicians | Non-prescribing clinicians |
|------------------------|------------------------|---------------------------|
|                        | Yes | No | Odds ratio | 95% CI | Yes | No | Odds ratio | 95% CI |
| Clinician characteristics |     |    |            |        |     |    |            |        |
| Clinician | Physician | 79.4% | 79.4% | NS | - | - | - | - |
|            | Nurse | 20.6% | 20.6% | NS | - | - | - | - |
|            | Psychologist | 20.3% | 6.7% | NS | - | - | - | - |
|            | Social work | 49.2% | 61.7% | NS | - | - | - | - |
|            | Counselor | 30.5% | 31.7% | NS | - | - | - | - |
| Clinician sex | Female | 55.9% | 57.1% | NS | - | - | - | - |
|              | Male | 39.7% | 41.3% | NS | - | - | - | - |
| Years in practice | 0 to 5 years | 5.9% | 3.2% | NS | - | - | - | - |
|              | 6 to 10 years | 26.5% | 30.2% | NS | - | - | - | - |
|              | 11 to 20 years | 30.9% | 38.1% | NS | - | - | - | - |
|              | 21+ years | 36.8% | 28.6% | NS | - | - | - | - |
| Condition managed | MDD | 29.4% | 41.3% | NS | - | - | - | - |
|              | Bipolar disorder | 33.8% | 36.5% | NS | - | - | - | - |
|              | Schizophrenia | 36.8% | 22.2% | NS | - | - | - | - |
| Perspectives on adherence | Clinicians influence adherence to oral antipsychotic medication? | Agree | 95.6% | 95.2% | NS | - | - | - | - |
| | Disagree | 4.4% | 4.8% | NS | - | - | - | - | - |
| Concerned about self-reported adherence | Agree | 97.1% | 85.7% | 5.5 (1.1, 26.5) | - | - | - | - |
| | Disagree | 2.9% | 14.3% | NS | - | - | - | - | - |
| Adherence reduces consequences of the disorder | Agree | 88.2% | 82.5% | NS | - | - | - | - |
| | Disagree | 11.8% | 17.5% | NS | - | - | - | - |
| Adequate time to assess medication adherence | Agree | 80.9% | 87.3% | NS | - | - | - | - |
| | Disagree | 19.1% | 12.7% | NS | - | - | - | - |
| Assessing adherence important service provided | Agree | 91.5% | 88.3% | NS | - | - | - | - |
| | Disagree | 8.5% | 11.7% | NS | - | - | - | - |
| Concerned about adequately monitor adherence | Agree | 79.4% | 54.0% | 3.3 (1.5, 7.1) | - | - | - | - |
| | Disagree | 20.6% | 46.0% | NS | - | - | - | - |
| Concerned for patients’ well-being without adequate monitoring | Agree | 95.6% | 87.3% | NS | - | - | - | - |
| | Disagree | 4.4% | 12.7% | NS | - | - | - | - |
| Confident estimating patient’s medication adherence | Agree | 60.3% | 73.0% | NS | - | - | - | - |
| | Disagree | 39.7% | 27.0% | NS | - | - | - | - |

Abbreviation: MDD, major depressive disorder.
that the technology is in the patients’ best interest was also positively associated with being a prescribing clinician (OR: 2.2; 95% CI: 1.1, 4.5), with concern for patients’ well-being without adequate adherence monitoring (OR: 3.3; 95% CI: 1.2, 8.7), with the belief that adherence to antipsychotics reduces the health/social/financial consequences of the mental health disorder (OR: 3.8; 95% CI: 1.3, 11.0), and with the belief that the technology will decrease inter-visit contacts with patients (OR: 2.1; 95% CI: 1.0, 4.2) and was inversely associated with concern about appropriate follow-up actions (OR 0.4; 95% CI: 0.2, 0.9).

Concern about the validity of self-reported adherence was associated with an interest in being a beta test site (OR: 5.5; 95% CI: 1.6, 18.8) but not that the technology was in the patients’ best interest.

**DISCUSSION**

Nonadherence to antipsychotic medication is common (18–22) and a driver of potentially a voidable health service utilization and costs (23). Yet, assessing medication non-adherence during a clinic visit is a challenge for clinicians (24–27). Due to the lack of efficient, valid alternative data collection methods (28), providers routinely rely on patient or caregiver self-report (29,30) combined with assessment of symptom control for adherence information, and as a result, tend to significantly overestimate their patients’ level of adherence to medication (24,31) and confound medication effectiveness with adherence. Currently available alternative approaches to measuring medication adherence, including the use of reports based on pharmacy claims, the administration of standardized questionnaires, or technologies that measure the opening of prescription drug bottles are routine in clinical and epidemiologic research but are not widely adopted in clinical practice (32,33).

Inaccurate assessment of medication adherence leads to uninformed treatment, management, and prescribing decisions having clinical ramifications for patients and financial costs to payers (34).

When reviewing a series of clinical vignettes of patients with schizophrenia, clinicians whose vignettes included digitally captured adherence information (compared to those whose vignettes did not) were more likely to switch non-adherent patients to a long-acting injectable antipsychotic, and more likely to increase the dose of oral antipsychotic medication among patients who were adherent but poorly controlled (35). These results are consistent with an administrative claims analysis of 286,249 patients with serious mental illness which reported that physician awareness of nonadherence was associated with medication switching and dose increases (36).

By recording medication ingestion data and delivering timely reporting to patients and providers, the IEM technology platform provides a promising alternative to traditional methods of medication adherence assessment. Though the design, development, and testing of this novel IEM technology in psychiatry is still evolving (37,38), early studies suggest it meets criteria for usability, patient acceptance, and provider acceptance and utility (39,40).

**TABLE 5. Logistic regression results:** Factors associated with belief that the ingestible event monitoring technology is in the best interest of my patient, prescribing and non-prescribing clinicians

| Question                                                                 | Response                  | Patients’ best interest | Interest in beta testing |
|--------------------------------------------------------------------------|---------------------------|-------------------------|--------------------------|
| Clinician type                                                           |                           |                         |                          |
| Non-prescriber                                                          | Prescriber                |                         |                          |
| MEMS (continuous 1–6 ranking)                                           | Disagree                  | 0.76 (0.6, 0.9)         | 0.77 (0.6, 0.9)          |
| Concerned for patients’ well-being without adequate monitoring          | Agree                     | 3.3 (1.2, 8.7)          | NS                       |
| Adherence reduces consequences of the disorder                           | Disagree                  | 3.8 (1.3, 11.0)         | NS                       |
| I’m unclear on follow-up actions                                         | Agree                     | 0.4 (0.2, 0.9)          | NS                       |
| I’m unsure of my responsibility when using it                           | Disagree                  | 1                       | 1                        |
| This product is likely to decrease inter-visit contacts with patients    | Agree                     | 0.3 (0.1, 0.8)          | 0.5 (0.2, 0.9)           |
| Using this technology will _____________ my clinical alliance with patients | Erode                     | 1                       | 1.0                      |
| Increase patient engagement with treatment                              | Enhance                   | 3.1 (1.5, 6.3)          | 6.0 (3.1, 11.6)          |
| Concerned about self-reported adherence                                  | Increase/no effect         |                         |                          |
| Concerned about self-reported adherence                                  | Decrease                  | 3.0 (1.5, 6.2)          | 2.3 (1.2, 4.5)           |
| Concerned about self-reported adherence                                  | NS                        |                         | 1                        |
| Concerned about self-reported adherence                                  | Agree                     | 5.5 (1.6, 18.8)         |                          |

* Results obtained using backward elimination logistic regression.
Our results indicate support for the technology varied by views on medication and adherence, with support highest among respondents who believe that antipsychotics reduce the health, social, and financial consequences of the disorder, who are concerned about the validity of self-reported adherence, and who are concerned about patient well-being if adherence cannot be adequately managed. Further, support was more likely among providers who believed it would improve patient outcomes or increase practice efficiency, including enhanced clinical alliance and patient engagement. In contrast, support was lower among respondents who were unsure about their responsibility if using the technology and who were unclear on appropriate follow-up actions. These perspectives align with the growing body of evidence that medication non-adherence is a complex issue. A recent Cochrane review concluded that providing clinicians with medication adherence information improves the process of care but does not translate into “improved medication adherence, patient outcomes, or health resource use.” (41) This finding supports evidence that simple strategies, such as providing pill boxes or educating patient’s on the importance of consistency are only modestly effective (42) and that patient’s struggling with medication non-adherence are best supported by comprehensive, person-centered approaches (43). However, these approaches are complex, time-consuming to implement, and require additional training for providers and healthcare systems (44).

Support for the technology differed between clinicians who have authority to prescribe medications (75.6%) and extended care team members without prescribing authority (50.4%). Nonetheless, most allied care team members reported that medication adherence is an issue that can be influenced by clinicians and that reporting nonadherence to the prescribing clinician is important. Credible medication adherence data may help improve care coordination between care team members and the prescribing provider. Further, non-prescribing mental health professionals may use these data to employ alternative adherence interventions, approaches that do not involve changes to pharmaceutical treatment (45). For example, psychologists and counselors may integrate adherence information into cognitive-behavioral therapy to address negative perceptions about medication, into motivational interviewing techniques to reinforce the importance of taking medications and improve confidence in the ability to adhere, or into environmental supports such as alarms and checklists to remind individuals when to take medication.

These provider perspectives offer insights that can support the integration of this novel technology in clinical practice. Implementation strategies that identify and address an individual provider's priorities and perspectives will likely achieve the most success. Future research should focus on provider-centered approaches that integrate the value of objective medication adherence data and the methods for translating these results into effective interventions. Given the importance of extended care teams in mental health care (psychotherapists, social workers, case managers, etc.), future research should also focus on understanding their support for new approaches to adherence, psychosocial, and cognitive behavioral interventions.

Study limitations
A modest sample size recruited from a convenience sample limit the generalizability of results as participants may represent a select sub-group of care providers. Respondents did not have an ability to interact directly with the IEM sensor technology, rather, a description of the device was introduced as text within the questionnaire. Further, our study was focused on barriers and drivers of adopting this technology and did not explore how these data might be used in everyday practice, an important topic for future research. Finally, the survey focused only on the provider perspective and did not include the patient perspective, which should be investigated in future studies.

CONCLUSIONS
Mental health care providers are concerned about medication adherence, perceive current monitoring tools as problematic, and are open to using digital medicine technologies to improve accuracy of adherence assessment. Successful adoption of the IEM sensor technology will depend upon additional evidence that patients will benefit from the technology through improved outcomes and that the additional burden placed upon providers is minimal compared to the potential benefit. Given the importance of allied health professionals in mental health care, future research should focus on how this technology supports care coordination with prescribing clinicians and on empowering clinicians with tools to translate insights into impactful adherence interventions.

AUTHOR AND ARTICLE INFORMATION
Health Analytics LLC, Columbia, MD (Liberman, Davis, Ruetsch); University of Texas Health Science Center, San Antonio, TX (Velligan); Northwell Health, Feinstein Institutes for Medical Research, Hempstead, NY (Robinson); School of Medicine, University of Maryland, Baltimore, MD (Carpenter); JHC Solutions LLC, San Francisco, CA (Jaeger); Otsuka Pharmaceutical Development & Commercialization Inc, Princeton, NJ (Waters, Forma).

Send correspondence to Dr. Liberman (j.liberman@healthanalytics.com).

The authors would like to thank Sara Heverly-Fitt for her administrative support and Pinyao Rui for her analytical support. This project was sponsored by Otsuka Pharmaceutical Development & Commercialization, Inc.

Dr. Heidi Waters is an employee of Otsuka Pharmaceutical Development and Commercialization, Inc. which funded the study. Ms. Felicia Forma was an employee of Otsuka Pharmaceutical Development and Commercialization, Inc. at the time the study was performed. Drs. Liberman, Davis, and Ruetsch are employees of Health Analytics, LLC, the company funded to perform the study.
REFERENCES
1. Mental illness: 2019. Retrieved from https://www.nimh.nih.gov/health/statistics/mental-illness.shtml (accessed 12/3/2019)
2. Fadden G, Bebbington P, Kuipers L: The burden of care: the impact of functional psychiatric illness on the family's burden. Br J Psychiatr J Ment Sci. 1987; 150:285–92
3. Stewart WF, Ricci JA, Chee E, Morganstein D, Lipton R: Lost productive time and cost due to common pain conditions in the US workforce. JAMA. 2003; 290(18):2443–54
4. Fava M, Kendler KS: Major depressive disorder. Neuron. 2000; 28(2):335–41
5. Griswold KS, Pessar LF: Management of bipolar disorder. Am Fam Physician. 2000; 62(6):1343–53
6. Keck PE, Jr., McElroy SL, Strakowski SM, Bourne ML, West SA: Compliance with maintenance treatment in bipolar disorder. Psychopharmacol Bull. 1997; 33(1):87–91
7. DiMatteo MR, Lepper HS, Croghan TW: Depression is a risk factor for noncompliance with medical treatment: meta-analysis of the effects of anxiety and depression on patient adherence. Arch Intern Med. 2000; 160(14):2101–07
8. Yen CF, Chen CS, Ko CH, Yeh ML, Yang SJ, Yen JY, et al: Relationships between insight and medication adherence in outpatients with schizophrenia and bipolar disorder: prospective study. Psychiatr Clin Neurosci. 2005; 59(4):403–9
9. Lee DJ, Farchione TR, Mathis MV, Muniz J, Muoio BM: US food and drug administration's approval of aripiprazole tablets with sensor: our perspective. J Clin Psychiatr. 2018 (3)
10. Plowman RS, Peters-Strickland T, Savage GM: Digital medicines: clinical review on the safety of tablets with sensors for monitoring adherence to tuberculosis therapy. PLoS One. 2013; 8(1):e53373
11. Dickson V: FDA looks to regulate digital drug products. Mod Healthc. 2018
12. Meigs SL, Solomon M: Electronic health record use a bitter pill for many physicians. Perspect. Health Inf. Manag. 2016; 13 (Winter)
13. Chong WW, Aslani P, Chen TF: Effectiveness of interventions to improve antidepressant medication adherence: a systematic review. Int J Clin Pract. 2011; 65(9):954–75
14. Adjeukam A, Blasimme A, Vayena E: Elements of trust in digital health systems: scoping review. J Med Internet Res. 2018; 20(12):e11254
15. Bauer M, Glenn T, Monteith S, Bauer R, Whybrow PC, Geddes J: Ethical perspectives on recommending digital technology for patients with mental illness. Int J Bipolar Disord. 2017; 5(1):1–14
16. Reamer FG: Clinical social work in a digital environment: ethical and risk-management challenges. Clin Soc Work J. 2014; 43(2): 120–32
17. Garcia S, Martinez-Centrotabengoa M, Lopez-Zurbano S, Zorrilla I, Lopez P, Vieta E, et al: Adherence to antipsychotic medication in bipolar disorder and schizophrenic patients: a systematic review. J Clin Psychopharmacol. 2016; 36(4):355–71
18. Haddad PM, Brain C, Scott J: Nonadherence with antipsychotic medication in schizophrenia: challenges and management strategies. Patient Relat Outcome Meas. 2014; 5:43–62
19. MacEwan JP, Forma FM, Shafrin J, Hatch A, Lakdawalla DN, Lindenmayer JP: Patterns of adherence to oral atypical antipsychotics among patients diagnosed with schizophrenia. J Manag Care Spec Pharm. 2016; 22(11):1349–61
20. Sajatovic M, Valenstein M, Blow FC, Ganzoczy D, Ignacio RV: Treatment adherence with antipsychotic medications in bipolar disorder. Bipolar Disord. 2006; 8(3):232–41
21. Semahneg A, Torpey K, Manu A, Assefa N, Tesfaye G, Ankoma A: Psychotropic medication non-adherence and its associated factors among patients with major psychiatric disorders: a systematic review and meta-analysis. Syst Rev. 2020; 9(1):17
22. Gilmer TP, Dolder CR, Lacro JP, Folsom DP, Lindamer L, Garcia P, et al: Adherence to treatment with antipsychotic medication and health care costs among Medicaid beneficiaries with schizophrenia. Am J Psychiatr. 2004; 161(4):692–99
23. Stephenson JJ, Tuncelli O, Gu T, Eisenberg D, Panish J, Crivera C, et al: Adherence to oral second-generation antipsychotic medications in patients with schizophrenia and bipolar disorder: physicians' perceptions of adherence vs. pharmacy claims. Int J Clin Pract. 2012; 66(6):565–73
24. Masand PS, Roca M, Turner MS, Kane JM: Partial adherence to antipsychotic medication impacts the course of illness in patients with schizophrenia: a review. Prim Care Companion J Clin Psychiatry. 2009; 11(4):147–54
25. Chapman SC, Horne R: Medication nonadherence and psychiatry. Curr Opin Psychiatr. 2013; 26(5):446–52
26. Sajatovic M, Velligan DI, Weiden PJ, Valenstein MA, Ogedegbe G: Measurement of psychiatric treatment adherence. J Psychosom Res. 2010; 69(6):591–99
27. Stirratt MJ, Dunbar-Jacob J, Crane HM, Simoni JM, Czajkowski S, Hilliard ME, et al: Self-report measures of medication adherence behavior: recommendations on optimal use. Translat Behav Med. 2015; 5(4):470–82
28. Velligan DI, Wang M, Diamond P, Glahn DC, Castillo D, Bendle S, et al: Relationships among subjective and objective measures of adherence to oral antipsychotic medications. Psychiatr Serv. 2007; 58(9):1187–92
29. Sajatovic M, Velligan DI, Weiden PJ, Valenstein MA, Ogedegbe G: Physician perception of patient adherence compared to patient adherence information to providers for their patients with schizophrenia. J Manag Care Spec Pharm. 2016; 14(5):415–21
30. Copher R, Buzinec P, Zorotvy S, Kazis L, Iqbal SU, Macarios D: Physician perception of patient adherence compared to patient adherence of osteoporosis medications from pharmacy claims. Curr Med Res Opin. 2010; 26(4):777–85
31. Garfield S, Clifford S, Eliasson L, Barber N, Willson A: Suitability of measures of self-reported medication adherence for routine clinical use: a systematic review. BMC Med Res Methodol. 2011; 11(1):1–19
32. Velligan DI, Wang M, Diamond P, Glahn DC, Castillo D, Bendle S, et al: Relationships among subjective and objective measures of adherence to oral antipsychotic medications. Psychiatr Serv. 2007; 58(9):1187–92
33. Sidorkiewicz S, Tran VT, Cousyn C, Perrodeau E, Ravaud P: Discordance between drug adherence as reported by patients and drug importance as assessed by physicians. Ann Fam Med. 2016; 14(5):415–21
34. Zurbano S, Zorotvy S, Kazis L, Iqbal SU, Macarios D: Physician perception of patient adherence compared to patient adherence of osteoporosis medications from pharmacy claims. Curr Med Res Opin. 2010; 26(4):777–85
35. Shafrin J, Schwartz TT, Lakdawalla DN, Forma FM: Estimating the value of new technologies that provide more accurate drug adherence information for providers for their patients with schizophrenia. J Manag Care Spec Pharm. 2016; 22(11):1285–91
36. Shafrin J, May SG, Shrestha A, Ruetsch C, Gerlanc N, Forma F, et al: Access to credible information on schizophrenia patients’ medication adherence by prescribers can change their treatment
strategies: evidence from an online survey of providers. Patient Prefer Adherence. 2017; 11:1071–81
36. Shafrin J, Bognar K, Everson K, Brauer M, Lakdawalla DN, Forma FM: Does knowledge of patient non-compliance change prescribing behavior in the real world? A claims-based analysis of patients with serious mental illness. Clin Outcome Res. 2018; 10:573–85
37. Rohatagi S, Profit D, Hatch A, Zhao C, Docherty JP, Peters-Strickland TS: Optimization of a digital medicine system in psychiatry. J Clin Psychiatr. 2016; 77(9):e1101–07
38. Peters-Strickland T, Hatch A, Adenwala A, Atkinson K, Bartfeld B: Human factors evaluation of a novel digital medicine system in psychiatry. Neuropsychiatric Dis Treat. 2018; 14:553–65
39. Peters-Strickland T, Pestreich L, Hatch A, Rohatagi S, Baker RA, Docherty JP, et al: Usability of a novel digital medicine system in adults with schizophrenia treated with sensor-embedded tablets of aripiprazole. Neuropsychiatric Dis Treat. 2016; 12:2587–94
40. Kopelowicz A, Baker RA, Zhao C, Brewer C, Lawson E, Peters-Strickland T: A multicenter, open-label, pilot study evaluating the functionality of an integrated call center for a digital medicine system to optimize monitoring of adherence to oral aripiprazole in adult patients with serious mental illness. Neuropsychiatric Dis Treat. 2017; 13:2641–51
41. Zaugg V, Korb-Savoldelli V, Durieux P, Sabatier B: Providing physicians with feedback on medication adherence for people with chronic diseases taking long-term medication. Cochrane Database Syst Rev. 2018; 1
42. Conn VS, Ruppar TM, Enriquez M, Cooper P: Medication adherence interventions that target subjects with adherence problems: systematic review and meta-analysis. Res Soc Adm Pharm. 2016; 12(2):218–46
43. Wiecek E, Tonin FS, Torres-Robles A, Benrimoj SI, Fernandez-Llimos F, Garcia-Cardenas V: Temporal effectiveness of interventions to improve medication adherence: a network meta-analysis. PLoS One. 2019; 14(3): e0213432
44. Bosworth HB, Fortmann SP, Kuntz J, Zullig LL, Mendys P, Safford M, et al: Recommendations for providers on person-centered approaches to assess and improve medication adherence. J Gen Intern Med. 2017; 32(1):93–100
45. El-Mallakh P, Findlay J: Strategies to improve medication adherence in patients with schizophrenia: the role of support services. Neuropsychiatric Dis Treat. 2015; 11:1077