

What helps the successful implementation of digital decision aids supporting shared decision-making in cardiovascular diseases? A systematic review

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Aims

Although digital decision aids (DAs) have been developed to improve shared decision-making (SDM), also in the cardiovascular realm, its implementation seems challenging. This study aims to systematically review the predictors of successful implementation of digital DAs for cardiovascular diseases.

Methods and results

Searches were conducted in MEDLINE, Embase, PsycInfo, CINAHL, and the Cochrane Library from inception to November 2021. Two reviewers independently assessed study eligibility and risk of bias. Data were extracted by using a predefined list of variables. Five good-quality studies were included, involving data of 215 patients and 235 clinicians. Studies focused on DAs for coronary artery disease, atrial fibrillation, and end-stage heart failure patients. Clinicians reported DA content, its effectivity, and a lack of knowledge on SDM and DA use as implementation barriers. Patients reported preference for another format, the way clinicians used the DA and anxiety for the upcoming intervention as barriers. In addition, barriers were related to the timing and Information and Communication Technology (ICT) integration of the DA, the limited duration of a consultation, a lack of communication among the team members, and maintaining the hospital's number of treatments. Clinicians' positive attitude towards preference elicitation and implementation of DAs in existing structures were reported as facilitators.

Conclusion

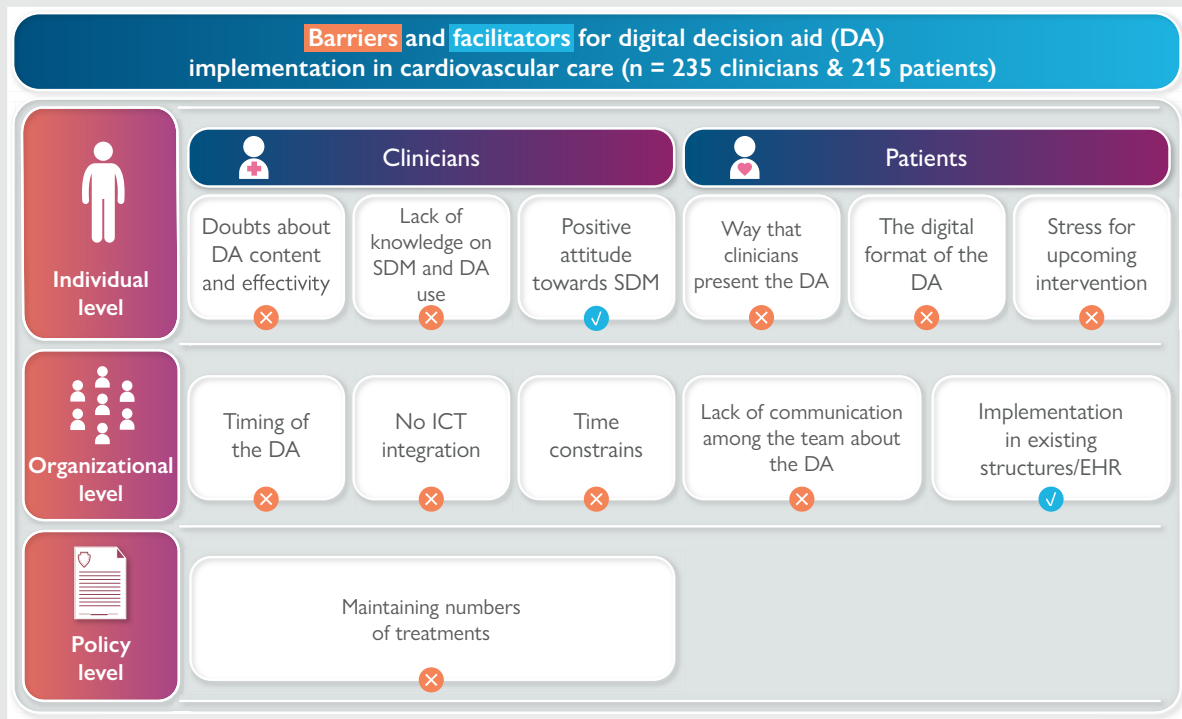
To improve digital DA use in cardiovascular diseases, the optimum timing of the DA, training healthcare professionals in SDM and DA usage, and integrating DAs into existing ICT structures need special effort. Current evidence, albeit limited, already offers advice on how to improve DA implementation in cardiovascular medicine.

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Graphical Abstract



Keywords

Shared decision-making • Digital tools • Decision aids • Cardiovascular diseases • Implementation • Barriers • Facilitators

Introduction

Patients with cardiovascular diseases can choose from different suitable treatment options, which sometimes are invasive and irreversible.^{1,2} Therefore, it is important that patients participate in the decision-making process. The American College of Cardiology and American Heart Association have incorporated shared decision-making (SDM) in guidelines for several cardiovascular diseases.^{3–6} In SDM, healthcare professionals and patients together choose the option that best fits the patients' circumstances and preferences.⁷ Although accumulating evidence shows the beneficial effect of SDM on the patients' knowledge, treatment adherence, satisfaction, and decisional conflict,^{8–12} the extent in which SDM is applied remains below expectations in routine care.¹³

To improve this, different decision aids (DAs) have been developed for different diseases,⁹ which differ in form (web-based aids, smartphone applications, paper-based aids, booklets, and videos). Such tools present evidence-based information about the different treatment options, state clear risk estimates, and elicit patient preferences.^{14,15}

However, there is limited knowledge of barriers and facilitators on various levels (personal, institutional, and healthcare policy) for the implementation of DAs for cardiovascular diseases. In acute cardiovascular diseases, SDM and the application of DAs appear challenging due to time constraints when informing the patient about possible treatment options.¹⁶ In other areas of medicine, perceived barriers to SDM are the uncertainty in the treatment decision, concern regarding adverse effects, and poor physician communication.¹⁷ In addition, barriers are related to patient characteristics; older people with low digital skills, low

educational levels, or comorbidities seem to participate less due to their poor health.^{18,19}

Furthermore, there is little evidence on the implementation of digital tools. Digital DAs have the potential to present a more complete content, a greater degree of interaction and scalability.²⁰ However, evidence is lacking whether digital DAs outperform paper-based DAs. Different formats may complement each other.²¹ International agencies, such as the National Institute for Health and Care Excellence, highlight relevant aspects related to the content of DAs in their guidelines for SDM-supporting tools, but not about the format.²²

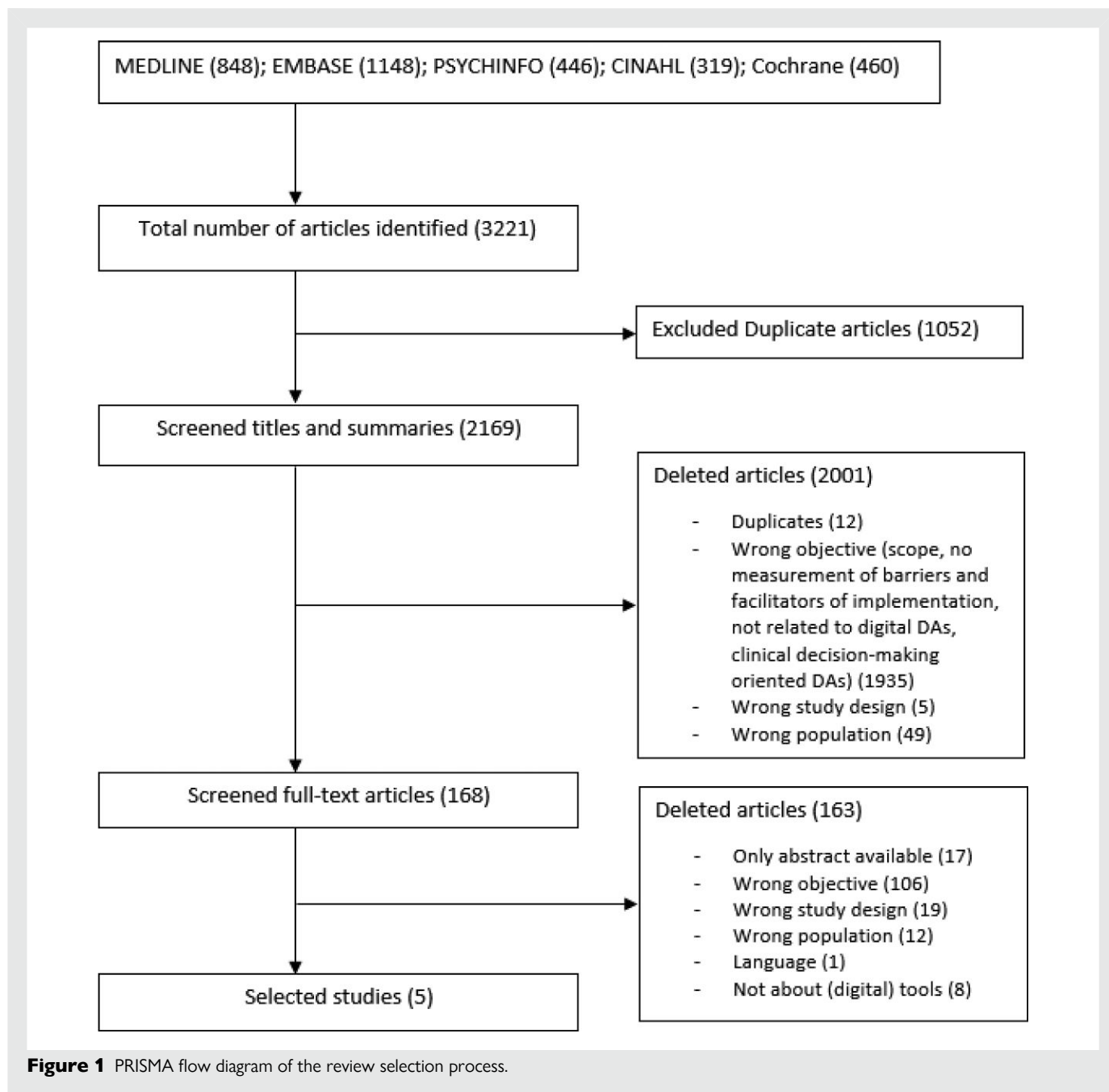
Therefore, this study aimed at systematically reviewing the barriers and facilitators for the implementation of digital DAs for cardiovascular diseases.

Methods

This systematic review is reported according to PRISMA guidelines²³ and was registered with PROSPERO (#CRD42021211731). Searches were conducted by a medical librarian (F.V.E.J.) in MEDLINE, Embase, PsychInfo, CINAHL, and the Cochrane Library, from their inception to 21 October 2021. [Supplementary material online, Table S1](#) shows the search strategy.

Two reviewers (L.P. and A.T.C.) independently assessed study eligibility. Any discrepancies were resolved by discussion or by a third reviewer (D.U./L.P.P.). [Figure 1](#) shows the study selection process.

Eligible studies should report qualitative (evaluation by patients or clinicians) or quantitative (about the implementation process) results on barriers and facilitators regarding implementation of digital DAs or



paper-based DAs with digital aspects (e.g. videos, online DAs, interactive applications, websites, and DVDs) in cardiovascular diseases in any setting, at the individual, organizational, and policy levels. Also, studies that did not have barriers and facilitators as a primary outcome but did report on barriers and facilitators as an evaluation of the implemented DA were included. Abstracts, study protocols, and articles that did not describe original data were excluded. Additionally, articles that investigated multiple conditions without reporting cardiovascular results separately or investigated the effectiveness of DAs (outcomes like; patient knowledge and decisional conflict) were excluded. Two reviewers (L.P. and A.T.C.) independently assessed risk of bias. In case of discrepancies, a third reviewer was involved (D.U./L.P.P.). For mixed-method studies, we used the Mixed-Method Appraisal Tool (MMAT) to assess risk of bias²⁴; for qualitative studies, the Critical Appraisal Skills Programme (CASP) checklist²⁵; and for pre-post studies, the Quality Assessment Tool for Before-After Studies with No Control Group.²⁶

A predefined list of variables was used for data extraction, including: publication year, authors, country, population, diagnosis, study design, collection method, and type of DA implemented. Data were summarized and analysed descriptively.

Results

Identified studies

The search yielded 3221 articles, leading to 2169 articles after removing duplicates. Based on title and abstract screening, 2001 articles were excluded. After full text screening, 163 articles were excluded leading to a final selection of five articles (Figure 1). Most papers were excluded because: they reported effectiveness outcomes (for instance, patient

knowledge, decisional conflict, and degree of use) instead of implementation outcomes; did not focus on (partly) digital DAs; focused on clinical decision-making instead of SDM; focused on DAs regarding cardiovascular risk prevention; or investigated SDM DA implementation within multiple diseases.

Study and participant characteristics

Characteristics of included studies are shown in [Table 1](#). The five studies included had been published recently (2017–21), were conducted in the USA, and focused on cardiology. Two studies provided a DA for patients with coronary artery disease (CAD),^{27,28} one for end-stage heart failure patients considering left ventricular assist device (LVAD),³⁰ and two for patients with atrial fibrillation (AF).^{32,34} Doll et al.²⁷ used a pre-post study design to test DA use, followed by a randomized pilot study design where cardiologists were assigned to receive vs. not receive patient preferences. However, these quantitative results did not meet our inclusion criteria and only a small section on patient reported barriers related to DA implementation in the discussion was included. Hsu et al.²⁸ was a qualitative study using in-depth interviews. Matlock et al.,³⁰ Spencer-Bonilla et al.,³² and Schott et al.³⁴ used a mixed-methods design: a stepped-wedge trial at six different sites using semi-structured interviews, a cross-sectional study using interviews, and a single-centre cluster-randomized trial using semi-structured interviews, respectively. Of the three mixed-method studies, only the qualitative interview results met our inclusion criteria and were used for analysis. Two out of five studies used implementation-based frameworks: Matlock et al. used the RE-AIM framework (outcome measures: reach, effectiveness, adoption, implementation, and maintenance)³⁰ and Spencer-Bonilla et al. used the Normalization process theory (outcome measures: coherence, cognitive participation, collective action, and reflexive monitoring).³² Although it is not an implementation theory, Hsu et al. used the Conceptual Model of Comparative Effectiveness Research (CER) for addressing the DA implementation process (outcome measures: promotion, translation, dissemination and utilization).²⁸

Risk of bias assessment

Although not all aspects of the CASP protocol and MMAT were reported in the included studies (mainly related to quantitative analyses), the overall risk of bias of reported aspects was low. The risk of bias assessments for each study is shown in [Table 2](#). Hsu et al. (2017) were assessed using the CASP protocol for qualitative studies. All sections (validation, synthesis and report of results, and implications) were scored as having low risk. The three mixed-method studies by Matlock et al. (2020), Spencer-Bonilla et al. (2020), and Schott et al. (2021) were assessed as low risk of bias, with some concerns for the integration of the qualitative and quantitative results as the divergences and inconsistencies between the different types of results were not discussed. Doll et al. (2019) were assessed according to the Quality Assessment Tool for Before-After (Pre-Post) Studies with No Control Group and were also found to have a low risk of bias.

Implementation characteristics

The characteristics of the DAs implemented in the different studies are shown in [Table 3](#). Two DAs consisted of a booklet and video^{28,30} and the other three of a web-based DA.^{27,32,34} Three studies used training for clinicians on how to use the DA alongside the implementation intervention.^{30,32,34}

The delivery method differed across the studies: In the papers by Hsu et al., Matlock et al., Spencer-Bonilla et al., and Schott et al., the DAs were delivered by the clinician^{28,30,32,34}; in the study by Doll et al., delivery of the DA was clinician independent.²⁷ DAs were presented to patients during consultation via the clinicians' monitor screen,^{28,32,34}

in the waiting room by means of a tablet,²⁷ or it was integrated in an already existing patient education structure.³⁰ Only for patients with CAD, the DA was delivered before diagnosis (angiography).^{27,28} Two out of five papers reported that the DA met (parts of) the International Patient Decision Aid Standards.^{30,34,35} All studies reported overall sufficient implementation levels.

Implementation barriers and facilitators

Attitudes towards SDM and DA implementation were reported at individual, (hospital) system, and (national healthcare) policy levels. An overview of reported barriers and facilitators of the digital SDM tool implementation is shown in [Table 4](#).

Individual level

At the individual level, clinician perspectives were more often reported than patient perspectives. According to Hsu et al., the main barrier was found at Stage 4 of the conceptual model of Halley and others: utilization.^{28,29} Clinicians had concerns about the content of the DA, as they thought it might not be appropriate or evidence based and contained too much information.²⁸ They preferred the DA to be accurate and evidence based.³² In addition, Hsu and Matlock reported a lack of knowledge among clinicians about the concept of SDM,²⁸ and about how to use the DA.³⁰ Schott et al. reported that, despite the attended training, clinicians used the DA differently and questioned whether the DA actually fostered SDM. The finding that clinicians endorsed eliciting patients' preferences was considered as a facilitator of DA usage.³⁰

The papers by Doll et al. and Schott et al.^{27,34} were the only studies reporting on patient perspectives. Doll reported that approximately half of the patients did not feel comfortable with the use of a tablet device and preferred the paper-based version. In addition, also about half of the patients did not indicate their treatment preferences in the DA. The authors hypothesized that they might entrust the decision to their clinician and may have had a lack of knowledge regarding SDM. Lastly, multiple patients (numbers not indicated) declined to complete the DA due to their anxiety for the upcoming angiography. According to Schott et al., patients reported that clinicians used selected parts of the DA to discuss with them, which affected their perceived usefulness of it. In addition, few patients (numbers not indicated) suspected that the clinician used the DA to guide the treatment choice towards the clinician's preference.

System level

At system level, the reported barriers and facilitators were either logistic or resource related. First, clinicians mentioned that accessing the tool during the consultation was challenging, as the DA was not integrated in the electronic medical record.³⁰ Conversely, integrating the DA in the electronic health record (EHR) was a facilitator of DA uptake.³⁴ Another study reported that integrating the DA in existing structures, like already existing patient education sessions, may also facilitate DA uptake.³⁰

Second, the right timing of DAs seems challenging. The study on patients with CAD reported that the DA did not fit into the care process,²⁸ as both diagnosis and treatment decision occurred during angiography for patients with CAD being sedated. Schott et al. reported that AF patients would prefer to receive the DA earlier in the process, specifically at the time of the diagnosis, which would improve its usefulness.

In addition, Matlock et al.³⁰ mentioned a lack of communication between clinical team members about the DA as a barrier. This resulted in unclear responsibilities about who should deliver the DA and when to deliver the DA, making the implementation success clinician dependent. As a consequence, some providers went through the DA superficially,

Table 1 Characteristics of included studies

Author	Year	Objective	Design	Comparator	Outcome measures	Implementation theory	Population	No. of participants
Doll²⁷	2019	To provide education and assess knowledge, attitudes, and preferences To test the impact of patient preferences on decision-making	Pre-post study Randomized clinical pilot study	Usual care Usual care	Patient knowledge, attitudes, preferences Concordance between preference and treatment	NA NA	CAD patients CAD patients	203 patients 99 patients
Hsu²⁸	2017	To investigate providers' attitudes towards DA implementation over time within different specialities	Qualitative study with in-depth semi-structured interviews, with 1 year follow up	NA	Providers' attitudes towards DAs and SDM	Conceptual Model of CER ²⁹	Cardiologists and orthopaedic surgeons	19 clinicians ^a
Matlock³⁰	2020	To evaluate effectiveness and implementation of a DA intervention	Stepped-wedge cluster-randomized design including checklists Semi-structured interviews at 3 different time points	Usual care NA	Reach, effectiveness, adoption, implementation, maintenance, and DA-providing characteristics Clinician's attitudes towards DA use	RE-AIM framework ³¹ RE-AIM framework ³¹	Clinicians and patients involved in LVAD care Clinicians involved in LVAD care	166 clinicians 248 patients 48 clinicians
Spencer-Bonilla³²	2020	To investigate factors that promote or hinder implementation of SDM tools, including contextual factors	Cross-sectional study with questionnaire	NA	Coherence, cognitive participation, collective action, reflexive monitoring and clinicians' burnout symptoms	Normalization Process Theory ³³	Clinicians treating patients with nonvalvular AF considering anticoagulation	168 clinicians
Schott³⁴	2021	To investigate the effectiveness of the DA To evaluate clinician and patient experience with the DA	Interviews Single-centre, mixed-methods study: cluster-randomized controlled trial Qualitative semi-structured interviews	NA Usual care	Attitudes towards DA use Patient knowledge, decisional conflict, CollaborATE, values concordance, trust, time spent with DA Patient's and clinician's experiences with DA	Normalization Process Theory ³³ NA	AF patients and their cardiologists/ cardiology APPs AF patients and their cardiologists/ cardiology APPs	30 clinicians 6 clinicians 66 patients 9 clinicians 12 patients

AF, atrial fibrillation; APPs, advanced practice providers; CAD, coronary artery disease; DA, decision aid; DT LVAD, destination therapy/left ventricular assist device; NA, not applicable; SDM, shared decision-making.

^aOf which 10 cardiologists, whose experiences were of interests for this study.

Table 2 Risk of bias analyses

Critical Appraisal Skills Programme	Hsu et al. 2016²⁸	
Was there a clear statement of the aims of the research?	Yes	
Is a qualitative methodology appropriate?	Yes	
Was the research design appropriate to address the aims of the research?	Yes	
Was the recruitment strategy appropriate to the aims of the research?	Yes	
Was the data collected in a way that addressed the research issue?	Yes	
Has the relationship between researcher and participants been adequately considered?	Can't tell	
Have ethical issues been taken into consideration?	Can't tell	
Was the data analysis sufficiently rigorous?	Yes	
Is there a clear statement of findings?	Yes	
How valuable is the research?	The researchers discuss the contribution that the present study makes to understand the attitudes of professionals towards the implementation of SDM. They do an analysis of the data in relation to the knowledge to date. They identify areas for future research: 'A major limitation of our evaluation was the lack of patient perspectives. We hope to address this in future research'.	
Mixed-Method Appraisal Tool	Matlock et al. 2019³⁰	Ponce et al. 2020
<i>Quantitative descriptive</i>		
Is the sampling strategy relevant to address the research question?	Yes	Yes
Is the sample representative of the target population?	Yes	Yes
Are the measurements appropriate?	Yes	Yes
Is the risk of nonresponse bias low?	Not reported	Yes
Is the statistical analysis appropriate to answer the research question?	Yes	Yes
<i>Qualitative</i>		
Is the qualitative approach appropriate to answer the research question?	Yes	Yes
Are the qualitative data collection methods adequate to address the research question?	Yes	Yes
Are the findings adequately derived from the data?	Yes	Yes
Is the interpretation of results sufficiently substantiated by data?	Yes	Yes
Is there coherence between qualitative data sources, collection, analysis, and interpretation?	Yes	Yes
<i>Mixed methods</i>		
Is there an adequate rationale for using a mixed-methods design to address the research question?	Yes	Yes
Are the different components of the study effectively integrated to answer the research question?	Yes	Yes
Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	No	No
Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	Not reported	Not reported
Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	Not reported	Yes
Mixed-Method Appraisal Tool	Schott et al. 2021³⁴	
<i>Quantitative randomized controlled trials</i>		
Is randomization appropriately performed?		Yes
Are the groups comparable at baseline?		Yes
Are there complete outcome data?		Not reported
Are outcome assessors blinded to the intervention provided?		No
Did the participants adhere to the assigned intervention?		Yes
<i>Qualitative</i>		
Are the qualitative data collection methods adequate to address the research question?		Yes
Are the findings adequately derived from the data?		Yes
Is the interpretation of results sufficiently substantiated by data?		Yes
Is there coherence between qualitative data sources, collection, analysis, and interpretation?		Yes
<i>Mixed methods</i>		
Is there an adequate rationale for using a mixed-methods design to address the research question?		Yes

Continued

Table 2 Continued

Mixed-Method Appraisal Tool	Schott et al. 2021³⁴
Are the different components of the study effectively integrated to answer the research question?	Yes
Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	Yes
Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	Not reported
Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	Yes
Quality Assessment Tool for Before-After (Pre-Post) Studies with No Control Group	Doll et al. 2019²⁷
Was the study question or objective clearly stated?	Yes
Were eligibility/selection criteria for the study population prespecified and clearly described?	Yes
Were the participants in the study representative of those who would be eligible for the test/service/intervention in the general or clinical population of interest?	Yes
Were all eligible participants that met the prespecified entry criteria enrolled?	Yes
Was the sample size sufficiently large to provide confidence in the findings?	No
Was the test/service/intervention clearly described and delivered consistently across the study population?	No
Were the outcome measures prespecified, clearly defined, valid, reliable, and assessed consistently across all study participants?	Yes
Were the people assessing the outcomes blinded to the participants' exposures/interventions?	Not reported
Was the loss to follow up after baseline 20% or less? Were those lost to follow up accounted for in the analysis?	Yes
Did the statistical methods examine changes in outcome measures from before to after the intervention? Were statistical tests done that provided <i>P</i> -values for the pre-to-post changes?	Yes
Were outcome measures of interest taken multiple times before the intervention and multiple times after the intervention (i.e. did they use an interrupted time-series design)?	Not reported
If the intervention was conducted at a group level (e.g. a whole hospital, a community, etc.) did the statistical analysis take into account the use of individual-level data to determine effects at the group level?	Yes

while others took more time. Schott *et al.* also found differences in use of the DA and future use plans between different clinicians.

Regarding resources for the successful implementation of DAs, time was mentioned twice as barrier to use the DA in the clinical setting.^{28,32} However, Schott *et al.* found that integrating the DA in the EHR led to more efficient use and the integrated personalized risk estimation was actually time saving.³⁴

Specific digital-related barriers consisted of technical difficulties for playing the video³⁰ and a lack of devices to show the DA to the patient, as most of the consultation rooms have only one screen for the clinician and the patient.³²

Policy level

One study reported a barrier at the policy level for use of the DA,³⁰ as it could lead to fewer people preferring the LVAD. Various centres participating in the stepped-wedge trial reported feeling pressure to maintain their LVAD numbers, to keep quality and accreditation of their intervention, which hampered the use of the DA.

Discussion

We systematically reviewed reported barriers and facilitators of implementation of digital DAs in the realm of cardiovascular diseases. Although we found relatively little evidence, the quality of the included studies was rather good. The studies reported barriers at the individual, system, and policy level within cardiology, mostly from the clinicians' perspective.

At the individual level, multiple barriers were reported from clinician perspectives. First, clinicians do not seem to be fully aware of the concept of SDM and how to use the DA. This is a frequently reported

barrier for SDM implementation, within several conditions, with and without Das.^{36–38} This could probably also explain the doubt of some clinicians about the effectivity of the DAs we found. On the other hand, we found that clinicians who endorse eliciting patient preferences can stimulate DA use,³⁰ which also holds for SDM behaviour.³⁷ So, training care providers in SDM communication and the use of evidence-based patient DAs might overcome this barrier.^{39,40} In addition, clinicians seem sceptical towards DA content, which is consistent with previous studies.^{37,38,41} Involving clinicians in a co-design process of DAs will likely cause more agreement on its content and thereby increase the uptake of DAs.

Only one study in our review reported on patient perspectives and showed that some patients tended to be reluctant to use or complete the DA, or to indicate their preferences. This might be explained by a lack of knowledge and entrusting the decision to the clinician.^{36,42} Indeed, many studies focus on clinician rather than patient perspectives when investigating DA implementation, which implies that evidence on patient perspectives is still lacking. As the primary goal of DAs is to inform the patient and stimulate preference elicitation, we recommend future studies to focus particularly on patient perspectives.

The main logistic barrier reported at the system level was the optimal timing of the DA for patients with CAD,^{27,28} as there was no interval between diagnostic angiography and treatment choice, and for AF patients, who preferred to receive the DA directly after their diagnosis. For patients with CAD, this timing-related barrier was disease specific. It has been previously shown that clinicians hold the opinion that SDM is not applicable to some clinical situations.³⁷ Although studies reporting similar difficulties with DA timing are lacking, the optimal timing of DAs might also be challenging for other cardiovascular diseases whereby the intervention directly follows diagnostic testing. A solution could be to introduce digital DAs before diagnostic testing, but this could lead

Table 3 Overview of tools

Tool	Diagnosis/ treatment	Type of tool	Time of delivery	Method of delivery
Web-based decision aid²⁷	CAD	Textual and visual (graphs and videos) information on significance of CAD, treatment options for CAD and benefits and risks of different options.	Before undergoing diagnostic angiography.	Clinician independent via a tablet.
DA 'Treatment Choices for Coronary Artery Disease'²⁸	Chronic Stable Angina/CAD	Video + booklet presenting efficacy and safety of different treatment options.	Half of the time it was delivered before the angiogram.	DAs were distributed by clinicians in office. The tool was also accessible in after-visit summary and patient portal via a link.
DECIDE DA³⁰	End-stage heart failure, LVAD treatment	26 min video and 8 page pamphlet + 60 min coaching session for clinicians.	Prior to final treatment decision.	Provided by clinician. The delivering method was up to clinicians.
The Anticoagulation Choice Decision Aid³¹	Atrial fibrillation, anticoagulation treatment	Web-based application that calculates 1-year and 5-year risks of stroke and questions how the options would fit in the patients' life. Clinicians receive training how to use it.	During consultation	By clinician via a screen in the consultation room.
HealthDecision³⁴	Atrial Fibrillation/ Atrial Flutter	An electronic health record integrated decision aid, including (i) risk factor review, (ii) assessment of stroke risk and bleeding risk, (ii) overview of medication and procedure options with individualized risk estimates.	During the consultation and after the consultation	By clinician via laptops or desktop computers during the consultation. Patients were also provided with a paper copy of the DA for review at home after the consultation

CAD, coronary artery disease; DA, decision aid; LVAD; left ventricular assist device.

to an overload of information that might turn out to be irrelevant to the patient.

In addition, we found a number of digital-specific barriers in three of the studies.^{27,30,32} The reported technical difficulties might be overcome eventually, as the number of remote (video) consultations is rising. Although integration of the DA in the electronic medical record might be fairly challenging, it has been acknowledged as an important hurdle to overcome and seems to be an important facilitator of SDM implementation.^{43–45} Integrating DAs in existing care processes and information and ICT structures could save time and overcome the frequently reported barrier of 'having a lack of time'.^{34,36,46} Besides, providing the DA independently of healthcare professionals also has been suggested as a facilitator of SDM tool uptake, as this requires no time of clinicians.^{36,47,48}

Furthermore, patients' preferences to follow the DA on paper also need special attention. Especially older patients and patients with low health literacy face difficulties using technology,^{19,49} which should be taken into account when developing DAs to facilitate equity of access to it.

As there is no conclusive evidence in favour of digital or web-based DA formats over paper-based DAs, either format could be used, considering the advantages of each: digital DAs offer detailed and complete information, while paper DAs present shorter and concise information.²¹ The choice of one format over another will depend on the needs of the patients (elderly patients or those with a low digital literacy may prefer paper-based DAs), as well as on the perceptions of, and resources available for, healthcare professionals. Likewise, it is important to highlight that integrating DAs in ICT structures and involving (especially elderly) patients in web-based DAs remain a challenge and may need specific effort.

Limitations

This study faces a few limitations. First, we could find only five articles for inclusion, partly due to our strict inclusion criteria, which is little evidence to draw robust conclusions. This lack of evidence on DA implementation has been found before,³⁶ emphasizing that more research is warranted on this topic. Nevertheless, current evidence already offers clear advice on how to improve SDM in cardiovascular medicine.

Further, the studies included were limited to cardiology. Therefore, it is not possible to generalize our results for cerebral and peripheral vascular disorders. However, most of the results we found were not disease-specific barriers and facilitators, and are likely applicable to other conditions as well.

In addition, as all five studies were undertaken within US institutions, it is difficult to generalize these results to other countries, types of hospital or healthcare systems. This emphasizes the limited evidence on digital tools supporting SDM and the need for further research on this topic. Moreover, countries in which the EHR and ICT structures are not yet well established might face other challenges than those reported by the included studies.

Last, we predominantly found patient and clinician attitudes as implementation outcomes. A systematic review on the implementation of DAs indicates that most of the current studies do not incorporate a design based on implementation theory and that the aspects that limit the adoption of SDM are under-investigated and under-specified.³⁶ This review also proposes to incorporate a dimension beyond the approach of barriers and facilitators of the implementation of SDM to understand the nature of professional and organizational resistance to implement DAs. Approaches such as cognitive task analysis, ethnography and action research, or other approaches that give prominence to the participants' perspectives and how they fit SDM with other demands, such

Table 4 Overview of reported barriers and facilitators of digital shared decision-making tool implementation

Level	Theme	Outcomes	Author		
Individual level	Clinicians	B: Concerns about the content of the DA ^{27,30}	Hsu, ²⁸ Spencer-Bonilla ³²		
		B: Lack of understanding of the concept of SDM ²⁷ or on how to use the DA ²⁸	Hsu, ²⁸ Matlock ³⁰		
		B: Clinicians questioning if use of DA fosters SDM	Schott ³⁴		
		F: Clinicians' positive attitude towards preference eliciting ²⁸	Matlock ³⁰		
	Patients	B: Many patients chose not to indicate their preference (not specified why) ²⁶	Doll ²⁷		
		B: Some patients did not complete the decision aid as they felt anxious for the upcoming angiography ²⁶	Doll ²⁷		
		B: Half of the patients declined to use the tablet device and preferred to complete the study on paper ²⁶	Doll ²⁷		
		B: Patients felt like clinicians selected parts of the DA and did not show it completely	Schott ³⁴		
		System level	Logistic	B: Difficult access to the tool prior to consultation, not integrated in electronic medical record ³⁰	Spencer-Bonilla ³²
				B: The timing of the DA does not fit into the care process and is challenging ^{26,27}	Hsu, ²⁸ Doll ²⁷
B: Receiving the DA too late in the care process	Schott ³⁴				
Resources	B: Little communication among team members about the DA ^{26,28}		Matlock, ³⁰ Doll ²⁷		
	F: Implementing the DA in existing structures (education session) ²⁸		Matlock ³⁰		
	F: Integrating the DA in the electronic health record		Schott ³⁴		
Policy level	Resources	B: Rooms for use of one screen together with patient ³⁰	Spencer-Bonilla ³²		
		B: Lack of time ^{27,30}	Spencer-Bonilla, ³² Hsu ²⁸		
	B: Technical difficulties for playing the video ²⁸	Matlock ³⁰			
		B: To maintain LVAD numbers ²⁸	Matlock ³⁰		

B, indicating a barrier; F, indicating a facilitator.

as the electronic medical records and performance metrics. In addition, Proctor's taxonomy has listed more specific concepts that could serve as implementation outcomes: acceptability, readiness for implementing change, appropriateness, and penetration.⁵⁰ Only two out of five articles included in our systematic review included an implementation theory. Thus, we recommend future studies to not only investigate attitudes towards DA implementation, but incorporate a design based on implementation theories.

Conclusion

In order to increase the use of digital DAs for cardiovascular diseases, special effort is necessary to find the optimal timing of the DA in the care process and to integrate the DA in the electronic medical record and ICT structures. In addition, training clinicians in SDM and DAs use might overcome their lack of knowledge and the variation in DA use. The low number of available studies shows the limited evidence on this topic, emphasizing that more research, mainly on patient perspectives, is warranted. However, we hypothesize that digital DAs will become a more common part of cardiovascular care than we have currently found in this systematic review, due to the digitalization of health care and growing interest and expertise in SDM.

Supplementary material

Supplementary material is available at *European Heart Journal – Digital Health*.

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Data availability

All data are included in this manuscript.

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