Integrating Implementation Measurement into a Stage Model of Digital Intervention Development

Construct	Stages of Intervention Development Most Relevant*	Intended Recipient	Measure	Citation	# items
Implementation Outcomes					
Acceptability	Stages 1-5	Client	• Unified Theory of Acceptance and Use of Technology Questionnaire 2 (UTAUT2) • All items measured on a 7-point Likert scale: Strongly Disagree-Strongly Agree • Measure can be scored by calculating subscale means or totals	Venkatesh V, L. Thong JY, Xu X. Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly.* 2012;36(1):157-178.	28
			• Acceptability of Intervention Measure (AIM) • All items measured on 5-point Likert scale: Completely Disagree-Completely Agree • Score is a calculated mean	Weiner BJ, Lewis CC, Stanick C, et al. Psychometric assessment of three newly developed implementation outcome measures. *Implementation Science.* 2017;12(1):108. doi: 10.1186/s13012-017-0635-3	4
	Stages 1-5	Provider/ Administrative Stakeholder	• Unified Theory of Acceptance and Use of Technology (UTAUT) • Original article does not provide information about item scales or scoring, we recommend using a 7-point Likert scale: Strongly Disagree-Strongly Agree for all items • Measure can be scored by calculating subscale means or totals	Venkatesh V, Morris MG, Davis GB, Davis FD. User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly.* 2003;27(3):425-478.	31
			• Acceptability of Intervention Measure (AIM) • All items measured on 5-point Likert scale: Completely Disagree-Completely Agree • Score is a calculated mean	Weiner BJ, Lewis CC, Stanick C, et al. Psychometric assessment of three newly developed implementation outcome measures. *Implementation Science.* 2017;12(1):108. doi: 10.1186/s13012-017-0635-3	4
Appropriateness	Stages 1-5	Client and provider/admin stakeholder	• Intervention Appropriateness Measure (IAM) • All items measured on 5-point Likert scale: Completely Disagree-Completely Agree • Score is calculated mean	Weiner BJ, Lewis CC, Stanick C, et al. Psychometric assessment of three newly developed implementation outcome measures. *Implementation Science.* 2017;12(1):108. doi: 10.1186/s13012-017-0635-3	4
Costs	Stages 3-5	Client	• Drug Abuse Treatment Cost Analysis Program (DATCAP) - Client • Used to calculate costs incurred by patients receiving inpatient or outpatient substance use treatment. • Instrument interpreted by calculating total costs associated with attending treatment. • Can be used for evaluating cost-effectiveness.	French, M.T. (2005). Drug Abuse Treatment Cost Analysis Program (DATCAP): Client (Outpatient/Inpatient) Version Third Edition, University of Miami, Coral Gables, Florida.	17: inpt 20:outpt
			• European Quality of Life Measure – 5 Dimension – 3 levels (EuroQOL-5D-3L) • Items 1-5 are measured on a 3-point Likert scale: no problems-extreme problems. Item 6 asks the participant to rate their health on a scale of 0-100 • Can be used for evaluating cost-effectiveness • Measure can be scored by calculating mean scores	Shaw JW, Johnson JA, Coons SJ. US valuation of the EQ-5D health states: development and testing of the D1 valuation model. *Med Care.* 2005;43(3):203-220.	6

			• Non-Study Medical Services • Used to measure service utilization and costs incurred by patients outside of services provided by the study • Instrument can be interpreted by developing cost estimates for services used to calculate total cost of service utilization • Can be used for evaluating cost-effectiveness	Polsky D, Glick HA, Yang J, Subramaniam GA, Poole SA, Woody GE. Cost-effectiveness of Extended Buprenorphine-Naloxone Treatment for Opioid-Dependent Youth: Data from a Randomized Trial. *Addiction (Abingdon, England)*. 2010;105(9):1616-1624. doi:10.1111/j.1360-0443.2010.03001.x.	6
	Stages 3-5	Provider/ Admin Stakeholder	• Brief Drug Abuse Treatment Cost Analysis Program (Brief DATCAP) • Used to estimate costs incurred by drug abuse treatment programs related to running the program • DATCAP can be used to calculate total expenditures in individual cost categories or the cost of operating the program as a whole.	French, M.T. (2003). Brief Drug Abuse Treatment Cost Analysis Program (Brief DATCAP): Program Version. First Edition, University of Miami, Coral Gables, Florida.	39
Feasibility	Stages 1-5	Client and Provider	• Feasibility of Intervention Measure (FIM) • All items measured on 5-point Likert scale: completely disagree-completely agree. • Score is calculated mean.	Weiner BJ, Lewis CC, Stanick C, et al. Psychometric assessment of three newly developed implementation outcome measures. *Implementation Science.* 2017;12(1):108. doi: 10.1186/s13012-017-0635-3	4
Fidelity	Stages 1-5	Client Provider/ Admin Stakeholder	Fidelity is defined as the degree to which an intervention is implemented as intended. This implementation outcome will vary by intervention. With digital interventions, tracking features can be integrated in software to allow for tracking of usage to automatically monitor fidelity (e.g., # logins, time on program, areas visited and how long, etc.) Digital interventions can also be specifically developed to deliver interventions according to prescribed protocols.	Proctor E, Silmere H, Raghavan R, et al. Outcomes for Implementation Research: Conceptual Distinctions, Measurement Challenges, and Research Agenda. *Administration and Policy in Mental Health and Mental Health Services Research.* 2011;38:65-76. doi: 10.1007/s10488-010-0319-7	
Penetration	Stages 3-5	Client Provider/ Admin Stakeholder	Penetration is defined as the reach of a given intervention within a service setting or system. Penetration can be calculated as the number of eligible persons who use an intervention divided by the total number of persons eligible for the intervention. Penetration can be assessed at both client/patient/consumer and provider levels. Tracking features can be integrated in software to monitor digital intervention reach.	Proctor E, Silmere H, Raghavan R, et al. Outcomes for Implementation Research: Conceptual Distinctions, Measurement Challenges, and Research Agenda. *Administration and Policy in Mental Health and Mental Health Services Research.* 2011;38:65-76. doi: 10.1007/s10488-010-0319-7	
Sustainability	Stages 3-5	Provider/ Admin Stakeholder	• Program Sustainability Assessment Tool • All items measured on a 7-point Likert scale: Little or No Extent - Very Great Extent, with the option to select not able to answer. • The measure is scored by calculating subscale means and totals.	Luke DA, Calhoun A, Robichaux CB, Elliott MB, Moreland-Russell S. The Program Sustainability Assessment Tool: A New Instrument for Public Health Programs. *Preventing Chronic Disease.* 2014;11:E12. doi: 10.5888/pcd11.130184	40
Characteristics of Intervention					
Usability	Stage 0	Client and provider/admin stakeholder	• System usability Scale (SUS) • All items measured on a 5-item Likert scale (Strongly Disagree-Strongly Agree) • Directions for scoring provided by authors, requires conversions	Brooke J. SUS-A quick and dirty usability scale. In: Jordan PW, Thomas B, Weerdmeester BA, eds. *Usability Evaluation in Industry*. London: Taylor & Francis; 1996:189–194.	10
Perceived Intervention Characteristics • Relative Advantage	Stages 1-5	Client	• Perceptions of Computerized Therapy Questionnaire-Patient • All items measured on a 7-point Likert scale: Strongly Disagree-Strongly Agree	Carper MM, McHugh RK, Murray HW, Barlow DH. Psychometric Analysis of the Perceptions of Computerized Therapy	25

• Compatibility • Observability • Ease of use • Strength of Evidence • Trialability • Engagement • Design Quality and Packaging			• Measure is scored by calculating subscale means	Questionnaire-Patient Version (PCTQ-P). *Administration and Policy in Mental Health and Mental Health Services Research.* 2014;41(1):104-113. doi: 10.1007/s10488-012-0440-x	
			• Perceived Characteristics of Innovating Questionnaire: Result Demonstrability subscale • Original article does not provide information about item scales or scoring, we recommend using a 7-point Likert scale: Strongly Disagree-Strongly Agree • Measure can be scored by calculating subscale means or totals	Moore GC, Benbasat I. Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. *Information Systems Research.* 1991;2(3):192-222. doi: 10.1287/isre.2.3.192	4
			• User Engagement Scale (UES) – Long Form • All items measured on a 5-point Likert scale Likert scale: Strongly Disagree-Strongly Agree • Measure scored by calculating subscale means • A short-form version was empirically derived in 2018, has not yet been thoroughly evaluated	O'Brien HL, Cairns P, Hall M. A practical approach to measuring user engagement with the refined user engagement scale (UES) and new UES short form. *International Journal of Human-Computer Studies.* 2018;112:28-39. doi: 10.1016/j.ijhcs.2018.01.004	30
		Provider/ Admin Stakeholder	• Perceived Characteristics of Innovating Questionnaire • Original article does not provide information about item scales or scoring, we recommend using a 7-point Likert scale: Strongly Disagree-Strongly Agree • Measure can be scored by calculating subscale means or totals	Moore GC, Benbasat I. Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. *Information Systems Research.* 1991;2(3):192-222. doi: 10.1287/isre.2.3.192	25
			• Compatibility Beliefs in Technology Questionnaire • All items measured on a 7-point Likert scale: Strongly Disagree-Strongly Agree • Measure can be scored by calculating means for subscales	Karahanna E, Agarwal R, Angst CM. Reconceptualizing Compatibility Beliefs in Technology Acceptance Research. *MIS Quarterly.* 2006;30(4):781-804. doi: 10.2307/25148754	21
Characteristics of Inner Setting					
Implementation Leadership Scale	Stages 2-5	Provider/ Admin Stakeholder	• Implementation Leadership Scale • All items measured on a 5-point Likert scale: Not at All - Very Great Extent • Score by calculating subscale means or an average of scale means for total score	Aarons GA, Ehrhart MG, Farahnak LR. The implementation leadership scale (ILS): development of a brief measure of unit level implementation leadership. Implementation Science. 2014;9(1):45. doi: 10.1186/1748-5908-9-45	12
Implementation Climate	Stages 2-5	Provider/ Admin Stakeholder	• Implementation Climate Scale • All items measured on a 5-point Likert scale: Not at All - Very Great Extent • Score by calculating subscale means or an average of scale means for total score	Ehrhart MG, Aarons GA, Farahnak LR. Assessing the organizational context for EBP implementation: the development and validity testing of the Implementation Climate Scale (ICS). *Implementation Science.* 2014;9(1):157. doi: 10.1186/s13012-014-0157-1	18
Organizational Readiness	Stages 2-5	Provider/ Admin Stakeholder	• Organizational Readiness for Implementing Change • All items are measured on a 5-point Likert scale: disagree-agree. • Score is calculated mean.	Shea CM, Jacobs SR, Esserman DA, Bruce K, Weiner BJ. Organizational readiness for implementing change: a psychometric assessment of a new measure. *Implementation Science.* 2014;9(1):7. doi: 10.1186/1748-5908-9-7	12

* Stages of intervention development are based on the Stage Model of behavioral treatment development described in:

Onken LS, Carroll KM, Shoham V, Cuthbert BN, Riddle M. Reenvisioning Clinical Science. *Clinical Psychological Science.* 2013;2(1):22-34. doi: 10.1177/2167702613497932