

Trust & Patient-Centeredness Workgroup: Improving the Source Credibility of Patient-Centered Clinical Decision Support Tools

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www.ahrq.gov

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Prepared by:

Tonya Hongsermeier, MD, MBA
Angela Dobes, MPH
Elizabeth Cope, PhD, MPH
Prashila M. Dullabh, MD, FAMIA
Priyanka J. Desai, PhD, MSPH
Rachel Dungan, MSSP
Marley Catlett, MPH
Sarah Weinberg
CDSiC Trust and Patient-Centeredness Workgroup

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PURPOSE

The Clinical Decision Support Innovation Collaborative (CDSiC) Trust and Patient-Centeredness Workgroup is charged with (1) supporting the design, implementation, and uptake of PC CDS—to enhance trust, foster shared decision making, and engage patients and clinicians as partners alongside all members of the care team; (2) promoting and enabling the use of PC CDS and developing related outputs that can support clinicians and patients as partners in a care team, equally committed to creating effective treatment and care coordination plans; and (3) ensuring that PC CDS products are understandable by the care team, designed with end users (including both clinicians and patients) in mind, and involves them from the very beginning of PC CDS development. The Workgroup is composed of 11 experts and stakeholders representing a diversity of perspectives within the CDS community. This report is intended primarily for PC CDS tool developers and priority end users.

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Contributors: CDSiC Trust & Patient-Centeredness Workgroup

Members of the Trust & Patient-Centeredness Workgroup are listed below.

Table 1. Trust & Patient-Centeredness Workgroup Members

Name	Affiliation
Deborah Collyar, MBA	Patient Advocates in Research
Catherine M. DesRoches, DrPH	Harvard University
Sarah Krug, MS	Cancer101
Elisabeth Oehrlein, PhD, MS	Applied Patient Experience
Jodyn Platt, PhD, MPH	University of Michigan
James Ralston, MD, MPH	Kaiser Permanente Washington Health Research Institute
Thomas Reese, PharmD, PhD	Vanderbilt University
Joshua Richardson, PhD, MS, MLIS, FAMIA	Research Triangle Institute
Danny Sands, MD, MPH	Consultant
Michael Valenti, PhD	Pressley Ridge
Jonathan Wald, MD, MPH	InterSystems

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Executive Summary

Patient-centered clinical decision support (PC CDS) is CDS designed to support health-related decision making informed by patient-centered factors including patient-centered research, patient-generated data, use of patient-facing tools, or use in shared decision making (SDM). Ensuring successful uptake and use of PC CDS requires strengthening patients' and clinicians' trust, in each other and in PC CDS recommendations designed to inform their decisions. Literature suggests a strong connection between trustworthiness and source credibility, or the degree to which a message recipient perceives the message sender as credible. As such, improving source credibility offers one route to enhancing trust in PC CDS.

Dialogue between care team members is often nuanced and iterative, such that PC CDS information is rarely communicated in a linear fashion or through a single source. Instead, information from the original **source of the evidence** (e.g., professional societies, clinical guidelines they produce) gets gathered, integrated, synthesized, translated, and transmitted through a series of PC CDS sources including the:

- **Source of the message**, specifically, PC CDS that translates evidence to clinicians and/or patients and caregivers.
- **Source of the delivery mechanism**, such as developers whose decisions shape the (1) message content, format, and design; (2) the underlying data and algorithms; and (3) the channel or platform for delivering messages.

For each PC CDS source, a series of interrelated factors enhances or undermines credibility. Understanding these factors—or source credibility “attributes”—can inform tailoring of PC CDS design and delivery in ways that demonstrate credibility and prompt adherence.

Due to the emerging nature of research on this topic in the context of PC CDS, the field needs further exploration of the (1) factors contributing to PC CDS source credibility and (2) strategies for improving source credibility. This report serves as a critical first step to addressing this evidence gap, by providing a preliminary framework for understanding the role of source credibility in PC CDS.

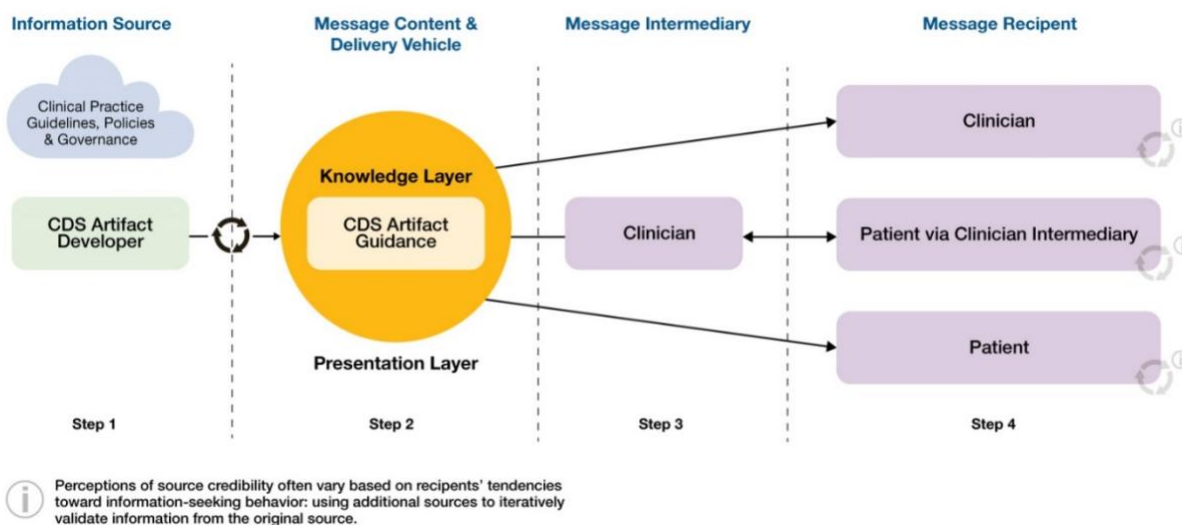
Methods

Our work was guided by the main objectives of (1) defining source credibility attributes relevant for PC CDS, (2) describing how these influence PC CDS adoption and use, and (3) identifying emerging or promising approaches to enhance PC CDS source credibility for clinician and patient end users (e.g., patients themselves, their families and/or caretakers). We conducted a scoping review of the literature to identify relevant attributes and strategies to enhance source credibility. Following review of peer-reviewed and gray literature, preliminary findings were iteratively validated through key informant interviews (KIIs).

Results

Findings from the literature review and KIs informed creation and iterative refinement of an **Information Flow Diagram**, which served as the framework for capturing and organizing information about PC CDS source credibility. The diagram illustrates how information from original sources of evidence is translated and transmitted to patients through PC CDS. It depicts various communication pathways for clinician-facing PC CDS (i.e., where clinicians serve as message intermediaries communicating PC CDS recommendations to patients) and patient-facing PC CDS (i.e., where patients receive and factor PC CDS recommendations into clinical decisions, with clinicians' guidance). The diagram breaks the information flow into four steps:

- **Step 1:** Developers design a PC CDS tool that can translate clinical practice guidelines, policies, and other sources of evidence into messages (e.g., alerts, recommendations) for end users.
- **Step 2:** An iterative process is used to refine and finalize the design, which includes the:
 - **Knowledge Layer** including underlying data, algorithms, and other forms of evidence on which the PC CDS guidance is based. This dictates the **message content**.
 - **Presentation Layer** including the format and channel (e.g., platforms, interfaces) for delivering these messages—or the **message delivery vehicle**.
- **Step 3:** For clinician-facing PC CDS, clinicians who interact with the PC CDS tool serve as intermediaries that frame and convey PC CDS guidance to patients.
- **Step 4:** Message recipients (e.g., clinicians and patients) engage in shared decision making, based on PC CDS recommendations delivered to patients either (1) by the clinician, or (2) through patient-facing tools.



Steps 1 and 2 represent PC CDS design, whereas Steps 3 and 4 represent PC CDS deployment. Icons are used to represent iterative information seeking and integration that can occur during deployment, as different end users may have different perceptions of source

credibility and information-seeking behaviors. For example: these end users may seek additional information (e.g., from media or non-clinician sources such as family and friends) to validate their perceptions about PC CDS guidance and its personal relevance for them.

PC CDS Source Credibility Attributes
<ul style="list-style-type: none">• Accuracy• Consistency• Objectivity• Reliability• Currency• Relevance• Transparency• Competence• Usability• Expertise
End User Perception-Based Source Credibility Attributes
<ul style="list-style-type: none">• Authority or Authoritativeness• Relatability• Appeal• Openness and Receptivity

The **Glossary of PC CDS Source Credibility Attributes** presents and describes the relevance of attributes salient for PC CDS and thus most likely to impact source credibility. Organized into two discrete sections, it differentiates direct attributes of PC CDS source credibility from perception-based attributes (affecting perceived source credibility based on the message intermediary and recipient factors).

- PC CDS Source Credibility Attributes are properties of the guidance and information underlying a PC CDS tool. They are influenced by developers’ choices regarding how to design PC CDS.
- End User Perception-Based Source Credibility Attributes are properties of how end users assign credibility to a PC CDS tool based on a combination of personal factors (e.g., knowledge, attitudes, beliefs). For example: different end users’ perceptions about the appeal or relatability of a source will vary based on what they personally find appealing or relatable.

Specifically, the role and impact of these perception-based attributes on overall source credibility can be influenced by individual-level factors such as:

- Sociodemographic characteristics (e.g., age, race or ethnicity, condition or disease status, health and digital literacy).
- Attitudes, behaviors, and motivations.
- Historical, personal, and sociocultural circumstances.
- Group ties, social networks, and the effects of social contagion.

Thus, when possible, designing and deploying PC CDS in ways that are tailored to best align with individual-level characteristics can improve source credibility—and thus trust in PC CDS.

Strategies for improving source credibility by modifying the attributes of PC CDS include:

- Engaging clinicians and patients in PC CDS codesign and codevelopment.
- Communicating key information regarding PC CDS construction and creation.
- Designing CDS tools and systems that run on up-to-date information and signal the timeliness of embedded knowledge.

Strategies for improving perceptions of source credibility by modifying perception-based attributes include:

- Tailoring PC CDS messages and delivery mechanisms.
- Creating feedback loops to solicit end-user feedback and iteratively inform PC CDS deployment.

Areas for Future Work

Enhancing source credibility of PC CDS requires understanding the opportunities, means, and impact of modifying various source credibility attributes. This work surfaced multiple considerations that must be addressed to optimize PC CDS source credibility, including (1) the nascence of the field and formative nature of this work; (2) the need for consideration of end-user characteristics, needs, and perspectives—as well direct end-user involvement—in PC CDS codesign; and (3) the role of source credibility as one of several factors influencing attitudinal and behavior change, such that it can impact PC CDS use and effectiveness.

Findings from the literature and KIs highlighted meaningful gaps in the current landscape of research on PC CDS source credibility. Thus, we have outlined a series of priority research topics that can address evidence gaps and advance PC CDS source credibility in three areas:

- **Attributes:** Priority research topics focus on the independent and interactional effects of source credibility attributes. Research in this area can support study of each attribute's impact, and of which attributes should be prioritized for intervention to improve PC CDS source credibility.
- **Strategies:** Further work is needed to determine which practices effectively improve source credibility and how to optimize them. For example, training clinician intermediaries on tailoring their delivery of guidance may optimize strategies for adapting PC CDS per end-user factors.
- **End-User Factors:** Additional research on how end-user factors influence source credibility will provide insight into the means and benefits of tailoring. Additionally, exploring how (and how well) end users assess source credibility will inform an understanding of how to adjust PC CDS design and deployment to mitigate the barriers of limited health and digital literacy.

Conclusion

Addressing these research questions can increase knowledge of how source credibility influences patients' and clinicians' interactions with each other, with PC CDS, and with recommendations designed to inform shared clinical decision making. Early exploration of this topic indicates that source credibility, and perceptions of it, are influenced by multiple PC CDS attributes—as well as characteristics of end users receiving and interpreting information from those tools. Thus, modifying attributes (e.g., increasing transparency, engaging end users in codesign) can enhance source credibility, reinforce trust, and promote adherence to clinical guidance. In this way, identifying and optimizing strategies to improve source credibility holds promise for increasing PC CDS uptake and effective use, ensuring the patient-centeredness of clinical decision making, and ultimately improving patient outcomes.

1. Introduction

Clinical decision support (CDS) encompasses tools and processes designed to enable timely decision making and subsequent delivery of evidence-based care.¹ CDS has historically been clinician-facing and used to deliver diagnostic or treatment guidance at the point of care, based on clinical guidelines;² it is often delivered through reminders, alerts, or order sets. Patient-centered (PC) CDS supports decision making informed by patient-centered factors related to:

- Knowledge, such as findings from patient-centered outcomes research (PCOR) and comparative effectiveness research (CER).
- Data including patient-generated, patient-reported, and patient-specific data.
- Delivery and incorporation of patient-facing tools.
- Use, particularly in the context of shared decision making (SDM).³

As is the case for patient-centered care more broadly, trust is fundamental to successful PC CDS. In many healthcare contexts, trust is assessed in terms of fairness, fidelity to patients' best interests, confidence in policies or procedures, and respect for confidentiality and privacy.⁴ Evidence suggests that clinician trustworthiness (i.e., providing valid information in an honest, fair, sincere manner)^{7,8} influences patients' adherence to treatment recommendations.⁹ Similarly, it indicates that broad uptake and effective use of PC CDS depends on clinicians' and patients' trust that generated recommendations can credibly inform clinical decisions.^{3,7,10,11}

Throughout the literature, trustworthiness is described as strongly linked to source credibility. However, there has not yet been explicit investigation to identify (1) factors contributing to PC CDS source credibility, and (2) strategies for improving source credibility. This report serves as a critical first step in addressing this evidence gap, by providing a preliminary framework for understanding the significance and influence of source credibility for PC CDS.

1.1 Roadmap for the Report

This report provides an exploratory analysis that examines the relationship between various factors influencing source credibility and characterizes how these factors relate to PC CDS. It also identifies potential strategies (i.e., during PC CDS design and deployment) for improving source credibility—as well as surfacing knowledge gaps and research opportunities.

- Section 3, *Background*, defines source credibility and its relevance to PC CDS uptake and use.
- Section 4, *Methods*, describes our research aims and approaches used for the literature review and key informant interviews (KIIs).
- Section 5, *Results*, presents key findings on source credibility attributes, how these attributes influence PC CDS, key considerations for enhancing source credibility, and emerging strategies for improving PC CDS source credibility.
- Section 6, *Discussion*, synthesizes our findings and explores key considerations regarding the complexity and nascency of research on source credibility—specifically in

PC CDS contexts. It further identifies areas for future research, to address gaps in the emerging evidence on PC CDS source credibility.

- Section 7, *Conclusion*, summarizes this work's contribution to the field and highlights themes related to source credibility's relevance for real-world PC CDS.

This report is primarily designed for PC CDS tool developers (e.g., those that reside within health systems as well as those outside, such as commercial publishers or professional societies) and priority end users (e.g., healthcare organizations, clinicians, patient audiences).

2. Background

PC CDS facilitates the (1) identification and communication of evidence-based guidance that is tailored to, and informed by, individual patients' needs, goals, and preferences; and (2) engagement of patients and caregivers in decision making about care plans.

Outcomes of successful PC CDS may include improved patient and clinician adherence to clinical practice guidelines and recommendations, and consequently improved patient outcomes (e.g., knowledge, health-related behaviors and/or practices, clinical and/or patient-reported outcomes).

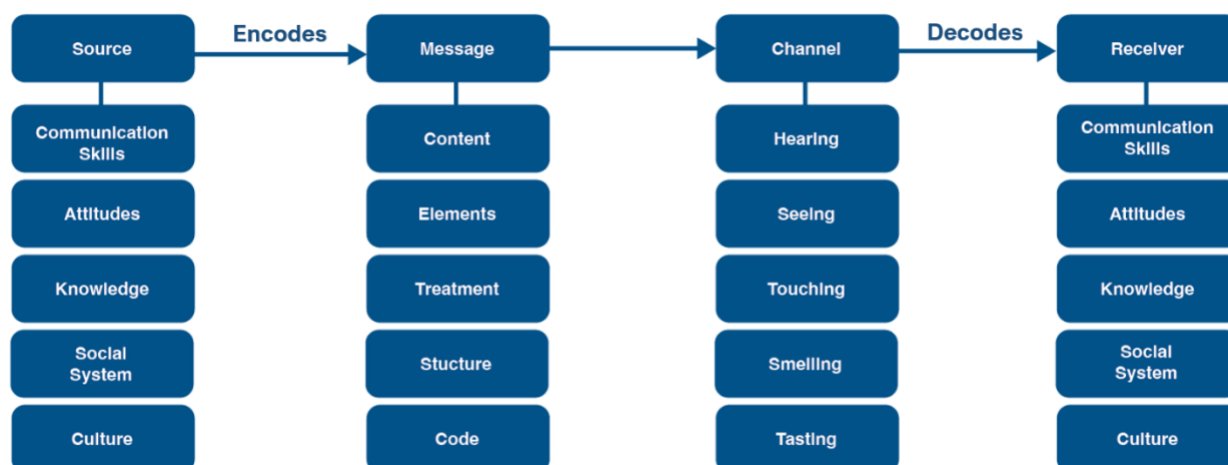
Public health literature indicates that source credibility, among other factors, mediates the relationship between health-related communications and subsequent uptake of guidance.¹² In health-related contexts, source credibility influences whether someone accepts or rejects a health-related message (e.g., smoking cessation, vaccination intention); it affects whether someone will be persuaded to adopt a health belief or change a health behavior.^{9,12,13} Improving source credibility offers one route to increasing message persuasiveness and the likelihood that message recipients trust and adhere to embedded guidance.

2.1 Source Credibility & Patient-Centered Clinical Decision Support

Trust in a source's credibility or reputation gets extended to beliefs about information or messages from that source.^{14,15} Thus, source credibility reflects the degree to which a message recipient perceives the message, and its sender, as credible.^{16,17} It encompasses the extent that people can trust information from a particular source (e.g., tool, person, resource, organization).¹⁸⁻²⁰

Source credibility is primarily concerned with characteristics of the message source, content, delivery mechanism, and recipients.²¹ The Source-Message-Channel-Receiver (SMCR) model of communication (**Exhibit 1**)^{22,23} depicts relationships between, and factors influencing, key elements of communication. It also demonstrates where encoding and decoding processes support the translation of information that gets transmitted from source to receiver.

Exhibit 1. The Source-Message-Channel-Receiver (SMCR) Model of Communication



For this report, we reference definitions of these key communication elements (e.g., message, message recipient),²² and adapt them as appropriate for PC CDS communications. In these contexts, dialogue between members of the care team is often nuanced and iterative. Rather than communicated in a linear fashion or through a single source, information from the original **source of the evidence** (e.g., professional societies, clinical guidelines they produce) gets gathered, integrated, synthesized, translated, and transmitted through a series of PC CDS sources including the:

- **Source of the message**, specifically, PC CDS that translates and transmits evidence to clinicians and/or patients and caregivers.
- **Source of the delivery mechanism**, such as developers whose decisions shape the (1) message content, format, and design; (2) the underlying data and algorithms; and (3) the channel or platform for delivering messages.

For each source, a series of interrelated factors enhances or undermines credibility. Understanding these factors—or source credibility “attributes”—can inform tailoring PC CDS design and delivery in ways that demonstrate credibility and prompt adherence. Emerging evidence suggests that, for clinicians, enhancing PC CDS source credibility involves efficient integration of PC CDS in workflows and patient-specific relevance of PC CDS outputs.^{3,24} The evidence is underdeveloped regarding how to identify, label, and disseminate health information in ways that help patients assess and elevate credible sources.²⁵⁻²⁷ For both patients and clinicians, general mistrust or misunderstanding of PC CDS (e.g., due to lack of transparency, limited digital or health literacy) can undermine overall uptake and use, as well as adherence to system-generated guidance.²⁸ Equipping message recipients with skills and knowledge to assess source credibility can increase trust and improve informed health decision making.

Understanding the role and influence of source credibility can help inform future PC CDS development and deployment. Thus, to scale and sustain effective PC CDS, it is helpful to explore:

- Which attributes of source credibility are most salient to PC CDS.

- The extent that identifying and understanding these attributes presents opportunities to enhance PC CDS source credibility.
- Clinician and patient perspectives regarding PC CDS source credibility and how it affects their willingness to trust and adhere to PC CDS-generated recommendations.

3. Methods

Our work was guided by the main objectives of:

- Defining attributes of source credibility relevant for PC CDS.
- Describing how these attributes influence PC CDS adoption and use.
- Identifying emerging or promising approaches to enhance PC CDS source credibility for both clinicians and patient audiences (e.g., patients themselves, their families and/or caretakers).

Preliminary findings from a scan of peer-reviewed and gray literature were iteratively validated through KIIIs. These discussions informed interpretation of our findings, and they helped to identify and fill evidence gaps. Our methods, summarized below, are fully detailed in **Appendix A**.

3.1 Literature Review

A scoping literature search was used to identify and define source credibility attributes, and to explore potential strategies for improving PC CDS source credibility. Given the formative nature of our work and the nascence of literature specific to PC CDS contexts, we grounded our understanding of source credibility in literature from adjacent and more established disciplines (e.g., public health, education, communications). Literature identified through semi-systematic searches and recommendations from Workgroup leads, Workgroup members, and CDSiC advisors provided foundational definitions of source credibility and related concepts. These seeded CDS-specific targeted searches using PubMed to identify peer-reviewed literature, as well as Google and Google Scholar for gray literature.

Initial PubMed searches in adjacent disciplines yielded 29 peer-reviewed articles. The second round of literature searches yielded an additional 41 articles identified via PubMed and Workgroup member recommendations. Following de-duplication, 63 articles underwent a two-phase screening process. At each level of review, we assessed whether articles met our eligibility criteria (see **Appendix A**) and marked them accordingly: as *eligible*, *ineligible*, or *uncertain*. Articles were deemed eligible if they were: (1) published/developed in the last 5 years, from 2017 to present; (2) focused on the use of PC CDS in the United States (for CDS-specific targeted searches); (3) relevant to patient-centered CDS interventions (for CDS-specific targeted searches); (4) including mention of credibility, source credibility, and/or relevant concepts in adjacent disciplines such as public health, education, and communications; and (5) in English.

During preliminary screening, titles and abstracts were reviewed for all sourced articles (n=63). Articles deemed *eligible* or *uncertain* at this level were automatically forwarded for secondary

review. This subset of articles (n=50) then underwent review at the full-text level, during which relevant data were abstracted per the coding matrix and definitions reviewed by CDS experts. Following this data abstraction process, articles labeled *ineligible* were removed. The final list of 35 articles was included in the literature review.

3.2 Key Informant Interviews

We conducted KIIs to validate preliminary findings from the literature regarding source credibility attributes and their relevance for PC CDS. Informants provided feedback on two products: the PC CDS Information Flow Diagram (**Exhibit 2**), and the Glossary of PC CDS Source Credibility Attributes (**Tables 3 and 4; Appendix B**). The Information Flow Diagram, introduced in **Section 4.1**, illustrates the general pathway by which information from an original source (e.g., evidence in the form of clinical practice guidelines) gets translated into PC CDS design, delivered through PC CDS outputs, and ultimately communicated to patient and clinician recipients. Further described below in **Section 4.2**, the Glossary defines key source credibility attributes and describes their applicability for PC CDS, according to established frameworks of CDS development.^{7,29-32}

To review and refine these products, nine KIIs were conducted between December 2022 and January 2023. As shown in **Table 2**, key informants represented three main stakeholder groups: source credibility experts, PC CDS developers (i.e., health IT developers), and both clinician and patient PC CDS end users. Five of these informants were members of the Trust and Patient-Centeredness Workgroup.

Interviews were organized using a semistructured discussion guide. Versions of this interview guide, tailored for each of the three major stakeholder types, were iteratively refined and validated through Workgroup discussion. Each informant was interviewed individually, during an approximately 1-hour conversation hosted on Zoom.

Table 2. Validation Key Informants by Stakeholder Type

Stakeholder Perspective Type	Number of Key Informants
Source Credibility Expert	1
PC CDS Developer	3
PC CDS End User	5
Total	9

3.3 Analysis and Synthesis

We used thematic approaches for analyzing data from the literature and KIIs to identify attributes of source credibility and potential strategies for improving PC CDS source credibility. A coding matrix (i.e., coding categories, definitions, or coding parameters for each category) was developed to guide capture of relevant text excerpts from the literature. Team members reviewed qualitative data from KIIs to identify key themes within and across interviews.

Developed via an iterative process, the Glossary of PC CDS Source Credibility Attributes functioned as an organizing framework for key findings. Originally based on information from the literature regarding each attribute and its relationship to PC CDS, the Glossary evolved as key informants' input refined, validated, or supplemented its content.

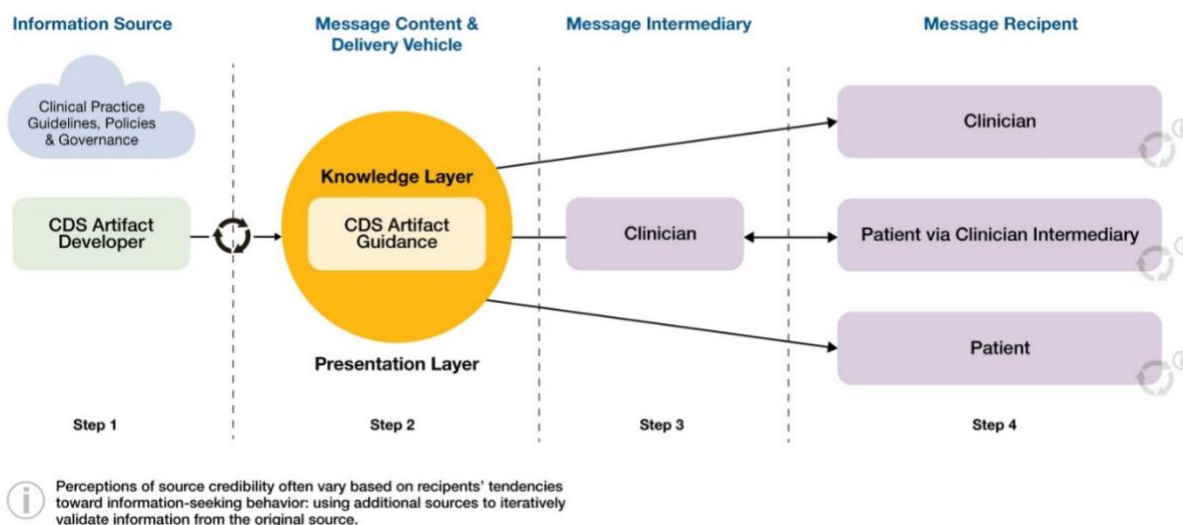
4. Results

Findings from the literature review and KIIs are presented below. First, we discuss the Information Flow Diagram. We then review the Glossary, the full version of which is presented in **Appendix B**. Here, it is separated into two sections: source credibility attributes of PC CDS (e.g., of the interface through which clinicians and patients receive alerts) and perception-based source credibility attributes influenced by the circumstances and characteristics of each PC CDS end user (e.g., the clinician intermediary through which patients receive recommendations). Finally, we present real-world considerations and highlight emerging strategies for improving PC CDS source credibility.

4.1 Understanding Information Flows for PC CDS

We developed the PC CDS Information Flow Diagram (**Exhibit 2**) to clarify the complex flow of information from PC CDS sources to message recipients, which includes opportunities to improve the credibility of each source in that flow. The diagram illustrates the general pathway by which information from original sources gets translated and transmitted, ultimately to patients. Assessing the credibility of original sources of evidence is beyond scope of this report; thus, these sources have been represented in the figure as pre-developed inputs to the PC CDS information flow. Additionally, since informants highlighted that this process is rarely linear, we use visual icons to acknowledge points of nuance and iteration.

Exhibit 2. PC CDS Information Flow Diagram



Step 1: Information Source.

The flow of information originates with the source of evidence for decision support: clinical practice guidelines, policies, and governance generated by professional societies. Here, PC CDS developers function as the source of the delivery mechanism: designing PC CDS that can translate this evidence into messages (e.g., alerts, recommendations) for end users.

Step 2: Message Content & Delivery Vehicle.

Informants indicated that PC CDS development may be cyclical (as shown between Steps 1 and 2), as developers interact with governance entities such as clinical leaders, operational leaders, and/or stakeholder end users who vet the PC CDS tool (and implementation plan) before its use in clinical encounters. Thus, an iterative process is often used to refine and finalize the PC CDS tool. This tool, as a source of PC CDS messages, includes a:

- **Knowledge Layer** encompassing underlying data, algorithms, and other forms of evidence on which the PC CDS guidance is based. This dictates the **message content**.
- **Presentation Layer** encompassing the format and channel (e.g., platforms, interfaces) for delivering these messages—or the **message delivery vehicle**.

Step 3: Message Intermediary.

Clinician-facing PC CDS situates clinicians as “intermediaries” of information with two distinct roles.³³ Clinicians first function as message recipients: receiving information through PC CDS alerts or recommendations. Then, they also serve as sources of a message: translating and transmitting health-related messaging to patients.

Step 4: Message Recipient.

Just as multiple sources of information are involved in PC CDS communications, multiple recipients are, also. Clinicians are often the recipients of messages from PC CDS, except in the case of patient-facing PC CDS where patients directly interact with tools. Here, clinicians still play an important role by framing information delivered through patient-facing PC CDS. Clinicians help patients understand the implications of PC CDS recommendations through guidance, oversight, and advising. In both cases, this is the step during which message recipients (e.g., clinicians and patients) receive the final messages and engage in shared decision making based on PC CDS recommendations. Informants noted that these communications may be bidirectional (Steps 3 and 4), given patients’ and clinicians’ iterative information seeking and integration. Icons are used in Step 4 to represent this dynamic process, which varies based on individuals’ perceptions of source credibility and information-seeking behaviors. For instance, some message recipients may seek additional sources of information (e.g., from media or non-clinician sources, such as family and friends) to validate PC CDS guidance and its personal relevance.

4.2 Distinguishing PC CDS and Perception-Based Source Credibility Attributes

At different steps in the information flow, attributes may have varying saliency and impact on source credibility. By determining where each attribute is most salient, key actors can anticipate “intervention” points for “leveraging” that attribute to improve PC CDS source credibility.

Here, it becomes important to distinguish between source credibility attributes most salient in:

- PC CDS design, when developers create the PC CDS tools that provide clinicians and/or patients guidance to support healthcare decision making.
 - We refer to these as **PC CDS Source Credibility Attributes**.
 - PC CDS Source Credibility Attributes are properties of the guidance and information underlying a PC CDS tool. They are influenced by developers’ choices regarding how to design PC CDS.
- PC CDS deployment, when clinicians or patients interact with the PC CDS.
 - We refer to these as **End-User Perception-Based Source Credibility Attributes**.
 - End-User Perception-Based Source Credibility Attributes are properties of how end users assign credibility to a PC CDS tool based on a combination of personal factors (e.g., knowledge, attitudes, beliefs). For example: different end users’ perceptions about the appeal or relatability of a source will vary based on what they personally find appealing or relatable.

As PC CDS is deployed and end users interact with it, their perceptions (influenced by individual-level factors such as personal attitudes or history) influence how they receive and transmit information.³⁴ Thus, perception-based attributes can vary by end users’ personal context or characteristics.

4.2.1 PC CDS Source Credibility Attributes

Table 3 describes 10 source credibility attributes of PC CDS tools and describes how each is relevant for PC CDS.

Table 3. Glossary of PC CDS Source Credibility Attributes

Attribute	Relevance to PC CDS
Accuracy	In PC CDS contexts, accuracy refers to the scientific validity, correctness, or completeness of: <ul style="list-style-type: none"> • data or evidence inputs translated into CDS tools or processed in CDS systems;^{35,36} and • diagnoses, recommendations, or alerts produced through CDS systems and processes.³⁷⁻⁴² It also refers to the clinical appropriateness and applicability of alerts or recommendations, for the patient at hand.
Consistency	In the context of PC CDS, consistency requires that communicated information aligns with other existing evidence deemed credible or information previously shared by the same source. ⁴³

Attribute	Relevance to PC CDS
Objectivity	<p>In the context of PC CDS, initial sources of information translated into PC CDS tools—as well as those sponsoring or involved in their design and deployment—should be:</p> <ul style="list-style-type: none"> • free of bias,^{44,45} and • not subject to commercial or other conflicts of interest.
Reliability	<p>In the context of PC CDS, reliability is based on whether:</p> <ul style="list-style-type: none"> • the tool produces the same information given the same inputs (e.g., patient data),⁴³ or • generated recommendations yield the same outcomes in similar patients.⁷
Currency	<p>In the context of PC CDS, currency requires that:</p> <ul style="list-style-type: none"> • tools are based on the most up-to-date evidence. Models run on outdated information or guidelines based on outdated evidence can render PC CDS recommendations inaccurate or ineffective.⁷ • alerts and recommendations are delivered at appropriate times in the clinical workflow.²⁴ • tools and guidelines are monitored and maintained to ensure CDS is current.³⁸ • tools are equipped to deliver timely alerts and recommendations.
Relevance	<p>In the context of PC CDS, the relevance of PC CDS alerts, recommendations, and treatment options depends on whether:</p> <ul style="list-style-type: none"> • CDS tools, systems, and processes generate clinically appropriate alerts or recommendations;³⁷ and • clinicians frame PC CDS recommendations in ways that are appropriate for that patient.
Transparency	<p>In the context of PC CDS, transparency requires clearly and proactively disclosing information regarding:⁷</p> <ul style="list-style-type: none"> • the source and latest version of guidelines that informed the PC CDS tool. • commercial or other conflicts of interest related to the tool or its sponsors/developers; PC CDS end users should be able to readily access information about all conflicts of interest related to a tool's development.⁷ • the process of developing the PC CDS tool. • whether the tool is designed to detect (or likely to perpetuate) bias. • the expected use cases, caveats, capabilities, and limitations of a tool.
Expertise	<p>In the context of PC CDS, expertise refers to the extent to which a source is:⁴⁶</p> <ul style="list-style-type: none"> • qualified, • professional, or • otherwise holding advanced knowledge or specialized training.
Competence	<p>In the context of PC CDS, competence refers to the efficacy or capability of:</p> <ul style="list-style-type: none"> • Electronic health records (EHRs) and/or health IT developers creating effective tools;⁴⁷ and • PC CDS tools effectively delivering recommendations; and • clinicians effectively translating and communicating PC CDS recommendations to patients, while advising their care.⁴
Usability	<p>In the context of PC CDS, usability refers to the degree or ease of use for tools. This encompasses the actionability, accessibility, or explainability of PC CDS and the information it conveys. End-user assessments of usability often depend on:^{38,48}</p> <ul style="list-style-type: none"> • alert specificity; • information clarity; and • seamless integration with clinical workflow or patient experience.

Accuracy refers to the quality or scientific validity, correctness, or completeness of information. This includes data or evidence inputs translated into PC CDS tools, or processed in PC CDS systems.^{35,36} It also includes diagnoses, recommendations, or alerts generated as PC CDS outputs.³⁷⁻⁴² For this information to be considered valid and correct, and thus for PC CDS to be accurate, the underlying evidence (i.e., that supports the clinical guideline or predictive model) must be substantiated. If PC CDS recommendations are based on insufficient or conflicting

research results (or key information missing from the health record), these may not be considered accurate. For example: if a clinician prescribes a drug the patient is allergic to, and the PC CDS recommends an alternative that is also inappropriate for this patient (e.g., because the patient has another contraindication for that drug that may not have been captured in the record), guidance to prescribe this medication would be inaccurate.

Completeness of information requires that a PC CDS provides diagnoses, recommendations, or alerts free of unintentional omissions. For example: PC CDS that fails to alert diabetic patients of the need for annual eye and foot exams is not accurate or adherent with current clinical guidelines. Completeness also relates to patient health data processed in PC CDS tools.

Consistency reflects the extent that information or messages agree with, or do not vary significantly from, information previously shared by the same source or captured in existing evidence.⁴³ In PC CDS, authors of guidelines and developers of tools are responsible for ensuring consistent knowledge translation.⁴³ PC CDS source credibility can be undermined when information transmitted by the tool, clinician, or another source contradicts information or recommendations that have previously been shared by that same source or elsewhere in the field of evidence. For example: if the evidence suggests most frequent colonoscopy screening for high-risk patients, but the PC CDS is not configured to recommend such higher frequency screening, that tool's alerts and recommendations might be deemed inconsistent with the current evidence.

Objectivity refers to the extent that (1) original sources of information or evidence translated into PC CDS tools and (2) entities commissioning or sponsoring the tool's development are free from bias,^{44,45} commercial interest, or conflicts of interest.

For example, PC CDS recommendations may not be deemed objective or credible if they suggest patients use a particular glucose monitor or class of medications—and then justify that suggestion by referencing guidelines published by the manufacturer of that diabetic device or medication. Notably, sources that do have conflicts of interest can improve source credibility by communicating clearly about these influencing factors.²⁵

Reliability refers to the repeated triggering of PC CDS given a certain set of conditions and the repeated generation of expected results over time, when given the same inputs (e.g., patient data).⁷ Reliable PC CDS will repeatedly yield the same outputs for (1) different patients with the same characteristics or (2) the same patient, even when PC CDS gets deployed by different clinicians. Reliable PC CDS rules for diabetic patient management, for example, would yield the same evidence-based guidance for two patients with the same demographics, laboratory results for HbA1c, medication regime, comorbidities, and disease complications. Reliability also encompasses the consistent timeliness of results, such that the PC CDS tool repeatedly generates results in the same amount of time, when given the same inputs.

Currency reflects PC CDS responsiveness to the most current evidence.⁷ PC CDS tools should be (1) designed to run on up-to-date evidence and patient information,⁷ (2) monitored and maintained to ensure information is current,³⁸ and (3) equipped to deliver timely alerts and recommendations.

If PC CDS tools run on outdated clinical information or guidelines, generated recommendations may be ineffective. For example, if a patient's chart has not been updated following a routine colonoscopy, a PC CDS tool may push reminders that indicate the patient still needs to undergo the procedure; in this case, these alerts based on outdated information would be ineffective. One informant highlighted how rapidly clinical knowledge can evolve, and acknowledged the inherent source credibility limitations of PC CDS tools that cannot be updated as quickly the field evolves, technology advances, or evidence emerges. Opportunities may exist, however, for ensuring that PC CDS at least runs on the most currently available patient-reported inputs, such as those captured pre-visit in patient portals.

Relevance refers to the applicability and/or clinical appropriateness of PC CDS alerts, recommendations, and treatment options. This includes the extent that alerts are sensitive to relevant information (i.e., trigger appropriate alerts given relevant information), and presented in appropriate sequence.²⁴ If alerts are not presented in an appropriate sequence, a clinician deploying PC CDS may use the resource or information ineffectively—or may lack the information needed at a given time to make appropriate recommendations for their patient. Similarly, if a patient is seen in an urgent care or emergency department setting for some reason, the PC CDS may be intentionally designed not to fire recommendations for chronic care (e.g., pap smears, colonoscopies), focusing attention on the highest-priority and most context-relevant alerts.

Relevance also refers to whether PC CDS outputs align with patients' goals, needs, and preferences^{24,49} and account for their circumstances, characteristics, and other contextual (e.g., historical,^{12,50-52} personal,⁵² sociocultural⁵³) factors. PC CDS outputs may be considered relevant if they are equipped to anticipate patient needs and preferences, such that recommendations are adapted accordingly for each patient.⁴⁹ For example, a clinician might suggest that a patient with mild anemia eat foods rich in vitamin B12, such as red meat or seafood. However, if this patient adheres to a vegan diet, they may instead need to pursue a medication-supported treatment regimen. To produce a relevant recommendation, PC CDS would account for documented patient preferences (e.g., dietary restrictions) and suggest the more patient-appropriate treatment regimen instead of dietary modification.

Transparency involves clear and proactive disclosure of conflicts of interest,^{25,54} biases,⁵⁴ limitations,²⁵ and other important caveats⁷ on information being shared. Transparency is especially salient for machine learning or algorithm-driven PC CDS systems, given increasing calls to avoid creating “black box” systems that fail to provide end users with information about how outputs are generated.^{7,55} PC CDS end users should be able to readily access information about all conflicts of interest related to a tool's development,⁷ whether the tool is designed to detect (or likely to perpetuate) bias, and regarding any known biases embedded in the data that an algorithm is design to reason over.

Several informants confirmed this, suggesting that clinicians may find PC CDS more credible if these tools clearly communicate information about the source of underlying clinical guidelines, as well as the developer, and about appropriate uses and known limitations of the tool. For example, clinicians receiving PC CDS alerts or order sets should also receive reference links for

underlying guideline(s), as well as information regarding any conflicts of interest for those (e.g., sponsors, expert advisors) who developed either the guidelines or the PC CDS.

Expertise refers to the extent that a source is qualified, professional, or otherwise holding advanced knowledge or specialized training.⁴⁶ Some informants underscored that source expertise may not only be reflected solely in credentials (e.g., degrees, qualifications), but also through first-hand experience.³³ In PC CDS contexts, it is important to recognize a range of expertise: held by individuals affiliated with notable authorities or institutions (e.g., academic centers, professional societies, regulatory bodies),⁵⁶ as well as those familiar with specialized contexts or perspectives (e.g., clinicians' perspectives on workflow integration, patients' knowledge of their home context).^{57,58} Expertise, strongly linked to source credibility,⁵⁹ might prompt a patient to follow diet and nutrition guidance from the American Diabetes Association rather than guidance from less expert sources—or those with expertise in different areas.

In the case of PC CDS sources with visual elements, such as websites or other interfaces, source expertise can be signaled by comprehensive information, valid evidence, and professional presentation—or through sponsors' or developers' credentials.³³ For example, informing patient end users that PC CDS recommendations are based on guidelines created by professional societies (recognized for their expertise), and/or by providing details regarding the credentials of PC CDS developers who translated that guidance, may increase their likelihood of viewing PC CDS sources as credible.

Competence relates to the capability or effectiveness of PC CDS developers,⁴⁷ the tools themselves, and those deploying the tools.⁷ The developer may be deemed competent based on past performance, professional qualifications, or certifications.⁷ For example, if a PC CDS tool repeatedly fails to work due to software bugs or encoding errors, clinicians may not view its developers as competent. Similarly, if a PC CDS tool repeatedly fails to generate clinically appropriate alerts or recommendations, clinicians might not view the system as competent. In both cases, lack of competence could undermine clinicians' belief that PC CDS and its outputs are credible.

Usability encompasses the extent that PC CDS provides end users with the best available knowledge at the right time.^{38,48} Related to the degree or ease of use, evidence suggests that usability is of high priority for clinician end users of PC CDS.¹¹ Further, key informants identified usability among the attributes most salient for PC CDS. Both the literature and KIs indicate that usability often influences people's (1) likelihood of PC CDS use, (2) belief in its effectiveness, and (3) trust in the credibility of embedded or generated information.¹¹ Limited usability can undermine the credibility of PC CDS developers who, in failing to design a tool that meets end-user needs, may demonstrate lack of research or understanding about technical aspects of real-world PC CDS deployment.

Finally, PC CDS tools lacking usability may present barriers to implementation; if end users are unable or unclear on how to properly integrate PC CDS with their usual workflow, they might use decision support inappropriately and yield inaccurate recommendations. For example, a PC CDS tool may have limited usability if alerts are delivered at times that disrupt the clinical

workflow and result in alert fatigue, which can lead to inappropriate alert overrides by clinicians.²⁴

4.2.2 End-User Perception-Based Source Credibility Attributes

Table 4 presents four perception-based source credibility attributes and describes their relevance to PC CDS.

Table 4. Glossary of End-User Perception-Based Source Credibility Attributes

Attribute	Relevance to PC CDS
Authority or Authoritativeness	In the context of PC CDS, authority or authoritativeness refers to: <ul style="list-style-type: none"> professional societies’ authority, based on knowledge of the domain and the charger or power to set clinical guidelines. PC CDS tools derived from evidence-based guidelines.
Appeal	In the context of PC CDS, the appeal of a tool or information source may be based on: <ul style="list-style-type: none"> the extent to which it facilitates natural clinical workflows or dialogues; its aesthetic-, appearance-, or design-related features; or its subjective desirability or likability (as in the case of a clinician intermediate who communicates CDS-related information to patients or caregivers).^{59,122,123}
Openness and Receptivity	In the context of PC CDS, openness and receptivity refers to: <ul style="list-style-type: none"> the extent that a PC CDS tool or deploying clinician is willing to receive and potentially integrate feedback or new information.⁷
Relatability	In the context of PC CDS, relatability refers to: <ul style="list-style-type: none"> the extent to which a source entity seems familiar or likely to have shared a common or universal experience, such that message recipients can recognize aspects of themselves or their lives in the source entity.^{12,33,60}

Authority or Authoritativeness signals a relationship in which one party, bearing a particular quality or type/depth of knowledge, has influence over another’s actions or knowledge.⁶¹ According to key informants, within the context of PC CDS, authority refers to the influence of professional societies and experts who set clinical guidelines—and of those deploying PC CDS based on based on those guidelines. While certain types of experts or entities (e.g., medical or scientific professionals) have traditionally been recognized as authorities, evidence suggests growing mistrust of such authorities and indicates this may be variable (in part) based on cultural or contextual factors.^{12,25,52,62}

Patients who view authorities as inherently credible may automatically accept information from sources they recognize as healthcare authorities (e.g., clinicians, leaders of health institutions). Other patients, who may doubt the credibility of individuals or institutions with authority, may be skeptical about their clinician’s credibility. This is especially true if that clinician’s guidance differs from guidance previously offered by another, more authoritative source. For example, patients may recognize both their clinicians and entities such as the Centers for Disease Control and Prevention (CDC) as authorities. However, if a patient doubts the credibility of vaccine guidance issued by the CDC, that patient might also doubt PC CDS recommendations based on CDC guidelines.

Appeal encompasses the subjective likability or desirability of a PC CDS source (e.g., an app interface, a clinician intermediary).^{37,59} Relative appeal is often based not only on perceptions of the attractiveness or design of a source or delivery mechanism, but also on whether PC CDS facilitates or interrupts the natural clinical workflow or dialogue, as noted by one informant. Evidence suggests that communicating information in personalized ways, tailored to someone's preferences (or things that "appeal" to them) significantly improves perceived source credibility.¹² For example, a clinician or patient who feels the graphic design of an interface is old-fashioned, confusing, undesirable, or unintuitive may question the credibility of the PC CDS.

Openness & Receptivity to feedback or new information was emphasized across patient, clinician, and developer informants as important for demonstrating source credibility; they suggested this is necessary for establishing the trust fundamental to shared decision making. Informants confirmed suggestions from the literature that patients view clinicians attributed with openness and receptivity as more credible than others.³³ This may be partly due to patients' belief that clinicians who accept their new information or insights will likely arrive at treatment recommendations meeting their personal needs—based on their personal inputs. Clinicians can demonstrate openness and receptivity by considering and integrating new information (e.g., patient details) and insights contributed by patients into clinical decisions.

Similarly, clinicians may view PC CDS signaling openness and receptivity as more likely to generate relevant recommendations—and thus as more credible. PC CDS that includes mechanisms for receiving and responding to clinician input signals the potential for iterative refinement, and the likelihood that PC CDS will generate increasingly relevant recommendations following system improvements.⁶³ Similarly, one informant suggested that developers can signal the PC CDS openness and receptivity by embedding visual cues alerting clinicians to channels for sharing their feedback, for example, when they encounter irrelevant alerts or experience misalignment between PC CDS and the implementation context.

Relatability reflects the extent to which a source seems familiar or likely to have shared a common or universal experience, such that message recipients recognize aspects of themselves or their lives in that source.⁶⁰ In healthcare contexts, for example, patients may be most comfortable divulging sensitive information to clinicians with characteristics or past experiences similar to their own. Evidence suggests that patients may give precedence to advice or anecdotes from familiar or likable sources (e.g., friends or neighbors who share their own qualities or attitudes).^{14,33} This is especially true when patients face challenging decisions, leaving them too tired or overwhelmed to seek and vet evidence.³³ For example, a patient may ignore clinicians' suggestions to start a statin if family members reported (in contrast to the evidence) seeing no clinical benefit from the medication and experiencing negative side effects.

Notably, relatable sources can prove helpful in cases where they share a patient's symptoms, diagnoses, or characteristics.^{14,33} However, relying on these sources independent of other evidence can also do harm and spread misinformation.

4.2.3 The Role of End-User Factors in Source Credibility

It is important to note that perception-based source credibility attributes are directly affected by individual-level end-user factors such as:

- **Sociodemographic characteristics (e.g., age, racial identity, ethnicity, condition or disease status, health, and digital literacy).**²⁵ In one study, for example, age moderated the interaction between information credibility and health literacy, but only among younger patients and those less likely to have chronic conditions.¹⁴
- **Attitudes, behaviors,**^{12,14,64,65} **and motivations**^{8,14,16} **as well as historical,**^{12,50-52} **personal,**^{52,62,66-68} **and sociocultural circumstances.**^{8,53} For example: patients who personally have had negative healthcare experiences, or who identify with groups that experienced historical mistreatment by scientific or medical authorities, may automatically be skeptical of clinicians' credibility.^{12,52}
- **Group ties, social networks, and the effects of social contagion.**^{69,70} If, for example, a patient's peers express negative sentiments toward vaccination, that patient may seek social reinforcement rather than adhere to PC CDS recommendations regarding immunization.

These and other individual PC CDS end-user factors affect the extent that each perception-based attribute impacts source credibility. Consider the example of a patient who identifies with a particular racial or ethnic group that experienced historical mistreatment by health authorities. Such a patient may be skeptical of a clinician's recommendation to use a wearable device (sometimes, seen as reminiscent to ankle monitors) for home health monitoring.^{12,52} While using this device could provide the clinician with helpful real-time data regarding the patient's state of health, this patient may mistrust guidance to use wearables. This same patient, however, may trust the guidance if delivered by a clinician who shares the patient's own racial or ethnic background⁷¹⁻⁷⁴—believing that this clinician is aware of past harms, sensitive to patient concerns, and likely to effectively honor the patient's best interests.

Taking this hypothetical further, consider the attribute of relatability (i.e., the extent a source is similar, familiar, or likely to have common features or experiences). In our example above, individual-level end-user characteristics (i.e., racial or ethnic identity) and related historical circumstances create a scenario where relatability could take on outsized importance; the more relatable the clinician is, the more likely the patient is to view the clinician's guidance as credible. This example helps illustrate how individual end-user factors influence the significance and impact of perception-based attributes. It also highlights the benefits of factoring in knowledge about target end users, such that PC CDS design and deployment can be tailored (where possible) to signal source credibility.

4.2.4 Digital Health Literacy

Digital health literacy refers to people's ability to source, understand, and assess health information from electronic resources such that they can apply this knowledge to address a problem.^{75,76} Both health and digital literacy—in tandem with health status, personal knowledge

and beliefs, and situational factors—influence patients’ judgments regarding the quality, credibility, and trustworthiness of a source.⁶²

Low digital literacy limits people’s ability to critically and accurately vet source credibility, which impedes effective uptake and use of PC CDS. In patient-facing CDS, limited digital literacy can hinder a patient’s ability to engage with PC CDS tools.^{77,78,79,80} For example, studies show that older adults tend to have low health/digital literacy as well as low trust in online health information; both of these factors influence their search patterns and resources, as well as their ability to successfully vet and identify credible sources.^{44,81,82,83,84} Given increasing recognition that digital determinants of health contribute to inequities in health access and outcomes,⁸⁵ efforts to improve digital health literacy are needed. This may include steps to ensure easy, reliable access to credible information, especially for those less likely or able to source and vet the proliferating sources available through digital tools or outlets.^{14,44,86} Additionally, patient-facing PC CDS can be intentionally designed (i.e., format, language, reading level) to help patients find, understand, and use information or services to inform their health decisions.

Digital health literacy is similarly important for clinician-facing PC CDS, as a clinician’s successful use of advanced CDS systems may depend on their technical proficiency.⁷⁷ Clinician comfort with technology can be enhanced through initial and ongoing training,^{77,87} and the design of technologies using, or based on, existing systems and/or interfaces with which clinicians are familiar.⁷⁷

4.3 Strategies to Improve PC CDS Source Credibility

Developers, clinicians, and other key actors have opportunities throughout PC CDS design and deployment to adopt strategies for improving source credibility. Below, we describe five strategies referenced in the literature and present a summary of the available evidence for each. This includes strategies aimed at improving:

- Source credibility, by targeting PC CDS attributes.
- End-user perceptions of source credibility, by targeting perception-based attributes.

We describe considerations for implementing each strategy in PC CDS contexts. We also identify knowledge gaps that, if addressed, can help people to gauge anticipated strategy effectiveness and the conditions under which effectiveness can be optimized.

4.3.1 Strategies for Improving the Source Credibility of PC CDS

The following strategies, found in the literature or raised by key informants, improve source credibility by targeting attributes of PC CDS.

1. Engage clinicians and patients in PC CDS codesign and codevelopment.

Throughout the PC CDS codesign process are many approaches for soliciting input or involvement from clinician and patient end users, including during:⁸⁸ tool concept generation and workflow analysis; prototyping with early user-testing and iterative tool refinement; tool development and pilot testing; or tool optimization, release, and scaling.

Designers and developers can select from a range of methods in determining how best to involve end users in PC CDS codesign. These methods are often used in combination to generate needed input, achieve desired levels of engagement, and inform key PC CDS design-related decisions. Specific methods that have been used or tested in PC CDS design contexts include, but are not limited to:

- Hosting focus groups, coproduction workshops, or other participatory design activities.^{89,90,91,92,93}
- Conducting pre-deployment user testing or “think aloud” sessions as end users interact with tool prototypes.^{89,94,95,96}
- Collecting feedback via surveys or interviews, on case or pilot PC CDS deployment scenarios.^{89,97}

Current evidence. Recognizing this range of codesign methods, and acknowledging that even simply eliciting end-user preferences can benefit and inform PC CDS development, evidence indicates the added benefits of approaches that:⁹⁸

- Position end users in shared leadership and/or decision-making roles, as full partners in codesign.
- Afford customization by end users such that, even once PC CDS is deployed, end users have opportunities to codesign their experience.
- Actively engage end users throughout codesign (i.e., during ideating, prototyping, user testing, interpreting results, pilot testing).

Evidence from the literature, reinforced by multiple informants, suggests that engaging end users in upstream design results in PC CDS solutions that better fit end-user needs.^{88,96} Codesigned PC CDS tends to offer formats, features, and functionality best aligned with patient and clinician end users’ information needs and delivery preferences.⁹⁹ Some studies have found, for example, that clinician-facing PC CDS tools codesigned with clinicians tend to more naturally align with clinical workflows (e.g., referencing current information, providing relevant alerts, featuring usable EHR and other interfaces).^{77,100} Evidence also suggests that codesign can help mitigate some challenges associated with algorithm-driven CDS systems including lack of transparency, limited accountability, and issues related to fairness.^{96,101-,102,103,104,105,106,107}

Evidence gaps. Ample literature on the benefits of end-user involvement includes a growing body of evidence specifically on PC CDS codesign. However, limited evaluation and analysis of specific PC CDS codesign methods hinders our ability to identify or recommend best practices. Thus, establishing codesign as normative will require further research into (1) which codesign methods most effectively improve PC CDS and (2) how to operationalize these for different end users, in different settings, to different ends.

2. Communicate key information regarding PC CDS construction and creation.

Providing PC CDS end users with information about (1) the content and development of embedded guidelines, algorithms, and data; and (2) the intended uses, capabilities, and limitations of PC CDS tools can improve source credibility by increasing transparency. This

strategy has been employed in the creation of data “nutrition” labels, which offer one suggested approach to presenting key metadata in simple, standard, accessible formats.¹⁰⁸

Current evidence. Findings from the literature and validated through KIs highlight the need for transparency around PC CDS creation—including transparency regarding developers’ processes and conflicts of interest.^{77,96} Research also indicates that providing key details about PC CDS recommendations (e.g., the expertise of its developers, rationale for why the recommendations exist) can help mitigate potential harms associated with using CDS systems.^{77,109}

Informants noted that this information need not always be displayed on alerts or interfaces; links, buttons, or visual cues that more information is available may, themselves, improve source credibility.¹¹⁰

Evidence gaps. Despite interest in approaches for communicating key metadata (as with the aforementioned “nutrition” labels) knowledge regarding their impact is limited, beyond research on several specific use cases.¹⁰⁸ As such, standards for their design and implementation do not yet exist. Further research is needed to identify and evaluate other potential approaches to communicating key metadata and/or other priority information.

3. Design PC CDS that runs on up-to-date information and signals the timeliness of embedded knowledge.

It is important that PC CDS tools are created and equipped to source and run on current information. Designers can improve PC CDS source credibility by (1) providing end users with information regarding the timeliness (e.g., recency of publication, data collection, algorithm updates) of embedded knowledge and (2) creating visual cues that emphasize the transparency of such information.

Current evidence. The accuracy, currency, and relevance of PC CDS depends on ongoing system monitoring and maintenance.^{38,111} Researchers have suggested that ongoing monitoring and evaluation of PC CDS can draw attention to emerging concerns and prompt steps to mitigate potential harms or negative outcomes.⁷⁷ Such steps may include creating standard operating procedures for (1) revising the underlying knowledge layer to account for new data or evidence;^{77,112} (2) updating clinical/decision rules as new versions of guidelines are developed;^{38,111} or (3) making technical adjustments that improve deployment according to new information about real-world implementation. Similarly, maintaining information regarding the rationale underlying implementation processes and protocols, and making this available in easily digestible formats, might enable clinicians to quickly assess source credibility and properly implement PC CDS.

Evidence gaps. While technological advancements can enable faster sourcing and integration of new data once available, challenges still exist in data quality, interoperability, and other technical issues associated with operationalizing the use of real-time data for PC CDS.¹¹³ Thus, additional research on this subject is needed to ensure that PC CDS is equipped to run on the most updated information.

4.3.2 Strategies for Improving End-User Perceived Source Credibility of PC CDS

The following strategies from the literature or surfaced by key informants improve *perceived* source credibility by targeting perception-based attributes.

1. Tailor PC CDS messages and delivery mechanisms.

Tailoring PC CDS format and delivery per end users' needs and characteristics can help clinicians select the most case- or patient-appropriate treatment and can enable patients to select the most personally appealing or relevant treatment—both of which may improve source credibility.^{8,17,77,114}

Current evidence. “Tailorability” was identified as one of four core complementary constructs that guide patient health information-seeking behavior.^{64,65} Evidence suggests that patients guided by a clinician, but actively engaged in shared decision making, prefer tailored information and recommendations whenever possible.¹¹⁵ Several key informants validated this and further shared that tailoring patient-facing PC CDS to improve source credibility may involve adjusting message content and delivery based on stated patient information needs (e.g., reading level, depth of content) and communication preferences (e.g., types of resources, delivery format or channel).

When patient-facing PC CDS cannot be tailored, informants suggested an alternative approach: providing multiple, diverse sources of information (e.g., curated lists including sources for both technical and lay audiences) such that patients can still “customize” their PC CDS experience and consumption of related information. This parallels one similar approach to combat mistrust, as recommended in the literature.²⁵

In the context of clinician-facing PC CDS, tailoring may include embedding shortcuts for clinicians to make common corrections,⁶³ tailoring PC CDS system behavior based on clinical roles,⁶³ or providing rationale so that clinicians can tailor recommendations for specific subpopulations.¹¹⁰ One systematic review found that tailoring PC CDS system behavior based on clinical roles increased provider acceptance and mitigated alert fatigue.⁶³ Other evidence shows that systems providing only critical alerts (tailored for specific clinical specialties or personal disease severities) may help mitigate alert fatigue.^{77,116}

When PC CDS tools cannot be tailored, clinicians can still adapt their delivery of guidance in ways that help patients to understand the recommendation, rationale, and next steps regarding their decisions. Approaches for doing this include presenting the initial recommendation and rationale briefly, in concise language, and early enough in the process that patient feedback can be incorporated (where appropriate).¹¹⁵

Evidence gaps. Operationalizing tailoring or customization would require having documented, reliable information about PC CDS end-user needs or preferences. Standards are not yet in place for collecting, storing, or using this information; future research could be done to

determine how such information can best be used to inform tailoring activities, and the extent to which tailoring improves PC CDS effectiveness.

2. Create feedback loops to solicit end-user feedback that can help iteratively inform current or future PC CDS deployment.

Creating clinician- or patient-facing mechanisms that enable bidirectional exchange can improve source credibility by signaling openness and receptivity, and by supporting continuous learning of PC CDS systems and those developing/deploying them.¹¹⁷ In clinician-facing PC CDS, feedback loops should allow clinicians receiving alerts or recommendations to report errors, provide feedback, or highlight other technical issues implementing PC CDS. In patient-facing PC CDS, feedback loops can encourage open and bidirectional communication between patients and clinicians (e.g., during clinical encounters, via patient portals).

Current evidence. By creating streamlined mechanisms through which clinicians can share their feedback, developers make it possible to solicit important insight into PC CDS implementation at the point of care. This input from clinicians can be used to inform system-level improvements and to mitigate some their pain points in implementing PC CDS such as alert fatigue, workflow interruptions, and interoperability issues.^{77,111} Patient health records, increasingly used as extensions of EHRs,¹¹⁸ similarly enable two-way information exchange and direct integration of patient and clinical data—representing a significant step toward removing barriers to information¹¹⁹ and improving PC CDS.⁷⁷

Key informants emphasized that, beyond soliciting feedback, it is important to acknowledge and communicate receipt of feedback even in cases when a responsive solution to the feedback cannot be offered. When possible, offering solutions that are responsive to feedback helps to reinforce trust and improve source credibility. Multiple informants noted that trust is established over time, through repeat demonstration of PC CDS reliability. Thus, returning feedback to clinicians in the form of reporting on system-level PC CDS outcomes (e.g., yield of equitable outcomes, reported patient or clinician satisfaction) may bolster source credibility.

Evidence gaps. By creating feedback loops to solicit end-user input and designing systems that are adaptable and/or responsive to such feedback, developers can iteratively inform and improve successful PC CDS implementation. While creating bidirectional exchange between patients and clinicians can often be done at the discretion of a clinician or health system, processes for soliciting clinician feedback (especially through mechanisms embedded in PC CDS tools) are both more challenging and less transparent. Thus, additional evidence is needed on how best to collect and integrate clinician input into ongoing or future refinement of PC CDS design and deployment work.

5. Discussion

Source credibility is an important factor in ensuring that PC CDS delivers its full potential as a catalyst for high-value, patient-centered care. Enhancing source credibility requires understanding the complex array of influencing attributes—as well as the opportunities, means, and impact of modifying specific PC CDS tool- or perception-based attributes. This work surfaced multiple considerations and gaps in knowledge and/or consensus that must be

addressed to optimize PC CDS source credibility. These considerations, described in the sections below, include (1) the nascence of the field and formative nature of this work; (2) the need for consideration of end-user characteristics, needs, and perspectives—as well direct end-user involvement—in PC CDS codesign; and (3) the role of source credibility as one of several factors influencing attitudinal and behavior change, such that it can impact PC CDS use and effectiveness.

Our findings, combined with these considerations, culminate in a research agenda for addressing remaining knowledge and consensus gaps—and improving source credibility.

5.1 Key Considerations

While concerns regarding the credibility of health information sources are increasingly pressing, literature on the topic of PC CDS source credibility (and our corresponding understanding of it) is limited. Most literature identified in our search describes dimensions of source credibility in the broader contexts of public health and health communications. This broader evidence base suggests that the relative impact of individual source credibility attributes may be situational; however, an empirical understanding of these relationships and how they contribute to source credibility remains underdeveloped. Specifically in the context of PC CDS, research on how these relationships manifest and on how source credibility can be optimized for diverse patient and clinician end users is limited.

This work demonstrated that the number of attributes relevant for a given PC CDS tool can vary substantially; we began to explore these attributes' independent and interacting contributions to overall source credibility. We also examined dependencies (e.g., the role of individual-level factors) influencing each attribute's relative impact on source credibility and on the subsequent actions of PC CDS end users. Additional work to bolster the sophistication of knowledge on this subject (and the capacity to apply such knowledge) may include elucidation of (1) source credibility attributes' saliency by target audience and/or message recipient characteristics and (2) best practices for translating knowledge of source credibility attributes into features of PC CDS design and/or deployment.

Source credibility plays a significant role in communication-persuasion-behavior change,¹²⁰ and thus influences the extent that people's health attitudes and/or behaviors change in response to PC CDS recommendations. Achieving sustainable and effective PC CDS deployment at scale requires understanding not only the role of source credibility, but also the way it interacts with other factors to shape health information, communication, and decisions.

5.2 Limitations

While multiple studies indicate that all attributes have some moderating effect on source credibility,¹²¹ the extent of their respective impact is not fixed but rather heterogenous and fluid; the relative influence of each attribute depends on contextual or circumstantial factors. Further, given potential interplay between them, attributes can have both independent and interactive effects. To the extent individual-level end-user factors shape views of source credibility, one recipient may value some attributes more highly than others (e.g., prioritizing objectivity over

authority). Given the interacting and potentially conflicting or compounding interaction between attributes, measuring their relative impact is difficult. Thus, we did not differentiate among attributes with respect to potential magnitude of effects on source credibility, nor did we differentiate based on relative feasibility of attribute-specific interventions to influence source credibility.

5.3 Evidence Gaps & Research Opportunities

The importance of source credibility for PC CDS design and deployment has been described in the sections above. The literature review and KIs presented in this report revealed meaningful gaps in the current landscape of research on PC CDS source credibility and highlighted knowledge needs that can be addressed to advance source credibility of PC CDS in three areas: attributes of source credibility, strategies for improving source credibility, and the relationship between end-user factors and perceptions of PC CDS source credibility.

Attributes. Knowledge gaps remain, related to the ways attributes interact and vary by target audience, the relative impact of each attribute on source credibility most greatly, and the ways to measure this influence. Priority research topics in this area focus on the independent and interactional effects of source credibility attributes on PC CDS source credibility. Research in this area can support the study of each attribute's impact, and of attributes to prioritize as intervention points for improving PC CDS source credibility.

Strategies. While this work surfaced potential strategies for improving PC CDS source credibility, questions remain regarding best practices for collecting and integrating the types of end-user input and feedback needed to inform and successfully implement these strategies; this especially includes input regarding the strategies that are most appropriate for (and most likely to be effective in) various PC CDS contexts. In the future, once these strategies for improving source credibility can be vetted and/or evaluated, additional work can be done to determine how to optimize such strategies. For example, training clinician intermediaries to account for end-user factors in delivering PC CDS recommendations may optimize tailoring strategies.

End-User Factors. The literature reflects consensus that end-user factors influence perceptions of source credibility. However, questions remain regarding (1) the degree to which these factors have an impact and (2) how to best account for these factors in PC CDS design. Additional research on the role and impact of end-user factors on source credibility will provide important insight regarding the means and benefits of tailoring. Additionally, exploring how (and how well) end users assess source credibility will inform adjustments to PC CDS design and delivery—in ways that mitigate key barriers (e.g., limited health and digital literacy).

Table 5 outlines priority research topics that can address knowledge gaps and support future efforts to improve PC CDS source credibility.

Table 5. Research Topics to Address Gaps in PC CDS Source Credibility Evidence

Focus Area	Research Topics
Attributes	<ul style="list-style-type: none"> • What are the independent and interactional effects of source credibility attributes? • Which attributes have the greatest influence on source credibility? • How do attributes vary by time, target audience, recipient characteristics, and other factors? • Which attributes should be prioritized for intervention, considering potential impact and feasibility? • What is the best way to assess the strength of source credibility attributes by target audience? • How can the relative impact of source credibility attributes be measured in a given context?
Strategies	<ul style="list-style-type: none"> • What are best practices for improving source credibility? • What are best practices for tailoring PC CDS to maximize relevance for end users? • How can PC CDS tools be designed to account for end-user factors? • How can PC CDS tool design increase clinician intermediary awareness of end-user factors that might influence perceived source credibility? • What strategies to modify source credibility are most effective and appropriate for PC CDS? • What are best practices for appropriate and effective codesign in PC CDS? • To what extent does communicating key information about PC CDS creation impact perceptions of source credibility?
End-User Factors	<ul style="list-style-type: none"> • How does health/digital literacy impact patients' ability to assess source credibility? • What are best practices for improving patients' ability to assess source credibility? • To what degree do patient characteristics (sociodemographic factors, health condition, etc.) influence perceptions of source credibility?

6. Conclusion

Addressing these research questions can help increase knowledge regarding the ways source credibility influences patients' and clinician's interactions with each other, with PC CDS, and with the recommendations it generates to inform shared clinical decision making. Early exploration of this topic indicates that source credibility, and perceptions of source credibility, are influenced by multiple attributes of PC CDS and of the stakeholders who receive and interpret information from it. Where the source credibility attributes of PC CDS (e.g., accuracy, currency, transparency) have relatively consistent impact across end users, the impact of perception-based attributes (e.g., appeal, relatability) varies from person to person based on individual-level factors such as personal characteristics or circumstances. This suggests that, to some extent, source credibility can be improved by tailoring PC CDS design and deployment based on those individual factors—including an end user's health or digital literacy (and corresponding information or training needs). Additionally, source credibility can be improved via strategies that address attributes of PC CDS (e.g., such as designing tools to run on the most current information, increasing transparency regarding their design and limitations, or engaging end users in their codesign and codeployment). Finally, further research on the interplay and impact of attributes can identify strategies for improving source credibility and ways to optimize these strategies by considering end-user and other factors. Leveraging these strategies to improve source credibility, an important feature of health communications that motivate attitudinal and behavior change, can reinforce trust and promote adherence to clinical guidance. In this way, improving source credibility holds promise for increasing PC CDS uptake and

effective use, ensuring the patient-centeredness of clinical decision making, and ultimately improving patient outcomes.

7. Appendix

Appendix A. Detailed Methods

Table A1. Research Questions

Research Questions
1. What are the currently accepted definitions for “source credibility” as applied within and beyond the space of health services research (HSR) and/or clinical encounters?
2. What key models and drivers of source credibility have already been identified? What techniques are already used to confer credibility on published information and guidance?
3. What additional models, drivers, or techniques may need to be considered—specifically for source credibility related to PC CDS?
4. How might these components be best organized into an illustrative model that demonstrates the ways each factor amplifies or undermines source credibility?

Table A2. Key Search Terms

PubMed Search Terms
(“Decision Support Systems, Clinical”[MeSH] OR “Decision Support Techniques”[MeSH] OR “Decision Making, Shared”[MeSH] OR “Clinical Decision-making”[MeSH] OR “Patient Care Planning”[MeSH] OR “Professional-patient relations”[MeSH] OR “Clinical Decision Support”[tw] OR “CDS”[tw] OR “decision aid”[tw] OR “decision support”[tw] OR “patient-centered”[tw] OR “patient education as topic”[MeSH] OR “consumer health information”[MeSH])
AND
((“Trust”[MeSH] OR “Publication bias”[MeSH] OR “distrust”[tw] OR “mistrust”[tw] OR “transparency”[tw] OR “trust”[tw] OR “accura”[tw] OR “bias”[tw] OR “credential”[tw] OR “credible”[tw] OR “credibility”[tw] OR “expert”[tw] OR “objectivity”[tw] OR “reputable”[tw] OR “reliable”[tw] OR “reliability”[tw] OR “source attractiveness”[tw] OR “source characteristics”[tw] OR “source credibility”[tw] OR “source effect”[tw] OR “source expertise”[tw] OR “unbiased”[tw] OR “unreliable”[tw] OR “relational autonomy”[MeSH])
AND
(“patient education handout”[ptyp] OR “ethical review”[MeSH] OR “gray literature”[MeSH] OR “peer review”[MeSH] OR “commercially published”[tw] OR “gray literature”[tw] OR “peer review”[tw] OR “peer-reviewed”[tw] OR “refereed”[tw] OR “scholarly”[tw] NOT “clinical trial protocol”[ptyp]))
AND
(English[lang])
AND
2017 – present

Table A3. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
<ul style="list-style-type: none"> Published in past 5 years (2017-present) Published in English language Focus on the use of PC CDS in the United States (for CDS-specific searches) Relevant to patient centered CDS interventions (for CDS-specific searches) Include mention of credibility, source credibility, and/or relevant concepts in adjacent disciplines, including public health, education, and communications 	<ul style="list-style-type: none"> Does not include human patients (e.g., veterinary studies; algorithms or clinician-focused tools that do not involve some element of patient interaction)

Appendix B. Glossary of PC CDS Source Credibility Attributes and End-User Perception-Based Source Credibility Attributes

Attribute	Relevance to PC CDS
Glossary of PC CDS Source Credibility Attributes	
Accuracy	<p>In PC CDS contexts, accuracy refers to the scientific validity, correctness, or completeness of:</p> <ul style="list-style-type: none"> • data or evidence inputs translated into CDS tools or processed in CDS systems;^{35,36} and • diagnoses, recommendations, or alerts produced through CDS systems and processes.³⁷⁻⁴² <p>It also refers to the clinical appropriateness and applicability of alerts or recommendations, for the patient at hand.</p>
Consistency	<p>In the context of PC CDS, consistency requires that communicated information aligns with other existing evidence deemed credible or information previously shared by the same source.⁴³</p>
Objectivity	<p>In the context of PC CDS, initial sources of information translated into PC CDS tools—as well as those sponsoring or involved in their design and deployment—should be:</p> <ul style="list-style-type: none"> • free of bias,^{44,45} and • not subject to commercial or other conflicts of interest.
Reliability	<p>In the context of PC CDS, reliability is based on whether:</p> <ul style="list-style-type: none"> • the tool produces the same information given the same inputs (e.g., patient data),⁴³ or • generated recommendations yield the same outcomes in similar patients.⁷
Currency	<p>In the context of PC CDS, currency requires that:</p> <ul style="list-style-type: none"> • tools are based on the most up-to-date evidence. Models run on outdated information or guidelines based on outdated evidence can render PC CDS recommendations inaccurate or ineffective.⁷ • alerts and recommendations are delivered at appropriate times in the clinical workflow.²⁴ • tools and guidelines are monitored and maintained to ensure CDS is current.³⁸ • tools are equipped to deliver timely alerts and recommendations.
Relevance	<p>In the context of PC CDS, the relevance of PC CDS alerts, recommendations, and treatment options depends on whether:</p> <ul style="list-style-type: none"> • CDS tools, systems, and processes generate clinically appropriate alerts or recommendations;³⁷ and • clinicians frame PC CDS recommendations in ways that are appropriate for that patient.
Transparency	<p>In the context of PC CDS, transparency requires clearly and proactively disclosing information regarding:⁷</p> <ul style="list-style-type: none"> • the source and latest version of guidelines that informed the PC CDS tool. • commercial or other conflicts of interest related to the tool or its sponsors/developers; PC CDS end users should be able to readily access information about all conflicts of interest related to a tool's development.⁷ • the process of developing the PC CDS tool. • whether the tool is designed to detect (or likely to perpetuate) bias. • the expected use cases, caveats, capabilities, and limitations of a tool.
Expertise	<p>In the context of PC CDS, expertise refers to the extent to which a source is:⁴⁶</p> <ul style="list-style-type: none"> • qualified, • professional, or • otherwise holding advanced knowledge or specialized training.
Competence	<p>In the context of PC CDS, competence refers to the efficacy or capability of:</p> <ul style="list-style-type: none"> • Electronic health records (EHRs) and/or health IT developers creating effective tools;⁴⁷ and • PC CDS tools effectively delivering recommendations; and • clinicians effectively translating and communicating PC CDS recommendations to patients, while advising their care.⁴

Attribute	Relevance to PC CDS
Glossary of PC CDS Source Credibility Attributes	
Usability	<p>In the context of PC CDS, usability refers to the degree or ease of use for tools. This encompasses the actionability, accessibility, or explainability of PC CDS and the information it conveys. End-user assessments of usability often depend on:^{38,48}</p> <ul style="list-style-type: none"> • alert specificity; • information clarity; and • seamless integration with clinical workflow or patient experience.
Glossary of End-User Perception-Based Source Credibility Attributes	
Authority or Authoritativeness	<p>In the context of PC CDS, authority or authoritativeness refers to:</p> <ul style="list-style-type: none"> • professional societies' authority, based on knowledge of the domain and the charger or power to set clinical guidelines. <p>PC CDS tools derived from evidence-based guidelines.</p>
Appeal	<p>In the context of PC CDS, the appeal of a tool or information source may be based on:</p> <ul style="list-style-type: none"> • the extent to which it facilitates natural clinical workflows or dialogues; • its aesthetic-, appearance-, or design-related features; or <p>its subjective desirability or likability (as in the case of a clinician intermediate who communicates CDS-related information to patients or caregivers).^{59,122,123}</p>
Openness and Receptivity	<p>In the context of PC CDS, openness and receptivity refers to:</p> <ul style="list-style-type: none"> • the extent that a PC CDS tool or deploying clinician is willing to receive and potentially integrate feedback or new information.⁷
Relatability	<p>In the context of PC CDS, relatability refers to:</p> <ul style="list-style-type: none"> • the extent to which a source entity seems familiar or likely to have shared a common or universal experience, such that message recipients can recognize aspects of themselves or their lives in the source entity.^{12,33,60}

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