PERSPECTIVES

Understanding Processes, Outcomes, and Contexts in Medication Adherence: The Medication Adherence Context and Outcomes (MACO) Framework

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Abstract: Poor medication adherence is a significant problem, yet interventions to improve it have been largely ineffective. Existing ecological models indicate that adherence is multi-dimensional; however, they do not reflect understanding of context-specific processes and how they lead to adherence outcomes. A framework that reflects context-specific processes is important because it could be used to inform context-specific intervention delivery and measure associated adherence outcomes. The purpose of this paper is to describe the Medication Adherence Context and Outcomes (MACO) framework, which includes contexts (ie, clinics, pharmacies, and home) and context-specific processes (ie, shared decision-making, prescription filling strategies, home medication management) that lead to adherence outcomes (initiation, implementation, discontinuation, and persistence). The Medication and Adherence Contexts and Outcomes (MACO) framework was iteratively developed between 2015 and 2018 based on theory, practice, and research and combining patient experience journey mapping to chronologically describe the environmental contexts and actions (processes) that occur within the contexts and how they contribute to medication adherence as outcome. The three distinct yet interrelated contexts described in the MACO framework are 1) clinical encounters, 2) pharmacy encounters, and 3) day-to-day home management. Within these contexts are specific medication management actions that occur (processes) in order to produce adherence-related outcomes (initiation, implementation, and discontinuation/persistence). The MACO framework distinguishes context-specific processes and outcomes. The MACO framework may be useful to understand at which point(s) along the continuum people experience problems with managing medications. This understanding is potentially useful for developing and delivering context-specific interventions that are based on processes that underlie nonadherence and selecting adherence measures appropriate for the contexts.

Keywords: medication management, health behavior, implementation, ecological models, medication adherence

Introduction

Medication adherence refers to the extent to which people take medications as prescribed; conversely, nonadherence refers to when people do not take medications as prescribed. As many as 30–50% of patients do not take their medications as prescribed. In the United States, medication nonadherence adds an estimated $290 billion annually to healthcare costs.[1] Despite 50 years of adherence research and greater understanding of more than 200 factors known to influence patients' adherence, nonadherence rates remain relatively unchanged.[2,3] Medication nonadherence is a key obstacle to individuals receiving the full treatment benefits of prescribed medications and is associated with significant morbidity and mortality. While it is often easy to focus solely on patients' behavior, medication nonadherence results from complex systems that include healthcare providers, healthcare settings and health policies.

To date, interventions to reduce medication nonadherence (ie, improve adherence) are only modestly effective.[2,4,5] In a recent meta-analysis of 771 adherence intervention studies, the overall effect was equivalent to the intervention group taking 7% more of their prescribed doses, compared with controls.[2] This is equivalent to taking only two additional doses per month of a once per day medication. Moderator analyses indicate that adherence differs depending on the type of

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adherence-enhancing strategies used, the way adherence is measured, who delivers the intervention, where and how the intervention is delivered, and whether, or not, the intervention focuses on behavior change. Clearly, there are multi-dimensional factors that affect adherence.

Although some ecological models reflect multi-dimensional factors influencing adherence,[6,7] they do not describe how these factors affect adherence processes across multiple contexts. Bronfenbrenner's model, the first widely applied ecological model for understanding environmental influences on a broad range of human behaviors, includes adherence across multiple environmental levels (ie, micro, meso and macro)[8,9] The World Health Organization's model identifies five interacting dimensions affecting adherence: (a) patient-related factors, (b) condition-related factors, (c) therapy-related factors, (d) social and economic factors, and (e) health care system–related and health care team–related factors.[7] In addition, other models and frameworks reflect multidimensional aspects of medication adherence.[8,10,11] These multi-dimensional models identify a variety of factors that influence behavior and medication adherence. However, none of these models lay out how these factors are organized in a way that reflects how a patient experiences these dimensions as they navigate the healthcare system associated with managing and adhering to prescribed medications. These models do not specify the settings and/or circumstances inherent to how prescriptions are written, acquired, and then managed as a patient journeys across sites of care and then to the point of managing medications in their home context. Additionally, these multidimensional models do not explicate the context-specific processes of medication management or ways context-specific processes lead to adherence outcomes. A framework that reflects patient-centered context-specific processes is important because it enhances understanding of contexts, what occurs within in them, how they are influenced by other related contexts and ultimately influence adherence outcomes. A contextual framework can be helpful for guiding adherence intervention development, intervention implementation, and measurement of the most salient adherence outcomes based on the appropriate context.

In this paper, we describe the Medication Adherence Context and Outcomes (MACO) framework, including contexts (clinic settings, pharmacies, and home management) and context-specific processes (shared decision-making, filling strategies, home medication management) that lead to adherence (or nonadherence) outcomes. This paper describes how the MACO framework rethinks medication adherence as an outcome that arises from a series of processes that occur in distinctly different, yet interrelated contexts. The MACO framework can be used as an overarching framework to help clinicians and researchers develop and implement adherence interventions that address context-specific influences on adherence outcomes.

Development of the MACO Framework

The MACO framework was iteratively designed and developed with work beginning in 2015. The first version of the MACO framework consisted of specifying the contexts (ie, settings) in which patient behaviors occurred as individuals manage their medications.[12] This first version reflected that medications were prescribed in the clinic, obtained from the pharmacy, and then managed in the home context and these context settings were ordered this way to reflect the user-experience. To develop the first version of the MACO framework, one expert in medication adherence research worked with an expert nurse scientist with extensive caregiving and medication management experience to journey map the patient experience of managing and adhering to medications. Journey maps are rooted in user-centered design and provide a way to visualize a person's experience as they interact with a product or service.[13] Journey mapping has been used in healthcare organizations to visually outline, or flowchart, the steps that patients experience as they interact with healthcare system services.[14] Journey maps reflect the major processes that people experience along a time continuum.[14] A journey map, for example, would show how a patient might go through the phases of registering for laboratory work, then sit in the waiting room before being called back to have labs drawn, and so on. Journey maps have a horizontal axis that is used to sequence the events and experiences of customers as they progress through and interact with others in receiving a service. The journey mapping was enhanced in 2018 by adding foundational components of the ABC adherence taxonomy,[3] outlining key concepts in the framework and designed using concepts of explanatory process modeling.[15]

The MACO Framework

The MACO framework describes relationships between contexts, processes, and adherence outcomes (see Figure 1). Consistent with other ecological models that recognize adherence as multidimensional,[7–9] the MACO framework is multidimensional and includes dimensions of the patient, people patients interact with to manage medications (ie, caregivers, prescribers or other clinical staff, pharmacists and pharmacy staff), and environmental contexts (ie, clinic, pharmacy and home).

Explanatory Process Model Approach

The MACO framework is designed based on the concepts of an explanatory process model and explains possible courses of actions and behaviors that individuals might engage in to manage their medications. Explanatory process models are logic models that explain causal relationships between observed inputs (independent variables) and outputs (dependent variables).[15] Explanatory process models are more advanced than two other types of process models: (1) descriptive process models are used to understand what happens during a process;[17] and (2) prescriptive process models are used to outline the required behaviors that should be followed in order to achieve desired outcomes.[18] By organizing process variables and outcome variables in the MACO framework, abstract and ambiguous notions can be reduced to a set of concrete behavioral indicators.[19] By doing this, the MACO framework specifies outcomes, presumed causal pathways that link proximal and distal outcomes, and outcomes – all of which are recommended by DeVellis and Blalock to develop effective self-management interventions.[20]

Key Concepts in the Framework

As reflected in Figure 1, the MACO framework has four main key concepts: contexts, processes, antecedent events, and outcomes. Below we define these key concepts as they are organized within the MACO framework.

The three distinct yet interrelated contexts described in the MACO framework are 1) clinic, 2) pharmacy, and 3) home. The clinic context is the establishment where patients receive medical care and treatment from a healthcare provider. The clinic context includes interactions with providers and/or their staff which may be in-person, telehealth or
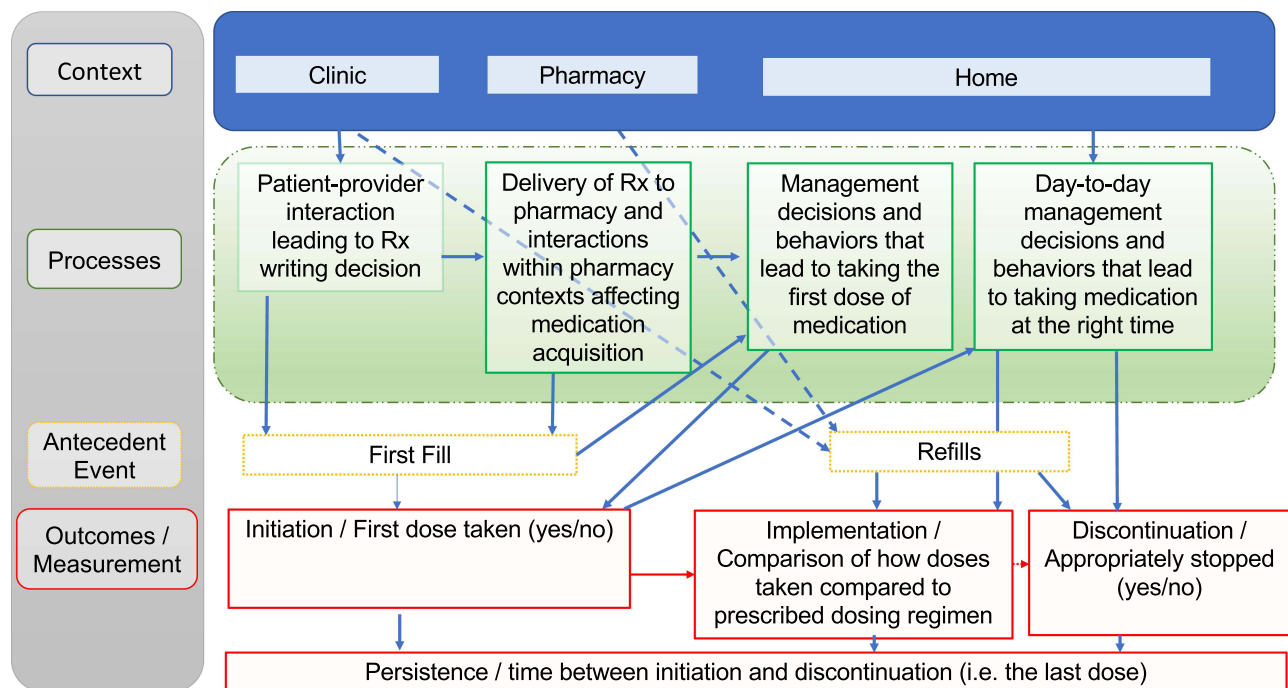

Figure 1 The MACO framework. The medication adherence context and outcomes framework image by Bartlett Ellis RJ and Ruppar TM is licensed under a creative commons international 4.0 license. Available from: https://scholarworks.iupui.edu/handle/1805/30882.[16]

telephone, or other forms of communication with individuals affiliated with the clinic in the context of managing a health condition that requires treatment with a prescribed or recommended medication. The pharmacy context refers to the establishment or setting where medications are obtained and can include a local pharmacy, mail-order service, or directly from the healthcare providers wherein physician/pharmacy encounters are merged (ie, the prescriber provides the medication). Similar to the clinic context, the patient interacts with people or services (eg, online platform to order medication) associated with the pharmacy in the process of obtaining medications. The home context is outside of the healthcare system and is defined as the environment in which the patient would routinely take medication and can include places such as the patient's home, school, work, etc.

Processes are the behaviors and decisions, conceptualized as a series of actions or steps that people take, related to their medications. Each process is context-specific, organized in the framework figure under each of the three contexts to which they belong. Processes serve to describe the sequential and the most prevalent and observable courses of actions in specific settings. Context-specific processes are linked to context-specific outcomes, and they are also linked sequentially to other context processes. The linkages are noted in Figure 1 with directional lines that connect processes and outcomes.

Antecedent events precede adherence outcomes and reflect the necessity for patients to have medications on hand to take them, conditions which are necessary, but not sufficient for adherence. The outcomes in the MACO framework are based on the Ascertaining Barriers to Compliance (ABC) taxonomy for specifying adherence outcomes.[3] The ABC Taxonomy categorizes adherence into three phases: initiation, implementation, and discontinuation.[3] These adherence outcomes are reflected as the outcomes in the MACO and outlined in red, see Figure 1.

We define "outcome" as

The output, result or consequence of something that precedes it. (Merriam)

Processes and antecedent events precede adherence outcomes in the MACO framework, and therefore serve as inputs, or the pathways that explain steps that lead to outcomes. The MACO framework is designed as a longitudinal framework, reflecting the patient journey in managing and adhering to medications as a continuum beginning with the clinic context and moving to subsequent contexts. Based on the patient journey, there are context-specific processes that precede one another in time, in chronological order.

Operationalizing Adherence Outcomes in the MACO Framework

Medication initiation, implementation, and discontinuation are sequentially and chronologically organized MACO adherence outcomes, reflecting a time ordered continuum. Initiation and implementation are measurable adherence outcomes that reflect medication has been taken (ie, ingested), whereas discontinuation reflects that medication taking has ceased altogether. Discontinuation can occur because a short-term medication regimen (eg, antibiotics, short-term steroids) has been appropriately completed as prescribed (ie, adherence) or because of other processes that are consistent with nonadherence (eg, choosing not to take a medication because of side effects, beliefs, or costs).

Consistent with the ABC Taxonomy, initiation occurs when a patient takes the first dose of a newly prescribed medication. The MACO framework operationalizes initiation as a binary outcome variable, measured by whether or not a person initiates the treatment.[3] Implementation addresses how well the patient's dosing history corresponds with the prescribed dosing regimen. Implementation is best measured as a continuous outcome variable determined by an individual's dosing history. Finally, discontinuation occurs when the patient stops taking a medication. Discontinuation is operationalized as a dichotomous variable, measured as the time point when the patient stops taking the medication. The time between initiation and discontinuation is a measure of medication persistence. Persistence is a continuous outcome variable determined by the length of time that a person has taken a particular medication, beginning with initiation, and ending with the last dose taken. These definitions are particularly useful for improving the specificity and precision of adherence measurement.

Because adherence outcomes precede one another in time, they can be described as proximal and distal outcomes, depending upon where they occur in the adherence continuum. The outcome remains the important focus for researchers to determine if interventions are effective; thus outcomes are the focus of measurement. If initiation is the target outcome, then it is a distal outcome. When implementation is the target outcome, then initiation becomes the proximal outcome

and implementation becomes the distal outcome. Similarly, when discontinuation is the target outcome, then initiation and implementation are proximal outcomes, time ordered according to the continuum. Finally, when persistence is the target outcome, then initiation, implementation and discontinuation become consecutively ordered proximal outcomes.

Context-Specific Processes and Adherence Outcomes in the MACO Framework

Below, we describe context-specific processes leading to the various adherence outcomes using a "typical use-case" recognizing that there are possible variations in these processes and noting these where possible. This typical use-case reflects both the short-term and long-term adherence to medications in which individuals are self-managing their own medications or managing with the assistance of an informal caregiver. This use-case does not necessarily apply to situations where professional caregivers are administering medications, such as during inpatient hospitalizations or other similar institutionalized settings. Our description of the MACO primarily represents the patient perspective; however, often medication-management processes include other people, like caregivers or others who support patients across the continuum. These other important people may provide transportation to access clinics and pharmacies or have a more active role by participating more directly, which should be considered when applying these context-specific processes to understanding individual patient perspectives.

Context-Specific Processes Leading to Initiation

The first adherence outcome that the MACO framework focuses on is initiation. To take the first dose of a medication, the person must possess the medication, which requires two steps. First, a prescription is written for the medication. Second, the patient physically acquires the medication. Generally, these initiation steps occur in two different contexts: clinicand pharmacy. Within the clinical context, prescription writing usually occurs in-person, via telehealth visits or via phone, when patients and providers share information that results in a treatment recommendation and a prescription (either written and given to the patient, or electronically transmitted to a pharmacy). Ideally, this patient–provider interaction reflects shared decision-making. After a prescription is provided, the patient must obtain the medication, commonly in the context of a "pharmacy encounter", at either at a local pharmacy, via mail-order service, or directly from the healthcare providers wherein physician/pharmacy encounters are merged. Like the clinic context, in the pharmacy context encounter, patients' interactions with healthcare providers may or may not contribute to patients' decisions that lead to physically obtaining the medication. For example, concerns about cost, side effects, or drug interactions may deter individuals from obtaining the medicine. Inconveniences in obtaining medications such as wait times, transportation, and number of trips and prescriptions needing to be picked up can also affect filling medications. Navigating both the interactions with pharmacy staff and barriers to acquiring medications are reflected in the filling strategy processes. When the demands of pharmacy filling strategies outweigh the resources and coping mechanisms, prescriptions are not obtained. When filling strategy processes are successful, the adherence continuum moves forward.

Once a prescription medication is obtained, the next step is to initiate taking the medication. Initiation typically occurs in the home context. Medication management behaviors and decision-making processes that occur in the home context affect initiation. The processes in the home leading to initiation include planning to take the medication by selecting a time to take the medication, organizing medications, opening the packaging, and removing the medication, preparing the medication for administration if needed (eg, getting water, mixing with food, splitting pills) and then taking the medication (eg, ingesting, inserting, spreading) based on the route of administration.

As reflected in the MACO, filling a prescription is an antecedent event that occurs in the context of the pharmacy. Filling a prescription is required for patients to have medications on hand to subsequently take them in the home context, but filling a prescription is not a measure of initiation, nor do we think it should it be considered a proxy for initiation. In the MACO framework, filling a prescription is antecedent to initiation, and should be considered in studies of adherence interventions as an important behavior and necessary for initiation, but it is not an adherence outcome.

Context-Specific Processes Leading to Implementation

Processes that underlie the outcome of implementation are the most complex, for several reasons. First, like initiation, implementation is preceded by prior context-specific processes that include the clinic and pharmacy and additionally the home context process leading to the adherence outcome of initiation. That means that the processes that occur in the clinic encounter and pharmacy encounters and subsequent initiation are antecedents to implementation. Second, processes of implementation take place repeatedly (eg, over and over every day) based on the dosing regimen. For example, if the dosing regimen is daily, then the actions take place once daily, whereas if the dosing regimen is twice daily, then the actions take place two times each day.

Processes leading to implementation include antecedent processes of the clinic and pharmacy contexts, behaviors associated with initiation, plus behaviors required for maintaining dosing over time. These behaviors include deciding to take medications, keeping prescriptions on hand, prioritizing and planning to take medications (ie, creating routines), preparing correct doses of medications, organizing and sorting, self-monitoring behavior, tracking time for time-dependent medications, and managing side effects.

The repetitive, cyclical implementation processes occur in the context of day-to-day living, which in turn requires awareness of time and adherence to prescribed timing intervals. In addition, individuals need to have the medication on hand, and accessible at the scheduled time the dose is to be taken. Patients then must use processes to organize, prepare, and administer the medication, in the same way they prepare and administer taking the first dose of medication in the initiation phase. However, decision-making processes to support ongoing implementation can be more complex than those required for initiation, as day-to-day experiences can shape decision-making. For example, if a patient perceives an improvement in symptoms, the patient may decide the medication is not needed and then discontinue taking it. Alternatively, the medication may be causing unwanted side effects and a patient may then decide to skip doses or discontinue the medication.

To continue taking medication as prescribed, medications need to be refilled prior to the next scheduled dose; thus, refilling medications is antecedent to day-to-day home management. Day-to-day home management in the home context intersects with the pharmacy context because individuals also need to acquire medication refills to continue taking medications. Day-to-day home management also intersects with clinical contexts because individuals self-monitor for potential side effects and self-monitor symptoms associated with the reason medications are prescribed. In many cases, healthcare providers need to renew the prescription for patients to obtain medication refills, which often requires patients be seen in the clinic setting. Long-term medication implementation involves both cyclical day-to-day dosing behavior and the secondary cyclical initiation-like process which follows the refill interval (eg, 30 days, 90 days).

Context-Specific Processes Leading to Discontinuation and Persistence

Persistence is another adherence outcome variable in the framework; however, unlike initiation and implementation which focus on the behavior of "taking medication", persistence refers to the length of time people remain engaged in implementation; thus, persistence is a distal outcome of initiation and implementation. Persistence requires patients to continue to refill and take their medication for as long as it is indicated, which reflects the same processes embedded in the home context that lead to implementation. The ability to measure persistence to long-term medication regimens is influenced by the duration of follow-up. Because persistence is a measure of time, it must have a start and end time point. In the medication adherence taxonomy,[3] the starting point is initiation, which reflects taking a medication for the first time, whereas the end point is marked when medication taking has been discontinued. For long-term medications, an appropriate end point may not exist, so patients who are appropriately continuing to take their medication are considered persistent. In a research study, this would be treated as censored data. For short-term medications with a planned discontinuation, such as antibiotics or short-course corticosteroids, a measure of time is possible, but there is also a dichotomous determination of whether discontinuation occurred at the correct time.

Discussion

The MACO framework uses the ABC Taxonomy[3] and describes context-specific processes of medication management and associated adherence outcomes. No conceptual frameworks to date reflect processes that occur in these three different, yet interrelated contexts (clinic, pharmacy, home) and include adherence outcomes (initiation, implementation,

discontinuation, and persistence). The MACO framework is designed as a patient-centered, process-outcome model specific to managing and adhering to medications. The focus on medication management processes and adherence outcomes (initiation, implementation, discontinuation, and persistence) provide an overarching framework that could guide designing all future medication management interventions and selecting appropriate adherence outcome measures based on the process and contexts under study.

Operationalization of the Framework

Clinicians and researchers can use understanding of the context-specific processes that lead to initiation, implementation, discontinuation, and persistence to help inform and impact behavior change interventions. For clinicians, the framework could be useful to assess patient problems with adherence, by focusing first on the type of adherence outcome that may need additional support and working backwards through the framework to identify contexts and then processes associated with the respective adherence outcome. In this way, the framework could serve as an efficient heuristic to identify where in the medication management continuum the patient is experiencing problems affecting adherence. For example, if problems are occurring with non-initiation, then the clinician would seek to understand if the patient filled the prescription, an antecedent event. Antecedent events are associated with the clinic and pharmacy contexts, therefore there are two context-specific processes that can be explored to determine appropriate intervention. Processes are important because understanding them can help identify the set of core behaviors necessary for successful medication adherence, including when and where these behaviors take place (ie, context). These behaviors can then be targeted through context-specific intervention. In the clinical setting, perhaps, the provider may need to have more discussion with the patient about the recommended medication to enhance shared decision-making about the selected medication, determining if the patient intended to fill and take the medication when prescribed. Or the clinician may need to explore other medications, treatments, or resources that would help the patient obtain the medication. Or, in the pharmacy context, perhaps the patient did not fill the prescription because they did not have the time to go to the pharmacy or could not afford the medication. In that case, interventions that support patients more efficiently obtaining their medications may be needed, like mail-order services, for which the patient may need help in getting set-up. Coordination with the pharmacy may be necessary. In this example, the clinician can use the framework to assess the patient situation more efficiently, focusing on the context-specific processes that links with the affected adherence outcome, versus focusing on other context processes that are irrelevant. Asking questions about remembering to take medications becomes irrelevant in the discussion if the patient did not fill the prescription and never initiated the prescription. Supporting remembering to take medications or developing habits are interventions best aligned with the home context processes and adherence outcomes of implementation and persistence. Clinicians can use the framework to help focus the time spent with patients on the processes that matter most to the adherence outcome of interest.

   Researchers can use the MACO framework to select the best adherence outcome measures for their studies based on the study setting or point of intervention, identify potential mediators or moderators related to the processes, antecedent events, or adherence outcomes that might otherwise be overlooked in study design, and improve the reporting of medication adherence studies. Having the MACO framework as the overarching view is useful for identifying important context-specific processes and variables that might otherwise be overlooked. For instance, in their secondary analysis, Ellis et al[21] used the MACO framework to select context-specific variables hypothesized to be related to non-adherence. Because their outcome was implementation, they selected variables from the existing dataset that represented contexts of pharmacy and home management because those were the relevant contexts that precede implementation. In another study, in addition to specifying the range of behaviors individuals engage in to manage medications, Bartlett Ellis and Welch[22] also categorized patient adherence behaviors according to where they occurred (ie, clinic, pharmacy and home). In this way, the MACO framework served as the overarching organizing conceptual framework for adherence research. Using the MACO framework in this way may lead to more meaningfully generated and testable hypotheses to advance adherence science. Similarly, to improve rigor and reporting of results, the MACO framework may be a useful adjunct to the recently published EMERGE guidelines for reporting medication adherence research studies[23] with the inclusion of context. By using the framework and reporting research results according to MACO contexts and associated adherence

outcomes, researchers create opportunities for conducting systematic reviews and meta-analyses to investigate context effects on specific medication adherence outcomes.

Moving forward, we suggest the MACO framework be used as the overarching framework to understand relationships between contexts, processes, and adherence outcomes. The MACO is not a replacement for behavior change theories and associated variables (eg, cognition, motivation, affect) or other medication models, rather the MACO could serve as a useful anchor for them. For example, the MACO framework can be used to organize reasons for nonadherence according to context or organize medication benefits, barriers, beliefs, and concerns according to where (ie, MACO context) they are hypothesized to have the greatest effect and specific to the specified adherence outcome (initiation, implementation, discontinuation, persistence). Likewise, other variables, for example cognition or motivation, may exert moderating or mediating effects within the processes, which then brings about effects on the adherence outcomes. For this reason, it is essential to have an overarching framework that describes the behavioral phenomenon as a sequential description of a course of linked observable actions (ie, processes) most prevalent at specific settings and how those processes affect adherence outcomes.

Our intent in building on the foundation laid by the ABC Taxonomy[3] was to guide measurement of salient medication adherence outcomes that are most relevant to the processes patients experience and the contexts linked with them. Waltz et al[19] purports that measurement of variables that lack a conceptual point of view has a higher probability of overlooking important dimensions of variables. Measurement continues to be a concern in the adherence literature because of the different approaches for measuring adherence. Recent efforts to develop measurement frameworks[24] emphasize that the selection of measures should be based on understanding behavior and this perspective is in alignment with the MACO framework.

A conceptual framework linking processes with outcomes, such as the MACO framework, can be useful to move the adherence field forward in the design of more effective, user-centered and context-specific interventions. The MACO framework applies the ecological perspective, but unlike other ecological models, it is based on a process-outcome model and reflects the typical patient journey experience of medication management and adherence. Process-outcome models emphasize process as the causal pathway towards achieving a desired outcome.[25] Behavior change theory and existing medication adherence frameworks that focus on the individual[11,25] are important, and an understanding of context is also important to inform intervention delivery. The MACO framework seeks to explain the relationship between behavioral processes involved in managing medications and adherence outcomes, while also from the ecological perspective, embedding these processes in distinctly different yet interrelated contexts of clinic, pharmacy, and home. Other existing models focus on different concepts and factors, such as the WHO model, which identifies the multiple factors that affect adherence,[7] but does not organize the factors chronologically in a framework that reflects the patient journey across contexts related to specific adherence outcomes. While the ABC taxonomy describes adherence as a process of medication taking as a continuum from initiation to discontinuation,[3] the taxonomy does not align the adherence process with contexts nor reflect the processes within the contexts associated with the taxonomy. In this way, the MACO framework focuses on "how" the individual interacts within different contexts important to medication adherence and emphasizes patient behavior embedded in context-specific processes, which is an advancement over other ecological and multidimensional models[7–11] Processes and contexts are important because understanding processes can help identify the set of core behaviors necessary for successful medication adherence, including when and where these behaviors take place (ie, context). These behaviors can then be targeted through context-specific intervention.

Prior published intervention studies have produced only modest effects on adherence, as discussed in the introduction.[2,4,5] We posit that these modest effects may be due in part to a mismatch between the intervention and the context where the intervention is deployed. This mismatch is likely due in part because, to date, the field has lacked an organizing framework that reflects the typical patient journey across various contexts needed for adherence. Without an organizing framework that connects processes to contexts and outcomes, it becomes difficult to design and implement highly efficacious interventions.

Because the MACO framework focuses on the linkages between context-specific process and outcome, it could be useful for understanding "how" processes influence adherence (ie, outcome), and more specifically for intervention development. Understanding these components can shape intervention design to target the most appropriate context-specific process to achieve the desired adherence outcome. Framing medication research through the process-outcome

lens may provide greater understanding of the mechanisms that underlie improving medication adherence, thus moving beyond whether interventions work, to focusing on context-specific mechanisms of action. Research that explores mechanisms of action is a priority area for funding agencies and the focus for the NIH Science of Behavior Change (SOBC) Common Fund Program because science in general lacks understanding of basic mechanisms of behavior change.[26] A process-outcome view is useful for this purpose because intervening at the context-specific process level becomes the main focus for intervention design and these mechanisms can be empirically tested.

Future Research Opportunities

We propose the MACO framework as an initial starting point to guide future research, but causality will need to be tested in order to establish the MACO framework as an evidence-based explanatory process model. Empirical support for the extent to which the processes serve as causal pathways to adherence outcomes as diagrammed in the MACO Framework requires systematic investigation. To establish the MACO framework as an empirically supported model, future research should endeavor to establish causal pathways between process and outcomes and in the contexts in which they occur. As reflected in the framework, adherence occurs across a continuum, therefore longitudinal studies are warranted. Full-scale longitudinal studies are needed to model variance between and within each of the context-specific processes and associated adherence outcomes. Such studies would need to examine patient-provider relationships, and measure aspects of patient behavior and adherence at multiple time points, and in the different contexts. Using the MACO framework to advance intervention research requires greater understanding of patients' actions, when actions occur, and why actions are taken. Specifying these patient behaviors is necessary to changing them.

Conclusion

The MACO framework is an innovative and patient-centered way to organize the context-specific processes involved in how medications are prescribed, in clinic context encounters, obtained in the pharmacy context, and managed in the home context in daily life. The framework links context-specific processes with adherence outcomes of initiation, implementation, discontinuation, and persistence in the contexts in which they occur, recognizing the antecedent events of filling and refilling of medications needed for adherence. Because the framework was developed to represent the patient experience across the continuum of medication-related contexts, it is patient-centered and multidimensional, offering a framework to better understand the patient experience to improve adherence outcomes. Future research efforts are needed to establish the framework as an evidence-based validated process-outcome model, but clinicians and researchers can use the current framework in practice and research. Clinicians can use the framework to identify context-processes most salient to adherence problems and help focus time spent with patients on the context-specific processes most relevant to find solutions to support the patient. Researchers can use the framework as an overarching framework to frame how their studies and the settings they are conducted in align with the typical patient journey and continuum of medication management. The framework can help researchers select context-specific adherence outcomes and other relevant variables, enhance intervention delivery based on understanding of the context-specific processes and improve reporting of adherence studies by describing how studies align with the patient experience across the continuum represented in the MACO framework.

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References

1. New England Health Care Institute. *Thinking Outside the Pillbox: A System-Wide Approach to Improving Patient Medication Adherence for Chronic Disease*. New England Health Care Institute; 2009.
2. Conn VS, Ruppar TM. Medication adherence outcomes of 771 intervention trials: systematic review and meta-analysis. *Prev Med*. 2017;99:269–276. doi:10.1016/j.ypmed.2017.03.008
3. Vrijens B, De Geest S, Hughes DA, et al. A new taxonomy for describing and defining adherence to medications. *Br J Clin Pharmacol*. 2012;73 (5):691–705. doi:10.1111/j.1365-2125.2012.04167.x
4. Demonceau J, Ruppar T, Kristanto P, et al. Identification and assessment of adherence-enhancing interventions in studies assessing medication adherence through electronically compiled drug dosing histories: a systematic literature review and meta-analysis. *Drugs*. 2013;73(6):545–562. doi:10.1007/s40265-013-0041-3
5. Peterson AM, Takiya L, Finley R. Meta-analysis of trials of interventions to improve medication adherence. *Am J Health Syst Pharm*. 2003;60:657–665. doi:10.1093/ajhp/60.7.657
6. Kidd KE, Altman DG. Adherence in social context. *Control Clin Trials*. 2000;21:S184–S187. doi:10.1016/S0197-2456(00)00076-3
7. Sabaté E, Sabaté E. *Adherence to Long-Term Therapies: Evidence for Action*. World Health Organization; 2003.
8. Berben L, Dobbels F, Engberg S, Hill MN, De Geest S. An ecological perspective on medication adherence. *West J Nurs Res*. 2012;34(5):635–653. doi:10.1177/0193945911434518
9. Bronfenbrenner U. *The Ecology of Human Development: Experiments by Design and Nature*. Cambridge, MA: Harvard University Press; 1979.
10. Kardas P, Lewek P, Matyjaszczyk M. Determinants of patient adherence: a review of systematic reviews. *Front Pharmacol*. 2013;4:91. doi:10.3389/fphar.2013.00091
11. Phillips LA, Diefenbach MA, Kronish IM, Negron RM, Horowitz CR. The necessity-concerns framework: a multidimensional theory benefits from multidimensional analysis. *Ann Behav Med*. 2014;48:7–16. doi:10.1007/s12160-013-9579-2
12. Bartlett Ellis RJ. Medication-taking across the care continuum and adherence-related outcomes (MACO) framework; 2015.
13. Howard T. Journey mapping: a brief overview. *Commun Des Q Rev*. 2014;2(3):10–13. doi:10.1145/2644448.2644451
14. Joseph AL, Kushniruk AW, Borycki EM. Patient journey mapping: current practices, challenges and future opportunities in healthcare. *Knowl Manag E-Learn*. 2020;12:387–404.
15. Van de Ven AH. Suggestions for studying strategy process: a research note. *Strateg Manag J*. 1992;13(S1):169–188. doi:10.1002/smj.4250131013
16. Barlett Ellis RJ, Ruppar TM. The Trustees of Indiana University. The Medication Adherence Context and Outcomes Framework Image. Available from: https://scholarworks.iupui.edu/handle/1805/30882. Accessed 18 Jan 2023
17. Madhavji NH, Holtje D, Hong WK, Bruckhaus T. Elicit: a method for eliciting process models. In: Proceedings of the Third International Conference on the Software Process. Applying the Software Process; 1994; IEEE:111–122.
18. Münch J, Armbrust O, Kowalczyk M, Sotó M. *Software Process Definition and Management*. Springer; 2012.
19. Waltz C, Strickland O, Lenz E. *Measurement in Nursing and Health Research*. New York, US: Springer Publishing Company; 2010:87–89.
20. DeVellis RF, Blalock SJ. Outcomes of self-management interventions. In: Newman SS, Mulligan EK, editors. *Chronic Physical Illness: Self-Management and Behavioural Interventions*. UK: McGraw-Hill Education; 2008:148–167.
21. Ellis RJB, Hertz D, Callahan P, Ruppar TM. Self-reported nonadherence associated with pharmacy and home medication management inconvenience factors in a US adult population. *Patient Prefer Adherence*. 2020;14:529. doi:10.2147/PPA.S223408
22. Bartlett Ellis RJ, Welch JL. Medication-taking behaviours in chronic kidney disease with multiple chronic conditions: a meta-ethnographic synthesis of qualitative studies. *J Clin Nurs*. 2017;26:586–598. doi:10.1111/jocn.13588
23. De Geest S, Zullig LL, Dunbar-Jacob J, et al. ESPACOMP medication adherence reporting guideline (EMERGE). *Ann Intern Med*. 2018;169 (1):30–35. doi:10.7326/M18-0543
24. Kronish IM, Thorpe CT, Voils CI. Measuring the multiple domains of medication nonadherence: findings from a delphi survey of adherence experts. *Transl Behav Med*. 2021;11:104–113. doi:10.1093/tbm/ibz133
25. Johnson MJ. The medication adherence model: a guide for assessing medication taking. *Res Theory Nurs Pract*. 2002;16(3):179–192. doi:10.1891/rtnp.16.3.179.53008
26. Nielsen L, Riddle M, King JW, et al. The NIH science of behavior change program: transforming the science through a focus on mechanisms of change. *Behav Res Ther*. 2018;101:3–11. doi:10.1016/j.brat.2017.07.002