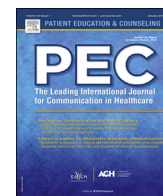




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Review Article

Decision aids to facilitate decision making around behavior change in the field of health promotion: A scoping review

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ABSTRACT

Objective: To broadly synthesize literature regarding decision aids (DAs) supporting decision making about diet, physical activity, sleeping and substance use a scoping review was performed.

Methods: Multiple sources were used: (1) Scientific literature searches, (2) excluded references from a Cochrane review regarding DAs for treatments and screenings, and (3) results from additional searches. Interventions had to (1) support informed decision making and (2) provide information and help to choose between at least two options. Two researchers screened titles and abstracts. Relevant information was extracted descriptively.

Results: Thirty-five scientific articles and four DAs (grey literature) were included. Results were heterogeneous. Twenty-nine (94%) studies described substance use DAs. All DAs offered information and value and/or preference clarification. Many other elements were included (e.g., goal-setting). DA's effects were mixed. Few studies used standardized measures, e.g., decisional conflict (n = 4, 13%). Some positive behavioral effects were reported: e.g., smoking abstinence (n = 1).

Conclusions: This research shows only some positive behavioral effects of DAs. However, studies reported heterogeneous results/outcomes, impeding knowledge synthesis. Areas of improvement were identified, e.g., establishing which intervention elements are effective regarding health behavior decision making. **Practice implications:** DAs can potentially be beneficial in supporting people to change health behaviors – especially regarding smoking.

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Contents

1. Introduction	00
2. Methods	00
2.1. Information sources	00
2.1.1. Scientific literature searches	00
2.1.2. Excluded publications from the Cochrane review	00
2.1.3. Additional searches	00
2.2. Article and DA selection	00
3. Results	00
3.1. Scientific literature	00
3.1.1. Descriptives and study characteristics	00
3.1.2. Theoretical foundations	00
3.1.3. Effectiveness and cost-effectiveness of the identified DAs	00

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3.2. Results grey literature	00
4. Discussion and conclusion	00
4.1. Discussion	00
4.1.1. Characteristics and intervention elements of the identified DAs	00
4.1.2. Theoretical foundations of the identified DAs	00
4.1.3. Effectiveness of the identified DAs	00
4.2. Limitations	00
4.3. Future research directions	00
4.4. Practice implications	00
4.5. Conclusions	00
Funding	00
Acknowledgements	00
References	00

1. Introduction

Noncommunicable diseases continue to be the leading cause of deaths worldwide, inflicting heavy economic burden [1]. These diseases' main modifiable risk factors (i.e., blood pressure, blood glucose, cholesterol, and weight) are heavily influenced by individual health behaviors, e.g., tobacco use, physical activity (PA), diet, alcohol use and sleep (duration) [2–5]. The occurrence of noncommunicable diseases can therefore be greatly reduced by changing these preventive health-related behaviors (for the sake of readability, we will use this term when referring to tobacco use, PA, diet, alcohol use, and sleep (duration) together).

In all these areas people face decision-making situations, such as deciding to check how well one is meeting behavioral recommendations or deciding whether to engage in actions to change an unhealthy behavior. In addition to these decisions, people are confronted with decisions between different possible actions to change their behavior, e.g., people wishing to stop smoking can choose between several effective cessation aids [6–9].

When multiple options exist and persons need to identify their own values (i.e., how (un)desirable certain options' characteristics are [10]) and preferences (i.e., how (un)desirable certain options themselves are taking values into account [10]), decisions are referred to as "preference-sensitive" [11]. This type of decision requires that people weigh the benefits and harms of each option on basis of their own values and preferences, since no option is objectively better than others [11]. In practice, it requires lay persons to gather available evidence, evaluate its quality and incorporate this information to assess which options fit their values and preferences best – tasks which can be difficult [12].

People facing such preference-sensitive decisions about preventive health-related behaviors may profit from support in their decision-making process, for instance by using decision aids (DAs). DAs are typically used to inform users about available options and their respective characteristics (e.g., effect, time investment and availability) in a balanced manner and help users to choose options that are value- and preference-concordant [11,13], in other words they help users to make informed decisions [14]. DAs structure the decision-making process with the help of value clarification methods (VCMs, previously also referred to as value clarification exercises or VCEs) [15] – which can be implicit (i.e., not including overt activity) or explicit (i.e., including overt activity) [16]. Such DAs, when applied to treatment or screening decisions (e.g., decisions about cancer treatment options), have shown to have a positive impact on knowledge, accuracy of risk perception, values-concordant choices, decisional conflict, feelings of being undecided, costs and the number of people making a decision [11]. However, it is unclear whether this promising approach to decision support can also help individuals make informed decisions about preventive health-related behaviors.

The most comprehensive knowledge synthesis in the field of DAs excluded studies conducted around DAs focusing on lifestyle [11]. However, a systematic review by Moyo et al. [17] has shown that DAs could be a promising approach to smoking cessation, as have individual studies (e.g., [18]). Currently, there is a lack of concrete knowledge of DAs in the broader area of preventive health-related behaviors. To the best of our knowledge, no knowledge synthesis of any kind has been carried out to fill this knowledge gap. We therefore do not know for which preventive health-related behaviors DAs actually exist. In the recent past, studies have been carried out to examine intervention elements [19] of DAs in general and the theoretical basis [20] of treatment and screening DAs in more detail. Effects of DAs focused on treatment and screening decisions are also routinely synthesized in the aforementioned comprehensive knowledge synthesis in the form of a Cochrane review [11] and at least one systematic review has investigated DAs' cost-effectiveness in general [21]. However, all of this information is not available regarding DAs aimed at making decisions about changing preventive health-related behaviors *specifically*.

Consequently, our aim was to broadly synthesize existing literature in the form of a scoping review by reviewing information regarding DAs supporting informed decision making about these behaviors, focusing on their characteristics, intervention elements, theoretical foundations and (cost-)effectiveness. The synthesized knowledge will be of value to guide future research directions, but also to inform (clinical) practice and to better understand the usefulness of DAs that focus on preventive health-related behavior change.

2. Methods

The methodological framework developed by Arksey & O'Malley [22], the Joanna Briggs Institute Reviewers' Manual [23] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) [24] guided the study protocol – which can be found on the Open Science Framework (<https://osf.io/9xkbv/>) [25]. However, one change was made: We decided to gather descriptive data instead of quantitative data as the heterogeneity of the results hindered us to conduct quantitative analyses. This made it impossible to calculate Cohen's kappa (however, other measures were taken to ensure reliability, see 2.2 *Article and DA selection*). Consequently, the data are therefore presented descriptively in text and/or tabular form. The completed PRISMA-ScR checklist can be found in Appendix A.

2.1. Information sources

Multiple sources were used to gather data: (1) Scientific literature search results, (2) the excluded publications from the Cochrane review on DAs for people facing health treatment or

screening decisions [11] (mentioned in the introduction) and (3) results from additional searches, such as a literature search on Google Scholar and a grey literature search on the Ottawa Hospital Research Institute Decision Aid Library Inventory (DALI) [26].

2.1.1. Scientific literature searches

Systematic literature searches were conducted in three relevant databases (i.e., PubMed, PsycINFO, and CINAHL) with search strings related to the aforementioned behaviors combined with “decision aid” (for the full overview see Tables B1 and B2 in Appendix B) in October 2018. Terms were included to exclude papers that focus on policy decision making as the focus of this scoping review was on individual decision making. Searches were restricted to publications pertaining to humans (again, due to the focus on individual human decision making) between January 2008 and October 2018 (to synthesize the most recent literature). Search strategies were specified to each database and discussed with a scientific information specialist (SJ, see Acknowledgements).

2.1.2. Excluded publications from the Cochrane review

As noted in the introduction, the most comprehensive knowledge synthesis in the field of DAs (the systematic review by Stacey et al. [11]) excluded articles describing DAs focusing on lifestyle – hence, those which were of interest for this scoping review. Therefore, all of those excluded publications were retrieved.

2.1.3. Additional searches

Using Google Scholar, we applied a systematic search (see Table B3 in Appendix B for the search strings). Publications within the first 50 hits were screened for each search string. Again, this search was limited to the last 10 years (between January 2008 and October 2018). We also created a Google Scholar Alert to inform us of any other relevant publications. Subsequently, we searched through the DALI [26] using all the search terms described above.

Finally, we tried to identify any DAs (in development) that were missed. For this purpose additional strategies were: (1) Cross-referencing included articles and articles only selected for full text screening (see 2.2 Article and DA selection, e.g., [17]), (2) checking the publications from first authors of included articles, (3) using Google Scholar's “related articles”-function and (4) using our existing professional network (e.g., by making use of newsletters of professional associations) and contacting authors of known DAs in development or with currently unpublished findings.

2.2. Article and DA selection

Retrieved titles and abstracts were screened by TG and DZ by using the following inclusion criteria: Articles had to describe interventions that (1) supported informed decision making in relation to preventive health-related behaviors and (2) provided information about the decision at hand and helped to choose between at least two options (e.g., by including VCMs) [27,28]. Articles describing (clinical) treatment DAs were excluded. Inconsistencies between the two reviewers were resolved by discussion. If an agreement could not be reached, CH helped to come to a conclusion. The selected full articles were assessed by DZ and TG, after which TG extracted all relevant information descriptively which was charted within an Excel spreadsheet developed a priori. After completion of the data extraction by TG, DZ reviewed 10% of the articles to ensure reliability. Inconsistencies were discussed between TG and DZ. The same procedure was applied to the DAs not found in scientific literature (i.e., grey literature), except for a change in author responsibilities, i.e., DZ initially abstracting the data and TG reviewing 10%. The charting of the information was based on the Cochrane review on treatment

and screening DAs (see Appendix C) [11]. Authors of the included articles were not contacted to clarify or add information.

3. Results

3.1. Scientific literature

3.1.1. Descriptives and study characteristics

Through this scoping review 35 articles [29–63] were identified, including four study protocols [37,42,44,47]. It was not possible to determine the exact number of DAs described in the 35 articles due to a lack of clear identification of DAs by name or other distinguishing characteristic in the majority of the articles. Therefore, the units of analysis for this scoping review were individual studies (not DAs) with the exception of protocol papers which were analyzed together with their associated effect papers. More than half of the studies were of American origin ($n = 16$, 52%) [30,42,43,49–55,57–63]. The main focus was on substance use ($n = 29$, 94%) [31–63] with 11 DAs solely focusing on smoking (35%) [47–54,56–58,63]. All studies described DAs that included both information provision and value clarification or described such DA content without explicitly using the terms. All developed DAs contained a multitude of other intervention elements, such as personal stories [51] or encouragement to set a quit date [47,48]. For an overview of the included articles see Table 1, for an overview of intervention elements see Table 2, and for a flow diagram depicting the selection process see Fig. 1.

3.1.2. Theoretical foundations

Twenty-two studies (71%) [29–32,34,40,41,44–51,54–62] reported using theoretical frameworks, most commonly to identify relevant outcome measures ($n = 15$, 48%) [31,32,34,40,41,46–50,54,55,59–62]. Janis' and Mann's Conflict Theory of Decision Making was used most often ($n = 6$, 19%) [55,57–60,62] – however, largely the same researchers were involved. An overview over the theoretical foundations can be seen in Table 3.

3.1.3. Effectiveness and cost-effectiveness of the identified DAs

Most effects were tested in either a cluster ($n = 7$, 23%) [31,33,37–41,56] or a randomized controlled trial (RCT) ($n = 8$, 26%) [47,48,50,54,55,59–62]. In this result section null effects are defined as insignificant findings that reflect neither an increase nor a decrease.

3.1.3.1. Effects on the attributes of the choice made. In six studies, knowledge (19%) was assessed [40,45,48,50,62,63], but only one [62] reported a significant increase in knowledge as compared to baseline measurement. In three studies (10%), null effects were reported regarding knowledge [40,50,63]. All other studies examined knowledge only as part of another overarching concept [45,48], e.g., informed choice. Effects on risk perception were examined in two studies (6%) [39,62], both found an increase in appropriateness of risk perceptions, however in one study the effects disappeared after correction for baseline characteristics [39] and in the other effects were not compared to a control group [62]. Value-congruency was tested in four studies (13%) [41,48,60,62]. In one of those studies value-congruency was not examined in isolation [48]. Sheridan et al. [60] found that adding an explicit VCM (called a VCE in their article) did not increase value-consistency. In one study an increased attitude towards the chosen option (i.e., “actual” value-consistency) was reported that was compared to a control group [41], while in another study positive effects on perceived value-consistency that were not compared to a control group were reported [62]. The one article that reported on the measurement of regret reported a significant positive effect (i.e., a decrease in regret) [40].

Table 1
Article characteristics.

Article	Study design/ methodology	Study population	Study aims and purposes	Country of origin	Behavior (general)	Behavior (specific)	DA Delivery	Duration to complete the DA	Sources of funding
Cupples et al. (2018) [29]	Mixed method feasibility study	Patients aged ≥ 18 years with (or at risk of) coronary heart disease (CHD)	To test the feasibility of using a novel, paper-based decision tool, to facilitate shared decision making (SDM, between health professional and patient) in the process of initiating behavior change for cardiovascular disease (CVD) prevention among patients with, or at high risk of, CHD in general practice	United Kingdom (UK)	Dietary behavior & physical activity (PA)	Not described	Paper-based, used during consultation with their general practitioner (GP)	Approximately 15 min (whole consultation)	Northern Ireland Chest Heart & Stroke (UK)
Geller et al. (2012) [30]	Not explicitly mentioned, probably pre- post pilot study	Older ethnically diverse population adults visiting two community housing sites in Hawaii	To test the implementation of a decisional balance sheet PA program and fruit and vegetable program, specifically describing the efficiency and effectiveness of the programs adapted for older adults residing in community living homes	United States of America (USA)	Dietary behavior & PA	Increasing PA and/or (daily) fruit and vegetable consumption	Combination of paper-based materials and group discussions, delivered in community housing sites, used in groups (see other included elements for more information)	30–40 minutes	The National Cancer Institute (USA)
Hirsch et al. (2010) [31]	Pragmatic cluster randomized controlled trial (CRT)	Patients who had their cholesterol levels measured during a period of four weeks	To evaluate the satisfaction level of both patients and physicians in a reciprocal relationship of SDM using a structured tool for cardiovascular prevention contrasted to the results of a control group	Germany	Included multiple cardiovascular prevention strategies, three of which were preventive health- related behaviors (dietary behavior, PA & substance use)	Eating fish 2x per week (or Omega-3 fatty acids), exercise 2–3x per week > 30 min, smoking (cessation)	Paper-based, used during consultation at the GPs	Not reported	Federal Ministry of Education and Research (Germany)
Hirsch et al. (2011) [32]	Mixed method evaluation study	German patients that visited their GP and had to make a decision which was covered by the decision aid (DA)	To evaluate the acceptance of SDM with reference to an interactive, transactional, and evidence-based library of DAs by patients and physicians in the primary care context	Germany	Modular library that contained multiple DAs: The DA for cardiovascular prevention was the only one that focused on preventive health- related behaviors, it included dietary behavior, PA & substance use	Ambiguous, but in all likelihood the same as in Krones et al. [40]: Eating fish 2x per week (or Omega- 3 fatty acids), exercise 2–3x per week > 30 min, smoking (cessation)	Digital-based, used during consultation at the GP	Not reported	Federal Ministry of Education and Research (Germany)
Hirsch et al. (2011) [33]	Pragmatic CRT	Patients who had their cholesterol levels measured during a period of four weeks	To evaluate methodological difficulties in calculating the correspondence between patient and physician satisfaction ratings and to show the relevance for SDM research	Germany	Included multiple cardiovascular prevention strategies, three of which were preventive health- related behaviors (dietary behavior, PA & substance use)	Ambiguous, but in all likelihood the same as in Krones et al. [40]: Eating fish 2x per week (or Omega- 3 fatty acids), exercise 2–3x per week > 30 min, smoking (cessation)	Ambiguous, but in all likelihood paper- based, used during consultation at the GPs	Not reported	Federal Ministry of Education and Research (Germany)

5	Hirsch et al. (2012) [34]	Mixed method evaluation study	German patients that visited their GP and had to make a decision which was covered by the DA	To evaluate associations between the use of an interactive, transactional and evidence-based library of DAs and communication and decision making in patients and physicians in the primary care context	Germany	Modular library that contained multiple DAs: The DA for cardiovascular prevention was the only one that focused on preventive health-related behaviors, it included dietary behavior, PA & substance use	Ambiguous, but in all likelihood the same as in Krones et al. [40]: Eating fish 2x per week (or Omega-3 fatty acids), exercise 2–3x per week > 30 min, smoking (cessation)	Digital-based, used during consultation at the GPs	Not reported	Federal Ministry of Education and Research (Germany)
	Hirsch et al. (2012) [35]	Mixed method evaluation study	German patients that visited their GP and had to make a decision which was covered by the DA	To evaluate the uptake of an interactive, transactional, and evidence-based library of DAs and its association to decision making in patients and physicians in the primary care context	Germany	Modular library that contained multiple DAs: The DA for cardiovascular prevention was the only one that focused on preventive health-related behaviors, it included dietary behavior, PA & substance use	Ambiguous, but in all likelihood the same as in Krones et al. [40]: Eating fish 2x per week (or Omega-3 fatty acids), exercise 2–3x per week > 30 min, smoking (cessation)	Digital-based, used during consultation at the GPs	Approximately 8 min on average	Federal Ministry of Education and Research (Germany)
	Hirsch et al. (2012) [36]	Not explicitly mentioned, analyses of log data	German patients that visited their GP and had to make a decision which was covered by the DA	To examine user interactions of primary-care physicians and their patients with the electronic library of DAs used during consultations, on the basis of log data	Germany	Modular library that contained multiple DAs: The DA for cardiovascular prevention was the only one that focused on preventive health-related behaviors, it included dietary behavior, PA & substance use	Ambiguous, but in all likelihood the same as in Krones et al. [40]: Eating fish 2x per week (or Omega-3 fatty acids), exercise 2–3x per week > 30 min, smoking (cessation)	Digital-based, used during consultation at the GPs	Approximately 8 min on average	Federal Ministry of Education and Research (Germany)
	Koelewijn-van Loon et al. (2008) (Protocol paper) & Koelewijn-van Loon et al. (2009) (Effect paper [37,38])	CRT	Adult patients eligible for cardiovascular risk management who met one or more of the following criteria: Blood pressure ≥ 140 mm Hg or receiving treatment for high blood pressure, total cholesterol ≥ 6.5 mmol/L or receiving treatment for high cholesterol, smoker aged ≥ 50 years (men) or ≥ 55 years (women), diabetes, a positive family history of cardiovascular disease, and visible obesity (based on the physician's opinion)	To investigated whether a nurse-led intervention in primary care had a positive effect on lifestyle and 10-year cardiovascular risk	Netherlands and the UK	Substance use, dietary behavior & PA	Smoking, alcohol use, saturated fat intake, fruit and vegetable consumptions & PA	Paper-based, delivered during a primary care consultation, had to be read at home (between two consultations)	Not reported (for the DA alone)	Netherlands Organisation for Health Research and Development (ZonMw, Netherlands) and Maastricht University (Netherlands)
	Koelewijn-van Loon et al. (2010) [39]	CRT	Adult patients eligible for cardiovascular risk management who met one or more of the following criteria: Blood pressure ≥ 140 mm Hg or receiving treatment for high blood pressure, total cholesterol ≥ 6.5 mmol/L or receiving treatment for high cholesterol, smoker aged ≥ 50 years (men) or ≥ 55 years (women), diabetes, a	To investigate the short-term effect of their nurse-led intervention on patients' risk perception and lifestyle, in comparison with usual nurse-led care	Netherlands and the UK	Substance use, dietary behavior & PA	Smoking, alcohol use, saturated fat intake, fruit and vegetable consumptions & PA	Paper-based, delivered during a primary care consultation, had to be read at home (between two consultations)	Not reported	Netherlands Organisation for Health Research and Development (ZonMw, Netherlands) and Maastricht University (Netherlands)

Table 1 (Continued)

Article	Study design/ methodology	Study population	Study aims and purposes	Country of origin	Behavior (general)	Behavior (specific)	DA Delivery	Duration to complete the DA	Sources of funding
Krones et al. (2008) [40]	Pragmatic CRT	positive family history of cardiovascular disease, and visible obesity (based on the physician's opinion) Patients who had their cholesterol levels measured during a period of four weeks	To evaluate the effectiveness of the DA as judged by patients	Germany and Austria	Included multiple cardiovascular prevention strategies, three of which were preventive health-related behaviors (dietary behavior, PA & substance use)	Eating fish 2x per week (or Omega-3 fatty acids), exercise 2–3x per week > 30 min, smoking (cessation)	Ambiguous, but in all likelihood paper-based, used during consultation at the GPs	Not reported	Federal Ministry of Education and Research (Germany)
Krones et al. (2010) [41]	Pragmatic CRT	Patients in whom discussion of preventive measures seemed indicated	To assess the feasibility and outcome of measuring the theory of planned behavior in patients receiving routine counseling versus counseling with a DA during primary care consultation on cardiovascular risk prevention	Germany and Austria	Included multiple cardiovascular prevention strategies, three of which were preventive health-related behaviors (dietary behavior, PA & substance use)	Ambiguous, but in all likelihood the same as in Krones et al. [40]; Eating fish 2x per week (or Omega-3 fatty acids), exercise 2–3x per week > 30 min, smoking (cessation)	Ambiguous, but in all likelihood paper-based, used during consultation at the GPs	Not reported	Ambiguous, but in all likelihood the same as in Krones et al. [40]; Federal Ministry of Education and Research (Germany)
Sheridan et al. (2013) (Protocol paper) & Keyserling et al. (2014) (Effect paper) [42,43]	Comparative effectiveness trial	Patients at participating practices (seen for an office visit within the past two years), age 35–79, and at high risk for CHD (angina, MI, or CHD death) defined by a Framingham risk score of $\geq 10\%$ or known CVD	To assess the effectiveness, acceptability, and cost-effectiveness of a combined lifestyle and medication intervention to reduce CHD risk offered in counselor-delivered and web-based formats	USA and Singapore	Included multiple cardiovascular prevention strategies, three of which were preventive health-related behaviors (dietary behavior, PA & substance use)	Changing diet (e.g., eating polyunsaturated fats rather than reducing total fat content), increasing PA, smoking (cessation)	Digital-based, used with the assistance of a health counselor	Not reported	U.S. Centers for Disease Control and Prevention (USA) and National Institutes of Health (USA)
Tinsel et al. (2017) (Protocol paper) & Tinsel et al. (2018) (Effect paper) [44,45]	Two-arm, randomized, controlled pilot study	Patients with at least one cardiovascular risk factor (hypertension, hypercholesterolemia, diabetes, arteriosclerosis, smoking, obesity, high stress level or drug prescription against hypertension, high cholesterol)	To test the intervention regarding its usability, acceptance and potential effects in primary care and to test the feasibility of the randomized study design	Germany	Included multiple cardiovascular prevention strategies, three of which were preventive health-related behaviors (PA, dietary behavior, substance use, sleep-related behaviors)	Ambiguous, but in all likelihood smoking, PA, alcohol use, changing diet and changing sleeping behavior	Paper-based, received at the GP	Not reported	German Heart Foundation (Germany)
Van Steenkiste et al. (2008) [46]	Cross-sectional study	Patients (aged 40–75 years) without established CVD who were at high, or at potentially high-cardiovascular risk	To assess patients' responsiveness to a decision support tool for primary prevention of CVDs	Netherlands	Included multiple cardiovascular prevention strategies, probably three of which were preventive health-related behaviors (dietary behavior, PA & substance use)	Ambiguous, but in all likelihood smoking, PA, alcohol use and changing diet	Paper-based, was presented during a consultation at the GP, participants were asked to complete it at home	22 min (SD 12 min)	Ambiguous, but in all likelihood The Netherlands Organization for Health Research and Development (ZonMw, Netherlands) [64]

BinDhim et al. (2014) (Protocol paper) & BinDhim et al. (2018) (Effect paper) [47,48]	Automated, double-blind randomized controlled trial (RCT)	Self-selected adult (≥ 18 years old) daily smokers from the USA, Australia, Singapore and the UK	To test the efficacy of an interactive smoking cessation DA app compared with a smoking cessation static information app on quit rates	Saudi Arabia and Australia	Substance use	Smoking (cessation)	App-based, freely available	Not reported	Ministry of Education (Saudi Arabia)
Brunette et al. (2011) [49]	Quasi experiment	Adult smokers with severe mental illnesses who were receiving supported housing and comprehensive psychiatric services at two settings within a large, urban, psychosocial rehabilitation center	To test the effectiveness of the first version of their motivational tool	USA	Substance use	Smoking (cessation)	Digital- and web-based	30–90 minutes	The West Family Foundation (USA) and the Segal Foundation (ambiguous, but in all likelihood the USA)
Brunette et al. (2013) [50]	RCT	Daily smokers with a mood or psychotic disorder with persisting functional disability, but without other current substance dependence	To assess whether a single session of a computerized motivational decision support system with carbon monoxide and health checklist feedback would lead to higher rates of initiating smoking cessation treatment than a version of the system with health checklist feedback alone (no carbon monoxide feedback)	USA	Substance use	Smoking (cessation)	Digital-based, used together with a research assistant	30–90 minutes	U.S. Department of Education, National Institute on Disability and Rehabilitation Research (USA); the Substance Abuse and Mental Health Services Administration, Center for Mental Health Services and Consumer Affairs Program (USA) and the Bristol-Myers Squibb Foundation (USA) Dartmouth SYNERGY (USA)
Brunette et al. (2015) [51]	Pre-post pilot study, with a randomly selected control group (for which not all measures were assessed)	Safety net clinic patients between 18–70 years who smoked four cigarettes or more per day	To assess whether this web-based, motivational, decision-support system could engage smokers who were not motivated to use treatment in a primary care safety net clinic that serves disadvantaged people	USA	Substance use	Smoking (cessation)	Digital and web-based, used with a research assistant present	45–90 minutes	
Cupertino et al. (2010) [52]	Pre-test, post-test assessment with no control group	Underserved, low-literacy smokers (46.7% Latinos)	To assess the feasibility and preliminary outcomes of a computerized DA to improve knowledge and utilization of smoking cessation resources among underserved, low-literacy smokers	USA	Substance use	Smoking (cessation)	Digital-based, delivered in safety-net clinics and community health fairs	Not reported	The Healthcare Foundation of Greater Kansas City (USA)
Ferron et al. (2011) [53]	Mixed method usability test	Convenience sample of smokers between the age of 18 and 65	To test the usability of the intervention	USA	Substance use	Smoking (cessation)	Digital and web-based, used with a researcher present	47 min (SD = 24.6) in the third and final version	The Foundation for Informed Medical Decision Making (USA)
				USA	Substance use	Smoking (cessation)			

Table 1 (Continued)

Article	Study design/ methodology	Study population	Study aims and purposes	Country of origin	Behavior (general)	Behavior (specific)	DA Delivery	Duration to complete the DA	Sources of funding
Ferron et al. (2012) [54]	Secondary analysis of data from an RCT	Adult smokers with serious mental illness who were receiving care at an urban psychiatric rehabilitation center	To study whether cognitive functioning, clinical characteristics and computer experience predict time spent using a web-based DA and whether these variables predict the main proximal outcome, engagement in smoking cessation treatment, and other quit behaviors				Digital-based, delivered in a clinic office with research staff present	32.12–190.3 min (M = 92.27, SD = 32.77)	U.S. Department of Education, National Institute on Disability and Rehabilitation Research (USA); the Substance Abuse and Mental Health Services Administration, Center for Mental Health Services and Consumer Affairs Program (USA) and the Bristol-Myers Squibb Foundation (USA)
Hollen et al. (2013) [55]	Prospective RCT	Adolescents (14–19 years) survivors of childhood cancer who had a history of cancer diagnosed between birth and 12 years but had been disease-free for at least five years (no treatment during the past two years)	To test a DA for adolescent survivors of childhood cancer that is aimed at difficult decisions related to engaging in substance use risk behaviors	USA	Substance use	Smoking, alcohol consumption, and illicit drug use	As the DA consistent of multiple components, it was delivered in multiple ways: See other included elements (Table 2) for more information	Different modules varied in length, from 10–60 min, the whole intervention involved approximately 7.5 contact hours (including measurements) 7 minutes	National Institute of Nursing Research (USA)
Lee et al. (2016) [56]	CRT	Adult (≥ 18 years old) smokers visiting an outpatient clinic of a Department of Family Medicine and a Health Screening Center	To develop a culturally tailored DA for smoking cessation and to evaluate its effect on deciding to use smoking cessation medication	Republic of Korea	Substance use	Smoking (cessation)	Video-based (presented on a tablet computer), was watched before a consultation at a department of family medicine		Pfizer (USA)
McDonnell et al. (2014) [57]	Prospective, one-group repeated measures design	Smokers (at least 21 years) motivated to quit that were scheduled for surgery for a suspicious thoracic mass or known cancer, with a household family member that also smoked and was also motivated to quit	To test the feasibility of a multidisciplinary, multicomponent, theory- based DA	USA	Substance use	Smoking (cessation)	As the DA consistent of multiple components, it was delivered in multiple ways: See other included elements (Table 2) for more information	Different modules varied in length, face-to-face visits lasted about 45 min, while optional booster sessions lasted less than 15 min	The American Cancer Society (USA)
McDonnell et al. (2016) [58]	Prospective, one-group repeated measures, mixed- method feasibility study	Smokers (at least 21 years) motivated to quit that were scheduled for surgery for a suspicious thoracic mass or known cancer, with a household family member that also smoked and was also motivated to quit	To determine the feasibility and acceptability of a multidisciplinary, theory- based DA, for patients scheduled to undergo thoracic surgery and for their family members who smoke	USA	Substance use	Smoking (cessation)	As the DA consistent of multiple components, it was delivered in multiple ways: See other included elements (Table 2) for more information	Not reported	The American Cancer Society (USA) and the Oncology Nursing Society Foundation (USA)
Rhee et al. (2008) [59]	Prospective RCT	Rural adolescents (14–20 years old) with asthma without learning disabilities	To determine the feasibility of the decision-making program for adolescents with asthma and to conduct preliminary testing of the following hypothesis: Adolescents receiving the intervention, framed within	USA	Substance use	Smoking, alcohol consumption, and illicit drug use	As the DA consistent of multiple components, it was delivered in multiple ways: See other included elements (Table 2) for more information	Different modules varied in length, from 10 to 90 minutes	National Institute of Nursing Research (USA)

6	Sheridan et al. (2010) [60]	RCT	Convenience sample of men and women from a registry of participants interested in decision support testing between (\geq 45 years old) who were likely to be at moderate to high risk of heart diseases	the context of engaging in risk behaviors and asthma and its treatment, would report improved quality decision making, reduced risk motivation, and reduced risk behaviors at two, four, and six months post-intervention compared with the control group and to examine whether intervention effects would vary by gender or race	USA	Included multiple cardiovascular prevention strategies, only one of which was a preventive health-related behavior (substance use)	Smoking (cessation)	Digital and web-based, participants got access to either the DA with or without an explicit VCM ^a alongside a hypothetical scenario	Without explicit VCM ^a = 5 min (range 1–12 min), with explicit VCM ^a = 11 min (range 4–21 min)	The American Heart Association (USA), the National Heart Lung and Blood Institute (USA), and the National Cancer Institute (USA)
	Sheridan et al. (2011) [61]	RCT	Patients between the ages of 40–79 years presenting for routine care with no prior history of cardiovascular disease, diabetes mellitus, or other serious medical condition, and were at moderate or high risk of CHD over 10 years	To determine whether adding an explicit VCM ^a to a DA on heart disease prevention improved decision-making outcomes, including decisional conflict, intent for screening, perceived value concordance, and self-efficacy	USA	Included multiple cardiovascular prevention strategies, only one of which was a preventive health-related behavior (substance use)	Smoking (cessation)	Digital and web-based, used in one university internal medicine practice, before a consultation	12 min (range: 1–45 minutes)	The American Heart Association (USA), the National Heart Lung and Blood Institute (USA), and the National Cancer Institute (USA)
	Sheridan et al. (2014) [62]	RCT	Patients between the ages of 40–79 years presenting for routine care with no prior history of cardiovascular disease, diabetes mellitus, or other serious medical condition, and were at moderate or high risk of CHD over 10 years	To further understand earlier found effects	USA	Included multiple cardiovascular prevention strategies, only one of which was a preventive health-related behavior (substance use)	Smoking (cessation)	Digital and web-based, used in one university internal medicine practice, before a consultation	12 min (range: <1–45 minutes)	The American Heart Association (USA), the National Heart Lung and Blood Institute (USA), and the National Cancer Institute (USA)
	Warner et al. (2015) [63]	Randomized, two-group pilot study	Smoking patients (\geq 18 years old) scheduled for elective surgery	To develop and pilot test a DA to increase patient involvement in decisions regarding smoking behavior of cigarette smokers scheduled for elective surgery	USA	Substance use	Smoking (cessation)	Paper-based, delivered in an examination room of a preoperative evaluation center by clinicians that regularly staff the center	5–10 minutes	The National Cancer Institute (USA)

Note. Articles are sorted thematically, alphabetically and chronologically. Ambiguous information was not verified with the original authors.

^a Called a value clarification exercise (VCE) in their article.

Table 2
Intervention elements included.

Article	Intervention elements		
	Information provision	Value and/or preference clarification (explicit or implicit)	Other
Cupples et al. (2018) [29]	Yes	Yes, explicit	Questions regarding barriers and facilitators, goal setting, problem solving, action planning, practical and emotional social support
Geller et al. (2012) [30]	Ambiguous, but in all likelihood yes	Yes, explicit	Group discussions in which participants were encouraged to share personal experiences, participants were also guided through the process of completing the intervention (not specifically described)
Hirsch et al. (2010) [31]	Yes	Yes, ambiguous if explicit or implicit	Calculation of individual absolute risk for stroke and/or myocardial infarction, exploration of subjective risk, assessment of individual risk factors, risk comparison to the population with identical sex and age, planning course of action
Hirsch et al. (2011) [32]	Yes	Yes, ambiguous if explicit or implicit	Discussion of the individual risk, discussion of treatment options and plan for future actions
Hirsch et al. (2011) [33]	Yes	Yes, ambiguous if explicit or implicit	Ambiguous, but in all likelihood the same as in Krones et al. [40]: Calculation of individual absolute risk for stroke and/or myocardial infarction, exploration of subjective risk, assessment of individual risk factors, risk comparison to the population with identical sex and age, planning course of action
Hirsch et al. (2012) [34]	Yes	Yes, ambiguous if explicit or implicit	Discussion of the individual risk, discussion of treatment options and plan for future actions
Hirsch et al. (2012) [35]	Yes	Yes, ambiguous if explicit or implicit	Discussion of the individual risk, discussion of treatment options and plan for future actions
Hirsch et al. (2012) [36]	Yes	Yes, ambiguous if explicit or implicit	Discussion of the individual risk, discussion of treatment options and plan for future actions
Koelewijn-van Loon et al. (2008) (Protocol paper) & Koelewijn-van Loon et al. (2009) (Effect paper) [37,38]	Yes	Yes, explicit	The decision aid (DA) was one part of an intervention mix, the other parts being: Risk assessment, graphical risk communication tool, (adapted) motivational interviewing
Koelewijn-van Loon et al. (2010) [39]	Yes	Yes, explicit	The DA was one part of an intervention mix, the other parts being: Risk assessment, graphical risk communication tool, (adapted) motivational interviewing
Krones et al. (2008) [40]	Yes	Yes, ambiguous if explicit or implicit	Calculation of individual absolute risk for stroke and/or myocardial infarction, exploration of subjective risk, assessment of individual risk factors, risk comparison to the population with identical sex and age, planning course of action
Krones et al. (2010) [41]	Yes	Yes, ambiguous if explicit or implicit	Ambiguous, but in all likelihood the same as in Krones et al. [40]: Calculation of individual absolute risk for stroke and/or myocardial infarction, exploration of subjective risk, assessment of individual risk factors, risk comparison to the population with identical sex and age, planning course of action
Sheridan et al. (2013) (Protocol paper) & Keyserling et al. (2014) (Effect paper) [42,43]	Yes	Yes, implicit	The DA was one part of an intervention mix and included: Calculation of participants' coronary heart disease (CHD) risk, showing participants how much their CHD risk might be reduced by one or more of the following: Changes in diet, increased physical activity (PA), smoking cessation, initiation of aspirin (for men only), or initiation or intensification of treatment with statins or hypertension medication; encouragement to choose risk-reducing strategies, the other part being: Either counselor-delivered and web-based intervention sessions that included four intensive sessions (each up to 60 min in duration depending on participants' individual pace in the web or counselor-delivered sessions) at monthly intervals, followed by three maintenance sessions (each 15–30 min in duration) delivered at two month intervals, the intensive sessions included content related to self-assessment of lifestyle and barriers, tips to circumvent self-identified barriers, creation of first steps toward self-identified actionable goals, the content of maintenance sessions was tailored according to participants' success in adhering to their chosen risk reducing strategy or strategies, which were assessed at the beginning of the first maintenance visit. Messages focused on the following basic topics: Relapse prevention, problem solving and lessons for long-term maintenance, all participants received ancillary resources including a cookbook, pedometers and physical activity logs for self-monitoring of exercise and an illustrated community resource guide that specified local resources for healthy eating (e.g., farmers markets) and physical activity (e.g., walking trails)
Tinsel et al. (2017) (Protocol paper) & Tinsel et al. (2018) (Effect paper) [44,45]	Yes	Yes, ambiguous if explicit or implicit	The DAs were one part of the intervention, the other parts being: Two printed booklets which contained the DAs but also self-monitoring elements such as protocols, a homepage with further information about cardiovascular risks and diseases and structured consultations by general practitioners (GPs) which include risk calculation (at the start and after four months), SDM and goal setting, support individual action planning and self-monitoring. The control group received everything except the brochures.
Van Steenkiste et al. (2008) [46]	Yes	Yes, implicit	The DA was given to patients at a first consultation after which they could complete it and come back for a second consultation, the DA also

Table 2 (Continued)

Article	Intervention elements		
	Information provision	Value and/or preference clarification (explicit or implicit)	Other
BinDhim et al. (2014) (Protocol paper) & BinDhim et al. (2018) (Effect paper) [47,48]	Yes	Yes, implicit	<p>included: Risk charts for CVD prevention, case histories, smokers were questioned about their smoking behavior, worksheet to summarize patient's risk assessment, preferences for risk reduction and invitation to participate in the decision-making process on personal cardiovascular risk management plan</p> <p>Intervention group: Compulsory notification (e.g., daily motivational messages), quitting diaries, (visual) quitting benefits tracker; Control group: No other elements</p> <p>(Optional) tutorial on how to use a computer mouse, users could choose to receive more elaborate information, video-recorded narrator who identified as smoker, a smoking assessment (incl. carbon monoxide meter) followed by feedback, video of a smoker that used a nicotine patch during a cessation attempt, printout report that included: Summary of smoking level, individual pros and cons of smoking, treatment interests and a referral to a smoking cessation specialist, sign-up sheet for meeting with smoking cessation specialist</p> <p>Same elements as described in Brunette et al. [49], however only the intervention group received carbon monoxide feedback, the control group received the DA only</p> <p>Culturally diverse patient program guides, five interactive educational modules, video-based patient quit stories, function to evaluate both the financial costs as well as the health impact of smoking, tailoring of information, text-to-speech function, direct access to chosen treatment options at the study side, tailoring for pregnant women (e.g., different information)</p> <p>Presentation of information in two languages (English and Spanish), bilingual narrator, smoking behaviors query, combination of video and audio, involvement of well-known community members, printed three page tailored printout that included: Summary of reported reason for quitting, level of interest in quitting, treatment preferences, personalized recommendations for behavior change, for participants that were interested in stopping smoking: A cessation plan, for participants that were not interested in stopping smoking: Small changes to stop smoking, prompt to discuss smoking cessation with a health care provider, report and tips for health care providers, fax referral form for a quit line, for participants that were interested in using medication: Provision of nicotine patches or a coupon and prescription for bupropion</p> <p>Ambiguous, but in all likelihood the same elements as the DA mentioned in Brunette et al. [49]: (Optional) tutorial on how to use a computer mouse, users could choose to receive more elaborate information, video-recorded narrator who identified as smoker, a smoking assessment (incl. carbon monoxide meter) followed by feedback, video of a smoker that used a nicotine patch during a cessation attempt, printout report that included: Summary of smoking level, individual pros and cons of smoking, treatment interests and a referral to a smoking cessation specialist, sign-up sheet for meeting with smoking cessation specialist</p> <p>Same elements as the DA mentioned in Brunette et al. [49] and Brunette et al. [50], additionally a read-aloud function and the possibility to choose between different models</p> <p>There were five modules on: Decision making (a 17-minute video on decision making in general based on Janis and Mann's conflict model of decision making), smoking (a 11-minute, video on why some teens start smoking and why it is hard to stop), alcohol/drug use (a 10-minute videos about alcohol use), an interactive substance use module (a 30–60 minute interactive practice in how to handle difficult situations with substance use), and a health status module (15-minute discussion with an health professional), they also provided one-on-one counseling sessions, telephone calls for people with a high risk and web-based support</p> <p>Introduction to outpatient clinic, proactive smoking cessation counseling and prescription</p> <p>The DA was one part of the intervention and included: Brief decision-making tutorial (incl. a graphical handout and a CD), the other parts being: Brief smoking cessation counseling by a surgeon or other team member, a smoking cessation program booklet plus four face-to-face sessions and up to six optional booster sessions via the telephone and/or online, stress management mediation CD, and medication management</p> <p>The DA was one part of the intervention and included: Brief decision-making tutorial (incl. a graphical handout and a CD), the other parts being: Brief smoking cessation counseling by a surgeon or other team</p>
Brunette et al. (2011) [49]	Yes	Yes, explicit	
Brunette et al. (2013) [50]	Yes	Yes, explicit	
Brunette et al. (2015) [51]	Yes	Yes, explicit	
Cupertino et al. (2010) [52]	Yes	Yes, explicit	
Ferron et al. (2011) [53]	Ambiguous, but in all likelihood yes	Ambiguous, but in all likelihood yes; ambiguous if explicit or implicit	
Ferron et al. (2012) [54]	Yes	Yes, explicit	
Hollen et al. (2013) [55]	Yes	Yes, explicit	
Lee et al. (2016) [56]	Yes	Yes, implicit	
McDonnell et al. (2014) [57]	Yes	Yes, explicit	
McDonnell et al. (2016) [58]	Yes	Yes, explicit	

Table 2 (Continued)

Article	Intervention elements		
	Information provision	Value and/or preference clarification (explicit or implicit)	Other
Rhee et al. (2008) [59]	Yes	Yes, ambiguous if explicit or implicit	member, a smoking cessation program booklet plus four face-to-face sessions and up to six optional booster sessions via the telephone and/or online, stress management mediation CD, and medication management Brief counseling session guided by Risk Behavior Fact Sheets, digital decision-making module (discussing basic principles of decision making) which depicted 17 decisions using cartoon and real teen actors, digital risk behavior module with information about smoking and alcohol use, intervention boosters which included a repetition of the decision-making module and a workbook to provide reinforcement and an opportunity to apply information in a real life situation, interactive CD-ROM booster to practice substance use decisions, telephone follow-up interviews to assess and ensure compliance Same elements as in Sheridan et al. [61], except for the tailored adherence messages that were not included in this study
Sheridan et al. (2010) [60]	Yes	Yes, both (tested the added value of an additional explicit VCM ^a)	
Sheridan et al. (2011) [61]	Yes	Yes, explicit	The DA was one part of the intervention and included: Calculation of patients' overall risk of CHD events in the next 10 years, encouragement to choose risk-reducing strategies, and coaching to communicate their decisions with their physicians for this audio clips about ways to overcome common communication barriers were provided, the other part being: Tailored adherence messages to help patients to circumvent self-identified barriers and gain the resources and skills for adherence
Sheridan et al. (2014) [62]	Yes	Yes, explicit	The DA was one part of the intervention and included: Calculation of patients' overall risk of CHD events in the next 10 years, encouragement to choose risk-reducing strategies, and coaching to communicate their decisions with their physicians for this audio clips about ways to overcome common communication barriers were provided and a summary of their DA session to initiate discussion with their provider, the other part being: Tailored adherence messages to help patients to circumvent self-identified barriers and gain the resources and skills for adherence
Warner et al. (2015) [63]	Yes	Yes, implicit	Simple graphic illustrating the effects of smoking on the body, and a motivational phrase

Note. Articles are sorted thematically, alphabetically and chronologically. Ambiguous information was not verified with the original authors.

^a Called a value clarification exercise (VCE) in their article.

3.1.3.2. Effects on the attributes of the decision-making process. The most commonly investigated attribute was patient-practitioner communication ($n = 12$, 39%) [32–34,39,46,49,50,52,54,57,62,63]. However, mixed effects were found: Decrease in communication ($n = 1$) [52], increase in communication ($n = 2$, 6%) [49,62], increase in satisfaction with the communication ($n = 1$) [39], and null effects ($n = 1$) [63]. Other studies mainly reported descriptive characteristics, e.g., that most of the exposed patients were satisfied [32]. In four (13%) out of seven (23%) studies in which participation in decision making was investigated positive effects compared to a control group were found [31,32,40,63] (the majority came from similar researchers), in one study null effects were reported [62]. Positive effects were found regarding decisional conflict, assessed in four studies (13%) [48,60,62,63]; null effects were only reported in one study [60] on the added value of an explicit VCM. Positive effects were both observed compared to a control group ($n = 2$, 6%) [48,63], and not compared to a control group ($n = 1$) [62]. While the proportion of undecided people was reported in six studies (19%) [29,32,34,35,41,63] (again, the majority came from similar researchers), only in one the effect was tested [41]. They found a positive effect compared to a control group [41]. No study reported effects on decisional satisfaction.

3.1.3.3. Effects on behavior. In 18 (58%) articles an assessment on the impact of the DA on behavior was reported [29,30,32,34,38,39,43,45,48–52,54,56,57,59,63].

3.1.3.3.1. Dietary behavior. In one study in which differences between two study groups were tested, positive effects due to the interventions on fat and vegetable intake were found [38]. However, effects on fat and vegetable intake were not replicated in multilevel analyses [38]. In another study with a control group (same researchers) null effects for fat, fruit and vegetable consumption were found [39], while in another study negative effects on overall diet were reported [45]. In one study mixed effects in terms of fruit and vegetable intake were reported [30] which were not compared to a control group. In this study two different versions of a DA were tested: One targeting PA, the other fruit and vegetable intake [30]. Interestingly, only the version targeting PA resulted in an increase in fruit and vegetable consumption, the fruit and vegetable version resulted in a small decrease in fruit and vegetable consumption [30]. In another study the same DA was compared alongside counseling or a web-based lifestyle intervention (thus, both study arms received the same DA): Positive effects were found for fat quality, fruit and vegetable intake [43]. One article simply reported that diet changed without providing much detail [29].

3.1.3.3.2. Physical activity (PA). In two of the three studies (6%) [38,39] comparing effects to a control group no effects on PA were found (same researchers), the one that did [45] was a pilot study that only reported descriptive analyses. Within the study that tested two different versions of the same DA (one for PA, one for

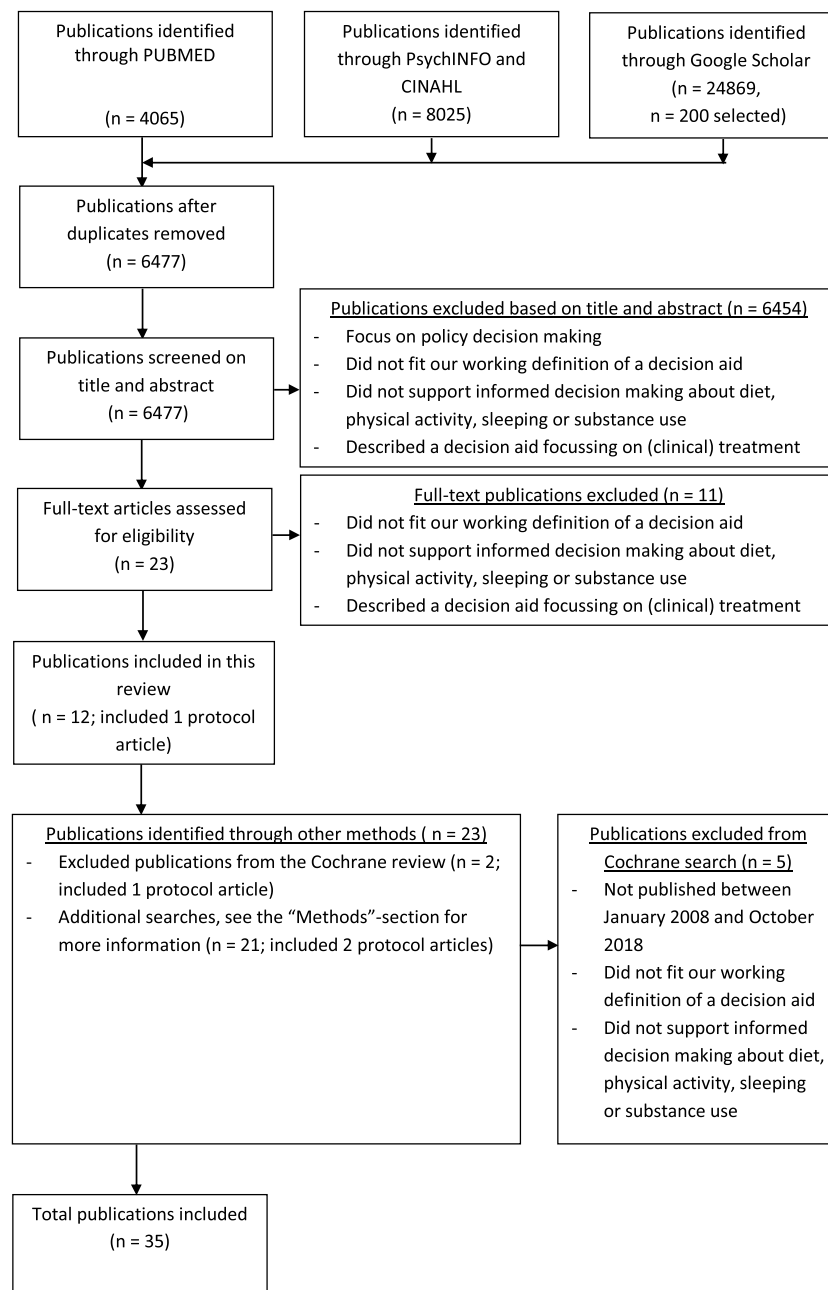


Fig. 1. Flow diagram.

fruit and vegetables) positive effects regarding PA were found in both groups [30]. Strikingly, the effects were stronger in the non-PA version. In another study without control group positive effects on weekly PA time and sedentary behavior were found [29], negative effects were found for minutes of PA and daily number of steps [29]. The study that compared the effects of the DA alongside counseling or a web-based lifestyle intervention found positive effects for weekly walking time and daily number of steps. However, the effect for weekly walking time was only observed in the counselor group [43].

3.1.3.3.3. Substance use. In studies including a control group positive effects on smoking cessation aid uptake (n = 3, 10%) [48,49,51] and smoking abstinence (n = 1) [48] were found, while

null effects were found on perioperative smoking behavior (n = 1) [63], smoking cessation medication (n = 1) [56], smoking abstinence (n = 3, 10%) [38,39,56] and smoking, alcohol and illicit drug uptake (n = 1) [59]. Only in one study that included a control group negative effects regarding smoking were found, however positive effects on alcohol consumption were found as well [45]. Interestingly, in one study both an effect on smoking cessation aid uptake and abstinence was found, but the researchers did not find that the DA's effect on abstinence was mediated by the quitting method [48]. In another study [38] a difference between intervention and control group was found, however the difference was already present at baseline. In the one study without control group, positive effects were found on smoking cessation aid uptake and number of cigarettes, while negative effects were found on

Table 3
Use of theories.

Has a theory been used at all?	Yes	n = 22
	Not reported	n = 9
Specific theories/frameworks used ^a	Conflict Theory of Decision Making	n = 6
	Social Cognitive Theory	n = 5
	Transtheoretical Model of Change	n = 5
	Glyn Elwyn's Model of Shared Decision Making	n = 5
	Theory of Planned Behavior	n = 4
	Self-Determination Theory	n = 2
	Ottawa Decision Support Framework (ODSF)	n = 1
	Integrative Theory	n = 1
	Protection Motivation Theory	n = 1
	Hersey-Blanchard Model	n = 1
	Behaviour Change Wheel	n = 1
	Prospect Theory	n = 1
	Expectancy Value Theory	n = 1
	Health Action Process Approach (HAPA)	n = 1
	Other/model developed by authors for the study	n = 1
Ways theories were used ^a	Theories' concepts used as outcome measure	n = 15
	To guide content development	n = 14
	Part of the DA	n = 3
	To guide study design	n = 1
	To compare study groups at baseline	n = 1

Note.

^a In some studies, multiple theories have been used for multiple purposes. Therefore, the absolute amount exceeds 31.

planning of a quit date and talking to health-care providers about smoking cessation [52]. Other effects that were found: Adding carbon monoxide feedback to a DA did not make it more effective (n = 1) [50], a DA for dyads (patient plus family member) seemed to be more effective for patients' quitting behavior than family members' quitting behavior (n = 1) [57] and in the study [43] that compared the effects of the DA alongside counseling or a web-based lifestyle intervention positive effects for smoking were found in both groups.

3.1.3.4. Effects on adherence to the chosen option. Adherence was assessed in four (13%) studies [29,48,61,63]. Three (10%) compared the effects to a control group; one reported null effects [63], one positive effects (i.e., increased adherence) [61], and one reported that 97.7% adhered to their chosen option regardless of the assigned group [48].

3.1.3.5. Effects on economic impact. Cost-effectiveness was assessed in one study, however not the cost-effectiveness of the DA itself was tested but rather of a counseling or a web-based intervention used next to the DA [43].

3.1.3.6. Effects on health outcomes. Health status was assessed in five studies (16%) [38,40,43,45,61], both null (n = 3, 10%) [38,40,45] and positive effects (n = 2, 6%) [43,61] (both from similar research teams) were found. Quality of life [43] and anxiety [39] were only assessed once, in both cases significant improvements were found. No study reported effects on depression and emotional distress.

3.2. Results grey literature

The initial search into the DALI resulted in 10 DAs (dietary behavior n = 5 and substance use n = 5). Only four DAs were still available online at the time of the search [65–68]. All DAs stemmed from the same developer (www.healthwise.org), a nonprofit organization aimed at providing digital health education. All DAs shared a similar design. Theory application was not described.

All DAs made use of information provision and explicit elements to clarify values and preferences. Other elements were

personal stories, a knowledge quiz and a summary. Duration to complete the DAs was not reported.

The DAs were not reported in any scientific publications. No effects were reported. An overview of currently online accessible DAs can be seen in Table 4.

4. Discussion and conclusion

4.1. Discussion

With this scoping review we aimed to synthesize the literature on DAs that focus on preventive health-related behaviors by reviewing available information regarding their characteristics, intervention elements, theoretical foundations and (cost-)effectiveness. We identified 35 scientific papers describing DA development and/or evaluation and four DAs that focus on preventive health-related behaviors in the grey literature. We will focus on three key areas in this discussion: (1) Characteristics and intervention elements of identified DAs, (2) theoretical foundations of the identified DAs, and (3) effectiveness of the identified DAs.

4.1.1. Characteristics and intervention elements of the identified DAs

Identified DAs focused most often on substance use, primarily smoking. This could be due to the fact that smoking cessation trajectories show similarities with clinical treatment and screening trajectories, which is where the majority of DAs traditionally have been applied [11]. For example, one of the options that is regularly named in smoking cessation DAs is pharmacological support (e.g., [48]).

DAs were often combined with additional intervention elements. Therefore, it was difficult to ascertain the impact of the DA independent from these other components, as the additional components often had their basis in behavioral change theories, rather than informed decision making. Consequently, tested outcomes varied widely among studies, limiting the current evidence base for any behavior- or decision-related outcome.

Future studies should examine which intervention elements are effective regarding informed decision making in the area of

Table 4

DA characteristics grey literature.

Name	Behavior (general)	Behavior (specially)
Healthwise: Quitting Smoking: Should I Use Medicine? [65]	Substance use	Smoking (cessation)
Healthwise: Obesity: Should I Use a Diet Plan to Lose Weight? [66]	Dietary behavior	Diet
Healthwise: Weight Management: Should I Use Over-the-Counter Diet Aids? [67]	Dietary behavior	Use of diet aids
Healthwise: Sleep Apnea: Should I Have a Sleep Study? [68]	Sleep-related behaviors	General sleep management

preventive health-related behaviors. Furthermore, studies should be conducted to disentangle which intervention elements can be deployed to support which processes. To this end, however, consensus should be reached on which outcomes are relevant to be tested in studies investigating DAs that focus on preventive health-related behaviors. This would not only allow different intervention elements to be tested using the same criteria but would also enable developers of DAs that focus on preventive health-related behaviors to develop DAs that are even more rooted in evidence than current DAs. Ultimately, this could result in a taxonomy as used in behavior change [69] which clearly describes the purpose of most often applied intervention elements. Theoretical work to understand VCMs' effects and how those effects can be accomplished have recently been undertaken [70,71].

4.1.2. Theoretical foundations of the identified DAs

Around 70% of the studies reported that they used a theory, most commonly to identify relevant outcome measures. Multiple studies used theories such as the Self-Determination Theory [72] or the Theory of Planned Behavior [73]; theories meant to explore motivation or behavior (change). We also found studies that used decision-making-focused theories, such as the Conflict Theory of Decision Making [74], however these are not explicitly designed to support people in changing behavior. Given the dual purpose of DAs that focus on preventive health-related behaviors, insights from multiple theories should be used to develop these DAs.

There are two possible approaches to integrate insights from both areas when developing DAs that focus on preventive health-related behaviors: (1) Developers could flexibly integrate insights from multiple theories on respectively behavioral change and informed decision making as proposed by Peters & Crutzen [75], (2) or attempts could be made to establish an integrative framework that can be applied in multiple (unrelated) DA development projects. The second approach could be particularly helpful for developers that are not familiar with both research fields.

4.1.3. Effectiveness of the identified DAs

Studies reported positive effects such as uptake of effective smoking cessation aids and smoking abstinence, however interpretation is somewhat difficult as not all studies followed an RCT protocol and as we could not synthesize the effects quantitatively. Also, a formal analysis of the quality of the evidence has not taken place in this scoping review as this form of knowledge synthesis (often) does not include quality assessments in the same form as systematic reviews [24]. However, our findings are in line with a systematic review [17] in which it was found that smoking cessation DAs can be effective, but that there was major heterogeneity within studies and DAs. Beneficial effects were also identified regarding PA and nutritional behavior, however, due to the relatively low numbers of studies and the mixed findings found in the included studies, no clear conclusions can be drawn at this time.

Interestingly, the majority of the identified studies failed to report effects on decisional outcomes. Future studies should

investigate how DAs that focus on preventive health-related behaviors affect those decisional outcomes as well and how these outcomes relate to behavior (change). Insights from Self-Determination Theory [72], for example, would suggest that the offering of choices (i.e., what DAs do inherently) can support individuals in becoming autonomously motivated towards self-chosen options, which in turn can lead to greater behavioral maintenance [76,77].

4.2. Limitations

A possible limitation was the focus on studies as the units of analysis rather than individual DAs. However, not all studies that referred to similar DAs clearly described how they related to one another, which made it impossible to report results per DA. To minimize the impact of this on our results, we highlighted if studies were conducted by similar author(s). Another possible limitation would be that we decided to exclude all treatment DAs, including those aimed at preventing secondary diseases or complications (e.g., cardiovascular diseases due to diabetes mellitus). However, our working definition of DAs that focus on preventive health-related behaviors has only focused on primary disease prevention and we are convinced that DAs aimed at primary, secondary and tertiary prevention should be explored separately. Hence, the focus on DAs that focus on primary prevention.

4.3. Future research directions

Based on the discussion above, we have identified three main areas of interest for further research: (1) Establishing which intervention elements are effective regarding decision making in the domain of preventive health-related behaviors, and for which processes, (2) strengthening the integration between theoretical insights from behavior change and informed decision making, by either adopting a flexible approach or by establishing an integrative framework, and (3) conducting more randomized trials to enable systematic reviews and meta-analyses in order to draw stronger conclusions regarding behavioral and decisional outcomes and how those relate to one another.

4.4. Practice implications

While scoping reviews do not allow for strong conclusions to be drawn (compared to other forms of knowledge syntheses), our results show that DAs can potentially be beneficial in supporting people to change preventive health-related behaviors – especially regarding smoking (particularly when taken together with other evidence [17]). As such, DAs might be one potential approach to counteract the rise of noncommunicable diseases. However, further research is needed to substantiate this.

4.5. Conclusions

This study was the first attempt to broadly synthesize knowledge regarding DAs aimed at preventive health-related

behavioral decisions. Findings regarding the effects on behavior were potentially promising, especially regarding smoking (particularly when taken together with other evidence [17]). However, while certain beneficial effects could be identified, interpretation was hindered by heterogenous reporting. Certain areas of improvement were identified, such as establishing which intervention elements are effective regarding decision making in the domain of preventive health-related behaviors.

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Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist. [Table A1](#)

Table A1
PRISMA-ScR Checklist.

Section	Item	PRISMA-ScR Checklist item	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): Background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	2
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	2
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	2
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	3
Information sources	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	2–3
Search	8	Present the full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	3, Appendix B
Selection of sources of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	3
Data charting Process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	3, Appendix C
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Appendix C
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Not applicable
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	2–3
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Fig. 1
Characteristics of sources of Evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	3–14
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Not applicable
Results of Individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	3–14
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	3–14
DISCUSSION			
Summary of Evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	14–15
Limitations	20	Discuss the limitations of the scoping review process.	15
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	15–16
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	16, Table 1

Note. Adapted from www.prisma-statement.org/Extensions/ScopingReviews. Page numbers refer to PDF pages.

Appendix B

Search strings

Table B1

Search Strings for PubMed.

Behavior	Search terms
Dietary behavior	((“Decision Support Techniques”[Mesh] OR “Decision Support Techniques” [tiab] OR “Decision model”[tiab] OR “decision aid*”[tiab]) AND (“Diet”[Mesh] OR “Diet*”[tiab] OR “dietary behavio*”[tiab] OR “Eating”[Mesh] OR “Eating”[tiab] OR “food restriction”[tiab] OR “Weight Loss”[Mesh] OR “Weight Loss”[tiab] OR “Weight Gain”[tiab] OR “Diet, Food, OR Nutrition”[Mesh] OR “food”[tiab] OR “weight reduction plan”[tiab] OR “weight reduction”[tiab])) NOT (“Policy Making”[Mesh] OR “Policy Making”[tiab] OR “Public Policy”[Mesh] OR “Public Policy”[tiab] OR “Health Policy”[tiab])
Physical activity	((“Decision Support Techniques”[Mesh] OR “decision aid*”[tiab] OR “Decision Support Techniques” [tiab] OR “Decision model”[tiab]) AND (“Exercise”[Mesh] OR “Exercise*”[tiab] OR “Physical Activity”[tiab] OR “movement”[tiab] or “sport*”[tiab] or “active behavio*”[tiab] OR “fitness”[tiab])) NOT (“Policy Making”[Mesh] OR “Policy Making”[tiab] OR “Public Policy”[Mesh] OR “Public Policy”[tiab] OR “Health Policy”[tiab])
Sleep-related behaviors	((“Decision Support Techniques”[Mesh] OR “decision aid*”[tiab] OR “Decision Support Techniques” [tiab] OR “Decision model”[tiab]) AND (“Sleep”[Mesh] OR “Sleep*”[tiab] OR “Sleep hygiene”[MeSH] OR “Sleep hygiene”[tiab] OR “Sleep habit”[tiab] OR “Rest”[Mesh] OR “Rest*”[tiab])) NOT (“Policy Making”[Mesh] OR “Policy Making”[tiab] OR “Public Policy”[Mesh] OR “Public Policy”[tiab] OR “Health Policy”[tiab])
Substance use	((“Decision Support Techniques”[Mesh] OR “decision aid*”[tiab] OR “Decision Support Techniques” [tiab] OR “Decision model”[tiab]) AND (“Alcohol Drinking”[Mesh] OR “Alcohol Drinking”[tiab] OR “alcohol”[tiab] OR “Alcoholism”[Mesh] OR “Ethanol”[MeSH] OR “Ethanol”[tiab] OR “Alcoholic Beverages”[MeSH] OR “Alcoholic Beverages” [tiab] OR “Smoking”[Mesh] OR “Smok*”[tiab] OR “Smoking Cessation”[Mesh] OR “Smoking Cessation”[tiab] OR “Smoking Reduction”[Mesh] OR “Smoking Reduction”[tiab] OR “Tobacco Use Cessation Products”[Mesh] OR “Tobacco Use Cessation Products”[tiab] OR “Smoking Devices”[Mesh] OR “Smoking Devices”[tiab] OR “Tobacco”[Mesh] OR “Tobacco Use”[Mesh] OR “Tobacco Use”[tiab] OR “Tobacco Use Cessation”[Mesh] OR “Tobacco”[tiab] OR “cigarette”[tiab] OR “e-cigarette”[tiab] OR “Drug Misuse”[Mesh] OR “Drug”[tiab] OR “Substance-Related Disorders”[Mesh])) NOT (“Policy Making”[Mesh] OR “Policy Making”[tiab] OR “Public Policy”[Mesh] OR “Public Policy”[tiab] OR “Health Policy”[tiab])

Table B2

Search Strings for PsycINFO and CINAHL.

Behavior	Search terms
Dietary behavior	(SU Decision Support Systems OR TI “Decision Support Systems” OR AB “Decision Support Systems” OR TI “decision aid*” OR AB “decision aid*” OR TI “Decision Support Technique*” OR AB “Decision Support Technique*” OR TI “Decision model” OR AB “Decision model”) AND (SU Diets OR TI “Diet*” OR AB “Diet*” OR SU Eating Behavior OR TI “Eat*” OR AB “Eat*” OR SU Food Intake OR SU Food OR TI “food” OR AB “food” OR SU Nutrition OR SU Weight Control OR SU Weight Gain OR TI “Weight Gain” OR AB “Weight Gain” OR SU Weight Loss OR TI “Weight Loss” OR AB “Weight Loss” OR TI “dietary behavio*” OR AB “dietary behavio*” OR TI “eat*” OR AB “eat*” OR TI “food restriction” OR AB “food restriction” OR TI “weight reduction plan” OR AB “weight reduction plan”) NOT (SU Policy Making OR TI “Policy Making” OR AB “Policy Making” OR TI “public policy” OR AB “public policy” OR TI “health policy” OR AB “health policy”)
Physical activity	(SU Decision Support Systems OR TI “Decision Support Systems” OR AB “Decision Support Systems OR TI “decision aid*” OR AB “decision aid*” OR TI “Decision Support Technique*” OR AB “Decision Support Technique*” OR TI “Decision model” OR AB “Decision model”) AND (SU Physical Activity OR SU Physical Fitness OR TI Exercise* OR AB Exercise* OR SU Physical Activity OR TI Physical Activity OR AB Physical Activity OR TI movement OR AB movement OR SU Sports OR TI Sport* OR AB Sport* OR TI active behavio* OR AB active behavio* OR TI fitness OR AB fitness) NOT (SU Policy Making OR TI “Policy Making” OR AB “Policy Making” OR TI “public policy” OR AB “public policy” OR TI “health policy” OR AB “health policy”)
Sleep-related behaviors	(SU Decision Support Systems OR TIX “Decision Support Systems” OR AB “Decision Support Systems OR TI “decision aid*” OR AB “decision aid*” OR TI “Decision Support Technique*” OR AB “Decision Support Technique*” OR TI “Decision model” OR AB “Decision model”) AND (SU Sleep OR TI Sleep* OR AB Sleep* OR TI Rest* OR AB Rest*) NOT (SU Policy Making OR TI “Policy Making” OR AB “Policy Making” OR TI “public policy” OR AB “public policy” OR TI “health policy” OR AB “health policy”)
Substance use	(SU Decision Support Systems OR TIX “Decision Support Systems” OR AB “Decision Support Systems OR TI “decision aid*” OR AB “decision aid*” OR TI “Decision Support Technique*” OR AB “Decision Support Technique*” OR TI “Decision model” OR AB “Decision model”) AND (SU Drinking Behavior OR TI Alcohol* OR AB Alcohol* OR SU Drug Usage OR SU Ethanol OR TI Ethanol OR AB Ethanol OR SU Alcoholic Beverages OR TI Smok* OR AB Smok* OR SU Smoking Cessation OR SU Nicotine OR TI Tobacco* OR AB Tobacco* OR TI Nicotine* OR AB Nicotine* OR SU Drug Withdrawal OR TI Cigarette* OR AB Cigarette* OR TI e-cigarette* OR AB e-cigarette* OR TI drug* OR AB drug* OR TI substance* OR AB substance*) NOT (SU Policy Making OR TI “Policy Making” OR AB “Policy Making” OR TI “public policy” OR AB “public policy” OR TI “health policy” OR AB “health policy”)

Table B3

Search Strings for Google Scholar.

Behavior	Search terms
Dietary behavior	((“Decision Support Techniques” OR “Decision model” OR “decision aid”*) AND (“Diet*” OR “Eat*” OR “food*” OR “Weight”*)) -policy
Physical activity	((“Decision Support Techniques” OR “Decision model” OR “decision aid”*) AND (“Exercise*” OR “Physical Activity” OR “move*” or “sport*” or “active behavio*” OR “fitness”*)) -policy
Sleep-related behaviors	((“Decision Support Techniques” OR “Decision model” OR “decision aid”*) AND (“Sleep*” OR “Rest”*)) -policy
Substance use	((“Decision Support Techniques” OR “Decision model” OR “decision aid”*) AND (“alcohol*” OR “Ethanol” OR “Ethanol” OR “Smok*” OR “Tobacco*” OR “cigarette*” OR “e-cigarette*” OR “Drug*” OR “Substance”*)) -policy

Appendix C

Extracted information Table C1

Table C1

Extracted information.

Questions	Sub questions
On which behavior did the decision aid (DA) (under study) focus, both in general (e.g., dietary behavior) and specifically (e.g., weight loss)? How was the (studied) DA delivered to the user? How long did it take to complete the DA (under study)? Of which elements did the DA (under study) consist?	<ul style="list-style-type: none"> • Did the DA contain information provision elements? • Did the DA contain elements to clarify values and preferences? <ul style="list-style-type: none"> ◦ Were those elements explicit or implicit? • Which other intervention elements were employed?
Was the DA (under study) scientifically published (and was certain necessary information described)?	<ul style="list-style-type: none"> • If it was, what was/were the: <ul style="list-style-type: none"> ◦ Study design and methodology? ◦ Study population? ◦ Aims/purposes? ◦ Origin/country of origin? ◦ Author(s)? ◦ Year of publication?
How were theories used?	<ul style="list-style-type: none"> • Specifically: <ul style="list-style-type: none"> ◦ Has a theory been used at all? ◦ Which theory has been used specifically and how was it used?
What were the effects on the attributes of the choice made?	<ul style="list-style-type: none"> • Specifically, the effects on: <ul style="list-style-type: none"> ◦ Knowledge? ◦ Accurate risk perceptions? ◦ Value congruency? ◦ Regret?
What were the effects on the attributes of the decision-making process?	<ul style="list-style-type: none"> • Specifically, the effects on: <ul style="list-style-type: none"> ◦ Decisional conflict? ◦ Proportion undecided? ◦ Decisional satisfaction? ◦ Patient-practitioner communication, if applicable? ◦ Participation in decision making, if applicable?
What were the effects on behavior?	<ul style="list-style-type: none"> • Specifically, the effects on: <ul style="list-style-type: none"> ◦ (Actual) behavior after the choice has been made? ◦ Adherence to chosen option (time of adherence)?
What were the results regarding economic impact?	<ul style="list-style-type: none"> • Specifically, the effects on: <ul style="list-style-type: none"> ◦ Costs? ◦ Cost effectiveness?
What were the effects on health outcomes?	<ul style="list-style-type: none"> • Specifically, the effects on: <ul style="list-style-type: none"> ◦ Health status? ◦ Quality of life? ◦ Anxiety? ◦ Depression? ◦ Emotional distress?

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