Scaling, Measurement, and Dissemination of CDS Workgroup: Approaches to Measuring Patient-Centered CDS Workflow and Lifeflow Impact

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PURPOSE

The Clinical Decision Support (CDS) Innovation Collaborative (CDSiC) Scaling, Measurement, and Dissemination of CDS Workgroup is charged with identifying measures of patient-centered clinical decision support (PC CDS) adoption, implementation, and use that can be used to scale safe and effective CDS tools beyond initial implementation sites. The Workgroup is comprised of 12 experts and stakeholders representing diverse perspectives related to CDS. This report is intended to be used broadly by those interested in advancing the understanding and evaluation of PC CDS impacts on care team workflows and patient/caregiver lifeflows.

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Table of Contents

List of Exhibits

1. Introduction & Background

The healthcare ecosystem is undergoing unprecedented transition in how care, payment, and research is approached. Among the myriad innovations, emphasis on creating a health system that provides value-based, whole-person care and results in positive patient outcomes is a central theme. The quintuple aim helps realize this vision by outlining five goals for healthcare quality improvement: improving population health, enhancing patient care experience, reducing costs, improving the work life of providers, and advancing health equity.[1]

Patient-centered clinical decision support (PC CDS) is one mechanism that can help drive this transformation. PC CDS encompasses digital tools to support patients and their care teams in both independent and shared decision making. The goal is to promote health- and healthcare-related decisions and actions that are responsive to the individual's life circumstances and preferences and improve care processes and outcomes. PC CDS accomplishes this through the inclusion of information provided by the patient (e.g., patient-generated health data, social determinants of health data) as well as findings from patient-centered outcomes research (PCOR).[2,3] PC CDS can support patients, their caregivers, and their care teams in both the processes leading up to, during, and following a healthcare encounter and in patients' lives outside of the healthcare setting.

To be effective, PC CDS interventions must fit smoothly into clinical workflows and patient's daily activities (i.e., "lifeflows").[3] For example, CDS that does not fit comfortably into clinical workflows may contribute to low user acceptance and uptake of the decision support (e.g., evidence-based recommendation), leading to unintended consequences and suboptimal decisions and care.[4] Similarly for patients, if patient-facing decision support does not adequately consider and address not only their medical data and preferences but also real-world contexts, then health management solutions informed by the decision support will not properly accommodate the daily-living contexts in which they occur. This disconnect increases the possibility that the support will not optimally foster decisions and actions aligned with patient goals and circumstances.[5,6]

Understanding how decision support tools impact patients' decisions and actions is an emerging area, as digital health technology increasingly puts these tools directly in patients' hands. Patient-facing CDS takes many forms, including information delivered via mobile phone apps and text messages, remote monitoring via wearable devices and other sensors, and patient portals and personal health records. Patients use the tools to track symptoms and vital signs, view clinical data such as lab results, receive and review educational materials, manage chronic conditions, and communicate with their care team.[7]

These tools enable generation, transmission, and monitoring of patients' health-related data to their clinician's health information technology (IT) systems {e.g., an electronic health record (EHR)}, which can then be used to improve patient-centered decision making and care by providing a fuller picture of a patient's health status and preferences. The HL7® Patient Empowerment Workgroup defines such patient-contributed data as "any data, information, or insights created, collected by, or originating from a person regarding his or her health and care."[8] Common types of patient-contributed data generated outside of a clinical encounter include health histories and lifestyle choices, real-time self-reported

health conditions, mood, and behavior, patient-reported outcomes, and biometric data measured by patients.[6,9] These data are shared with clinical care team members to support collaboration around the person's health.[8] These patient data management tools also support patient activities in their daily life, including generating data that informs patient-specific PC CDS guidance on decisions and actions.

Despite growing implementation and use of PC CDS in healthcare, understanding PC CDS intervention effects on workflows and patient lifeflows–and where to best trigger CDS for optimal integration into workflows and lifeflows—remains nascent.[3,10] More information is needed about current approaches to measuring these effects to inform the development and use of more robust approaches.

Purpose of This Report. This report aims to identify how organizations and researchers measure the effect of PC CDS interventions on care team workflows and patient and caregiver lifeflows. We focus on three distinct types of PC CDS: 1) patient-facing CDS, 2) clinician-facing CDS, and 3) CDS for shared decision making. While we performed a broad review of the literature, this report is not an exhaustive list of workflow and lifeflow impact measures and measurement approaches; rather, it provides a discussion of commonly documented measurement concepts and tools. In addition to summarizing workflow and lifeflow impacts that are captured in the literature, this report provides a framework for how PC CDS interventions impact care team workflows and patient lifeflows, as well as pragmatic considerations informed by the current evidence base so that CDS researchers, implementers, evaluators, and others can apply these findings to their daily work.

How To Use the Report: This report's framework can help identify interactions between care teams and patients and caregivers and the PC CDS intervention, or "trigger points" within the clinical workflow and the patient lifeflow. This can help users:

- Consider the context of patients' lives when developing PC CDS tools and interventions and where key activities intersect with care team workflows.
- Optimally deploy PC CDS interventions within the patient lifeflow.

In *Section 2, Methods* we summarize our literature review and key informant interview approach to create a unified workflow diagram and the organizing workflow/lifeflow impact measure framework.

Section 3, How Does PC CDS Intersect with Patient Lifeflows and the Care Team Workflows? Presents a unified workflow diagram that illustrates the three clinical and patient/caregiver aspects of PC CDS interventions, including clinician-facing PC CDS that does not directly involve patients, PC CDS to support shared decision making, and patient-facing PC CDS.

Section 4, What Types of Approaches and Measures Have Been Used to Assess PC CDS Workflow and Lifeflow Impacts? Provides a discussion of measurement concepts and approaches used to measure the impacts of PC CDS interventions on workflow processes (i.e., workflow-related intervention dimensions).

Section 5, What Do We Know About the Effects of PC CDS on Care Team Workflows and Patient Lifeflows? Summarizes, at a high level, the state of the evidence of PC CDS intervention impacts on care team workflows and patient lifeflows measures as revealed by our literature review.

Section 6, What Measurement Gaps Remain and How Do We Move Forward? The report concludes with a discussion of gaps in the literature pertaining to workflow/lifeflow measures and measurement approaches, as well as opportunities to close these gaps.

2. Methods

We conducted a scoping review[11] of the peer-reviewed literature relevant to care team workflow impacts and patient lifeflow impacts resulting from CDS usage. Findings from the literature were supplemented with key informant interviews to inform the PC CDS Workflow Diagram and examples of real-world implementations of PC CDS to highlight in this report. The CDSiC Scaling, Measurement, and Dissemination Workgroup leaders and members provided input and guidance on the literature search, key informant interviews, synthesis, and presentation of findings. The Workgroup leaders and members also validated recommendations for the field. We briefly expand on our methods below; more detail is provided in **Appendix A**.

2.1 Scoping Review on PC CDS Workflow Measurement

We searched PubMed to identify peer-reviewed literature in a multi-phased approach. Our search yielded 565 peer-reviewed articles. We conducted two levels of screening—a title/abstract and a full-text review. At each level, we assessed whether the reviewed records appeared to meet our eligibility criteria (see **Appendix A**). Records deemed *eligible* at the title/abstract level were screened again at the full-text review. We conducted a full-text review of 79 peer-reviewed articles. We then determined the final list of eligible records for data abstraction, and for ineligible records, documented the reason(s) they were excluded. In total, 57 articles were included from the literature searches. Additionally, we included five articles that were either identified through snowball sampling (consulting the reference list of included articles for other relevant articles) or recommended by Workgroup members and CDSiC project members. In total, we screened 609 peer-reviewed journal articles and included 62 articles.

2.2 Development of PC CDS Workflow Diagram

We developed an initial workflow that builds on prior work addressing opportunities to improve health-related decisions and actions. This prior work includes definitions and use cases for PC CDS identified in the literature, previous and ongoing initiatives at AHRQ and the U.S. Department of Veterans Affairs (VA) on patient lifeflows and health journeys,[12,13] and literature on PC CDS workflows identified in our scoping review. As outlined in the Health Service Blueprint,[12] we focused on interactions outside, between, and during clinical encounters, illustrating PC CDS workflows that involve patients/caregivers, clinicians, or both.

Following initial drafting, the diagram underwent iterative review and revision with input from the Scaling, Measurement, and Dissemination Workgroup and two experts within the CDSiC project. These experts provided feedback to improve the clarity, completeness, and accuracy of the diagram. An updated version of the diagram was then validated with two external informaticians through key informant interviews. Key informants provided feedback on the content's clarity and accuracy and the

readability of the diagram as well as information on examples of real-world implementations of PC CDS that demonstrate effectiveness and positive impacts of CDS on care team workflows and/or patient lifeflows.

We developed a semi-structured discussion guide for each key informant, which allowed the interviewer to steer the conversation toward the key informant's expertise. Each interview was conducted via Zoom, audio recorded, and lasted approximately 60 minutes. Transcript-style notes were created for each interview to support analysis.

2.3 Analysis and Synthesis

To support analysis of the articles included in our literature review for synthesis into this report, three independent reviewers extracted the following data from the included literature: study setting, intervention characteristics, measures and measurement approaches used to assess workflow or lifeflow impacts, and measurement findings. We conduced thematic analysis[14] of qualitative and quantitative measures from the scoping review and classified measures by workflow-related intervention dimension: workflow context, uptake, use, and subjective value (see Exhibit 1 for more detail).

Exhibit 1. Workflow-related Intervention Dimensions

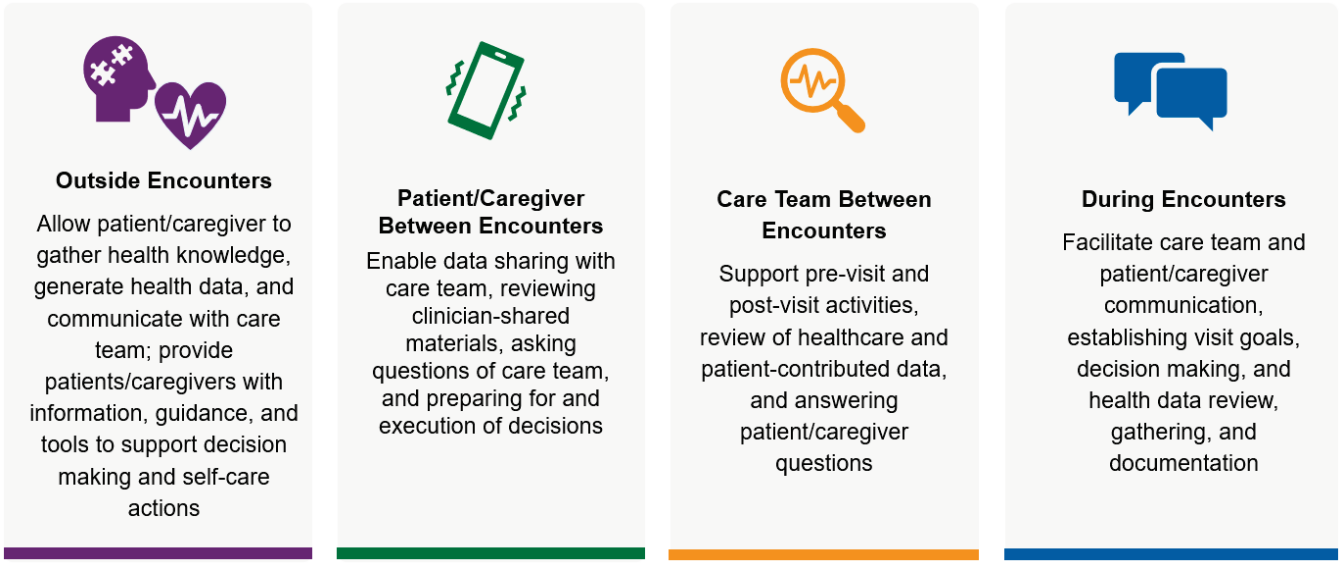
Workflow-Related Intervention Dimension	Definition	Example
Workflow Context	The source of data inputs for the CDS logic	Decision support triggers based on pertinent activities that provide the clinical context for the CDS intervention
Uptake	The initiation or adoption of the intervention	Frequency with which the intervention is seen/used, or given opportunities to do so
Use	Changes in knowledge, behavior, or action due to use of the tool	Specific workflow task/decision the intervention is designed to support and the intervention's effects on decisions and actions (such as time to complete a specific task)
Subjective Value	The user's perceptions of how the intervention impacted them	Change in satisfaction or burden with the workflow/lifeflow as modified by the CDS intervention

Quantitative and qualitative measures were further organized by whether they assessed features of patient/caregiver lifeflows or clinician/care team workflows outside of a healthcare encounter, during a healthcare encounter, and between healthcare encounters, as well as patient/caregiver and clinician/care team interactions between and during healthcare encounters.[12]

3. How Does PC CDS Intersect with Patient Lifeflows and the Care Team Workflows?

PC CDS supports patients, caregivers, and their care team across a range of settings within and outside of healthcare encounters. These interventions help to gather, send, and document patient-contributed health data that can be used to inform health-related decisions and processes and otherwise help optimize key healthcare decisions and actions (Exhibit 2). Understanding how patients and care teams interact with PC CDS and how those interactions influence their own and each other's workflows/lifeflows is important to advancing the measurement of PC CDS workflow and lifeflow impacts. By recognizing where and when interactions occur, we can develop and field measures and measurement approaches that better assess interventions' impacts on users, and ultimately develop more effective and acceptable PC CDS tools.

Exhibit 2. Uses of PC CDS Outside of, Between, and During Healthcare Encounters



Defining Workflow and Lifeflow

Generally, workflow is defined as "the set of tasks—grouped chronologically into processes—and the set of people or resources needed for those tasks that are necessary to accomplish a given goal".[15] Within the context of PC CDS, workflows represent the intersection of the decision support with the tasks of clinician and care team (e.g., preparing for clinician visits, reviewing data, documenting decisions) and the daily lifeflows of the patient health journey (e.g., self-care actions, completing activities of daily living, generating health data) between, during, and outside of clinical encounters.

Clinician/Care Team Workflows. While there is no single, broadly applicable definition for clinical workflow,[16] we define clinical workflow as the steps needed or taken to perform a clinical activity or task.[17] Clinical workflows are changing, often complex, and reflect the interdependencies between clinical tasks. Additionally, they are influenced by behavioral, organizational, and societal factors.[4]

Patient/Caregiver Lifeflow. We consider the patient "lifeflow" to be patient activities both within and external to a healthcare encounter that influence an individual's health. Health Service Blueprints, an approach currently used by VA and other participants in the Learning Health System Collaborative (LHS) to inform care transformation initiatives, offer one approach to describing these patient activities. In this report, we describe seven key activities in the patient lifeflow that echo portions of the AHRQ Patient Journey and Service Blueprint[13] and the VA-funded LHS Health Service Blueprint[12]: 1) engage in daily activities, 2) generate health data, 3) gather health knowledge, 4) make health decisions, 5) take self-care actions, 6) have healthcare encounter, and 7) communicate with care team.

Contextual Considerations

Mobile phones, remote monitoring and wearable devices, and sensors allow patients to continuously gather and transmit data to their providers' EHRs while they are living their lives, outside of medical encounters. Unlike traditional healthcare data generation, patients, not their care team, choose what data to generate and when to share it with their care team. Six factors motivate patients to collect such data: 1) usability, 2) illness experience, 3) relevance of observations of daily living, 4) information technology infrastructure, 5) degree of burden to collect and transmit data, and 6) emotional activation.[18]

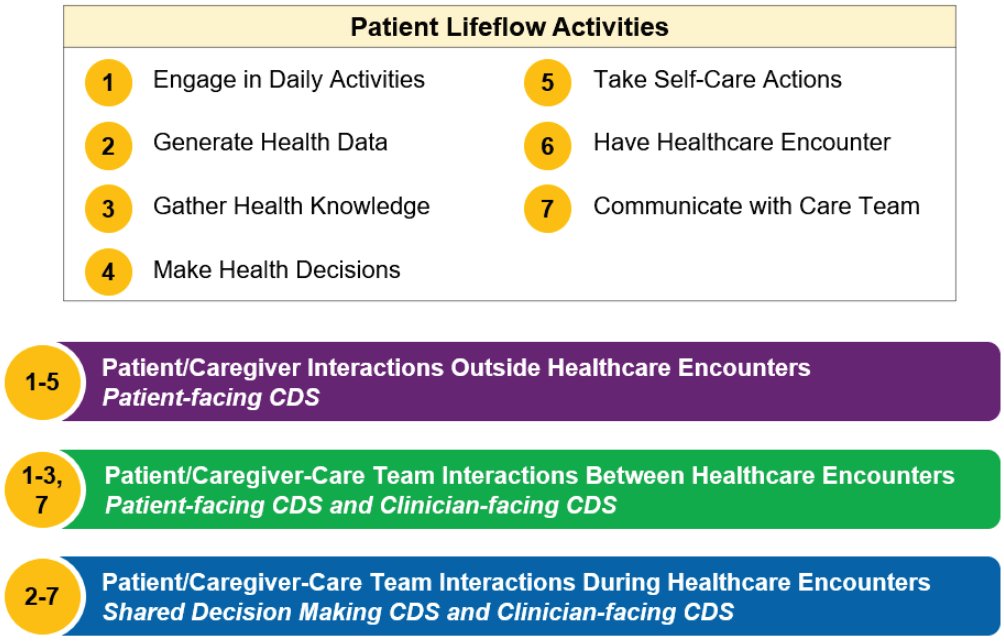
Health equity and social determinants of health (SDOH) are also important considerations when developing and implementing PC CDS tools and understanding their role in patient lifeflows. Importantly, equity issues related to unequal access to devices that support patient-facing CDS can lead to PC CDS being disproportionately used by wealthier, more educated, white patient populations.[19,20] Additionally, these tools should collect and take into account patient data related to their SDOH, like access to transportation, food insecurity, employment, where they live, and others, and additional demographic data to tailor interventions to patient needs for increased likelihood of adoption.[21] These two lenses of health equity and SDOH should be routinely applied in PC CDS approaches to collecting, capturing, and processing patient-contributed data.

The Unified PC CDS Workflow Diagram

Here, we present a framework that reflects the patient experience in using PC CDS tools, both within and outside of the patient encounter and the relationship between clinician workflows and patient lifeflows, named the Unified PC CDS Workflow Diagram. Our unified workflow diagram captures clinician workflows and patient lifeflows across three settings: 1) outside healthcare encounters, 2) between healthcare encounters, and 3) during healthcare encounters. Within these settings, PC CDS interventions can be patient-facing only (i.e., tools that are used by patients without the support of a care team member), clinician-facing only (i.e., intervention use does not directly involve patients), or both patient- and clinician-facing to support shared decision making.

In each setting, PC CDS intersects with the seven steps of the patient "lifeflow" (Exhibit 3), which represent interactions between the patient and the PC CDS intervention, or "trigger points" within the patient lifeflow for a PC CDS tool.[12] Below, we elaborate on the intersection of PC CDS with the patient lifeflow and the clinician workflow, first presenting the individual components of the diagram and then the unified diagram.

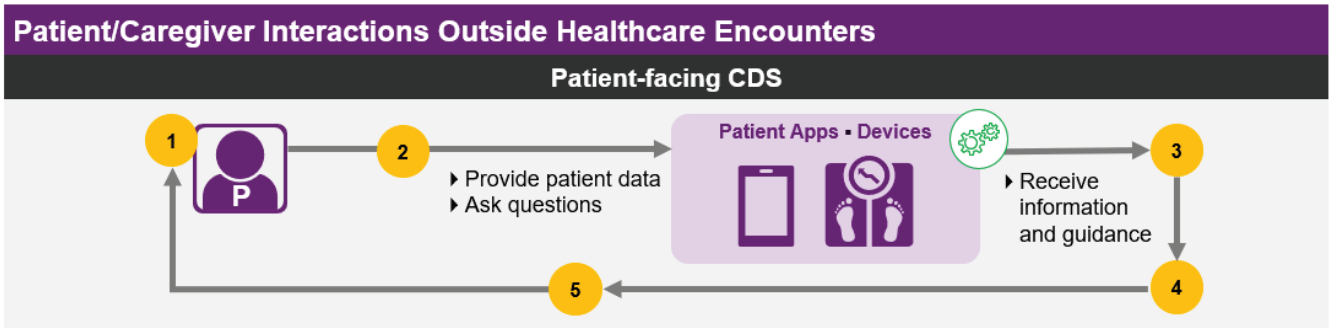
Exhibit 3. Intersection of Patient Lifeflow with PC CDS Outside, Between, and During Healthcare Encounters



3.1 Patient/Caregiver Interactions Outside Healthcare Encounters

Outside of healthcare encounters, patients and/or caregivers interact with PC CDS tools in their daily lives (Exhibit 4). The flow of information between patients/caregivers (indicated by "P") and patient-facing CDS tools, like patient apps and personal devices, provides patients with the guidance needed to support health-related decisions and self-care actions as they live their lives. These interactions can also inform patient/caregiver interactions with their care team between and during healthcare encounters, as these data can provide a fuller picture of their patient's health in their daily lives, including patterns and trends that may influence health.

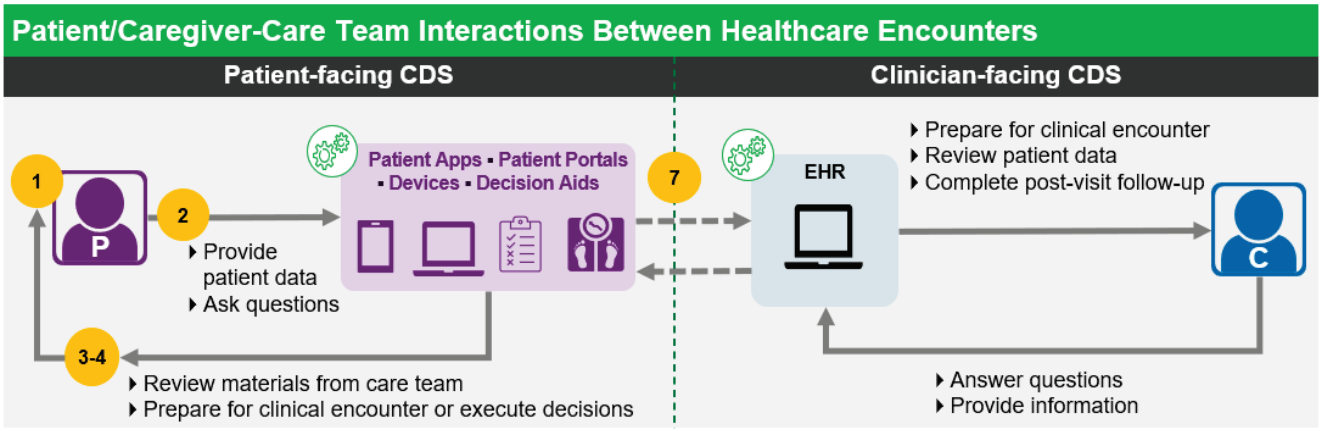
Exhibit 4. Intersection of PC CDS with the Patient Lifeflow Outside Healthcare Encounters



3.2 Patient/Caregiver Interactions and Care Team Workflows Between Healthcare Encounters

Patient-facing CDS and clinician-facing CDS both support health-related activities between healthcare encounters (Exhibit 5). In this stage, patient-facing CDS enables patients to share data with their care team, ask questions of their care team (indicated by "C"), review materials shared by clinicians, and prepare to and make decisions. These activities support patient lifeflow activities of generating health data, gathering health knowledge, making health-related decisions, and communicating with their care team. The clinician-facing tools used between healthcare encounters support the care team's pre-visit activities and post-visit follow-up. Clinician-facing CDS also allow care teams to interact with patient-contributed data and answer patient questions between healthcare encounters to support ongoing care management and patient decision making.

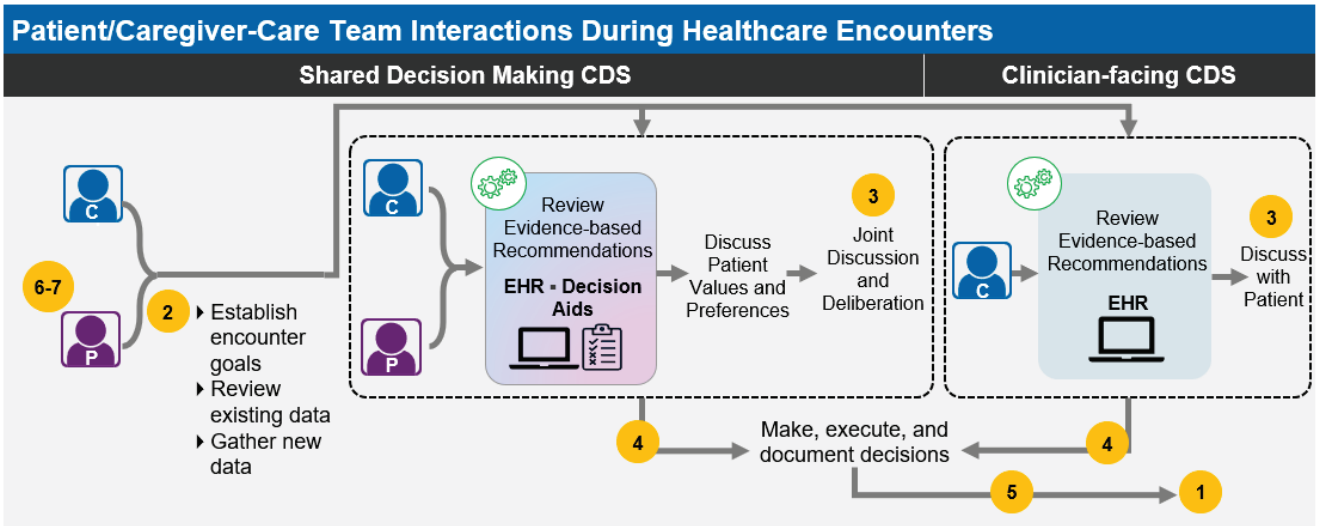
Exhibit 5. Intersection of PC CDS with the Patient Lifeflow and Care Team Workflows Between Healthcare Encounters



3.3 Patient/Caregiver Interactions and Care Team Workflows During Healthcare Encounters

During the clinical encounter, PC CDS can be either clinician- and patient-facing (i.e., shared decision making CDS) or just clinician-facing (Exhibit 6). Both types of PC CDS support patients/caregivers and their care teams in establishing encounter goals, reviewing existing data, gathering new data during the visit, reviewing evidence-based guidance, making decisions, executing decisions, and documenting data, decisions, and actions.

Exhibit 6. Intersection of PC CDS During Healthcare Encounters



PC CDS to support shared decision making between patients/caregivers and care teams allows patients' care teams to share and document key information and apply it to support evidence-based health-related decisions and actions. Under ideal conditions, the clinician and patient/caregiver will review PC CDS output together, followed by a discussion of patient values and preferences and discussion of their medical options to arrive at a mutually desirable plan. This process can play out over one or several encounters, with patients supplementing the shared decision-making conversation with additional inputs from their personal support network and independent information gathering to ultimately influence the self-care actions that they take.

For healthcare encounters supported by clinician-facing PC CDS, the tool will again use patient data (collected either outside of, between, and/or during the visit) to generate evidence-based guidance that the clinician uses to make a decision or take action (order labs, perform a screening, etc.). The care team member then discusses or applies that decision to the patients'/caregivers' treatment plan, and the PC CDS tool supports documentation of the decisions.

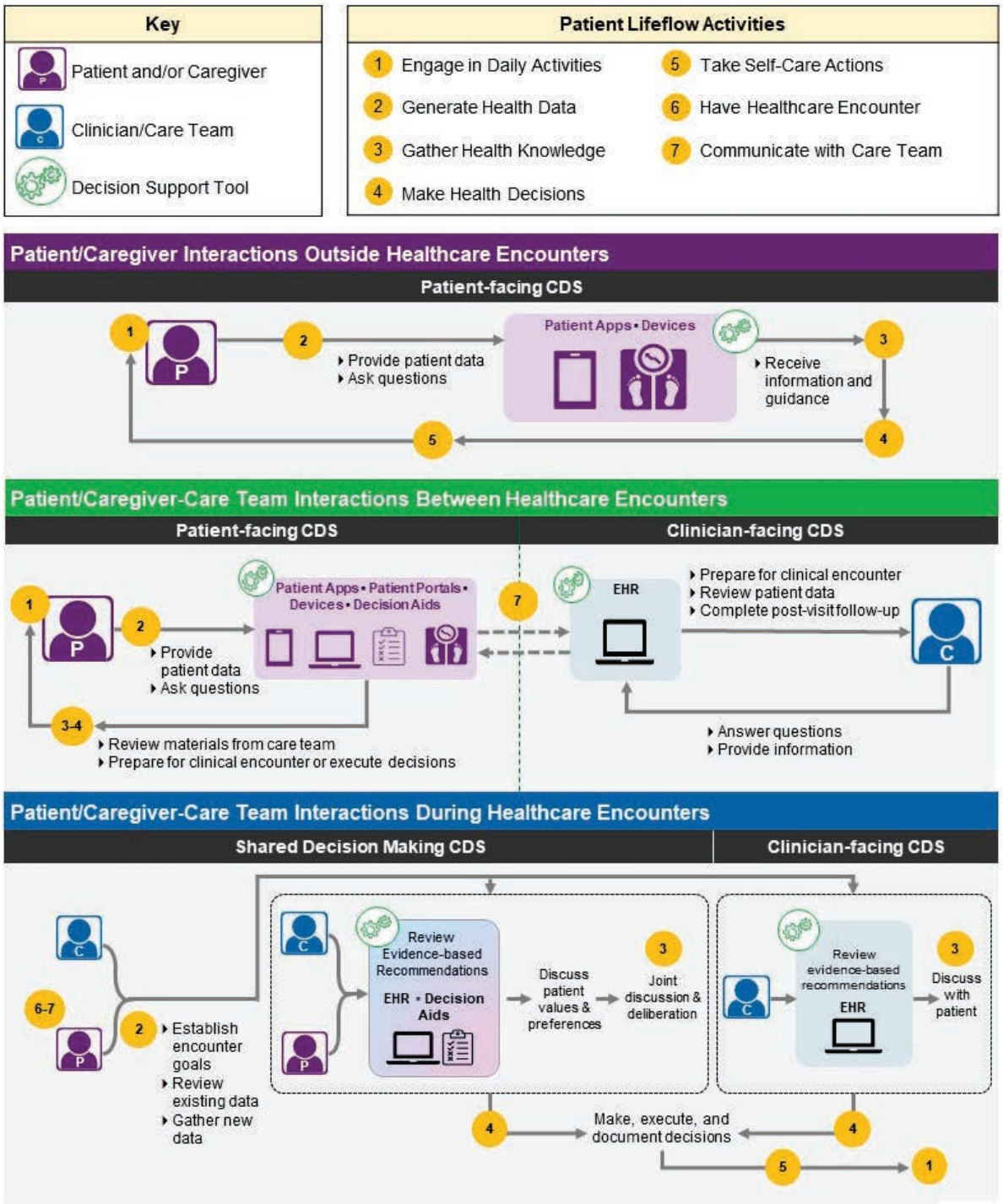
The information, guidance, and activities supported by the clinician-facing or shared decision-making PC CDS influences health-related decisions that patients make and carry out. Downstream effects of these decisions include patients' actions outside of and between healthcare encounters, including self-care actions that support management of health conditions as well as broader daily life activities.

3.4 A Unified View of PC CDS Workflows

These three workflow types combine to create a unified workflow diagram that accounts for both patient/caregiver lifeflows and care team workflows, illustrating how patients' activities and decisions are both influenced by and influencers of clinical workflows (Exhibit 7). While the individual components are presented separately above, the activities and actions of patients, caregivers, and care team members within each workflow setting (i.e., outside, between, and during encounters) reciprocally

influence each other and are inherently connected in their impact on patients' ability to gather health knowledge, make health decisions, and take self-care actions.

Exhibit 7. The Unified PC CDS Workflow and Lifeflow Diagram



Potential Uses of the Unified PC CDS Workflow Diagram

- For planning purposes to ensure CDS is patient-centered in its deployment (i.e., when and where clinicians/patients are prompted)
- To support discussions around resource needs and how to operationalize PC CDS tools
- For user (i.e., clinician) training, to convey how a tool can support patient self-care activities
- To support grant applications for PC CDS clinical trials

4. What Types of Approaches and Measures Have Been Used to Assess PC CDS Workflow and Lifeflow Impacts?

A range of measures can be used to assess the impact of PC CDS on workflows and lifeflows. While our review was not exhaustive, we identified 75 unique measures relevant to assessing the workflow or lifeflow impacts of PC CDS. Of these, the majority assessed effects of PC CDS during a healthcare encounter, with uses for between healthcare encounters, and a handful of measures assessing impacts occurring outside healthcare encounters.

Our review identified the greatest number of unique measures for the workflow dimension of use, followed by workflow context, uptake, and subjective value. In terms of measures captured by interaction type, there were fewer measures for assessing impacts of patient/caregiver and care team joint interactions facilitated by PC CDS, compared to patient/caregiver and care teams' independent interactions with PC CDS. The use of patient-centered measures to assess PC CDS effectiveness has centered primarily on adoption of specific patient-facing tools and the use of the decision aids. We observed greater variety in the application of workflow measures for care teams. However a large majority of measures were focused on reducing clinician workflow burdens to mitigate alert fatigue and clinician burnout.

Key Terminology

- **Measure:** The specific metric used to assess a workflow or lifeflow impact of PC CDS (e.g., cognitive task load, decisional conflict, intention to use).
- **Clinician-centered Measures**: Measures that assess the care team experience, behavior, or perspective, as related to clinical workflows.
- **Patient-centered Measures:** Measures that assess the care received, patient experience, behavior, or perspective, as related to the seven patient lifeflow activities. Note that a measure can be patient-centered even if it's reported by an observer or clinician.
- **Measurement Domain:** Includes who interacts with the PC CDS (i.e., patient/caregiver or care team) and where the interaction takes place (i.e., outside of, between, or during healthcare encounter).
- **Workflow Dimension:** Four CDS intervention-related dimensions; see Section 2.4 for more detail.
- **Measurement Concepts:** A grouping of individual measures used to assess a similar theme or outcome (e.g., patient participation, acceptance, adoption) for both patients and care teams.

Within each workflow-related intervention dimension of workflow context, uptake, use, and subjective value, we grouped individual measures under broader measure concepts, which are high-level measurement areas assessing the effect of a PC CDS intervention on patient lifeflows and care team workflows. See Exhibit 8 for a list of measure concepts used. While extensive, this is not an exhaustive

list of all measure concepts and measurement approaches that are currently used to assess workflow and lifeflow impacts of PC CDS interventions.

Exhibit 8. Measure Concepts within Each Workflow-related Intervention Dimension

Measure Concept	Definition
Workflow Context	
PC CDS design characteristics	The underlying design principles (i.e., theoretical frameworks, conceptual models) and processes (i.e., providing user training) of the PC CDS tool design.
PC CDS format	PC CDS intervention type (e.g., alert, flowsheet, order set, info button).
Workflow/lifeflow integration	PC CDS elements and how the intervention was deployed to integrate within existing clinical workflows and patient lifeflows.
Patient participation/involvement	The degree to which patients were involved in decision making about care and level of patient/provider communication (e.g., care planning).
Uptake	
Frequency shown/displayed to end-user	How often the PC CDS intervention was shown to the end-user.
Patient adoption	Documentation of patient adoption of the PC CDS tool and details of its reach.
Care team adoption	Documentation of care team adoption of the PC CDS tool and details of its reach.
Care team acceptance	Care team acceptance of the information / recommendations provided.
Use	
Knowledge	Changes in knowledge about a disease/condition, risks and benefits, treatment options, and clinical guidelines.
Efficiency	Assessment of efficiency of using the PC CDS tool, changes in the time or number of steps needed to complete a task, and time required to understand the information presented by the PC CDS tool.
Change in workflow appropriateness	The tool's support of and effect on clinicians' completion of guideline-recommended care.
Change in workflow timing and coordination	Changes in temporal aspects of workflows and teamwork.
Patient decision making	The resulting impacts from patients' involvement in decision making processes, user-rated assessments of decision-making aids, and support for patients' decision making that aligns with their goals.
Subjective Value	
Change in user satisfaction	User satisfaction with the PC CDS tool and processes supported by the tool.
Perceived utility	Users' perceptions of the tool's usefulness for supporting key healthcare decisions and actions.
Alert fatigue/burnout	User perception of the tool's impact on alert fatigue and/or feelings of burnout.
Mental workload	The cognitive load or burden associated with using the PC CDS tool or changes in user-rated cognitive load/burden when completing a workflow task or activity as a result of using the PC CDS tool.
Patient decision quality	Aspects related to the patient's satisfaction, certainty, and confidence in their decision and their decision's alignment with their values.

Researchers, CDS implementers/evaluators, and others use various measurement approaches to assess the impacts of interventions of workflows and lifeflows. Measurement approaches can be distinguished by 1) the type of measure used (e.g., distal, proxy, direct measure of workflow), 2) the type of data collected (e.g., quantitative or qualitative), and 3) who or how the data was collected (e.g., observer-reported, user-reported, or software/sensor observational data).

Quantitative, qualitative, and a combination of the two measurement approaches can be used to assess workflow and lifeflow impacts of CDS interventions. Approaches for collecting data to study the workflows themselves include workflow modeling approaches like sequential pattern mining and task transition analysis; qualitative approaches such as open-ended questionnaire responses, ethnographic observation of real-world or simulated care, focus groups, and interviews; and quantitative approaches, including time-motion studies and log analyses.[4] Computational ethnography, an emergent technique combining elements of traditional ethnography and digital data collection tools,[22] can also be used in workflow studies. Examples of methods that fall within computational ethnography include using screen capture software or sensors such as eye tracking devices.[23]

Practical Consideration

Which measurement approaches you use ultimately depends on:

- Study objectives
- Workflow and lifeflow contexts, intervention setting and contexts
- Resource availability
- Availability of relevant data
- EHR capabilities
- Relevance of existing validated tools and scales
- Ability to create study-specific tools/scales

Quantitative data sources can include numeric study observations, scores derived from participant-completed scales, EHR historical log data or other documentation, screen capture software data, and eye-tracking data. For measures assessing user opinions or experiences, some investigators develop questionnaires tailored to their intervention. While some studies did not cite existing theories or conceptual models (e.g., Theory of Acceptance Model[24]), in developing study- or intervention-specific questionnaire items, utilizing existing theories and conceptual models to inform questionnaire development is best practice.[25]

It is important to note that workflow studies tend to assess distal or proxy measures, such as time spent using the EHR, clinician performance, guideline compliance, and patient outcomes, rather than make direct assessments of changes to workflows, such as the completion of a set task or the order in which tasks are completed.[4]

Practical Consideration

Clinical workflows and patient lifeflows are highly context-specific. Therefore, considering contextual factors is integral to the design PC CDS interventions and study of workflow/lifeflow impacts. Reporting thorough and in-depth descriptions of context and methods is also extremely important to being able to understand which research findings are relevant to your work, given the contexts and settings studied.[16]

4.1 Clinician-centered Measures

Here we outline measure concepts relevant to clinicians' workflow impacts. Based on our literature review, clinician-centered measures have not been equally assessed across settings. Most sources identified measurement concepts related to clinician and care team interactions with PC CDS during healthcare encounters. See Exhibit 9 for a description of measurement concepts pertaining to clinician and care team interactions with PC CDS between and during healthcare encounters.

Exhibit 9. Measure Concepts Relevant to Clinician/Care Team PC CDS Interactions

Measure Concepts	Between Healthcare Encounters	During Healthcare Encounters
Workflow Context		
PC CDS design characteristics	X	X
PC CDS format	X	X
Workflow/lifeflow integration	X	X
Patient participation/involvement	X	X
Uptake		
Frequency shown/displayed to end user		X
Care team adoption	X	X
Care team acceptance		X
Use		
Change in workflow appropriateness		X
Changes in workflow timing and coordination		X
Efficiency	X	X
Knowledge		X
Patient decision making		X
Subjective Value		
Alert fatigue/burnout		X
Changes in user satisfaction	X	X
Mental workload	X	X
Perceived utility	X	X

4.2 Patient-centered Measures

There is far greater diversity in the measure concepts assessed for lifeflow impacts of patients/caregivers in the “during healthcare encounters” setting, compared to outside and between encounters. See Exhibit 10 for a description of measurement concepts used to assess patient and caregiver interactions with PC CDS between, during, and outside of healthcare encounters.

Exhibit 10. Measurement Concepts Relevant to Patient/Caregiver PC CDS Interactions

Measure Concepts	Outside Healthcare Encounters	Between Healthcare Encounters	During Healthcare Encounters
Workflow Context			
CDS Format	X	X	X
Workflow/lifeflow integration	X	X	X
Patient participation/involvement			X
Type of CDS	X	X	X
Uptake			
Patient adoption	X	X	X
Use			
Efficiency		X	X
Knowledge			X
Patient decision making	X	X	X
Subjective Value			
Change in user satisfaction			X
Patient decision quality		X	X
Mental workload		X	X
Perceived utility		X	X

Within each measure concept, several measures can be used to assess workflow and lifeflow impacts pertaining to the concept. Exhibit 11 presents examples of workflow impacts and corresponding measures or tools used. For many impacts, multiple tools exist and are used to assess the same outcome; for a few impacts, there was greater coalescence around one or two tools or approaches taken in the literature.

Exhibit 11. Sample Workflow Impacts and Measures for Measure Concepts

Measure Concept	Workflow Impact Measure	Measure/Tool Used	CDS Intervention
Patient decision quality	Patient decisional quality	• Decisional Conflict Scale[26] • Fours Habits Coding Scheme[27] • OPTION Scale[28] • Decision Support Analysis Tool[29,30] • Control Preference Scale[31]	Patient decision aid
Change in user satisfaction	Patient satisfaction with clinician communication	• Art of Medicine Questionnaire[32] • Quality of Communication Questionnaire[33] • Combined Outcome Measure for Risk Communication and Treatment Decision (COMRADE)[34] • Qualitative Interviews	Patient decision aid
Mental workload	Mental task load	• NASA-Task Load Index[35] • Rating Scale Mental Effort[36] • Subjective Workload Dominance Scale[37] • Total time required to complete task • Total number of CDS alerts • Total number of patient encounters • Eye-tracking to measure pupil dilation changes and eye fixations	EHR
Patient participation or involvement	Involvement of patients in decision making	• OPTION Scale[28] • Reynolds Intellectual Assessment Scales (RIAS)[38] • CollaboRATE[39,40] • COMRADE[34] • Problem-Solving Decision making Scale[41] • Shared Decision Making Scale[42] • The decision making subscale of the Modified Perceived Involvement in Care Scale (M-PICS)[43]	Patient decision aid
Efficiency	Task efficiency	• Mean time spent on clinical tasks (i.e., chart review) • Number of tasks per minute • Number steps required to complete a clinical task	Point-of-care CDS

5. What Do We Know About the Effects of PC CDS on Care Team Workflows and Patient Lifeflows?

Our review of the literature on PC CDS care team workflow and patient lifeflow impacts reinforced that this is an evolving field that lacks a clear consensus on how PC CDS interventions positively or negatively affect workflows and lifeflows – and even how these should be measured. The ambiguity is partly due to the current state of the evidence on workflow and lifeflow impacts as an emergent field with limited rigorous, generalizable findings and a lack of standardized measures and metrics. The inconsistent, non-systematic integration of PC CDS into clinician workflows and patient/caregiver lifeflows, as currently observed in the literature, is one contributing factor to the lack of rigorous and generalizable findings. A key factor in realizing positive workflow and lifeflow impacts is integration into existing workflows and lifeflows; however, many published studies have not done so due to the complex undertaking of full integration.

Care Team Workflow Impacts. To date, much of the available literature on care team workflow impacts of PC CDS has focused on the impacts of clinician-facing CDS, and to a lesser extent, PC CDS that supports shared decision making during the healthcare encounter. The evidence on the impact of PC CDS on clinician workflows is mixed, with findings from interventions both reporting positive, neutral, and negative impacts and inconsistency in how PC CDS affects workflows across studies.

Among positive care team impacts that were observed in the literature, adoption of shared decision-making processes, completion of guideline-recommended care, and provision of patient-centric care were described. Much of the clinician-centered outcomes related to workflow impacts concerned reducing alert fatigue and clinician burnout. While we observed that PC CDS interventions can increase clinician efficiency, an important metric due to its implications for alert fatigue and clinician burnout, PC CDS interventions can also contribute to alert fatigue and burnout. Efficiency is measured in several ways in the literature, in part due to the CDS tool and the objectives of the intervention. Studies measuring the impact of PC CDS interventions of clinician efficiency have reported positive effects in mean time spent on clinical tasks, including reducing time spent on chart review, completing more recommended tasks per minute, reducing the time needed to manage acute conditions,[44,45,46] and decreasing the number steps required to complete a clinical task.[44] However, while reduced time spent on individual tasks is often cited as a result of CDS interventions, it is important to note that these metrics do not capture the level of workflow fragmentation, another metric of clinician efficiency. When not implemented into workflows properly, CDS interventions can increase fragmentation of tasks and switching between tasks, which may explain why, clinicians' overall time spent on clinical tasks can decrease, yet clinicians may still report experiencing higher workloads and disrupted workflows.[4]

Patient Lifeflow Impacts. Much of the available literature on the impact of PC CDS on patient lifeflows focuses on activities that take place during the healthcare encounter; less is known about how PC CDS impacts patients outside of or between encounters. Some positive findings for the impact of patient portals and patient apps on patient adoption of the tools and improved care team communication between and outside of encounters have been reported; however, findings that these interventions have had no effect on tool adoption and communication between patients and their care team have also been found.[20,47] These PC CDS interventions are still a developing field, and available research does not support any strong conclusions about positive impacts.

While patient apps, devices, and portals are an emerging area, the literature on patient lifeflows has mainly focused on shared decision-making interventions deployed in the context of healthcare encounters and assessing the impact of patient decision aids on patients' decision making and experience with care. These interventions primarily involve the use of patient decision aids, provided either before or during a medical visit. Changes in patient knowledge, decisional conflict, and engagement were among the most commonly studied outcomes of patient decision aids. And while there is evidence to suggest that patient decision aids improve these outcomes, there are also reports of shared decision-making interventions having little or no impact.

For example, several systematic reviews have shown that patient decision aids have a significant moderate effect on improving patient knowledge of their disease compared to usual care.[48,49,50,51,52,53] However, meta-analyses indicated a high level of heterogeneity and deemed the level of evidence as having low certainty.[50,52,53,54] Additionally, while knowledge specific to the content of the decision aid may improve, evidence indicates that general disease-specific knowledge after using decision aids remains unchanged.[55] Importantly, improvements in patient knowledge have been associated with reducing decision making conflicts and a stronger commitment to treatment.[51]

Mixed results for decisional conflict are also reported across studies. Decisional conflict is defined in the literature as the uncertainty that a patient experiences when presented with competing actionable choices, and they must weigh the "risk, regret, or challenge to personal life values" of those choices.[56] While no studies reported an increase in decisional conflict following participation in a CDS intervention, some reported no change in decisional conflict, a non-significant reduction, or a significant decrease in decisional conflict in studies of patient decision aids[48,52,55,57,58] using the Decisional Conflict Scale.

Use of decision aids is associated with higher levels of patient engagement[59,60] and patient involvement.[52,53,55] However, significant heterogeneity between studies has been noted.[53] The variety in studies is in part attributed to the lack of a clear definition of patient engagement or involvement. These terms are used interchangeably, with definitions ranging from "the percent of patients and family members who reported knowing their personal condition-specific risk factors"[59] to "active involvement of patients in their own health care"[45].

Exhibit 12 summarizes these findings on PC CDS impacts to workflows and lifeflows.

Exhibit 12. Summary of Key Findings on PC CDS Effects on Care Team Workflows and Patient Lifeflows

Key Findings
Overall State of the Literature
The study of workflow and lifeflow impacts resulting from PC CDS interventions is an emerging field with evolving evidence.
We found that there is not yet a robust body of evidence across settings to indicate that a particular type of PC CDS intervention could be predictably expected to yield a specific, positive workflow and lifeflow impacts.
Care Team Workflows
The majority of literature related to workflow and lifeflow impacts focuses on impacts of clinician-facing CDS on care team workflows.
Alert fatigue and clinician burnout are common primary outcomes of clinician workflow studies. PC CDS interventions have been found to both reduce alert fatigue and burnout, but also can increase these outcomes due to workflow fragmentation and increased inefficiency.
Patient Lifeflows
Literature on patient lifeflows mainly focuses on shared decision making interventions deployed in the context of healthcare encounters, with the majority focusing on patient decision aids.
Decisional conflict, patient knowledge, and patient engagement or involvement in care were commonly assessed outcomes; however, mixed findings on the impact of PC CDS interventions on these outcomes were captured in the literature.

6. What Measurement Gaps Remain and How Can We Move Forward?

From our literature review, we identified measurement gaps in three areas: those fundamental to conducting workflow studies, gaps in the quality of evidence, and gaps related to specific measures and outcomes. Exhibit 13 presents gaps and corresponding recommendations to advance understanding of the impact of PC CDS interventions on workflows and lifeflows related to the conduct of workflow studies, quality of evidence, and gaps related to specific measures included in workflow/lifeflow impact assessments.

Exhibit 13. Workflow and Lifeflow Impact Measurement Gaps and Recommendations

Gap	Recommendation
Conducting and Reporting Workflow Studies	
Workflow Definition: Inconsistent definition of clinical workflow used in research. This presents challenges in understanding the purpose and findings of workflow research.	• Develop a precise definition of workflow—or context-specific definitions—to support study design. Using such definitions in study reporting will help others understand and build on of the research's purpose and impact.[16] • The Workflow Elements Model provides a conceptual model of clinical workflows that can be used by researchers designing and reporting on workflow studies to better define and study workflows.[16]
Reporting Impact: Limited information available about the impact of interventions on existing clinical workflows and adaptations required for successful deployment and use of CDS tools, and how these should be reported.	• Measure and report effects of CDS on temporal aspects of workflow to understand impacts related to workflow integration and fragmentation, such as when the appropriate time to elicit patient preferences is, or how the results of decision support tool activities fit within the patient–care team dialogue.[61] • Reporting should also include descriptions of variation in workflows from the standardized workflow to better understand variations in outcomes.[4]
Measuring Impact: Difficulty identifying clinical workflow aspects that are important to study and can be reliably measured. Most workflow studies do not directly assess impacts to workflows, but rather proxy measures that indicate the performance of the workflow.	Develop and use methods to directly study workflow and clinician workarounds during and following implementation of PC CDS interventions. Workflow measures should directly capture the completion of a set of necessary tasks and the order in which they were completed.[4]
Reporting Inconsistency: Inconsistency in how workflow studies report study design and results, which makes cross-study synthesis very difficult, diminishing the ability to accumulate knowledge as a field.	Develop reporting guidelines to improve consistency in how methods and findings are reported for workflow studies. For example, the STAMP (Suggested Time and Motion Procedures) Checklist is a potential resource that can support better reporting of workflow studies utilizing time-motion methods.[62]
Patient-facing PC CDS: Limited number of studies exist on the impact of CDS tools on patient activities outside of healthcare encounters context, with the majority focusing on patient portal usage. Further, patient portal studies are limited and present inconsistent results, often due to the use of non-standardized terminology related to portal features and implementation and limited analysis of patient portal usage data.	• Use standardized evaluation frameworks and measures to strengthen comparisons of patient portal implementation and outcomes.[18] For example, a taxonomy of patient portal functionalities could support standardized description of portal features and terminology, which can enable comparing and aggregating results across interventions.[63] • Analyze patient portal usage to identify relationships between portal usage and patient outcomes to understand what qualifies as meaningful portal usage.[47]
Lifeflow Analysis: The majority of workflow studies fail to consider the relationship and gaps between patient health-related activities in patients' daily lives and activities within the clinical context, prohibiting design of collaborative health technologies that can fill these gaps.	• Conduct workflow studies that are patient-oriented, include both clinical and daily living settings and include both process and structure measures. • Develop methods to capture health-related activities across clinical and daily living settings.[5]

Gap	Recommendation
Evidence Scope and Quality	
Patient-reported Indicators: Scant attention to measures composed of patient-reported outcomes and items to assess aspects such as disease activity and functional status needed to fully convey pertinent patient lifeflows outside and between healthcare encounters.	• Conduct research and utilize disease activity and functional status measures which can be adapted for use in telehealth/patient portal settings to support high-quality PC CDS. • Conduct research to better understand how these types of measures alleviate gaps in the patient/caregiver lifeflows.[64]
Evidence Quality: The majority of evidence related to PC CDS workflow and lifeflow impacts found was rated as “low quality” or at “high risk of bias” by systematic reviews and meta-analyses.	Conduct rigorous workflow studies employing larger, more representative sample sizes to fill gaps left by current studies that have utilized small, non-generalizable samples.[58]
Contributing Intervention Factors: Insufficient analysis of intervention characteristics or development attributes that are most effective in promoting shared decision making.	Develop studies to test the contributions of individual intervention characteristics on shared decision-making outcomes.[52]
Measurement Benchmarks: Benchmarks for workflow and lifeflow impacts have not been established for measures critical to assessing the effectiveness of PC CDS interventions.	• Develop standardized measures and validated tools to assess commonly measured workflow/lifeflow so that results across studies can be compared and workflow and lifeflow impact measures can be prioritized for benchmarking. • Focus future measurement research on key areas, including patient and clinician adoption, clinician time spent on clinical tasks, clinician completion of guideline-recommended care, decisional conflict, informed choice, patient activation, and decision making.
Measures	
Cognitive Workload: Clinician cognitive workload is not measured with high validity across studies.	Related concepts of alert fatigue and desensitization can be used as proxy measures of cognitive workload. These measures should be prioritized so that they can be leveraged in improving patient safety.[65]
Informed Choice: Informed choice—the extent to which a patient can make a choice that is based on relevant knowledge, consistent with the decision-maker's values, and behaviorally implemented[50]—is not consistently defined in the research or measured in a standard manner.	Conduct research to explore whether it is possible and beneficial to develop a generic scale for informed choice.[50]
Patient Knowledge: Need for a generalized measure of patient knowledge to assess the impact of CDS on disease-specific knowledge. Addressing this gap would reduce the need for developing study-specific assessment tools and may support intervention efforts to improve knowledge about a disease, and not just knowledge specific to the decision aid content.[55]	• Develop validated, intervention- and disease-agnostic scales and questionnaires for assessing patient knowledge outcomes. • Foster consensus on what constitutes “adequate knowledge”.[50]
Tool Acceptance: Inconsistent assessment of CDS acceptance, with a variety of concepts in use to assess user acceptance of CDS tools.	Develop standardized, low-cost, informative measures for determining CDS intervention acceptance.[54]

Conducting and Reporting Workflow Studies. While an increasing number of studies look at the impact of CDS on clinical workflows, existing studies are limited in their scope and tend to focus on one type of clinical setting or distinct processes rather than multiple processes and their interactions.[5] This is important because fully understanding CDS workflow impacts requires this broader perspective. Very few studies included in our review directly assessed changes to the clinician workflow or patient lifeflow. Instead, most studies measured proxy measures as indicators of the quality, completeness, or accuracy of a workflow. The Workflow Elements Model provides a conceptual model of clinical workflows that can be used by researchers designing and reporting on workflow studies to better define and study workflows.[16] Additionally, current studies primarily focus on outcomes related to prevention or mitigation of clinician burnout due to fragmented workflows, increased workload burdens, and alert fatigue. Despite the increase in the study of clinician workflows in recent years, relatively little is known across studies about the details of how CDS interventions affect clinical workflow.

CDS directly involving patients (a major component of PC CDS) is an increasing focus for driving care transformation; however, there are limited studies about how PC CDS affects patient lifeflow. Patient activities that influence health are not limited to the clinical care encounter, yet existing PC CDS studies often fail to consider the elements of a patient's life that occur outside of a medical encounter (e.g., social, organizational, cultural, and physical environments and routines) that influence and are influenced by healthcare activities.[5] In addition to activities that occur during healthcare encounters, implementation and evaluation of PC CDS interventions should consider activities both between healthcare encounters and activities outside of encounters completely. Increasingly, health technologies, through patient-facing apps and other PC CDS tools, are supporting patients between and outside of the healthcare encounter to manage symptoms, coordinate care, communicate with their care team, exchange health-related information with clinicians and their support network, and adhere to treatment protocols.[66,67,68]

While CDS interventions targeting patients in their daily lives are becoming more common, rigorous studies are still relatively scant. Our review identified a small number of studies documenting impacts of CDS interventions on patient lifeflows occurring outside of a clinical encounter. In particular, we did not identify any measures relevant to the subjective use workflow-related intervention dimension for patient lifeflows occurring outside of healthcare encounters. Additionally, one patient advocate noted the need for greater measurement of patient portal usage and utility to patients, including measures of data available to patients in the portal and assessment of clinicians' interactions with patients via the portal, such as how often and how quickly clinicians respond to patient messages.

Evidence Scope and Quality. Despite a growing focus on the workflow and lifeflow impacts of CDS interventions, the evidence for commonly assessed outcomes is often deemed to have a high risk of bias or be of low quality, due to a high-level of heterogeneity across studies, limiting the conclusiveness of meta-analyses and systematic reviews. Even though positive results have been reported by individual studies, when assessed across studies, the impact of interventions on outcomes is low to moderate.

Measures. Our literature review revealed very little standardization in approaches used to measure workflow and lifeflow impacts of PC CDS interventions. With the exception of decisional conflict, workflow/lifeflow impact measures were assessed using a variety of tools and measurement approaches, indicating a need for standardized, validated tools to assess commonly measured

workflow/lifeflow outcomes to enable comparability of results across studies. The literature identified several areas where further consensus to define and standardize measurement of outcomes is needed; for example, measures related to cognitive workload, informed choice, patient knowledge, and acceptance of the CDS tool. Developing benchmarks for measures of workflow/lifeflow impacts is a necessary step in standardizing the study of clinical workflows and patient lifeflows and guiding quality improvement efforts related to CDS interventions. Existing implementation frameworks[69,70,71] outline evaluation domains that should be captured in studies of health IT interventions. However, these are not tailored to patient-centered interventions. Given the current nascent state of the literature on PC CDS, additional research is needed to strengthen the evidence base so that benchmarking efforts in these areas can advance. Benchmarking efforts will likely depend on the context in which the CDS tool is implemented, with measure specifications and benchmarking values being influenced by the type of CDS used and setting.

In addition to employing rigorous study designs (e.g., randomized control trials), standardization of measures, assessment tools, and measurement approaches used could improve the comparability of studies and strengthen the quality of evidence about workflow impacts of PC CDS.

Limitations

While this report presents an extensive list of workflow and lifeflow impact measure concepts and approaches in use, we acknowledge the list is not an exhaustive inventory. We may not have captured all measures of workflow and lifeflow impacts relevant to CDS, in part, due to the limited reporting of workflow and lifeflow measures in the literature. Additionally, not all measures currently in use, particularly in non-academic or non-research settings, are captured in the literature. Furthermore, our environmental scan scope was limited to the healthcare and health information technology ecosystem and may have excluded measures and measurement approaches relevant to PC CDS interventions from other fields. For instance, there is ongoing research to understand workflow impacts from systems engineering and industrial engineering perspectives. However, these fields were not included in our search as we focused specifically on published CDS studies.

In Conclusion

Care team workflows and patient lifeflows are complex, ever-changing processes that ultimately influence health-related decisions that patients make in consultation with their clinical care team and/or caregivers. Yet, there is sparse study of the effects of PC CDS interventions on patient lifeflows and corresponding care team workflows that ultimately impact individual health. Our scoping review of the peer-reviewed literature revealed that the study of PC CDS intervention impacts on workflows and lifeflows is an emerging field, and that more robust, rigorous studies are needed to fully understand PC CDS' workflow and lifeflow impacts across settings, intervention types, and users.

To support such developments in the field, this report 1) provides a framework for understanding where PC CDS interventions can be implemented in patient lifeflows and clinician workflows that occur outside of, between, and during healthcare encounters, and 2) identifies workflow- and lifeflow-related measure concepts and measurement approaches relevant to clinical and patient activities that support patients in making and carrying out health-related decisions.

Efforts to strengthen the evidence base for workflow-enhancing PC CDS can help accelerate the development, implementation, and evaluation of PC CDS-enabled approaches to improving care processes and outcomes and realizing the quintuple aim.

Appendix A. Scoping Review Methodology

Research Questions

1. How do organizations, researchers, and implementers/evaluators currently measure clinical workflow and patient “lifeflow” in the following types of CDS?
    a. Workflow impacts for care team members that don’t directly involve patients for CDS interventions that meet the criteria for patient-centered (PC) CDS interventions;
    b. Workflow impacts associated PC CDS interventions that support shared decision making between patients and care teams; and
    c. Workflow/lifeflow impacts associated with PC CDS interventions where patients and caregivers are direct intervention recipients.
2. What CDS interventions workflow and user satisfaction results are reported?
    a. Which workflow impact measures present opportunities for future benchmarking of PC CDS intervention workflow effects?

Search Strategy

We conducted a search of the peer-reviewed literature in PubMed. Terms represent key areas of relevance (e.g., CDS) combined with more targeted searches of workflow-related keywords, including 1) alert fatigue and burnout; 2) shared decision making; and 3) systematic reviews of patient adoption of PC CDS tools. See Exhibit A1 for the set of search strings and Exhibit A2 for the searches ran in PubMed.

Exhibit A1. Key Search Terms

Systematic Reviews String	#1 CDS Search String	#1a Revised CDS Search String	#2 Alert Fatigue and Burnout	#3 Impact on Shared Decision Making	#4 Patient Adoption of PC CDS Tools
(("cochrane database syst rev"[Journal] AND "review"[Publication Type]) OR "systematic review"[Publication Type] OR ("systematic review"[Title] OR "systematic literature review"[Title] OR "systematic scoping review"[Title] OR "meta-analysis"[Title])) NOT ("comment"[Publicati	"clinical decision support"[tiab] OR "Decision Support Systems, Clinical"[Mesh] OR "Medical Order Entry Systems" [Majr] OR "Decision Making, Computer-Assisted"[Majr] OR "Clinical	"clinical decision support"[tiab] OR "Decision Support Systems, Clinical"[Mesh] OR "Decision Making, Computer-Assisted"[Majr] OR "Clinical Decision Rules"[Majr] OR "decision aid*"[tiab] OR	“alert fatigue”[tiab] OR “alarm fatigue”[tiab] OR “fatigue”[Majr] OR “Alert Fatigue, Health Personnel”[Mesh] OR “burnout”[tiab] OR “alert override”[tiab] OR “patient burden”[tiab] OR “care team burden”[tiab]	“shared decision making”[tiab] OR “patient engagement”[tiab] OR “Patient Participation” [Majr] OR “Decision Making, Shared” [Majr] OR “Patient Care Planning” [Majr]	“patient adoption”[tiab] OR “patient use”[tiab] OR “caregiver adoption”[tiab] OR “patient endorsement” OR “patient uptake”[tiab] OR Patient Acceptance of Health Care[MeSH] OR Patient Satisfaction[MeSH]

Systematic Reviews String	#1 CDS Search String	#1a Revised CDS Search String	#2 Alert Fatigue and Burnout	#3 Impact on Shared Decision Making	#4 Patient Adoption of PC CDS Tools
on Type] OR "protocol*"[Title])	Decision Rules"[Majr]	"patient portal"[tiab] OR "patient app*"[tiab] OR "personal health record"[tiab]			

Exhibit A2. Number of Results from Proposed Search Strings

Search	Records Returned
PC CDS Systematic Reviews *Systematic review search string AND #1a AND #4*	78
Alert Fatigue and Burnout *#1 AND #2*	279
Impact of CDS on Shared Decision Making *#1 AND #3*	208

Inclusion Criteria

Exhibit A3. Literature Search Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
• Published/developed in 2017 or later • Peer-reviewed literature including literature reviews, qualitative studies, implementation studies, viewpoints, and commentaries • Focuses on the use or implementation of clinical decision support, health technology, or person-centered care implementation in the United States • Describes approaches used to measure workflow or patient lifeflow impact of CDS interventions via the following dimensions: workflow context, uptake, use, or subjective value • Addresses PC CDS workflow archetypes, including but not limited to visit logistics (e.g., check-in), care plan development, shared decision making, encounter discharge, patient self-management and assessment, and their subcomponents	• Does not address a clinical decision support intervention or technologies that could be applied to improve PC CDS • Does not discuss measures to assess clinician workflow or patient lifeflow • Does not include human patients (e.g., veterinary studies; algorithms or provider-focused tools that do not involve some element of patient interaction) • Source is not peer-reviewed literature (e.g., grey literature, blogs, books, news articles, discussion forum, webinars) • Describes clinical outcomes measures, including measures related to population health

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