BMJ Open

Approaches to Improving Symptom Appraisal: A Systematic Literature Review

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2022-064521
Article Type:	Original research
Date Submitted by the Author:	06-May-2022
Complete List of Authors:	Xiang, Ling; Singapore General Hospital, Department of Rheumatology and Immunology; National University of Singapore, Yong Loo Lin School of Medicine Yoon, Sungwon; Duke-NUS Medical School, Health Services and Systems Research Low, Andrea; Singapore General Hospital, Department of Rheumatology and Immunology; Duke-NUS Medical School Leung, Ying Ying; Singapore General Hospital, Department of Rheumatology and Immunology; Duke-NUS Medical School Fong, Warren; Singapore General Hospital, Department of Rheumatology and Immunology; Duke-NUS Medical School Lau, Tang Ching; National University of Singapore, Yong Loo Lin School of Medicine; National University Hospital, Department of Medicine Koh, Dow Rhoon; National University of Singapore, Yong Loo Lin School of Medicine; National University Hospital, Department of Medicine Thumboo, Julian; Singapore General Hospital, Department of Rheumatology and Immunology; Duke-NUS Medical School
Keywords:	Rheumatology < INTERNAL MEDICINE, RHEUMATOLOGY, MEDICAL EDUCATION & TRAINING

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Approaches to Improving Symptom Appraisal: A Systematic Literature Review

Ling Xiang,[1,2] Sungwon Yoon,[3] Andrea HL Low,[1,2,4] Ying Ying Leung,[1,2,4] Warren Fong,[1,2,4] Tang Ching Lau,[2,5] Dow Rhoon Koh,[2,5] Julian Thumboo.[1,2,4]

[1]Department of Rheumatology and Immunology, Singapore General Hospital, Singapore
[2]Yong Loo Lin School of Medicine, National University of Singapore, Singapore
[3]Health Services and Systems Research, Duke-NUS Medical School, Singapore
[4]Duke-NUS Medical School, Singapore
[5]Department of Medicine, National University Hospital, Singapore

Corresponding author: Julian Thumboo, Department of Rheumatology and Immunology, Singapore General Hospital, Academia Building, Level 4, 20 College Road, Singapore, 169856. Tel: (65) 6321 4028, Fax: (65) 6220 3321, Email: julian.thumboo@singhealth.com.sg.

Abstract

Objectives
Poor symptom appraisal (detection, interpretation and response to symptoms) plays a major role in prolonged pre-diagnosis interval in various health conditions such as cancer and autoimmune rheumatic diseases (ARDs). Theories and models have been proposed to study the symptom appraisal process but how they could be employed to improve symptom appraisal remains unclear. We therefore aimed to review approaches to improving symptom appraisal in the literature and to develop a theoretical framework that could guide the development of approaches to improving symptom appraisal among individuals in the general population to facilitate early diagnosis.

Design
A systematic search was conducted through 30 March 2021.

Data sources
Medline, Web of Science, PsycInfo, Embase, CINAHL and Scopus.

Eligibility criteria
We included original articles in which approaches (or their components) to improve the detection, interpretation or response to symptoms for individuals with bodily changes/symptoms were described.

Data extraction and synthesis
A pre-defined data extraction form was used to extract the development, characteristics and evaluation of approaches to improving symptom appraisal. This formed the basis for the narrative synthesis.

Results
Of 19,046 publications identified from the literature search, 112 were selected for full text review and 29 approaches comprising provision of knowledge of symptoms/signs and additional components (e.g., symptom self-examination and comparison) for symptom appraisal were included in the synthesis. Less than half (41.4%) of these approaches were developed based on theories/models. Interestingly, despite the variety of theories/models adopted in developing these approaches, the components of these approaches were similar.

Conclusion
Symptom appraisal is an essential process in a patient's journey that can be targeted to facilitate early diagnosis but is largely unstudied. Building on the literature, we propose a theoretical framework and approaches to improving symptom appraisal. This could facilitate early identification of a variety of health conditions in the general population.

Strengths and limitations of this study
- Despite its known significance, approaches to improving symptom appraisal have been largely unstudied.
- Great heterogeneity exists in the development and evaluation of approaches to improving symptom appraisal.
- A theory-based framework can guide the development of approaches to improving symptom appraisal.

Introduction

Prolonged pre-diagnosis interval between symptom onset and diagnosis, also referred to as diagnostic delay, remains an unmet need among patients with various health conditions such as cancer and autoimmune rheumatic diseases (ARDs) and results in poor patient outcomes(1-8). Pre-diagnosis interval comprises largely the symptom appraisal interval between symptom onset and the first visit to healthcare professionals. Using the general model of total patient delay proposed by Andersen et al, symptom appraisal interval constituted the majority (more than 60%) of the total duration of delay among patients with various cancers(9). In a systematic review of pre-diagnosis interval among patients with rheumatoid arthritis (RA), the most common ARD, by Barhamain et al, symptom appraisal interval was found to be longer than intervals between the first visit to healthcare professionals and diagnosis (weighted average: 3.4 vs 2.1-2.9 months)(10).

Symptom appraisal is a process an individual undertakes when symptoms (bodily changes) are noticed till a decision is made on whether an action needs to be taken in response to the symptoms (bodily changes)(11). During the symptom appraisal interval, symptoms are being appraised and misperception of symptoms (bodily changes) may occur. Individuals may not perceive their symptoms as a health concern that requires prompt medical attention, and hence may not seek help from healthcare professionals or do so in a timely manner(12). Poor symptom appraisal has been shown to be a major cause of prolonged symptom appraisal interval and pre-diagnosis interval(13-17). In the meta-analysis by Petrova et al, poor symptom knowledge, wrong interpretation of symptoms, and negative beliefs about cancer were significantly associated with longer symptom appraisal/help-seeking intervals among patients with various cancers(16). In the systematic review by Stack et al, many patients with recent-onset RA reported that they were unaware of the significance of their symptoms before they were diagnosed and that they would have sought help earlier if they had more knowledge of RA and its symptoms(14).

It is thus important to develop approaches to improve symptom appraisal among symptomatic individuals in the general population to address the unmet need to shorten the pre-diagnosis interval. Many theories and models have been proposed to study the symptom appraisal process among patients with various chronic and acute health conditions(11, 18-27), however, how these theories and models could be employed to improve symptom appraisal remains unclear. We therefore aimed to review approaches to improving symptom appraisal in the literature, and to develop a theoretical framework that could guide the development of approaches to improving symptom appraisal among individuals in the general population to facilitate early diagnosis.

Methods

We conducted a systematic literature search of existing approaches developed to improve symptom appraisal among individuals with any health conditions. We first performed a preliminary search in Medline using the concepts of symptom and appraisal, based on which the definitions of symptom and symptom appraisal for use in this study were developed, and search terms for the concepts of symptom, appraisal and patient education were refined (Supplementary File 1)(11, 12, 18-20, 22-31). We performed the final literature search with the refined search terms in the following six electronic databases: Medline, Web of Science, PsycInfo, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Scopus. We included all articles published from inception to 30 March 2021.

This systematic review was registered with the PROSPERO International prospective register of systematic reviews (reference: CRD42021279500) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist was followed in the reporting (Supplementary File 2)(32).

Inclusion and Exclusion Criteria

One main reviewer (the first author) screened the title and abstract of all articles identified from the final literature search, with any uncertainty resolved by discussion with the other authors. We examined the references of all review articles to identify relevant publications. We included articles for full text review if they met the following three criteria: 1) original articles in which approaches (or their

components) to improving symptom appraisal were described, 2) approaches (or their components) aimed to improve the detection, interpretation or response to symptoms, and 3) approaches were developed for individuals with bodily changes/symptoms. We excluded articles in which approaches were developed to improve symptom appraisal among healthcare professionals such as medical trainees and nursing students.

Quality assessment

Quality assessment was conducted using the Joanna Briggs Institute (JBI) critical appraisal tools primarily by the first author, with any uncertainty resolved by discussion with the other authors(33, 34).

Data Extraction and Synthesis

Data on study design, participants, and the development, characteristics (type, format and components), and evaluation of approaches were extracted using a pre-defined data extraction form primarily by the first author, with any uncertainty resolved by discussion with the other authors. Due to the great heterogeneity in study design and outcome measures of the developed approaches, a narrative synthesis was performed.

Patient and Public Involvement

Patients and/or the public were not involved in the design, conduct, reporting or dissemination of this research.

Results

Study Selection

Among the 19,046 records identified from the final literature search, 10,613 were screened the title and abstract after removing duplicates, 196 were assessed for eligibility and 112 were included in the full text review (Figure 1). An additional 67 eligible records were identified from citation searching, yielding a total of 179 eligible publications from 160 unique studies.

After reviewing these 160 studies, we excluded 131 (81.9%) studies in which approaches comprised only provision of knowledge of symptoms/signs of a given health condition. We included the remaining 29 (18.1%) studies in which approaches comprised provision of both knowledge of symptoms/signs and additional components (such as demonstration and/or hands-on practice of self-examination and comparison of symptoms) to improve symptom appraisal in the synthesis (Table 1). This was based on the consideration that provision of knowledge (of symptoms/signs) alone might not be sufficient to produce the desired behavior (i.e., detection, interpretation and response to symptoms)(35), and that we aimed to develop similar approaches to help individuals recognize and respond promptly to their symptoms/signs.

Of these 29 studies, 13 were categorized as having low risk of bias(36-48), 10 were categorized as having moderate risk of bias(49-58), and 6 were unable to be assessed due to a lack of detailed evaluation of the developed approaches(59-64). We included all 29 studies in the synthesis as our focus was the development instead of the evaluation of approaches.

Table 1. Characteristics of studies included in the synthesis

Study	Health conditions	Type and format of approaches	Constructs of symptom appraisal addressed	Underlying theories/models
Cancer				
Dine et al, 2011(59)	BCLE	Education sessions	Detection (demonstration) and response	Nil
Brailey et al, 1986(36)	Breast cancer	Education sessions and materials (film, pamphlet)	Detection (demonstration and hands-on practice)	PRECEDE Model(65)
Burgess et al, 2008(60)	Breast cancer	Education sessions and materials (booklet with graphics and illustrations, photographs of symptoms)	Detection (demonstration) and response (role modelling)	SRT(66), TPB(67), Implementation Intentions(68) and SCT(69)
Byrne et al, 2009(61)	Breast cancer	Education sessions and materials (pictures or illustrations)	Detection (demonstration and hands-on practice) and response	Nil
Craun et al, 1987(49)	Breast cancer	Education sessions and materials (pamphlet)	Detection (demonstration and hands-on practice)	HBM(70)
Khokhar et al, 2009(50)	Breast cancer	Education sessions and materials (video clip and pamphlet)	Detection (demonstration and hands-on practice)	Nil
McLendon et al, 1982(51)	Breast cancer	Education sessions (one-to-one)	Detection (hands-on practice) and response	Nil
Shepherd et al, 2007(52)	Breast cancer	Education sessions and materials (multimedia: radio)	Detection (demonstration) and response	Orem's Self Care Nursing Model(71)
Sorensen et al, 2005(37)	Breast cancer	Education sessions (video)	Detection (demonstration)	Nil
Stratton et al, 1994(53)	Breast cancer	Education sessions and materials (film and booklet)	Detection (demonstration)	Nil
Styrd et al, 1982(38)	Breast cancer	Education sessions and materials (film and publication)	Detection (demonstration)	Nil
Luther et al, 1985(39)	Breast and testicular cancer	Education sessions and materials (movies)	Detection (demonstration)	Nil
Cornell et al, 2015(40)	Melanoma	Education materials (photographs)	Interpretation (comparison)	Nil
Robertson et al, 2014(41)	Melanoma	Education materials (video and images of skin lesions)	Interpretation (comparison)	Nil
Scott et al, 2012(42)	Oral cancer	Education sessions and materials (leaflet)	Detection (hands-on practice) and response	SRT(18,72), SCT(69)

Brooks et al, 2001(54)	Skin cancer	Education materials (pictures of skin lesions)	Interpretation (comparison)	Nil
Respiratory diseases				
Butz et al, 2005(55)	Asthma	Education sessions	Identification, interpretation (comparison) and response	MSM(22)
Colland et al, 2004(43)	Asthma	Education sessions	Identification, interpretation (comparison) and response	Nil
Gardner et al, 2016(62)	Asthma	Education sessions and materials (binder with large pictures)	Recognition, interpretation (comparison) and response	HBM(70)
Hendricson et al, 1996(44)	Asthma	Education sessions and materials (flip cards with illustrations, videotape, pamphlet)	Recognition and response (role modelling)	SLT(73), SCT(74)
Brandt et al, 2013(63)	COPD	Education sessions	Recognition, interpretation (comparison) and response	Collaborative Model for Self-Management of Chronic Disease(75)
Cardiovascular diseases				
Davis et al, 2019(45)	ACS	Education sessions and materials (pamphlet and pocket card)	Recognition, interpretation (comparison) and response	Nil
Raczynski et al, 1999(64)	AMI	Education sessions and materials (flyers/brochures, posters, magnets and other “tokens”; video)	Recognition and response (role modelling)	SCT(76), SRT(77), CO(78), DIT(79), SMT(80)
Jurgens et al, 2013(46)	HF	Education sessions and materials (booklet)	Detection, interpretation (comparison) and response	Theory of HF Self-Care(81), TUS(28, 82), UIT(83-86), SRT(72)
Other health conditions				
Hunt et al, 2015(56)	Concussion	Education materials (video)	Detection, interpretation (comparison) and response	Nil
Bonovich et al, 1990(57)	Labor	Education sessions and materials	Detection, interpretation (comparison) and response	Flanders’ Analyzing Teaching Behavior(87), Redman’s Principles of Patient Education(88)
Eriksen et al, 2010(47)	Malaria	Education sessions	Detection, interpretation and response (role modelling)	Nil
Matin et al, 2020(48)	Neonatal illness	Education apps/devices (audio, images of danger signs)	Detection, interpretation (comparison) and response	Nil
Ziadé et al, 2021(58)	RA	Education materials (video)	Detection (demonstration)	Nil

ACS: Acute Coronary Syndrome; AMI: Acute Myocardial Infarction; BCLE: LymphEdema secondary to Breast Cancer Treatment; CO: Community Organization Theory; COPD: Chronic Obstructive Pulmonary Disease; DIT: Diffusion of Innovation Theory; HBM: Health Belief Model; HF: Heart Failure; MSM: Model of Symptom Management; Nil: no theories/models were adopted; PRECEDE: Predisposing, Reinforcing, and Enabling Causes in Educational Diagnosis and Evaluation; RA: Rheumatoid Arthritis; SCT: Social Cognitive Theory; SLT: Social Learning Theory; SMT: Social Marketing Theory; SRT: Self-Regulation Theory; TPB: Theory of Planned Behavior; TUS: Theory of Unpleasant Symptoms; UIT: Uncertainty in Illness Theory.

Characteristics of Approaches Included in the Synthesis

Of the 29 studies included in the synthesis, 16 focused on cancer(36-42, 49-54, 59-61), 5 on respiratory diseases(43, 44, 55, 62, 63), 3 on cardiovascular diseases(45, 46, 64), and one each on other health conditions including concussion(56), labor(57), malaria(47), neonatal illness(48) and RA(58). Six were community-based studies engaging various parties (e.g., educators and women leaders) in the communities and employing different outreach efforts (e.g., flyers and radio advertisement)(37, 39, 47, 52, 61, 64), among which 2 involved training of both laypersons and health providers(47, 64). Five studies reported only the development of approaches(59, 60, 62-64), while the remaining 24 reported both the development and evaluation of approaches using quantitative and/or qualitative measures (Supplementary File 3)(36-58, 61).

The most common type of approaches was a combination of education sessions and education materials (n = 15), followed by education sessions alone (n = 8), education materials alone (n = 5), and education applications/devices (n = 1) (Table 2). The majority (n = 18) of these approaches utilized both text and audio visual aids or multimedia to describe and illustrate symptoms/signs. All approaches comprised provision of knowledge of target symptoms/sign, 14 comprised demonstration and/or hands-on practice of symptom self-examination, 12 comprised comparison or target symptoms/signs with symptoms/signs of other health conditions, and 3 comprised other components such as role modelling of the detection, interpretation and response to target symptoms/signs.

Table 2. Characteristics of approaches developed for various health conditions

	Cancer (n = 16)	**Respiratory diseases (n = 5)**	**Cardiovascular diseases (n = 3)**	**Other health conditions * (n = 5)**	**Total (n = 29)**
Type of approaches, n (%)					
Education sessions	4 (25.0)	3 (60.0)	0 (0.0)	1 (20.0)	8 (27.6)
Education materials	3 (18.8)	0 (0.0)	0 (0.0)	2 (40.0)	5 (17.2)
Education sessions and education materials	9 (56.3)	2 (40.0)	3 (100.0)	1 (20.0)	15 (51.7)
Education apps/devices	0 (0.0)	0 (0.0)	0 (0.0)	1 (20.0)	1 (3.5)
Format of approaches, n (%)					
Text	4 (25.0)	3 (60.0)	2 (66.7)	2 (40.0)	11 (37.9)
Audio visual aids	11 (68.8)	2 (40.0)	1 (33.3)	3 (60.0)	17 (58.6)
Multimedia	1 (6.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.5)
Components of approaches, n (%)					
Knowledge of symptoms/signs	16 (100.0)	5 (100.0)	3 (100.0)	5 (100.0)	29 (100.0)
Demonstration and/or hands-on practice of symptom self-examination	13 (81,3)	0 (0.0)	0 (0.0)	1 (20.0)	14 (48.3)
Symptom comparison	3 (18.8)	4 (80.0)	2 (66.7)	3 (60.0)	12 (41.4)
Other components: role modelling	0 (0.0)	1 (20.0)	1 (33.3)	1 (20.0)	3 (10.3)

Underlying theories/models adopted in the development of approaches, n (%)					
No	11 (68.8)	1 (20.0)	1 (33.3)	4 (80.0)	17 (58.6)
Yes	5 (31.3)	4 (80.0)	2 (66.7)	1 (20.0)	12 (41.4)

*Other health conditions included concussion (n = 1), labor (n = 1), malaria (n = 1), neonatal illness (n = 1), and rheumatoid arthritis (n = 1).

Theories/ Models Adopted in the Development of Approaches

Despite the apparent similarity of components in the approaches, less than half (n = 12) were developed based on theories/models and a variety of theories/models were adopted in the development of these approaches (Table 2). The adopted theories/models could be grouped into four categories:

1) Health behavior theories/models, including Predisposing, Reinforcing, and Enabling Causes in Educational Diagnosis and Evaluation (PRECEDE) Model(65), Theory of Planned Behavior (TPB)(67), Social Cognitive Theory (SCT)(69, 74, 76), Health Belief Model (HBM)(70), Community Organization (CO)(78), Diffusion of Innovations Theory (DIT)(79), and Social Marketing Theory (SMT)(80);
2) Symptom appraisal theories/models, including Self-Regulation Theory (SRT)(18, 66, 72, 77), Model of Symptom Management (MSM)(22), and Theory of Unpleasant Symptoms (TUS)(28, 82);
3) Educational theories/models, including Social Learning Theory (SLT)(73), Flanders' Analyzing Teaching Behavior(87), and Redman's Principles of Patient Education(88);
4) Other theories/models, including Implementation Intentions(68), Orem's Self Care Nursing Model(71), Collaborative Model for Self-Management of Chronic Disease(75), Theory of Heart Failure Self-Care(81), and Uncertainty in Illness Theory (UIT)(83-86).

The most common theories/models underlying the approaches were SCT and SRT, adopted in 4 studies each(42, 44, 46, 60, 64), among which 3 studies adopted both SCT and SRT(42, 60, 64). The second most common theory/model was HBM, adopted in 2 studies(49, 62). The remaining theories/models were adopted in only 1 study(36, 44, 46, 52, 55, 57, 60, 63, 64).

Evaluation of the Developed Approaches

Evaluation of the developed approaches focused primarily on their effectiveness in the majority of these studies(36-43, 45-58), while the reach, adoption and implementation of these approaches were evaluated in 5 studies(39, 44, 45, 48, 61), based on the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework(89). The outcome measures included the following:

- Knowledge, attitudes and beliefs about the given health conditions and symptoms/signs (n = 11)(36, 39, 42, 43, 45, 46, 48, 49, 51, 55, 56);
- Skills, attitudes and practice of symptom self-examination via self-reporting (n = 8)(36-39, 42, 49-51), observation by examiners (n = 3)(48, 52, 53), or qualitative interview (n = 1)(58);
- Accuracy comparison of target symptoms/signs and those of other health conditions (n = 4)(40, 41, 54, 57);
- Confidence and delay in help-seeking (n = 3)(42, 46, 48);
- Severity of health conditions (n = 3)(43, 46, 47);
- Satisfaction of educators (n = 1)(39) and satisfaction of patients and caregivers via self-reporting (n = 2)(44, 45) or qualitative interview (n = 1)(48);
- Implementation of approaches such as reviewing of education materials and appointment-making for clinical screening services (n = 2)(44, 61).

Discussion

In this study, we reviewed existing approaches to improving symptom appraisal in the literature. Provision of symptom knowledge, self-examination and comparison as well as demonstration/illustration of symptom appraisal using role modelling were common approaches

identified from the literature search. We found significant heterogeneity in whether theories/models were employed and the choice of theories/models employed in the development of these approaches. Only a small number of studies involving provision of both knowledge of symptoms/signs and other approaches were found in the literature search, highlighting the need for such studies with the goal of improving symptom appraisal and reducing pre-diagnosis interval among individuals in the general population.

Approaches that were developed in the vast majority (81.9%) of studies identified from the literature search comprised only provision of knowledge of symptoms/signs of a given health condition. While knowledge acquisition is a precondition for performing symptom appraisal (a given behavior), knowledge alone does not lead to the desired behavior (symptom appraisal)(35). For example, in the literature review by Teuschl et al, a discrepancy was observed between the theoretical knowledge of and response to stroke symptoms, with only one-quarter to one-half of the patients who had been educated on stroke signs recognized their symptoms as stroke and in turn responding promptly(90). As such, only approaches comprising both provision of the required knowledge and skills and additional components to enable personal, behavioral and environmental factors for symptom appraisal were included in the synthesis.

Theories and models present a systematic way of understanding complex issues (including symptom appraisal) by specifying the interrelationships among associated factors, which could provide a holistic framework for developing, implementing and evaluating interventions to address such issues(91). In addition to symptom appraisal theories/models, health behavior theories/models were also commonly adopted in the development of approaches identified in the literature. Depending on the given health problem and its social context, health behavior theories/models at different levels could be adopted(91). Since all of the three main constructs of symptom appraisal (i.e., detection, interpretation and response to symptoms) are influenced by social environment such as access to health resources(92, 93), health behavior theories/models at interpersonal level (SCT) would be more appropriate for use in the context of symptom appraisal and was thus adopted more frequently compared to theories/models at individual/intrapersonal (e.g., HBM and TPB) or community level (e.g., CO and DIT)(67, 69, 70, 73, 74, 76, 78, 79). Health behavior theories/models at interpersonal level provide the psychosocial mechanisms through which personal cognitive, behavioral and environmental factors interactively influence a given behavior, while theories/models at individual/intrapersonal level do not address the environment that the person and behavior interact in and theories/models at community level focus more on the engagement of communities(67, 69, 70, 73, 74, 76, 78, 79). Multiple theories and models that complement each other are often adopted to guide the development of different components of a given approach. This was seen in half of the studies in which theories/models were adopted(42, 44, 46, 57, 60, 64). Of note, health behavior and symptom appraisal theories/models were adopted together in 3 of the 4 studies where they were used(42, 60, 64).

Building on these studies, we propose an integrated conceptual framework from the major concepts of SCT (*reciprocal determinism, behavioral capacity, expectations, self-efficacy, observational learning* and *reinforcements*) and main constructs of symptom appraisal (Figure 2), in which approaches were proposed based on SCT to improve symptom appraisal(11, 69, 74). *Reciprocal determinism*, the reciprocal interaction of person, environment and behavior, highlights the importance of a multi-pronged approach to enhance not only a given behavior (*behavioral capability* and *reinforcements*) but also its associated personal (*self-efficacy* and *expectations*) and environmental (*observational learning* and social support) influences (Table 3). To enhance the *behavioral capacity* to perform symptom appraisal, one must possess the knowledge of the target symptoms/signs (eg through sight, touch, hearing and scent/smell) and the skills of how to detect, interpret and respond to the target symptoms/signs. This could be achieved through provision of essential knowledge of target symptoms/signs (symptom knowledge), demonstration of symptom self-examination, illustration of differences between target symptom/signs and symptoms/signs of other health conditions (symptom comparison), and instruction on actions to take upon detection of target symptoms/signs (symptom response). *Expectations*, the anticipated consequences of symptom appraisal, could be enhanced by demonstration of positive outcomes of symptom appraisal, or more specifically, prompt symptom detection and help-seeking. The positive outcomes of symptom appraisal could also work as *reinforcements* of symptom appraisal behavior. *Self-efficacy*, the confidence of performing symptom appraisal, could be increased by adopting various formats such as text, photo and video to enhance the knowledge and skills (*behavioral capacity*) required for symptom

appraisal and by demonstrating symptom appraisal, namely symptom self-examination, comparison and response using role models, the latter could enhance symptom appraisal through *observational learning*.

Table 3. Proposed approaches to improving symptom appraisal

Concepts of the Social Cognitive Theory	Definition of the concepts	Approaches to improving symptom appraisal in screening tools
Reciprocal determinism	Dynamic and reciprocal interaction of person, environment and behavior	• Provision of knowledge and skills (person and behavior) and supportive environment required for symptom appraisal, e.g., social support
Behavioral capacity	Ability (knowledge and skills) to perform a behavior	• Provision of symptom knowledge (sight and touch etc) • Demonstration of symptom self-examination (sight and touch etc) • Illustration of symptom comparison: differences between target symptoms/signs and symptoms/signs of other conditions (sight and touch etc) • Instructions on symptom response, namely actions to take upon symptom detection
Expectations	Anticipated consequences of a behavior	• Demonstration of positive outcomes of prompt symptom detection and help-seeking
Self-efficacy	Confidence in one's ability to perform a behavior	• Adoption of various formats such as text, photo and video to enhance symptom knowledge, self-examination, comparison, and response • Demonstration of symptom self-examination, comparison and response using role models
Observational learning	Learning through observation e.g., modelling of behaviors	• Demonstration of symptom self-examination, comparison and response using role models
Reinforcements	Responses to a behavior that affect the likelihood of reoccurrence	• Demonstration of positive outcomes of prompt symptom detection and help-seeking

The proposed framework and approaches could be incorporated into the development of self-administered screening tools (Supplementary File 4), which are cost-effective in facilitating early disease identification in the general population(94). Many existing screening tools, however, might be too challenging for individuals with lower health literacy to answer as they often assess only the presence of target symptoms/signs of a given health condition without any explanations of what target symptoms/signs are and how these might look, feel etc. While providing a description/explanation of target symptoms/signs could, to some extent, aid comprehension and improve the accuracy of self-reporting on screening tools, many symptoms/signs cannot be easily explained using text and would require illustrations such as photos and videos. For example, the three phases of color changes in Raynaud's phenomenon (RP), a common symptom seen among patients with ARDs, could be illustrated more clearly in the form of video instead of text. Such illustrations could prompt symptomatic individuals to notice the deviations from normality and enhance symptom appraisal by providing the context for interpretation, extra-lingual information, clarifying examples and redundancy to aid comprehension of the text(95). In the literature review by Levie et al, increased understanding was observed in 98% of the experiments using different illustrations(96). Furthermore, other approaches such as demonstration of symptom self-examination and response using role models could be better illustrated using photos and videos.

There are three main limitations in this study. First, only free-text search was conducted in Web of Science and Scopus due to a lack of controlled vocabularies in these two databases. However, in consultation with a medical librarian with expertise in literature searches, a list of comprehensive free-text search terms were developed based on a preliminary literature search and both controlled vocabulary search and free-text search were used in other databases (Medline, PsycInfo, Embase and CINAHL), which would be sufficient to identify most of the important articles in the literature. Second, five reports identified in the literature search were unable to be retrieved, which might contain theories/models and approaches that differ from those reviewed in this study. However, based on their title and abstract, these reports comprise mainly self-examination of symptoms/signs of breast, skin and testicular cancer and macular degeneration, and similar approaches had been included in our review and synthesis. Finally, the proposed framework is conceptual and requires empirical data to support it. Qualitative interviews with patients with ARDs are planned in our future work to further validate the framework by understanding the experience of symptom appraisal and approaches that could help the patients detect, interpret and take prompt actions in response to symptoms/signs. A screening tool comprising approaches to improving symptom appraisal will then be developed. Furthermore, the proposed framework and approaches target mainly knowledge, skills, attitudes and beliefs about symptom appraisal (behavior) among symptomatic individuals (person). The environment with which person and behavior interact such as cultural beliefs, social support, healthcare system and healthcare professionals also plays an important role in promoting or inhibiting symptom appraisal among these individuals. These environmental factors, however, could not be easily incorporated into screening tools but rather into large-scale public health screening programmes, which is a potential focus for our future work.

Conclusion

Symptom appraisal is an essential process in a patient's journey that can be targeted to facilitate early diagnosis but is largely unstudied. Building on the literature, we propose a theoretical framework and approaches to improving symptom appraisal. This could facilitate early identification of a variety of health conditions in the general population.

Funding

This work was supported by the SingHealth Duke-NUS Academic Medicine Research Grant (grant reference: AM/HSR015/2021) and Goh Cheng Liang Rheumatology ARISE (Advancing Research and Innovation with Synergistic Expertise) Programme Fund (funding reference: N/A). The funders had no role in the design of the study and collection, analysis, and interpretation of data and in writing of this manuscript.

Acknowledgements

We would like to thank Ms Suei-Nee Wong, a senior librarian in the medical library of the National University Singapore, for her assistance in the development of literature search strategy.

Author contributions

LX, AHLL, TCL, DRK and JT designed the search. LX conducted the search and narrative analysis. SY, AHLL, YYL, WF, TCL, DRK and JT contributed to the data interpretation and editing of the manuscript. LX drafted the manuscript. All authors read and approved the final manuscript.

Declarations of Interest

None

Data availability statement

All data relevant to the study are available on reasonable request to the corresponding author.

Research Ethics Approval

Not applicable.

Reference

1. Zhao SS, Pittam B, Harrison NL, Ahmed AE, Goodson NJ, Hughes DM. Diagnostic delay in axial spondyloarthritis: a systematic review and meta-analysis. Rheumatology. 2021;60(4):1620-8.
2. Lauritzen BB, Jensen JS, Gronhoj C, Wessel I, von Buchwald C. Impact of delay in diagnosis and treatment-initiation on disease stage and survival in oral cavity cancer: a systematic review. Acta Oncologica. 2021;60(9):1083-90.
3. Qu LG, Brand NR, Chao A, Ilbawi AM. Interventions Addressing Barriers to Delayed Cancer Diagnosis in Low- and Middle-Income Countries: A Systematic Review. Oncologist. 2020;25(9):e1382-e95.
4. Bello S, Afolabi RF, Ajayi DT, Sharma T, Owoeye DO, Oduyoye O, et al. Empirical evidence of delays in diagnosis and treatment of pulmonary tuberculosis: systematic review and meta-regression analysis. BMC Public Health. 2019;19(1):820.
5. Prior JA, Ranjbar H, Belcher J, Mackie SL, Helliwell T, Liddle J, et al. Diagnostic delay for giant cell arteritis - a systematic review and meta-analysis. BMC Medicine. 2017;15(1):120.
6. Jovani V, Blasco-Blasco M, Ruiz-Cantero MT, Pascual E. Understanding How the Diagnostic Delay of Spondyloarthritis Differs Between Women and Men: A Systematic Review and Metaanalysis. Journal of Rheumatology. 2017;44(2):174-83.
7. Getnet F, Demissie M, Assefa N, Mengistie B, Worku A. Delay in diagnosis of pulmonary tuberculosis in low-and middle-income settings: systematic review and meta-analysis. BMC Pulmonary Medicine. 2017;17(1):202.
8. Brasme JF, Morfouace M, Grill J, Martinot A, Amalberti R, Bons-Letouzey C, et al. Delays in diagnosis of paediatric cancers: a systematic review and comparison with expert testimony in lawsuits. Lancet Oncology. 2012;13(10):e445-59.
9. Andersen BL, Cacioppo JT. Delay in seeking a cancer diagnosis: delay stages and psychophysiological comparison processes. Br J Soc Psychol. 1995;34 (Pt 1):33-52.
10. Barhamain AS, Magliah RF, Shaheen MH, Munassar SF, Falemban AM, Alshareef MM, et al. The journey of rheumatoid arthritis patients: a review of reported lag times from the onset of symptoms. Open Access Rheumatol. 2017;9:139-50.
11. Whitaker KL, Scott SE, Wardle J. Applying symptom appraisal models to understand sociodemographic differences in responses to possible cancer symptoms: a research agenda. British Journal of Cancer. 2015;112(1):S27-S34.
12. Robbins JM, Kirmayer LJ. Attributions of common somatic symptoms. Psychol Med. 1991;21(4):1029-45.
13. Simons G, Mason A, Falahee M, Kumar K, Mallen CD, Raza K, et al. Qualitative Exploration of Illness Perceptions of Rheumatoid Arthritis in the General Public. Musculoskeletal Care. 2017;15(1):13-22.
14. Stack RJ, Shaw K, Mallen C, Herron-Marx S, Horne R, Raza K. Delays in help seeking at the onset of the symptoms of rheumatoid arthritis: a systematic synthesis of qualitative literature. Ann Rheum Dis. 2012;71(4):493-7.
15. Xiang L, Low AHL, Leung YY, Fong W, Gandhi M, Yoon S, et al. Interval between symptom onset and diagnosis among patients with autoimmune rheumatic diseases in a multi-ethnic Asian population. Int J Rheum Dis. 2021;24(8):1061-70.
16. Petrova D, Okan Y, Salamanca-Fernandez E, Dominguez-Lopez S, Sanchez MJ, Rodriguez-Barranco M. Psychological factors related to time to help-seeking for cancer symptoms: a meta-analysis across cancer sites. Health psychol. 2020;14(2):245-68.
17. Macdonald S, Macleod U, Campbell NC, Weller D, Mitchell E. Systematic review of factors influencing patient and practitioner delay in diagnosis of upper gastrointestinal cancer. British Journal of Cancer. 2006;94(9):1272-80.
18. Leventhal H, Meyer D, Nerenz D. The common sense representation of illness danger. In: Rachman S, editor. Contributions to Medical Psychology: Pergamon Press; 1980. p. 7-30.
19. Leventhal H, Benyamini Y, Brownlee S, Diefenbach M, Leventhal EA, Patrick-Miller L, et al. Illness Representations: Theoretical Foundations. In: Petrie KJ, Weinman J, editors. Perceptions of Health and Illness: Current Research and Applications: Harwood Academic Publishers; 1997.
20. Sorofman B, Tripp-Reimer T, Lauer GM, Martin ME. Symptom self-care. Holist Nurs Pract. 1990;4(2):45-55.
21. Cioffi D. Beyond attentional strategies: cognitive-perceptual model of somatic interpretation. Psychol Bull. 1991;109(1):25-41.
22. The University of California San Francisco School of Nursing Symptom Management Faculty Group. A model for symptom management. . Image J Nurs Sch. 1994;26(4):272-6.

23. Dodd M, Janson S, Facione N, Faucett J, Froelicher ES, Humphreys J, et al. Advancing the science of symptom management. J Adv Nurs. 2001;33(5):668-76.
24. Teel CS, Meek P, McNamara AM, Watson L. Perspectives unifying symptom interpretation. Image J Nurs Sch. 1997;29(2):175-81.
25. van Wijk CM, Kolk AM. Sex differences in physical symptoms: the contribution of symptom perception theory. Soc Sci Med. 1997;45(2):231-46.
26. Henly SJ, Kallas KD, Klatt CM, Swenson KK. The notion of time in symptom experiences. Nurs Res. 2003;52(6):410-7.
27. Petersen S, van den Berg RA, Janssens T, Van den Bergh O. Illness and symptom perception: a theoretical approach towards an integrative measurement model. Clin Psychol Rev. 2011;31(3):428-39.
28. Lenz ER, Pugh LC, Milligan RA, Gift A, Suppe F. The middle-range theory of unpleasant symptoms: an update. ANS Adv Nurs Sci. 1997;19(3):14-27.
29. Armstrong TS. Symptoms experience: a concept analysis. Oncol Nurs Forum. 2003;30(4):601-6.
30. Kolk AM, Hanewald GJ, Schagen S, Gijsbers van Wijk CM. A symptom perception approach to common physical symptoms. Soc Sci Med. 2003;57(12):2343-54.
31. Posey AD. Symptom Perception: A Concept Exploration. Nursing Forum. 2006;41(3):113-24.
32. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.
33. Tufanaru C, Munn Z, Aromataris E, Campbell J, Hopp L. Chapter 3: Systematic reviews of effectiveness. 2020. In: JBI Manual for Evidence Synthesis [Internet]. JBI. Available from: https://synthesismanual.jbi.global.
34. Lockwood C, Munn Z, Porritt K. Qualitative research synthesis: methodological guidance for systematic reviewers utilizing meta-aggregation. Int J Evid Based Healthc. 2015;13(3):179-87.
35. Bandura A. Health promotion by social cognitive means. Health Educ Behav. 2004;31(2):143-64.
36. Brailey LJ. Effects of health teaching in the workplace on women's knowledge, beliefs, and practices regarding breast self-examination. Research in Nursing & Health. 1986;9(3):223-31.
37. Sorensen J, Hertz A, Gudex C. Evaluation of a Danish teaching program in breast self-examination. Cancer Nursing. 2005;28(2):141-7.
38. Styrd AM. A breast self-examination program in an occupational health setting. Occup Health Nurs. 1982;30(4):33-5.
39. Luther SL, Sroka S, Goormastic M, Montie JE. Teaching breast and testicular self-exams: evaluation of a high school curriculum pilot project. Health Education. 1985;16(1):40-3.
40. Cornell E, Robertson K, McIntosh RD, Rees JL. Viewing Exemplars of Melanomas and Benign Mimics of Melanoma Modestly Improves Diagnostic Skills in Comparison with the ABCD Method and Other Image-based Methods for Lay Identification of Melanoma. Acta Dermato-Venereologica. 2015;95(6):681-5.
41. Robertson K, McIntosh RD, Bradley-Scott C, MacFarlane S, Rees JL. Image training, using random images of melanoma, performs as well as the ABC(D) criteria in enabling novices to distinguish between melanoma and mimics of melanoma. Acta Derm Venereol. 2014;94(3):265-70.
42. Scott SE, Khwaja M, Low EL, Weinman J, Grunfeld EA. A randomised controlled trial of a pilot intervention to encourage early presentation of oral cancer in high risk groups. Patient Education and Counseling. 2012;88(2):241-8.
43. Colland VT, van Essen-Zandvliet LE, Lans C, Denteneer A, Westers P, Brackel HJ. Poor adherence to self-medication instructions in children with asthma and their parents. Patient Education & Counseling. 2004;55(3):416-21.
44. Hendricson WD, Wood PR, Hidalgo HA, Ramirez AG, Kromer ME, Selva M, et al. Implementation of individualized patient education for Hispanic children with asthma. Patient Education & Counseling. 1996;29(2):155-65.
45. Davis LL, McCoy TP. An Educational and Skill-Building Intervention to Improve Symptom Recognition and Interpretation in Women With Acute Coronary Syndrome: A Pilot Study. Dccn. 2019;38(1):29-37.
46. Jurgens CY, Lee CS, Reitano JM, Riegel B. Heart failure symptom monitoring and response training. Heart & Lung. 2013;42(4):273-80.
47. Eriksen J, Mujinja P, Warsame M, Nsimba S, Kouyate B, Gustafsson LL, et al. Effectiveness of a community intervention on malaria in rural Tanzania - a randomised controlled trial. African Health Sciences. 2010;10(4):332-40.

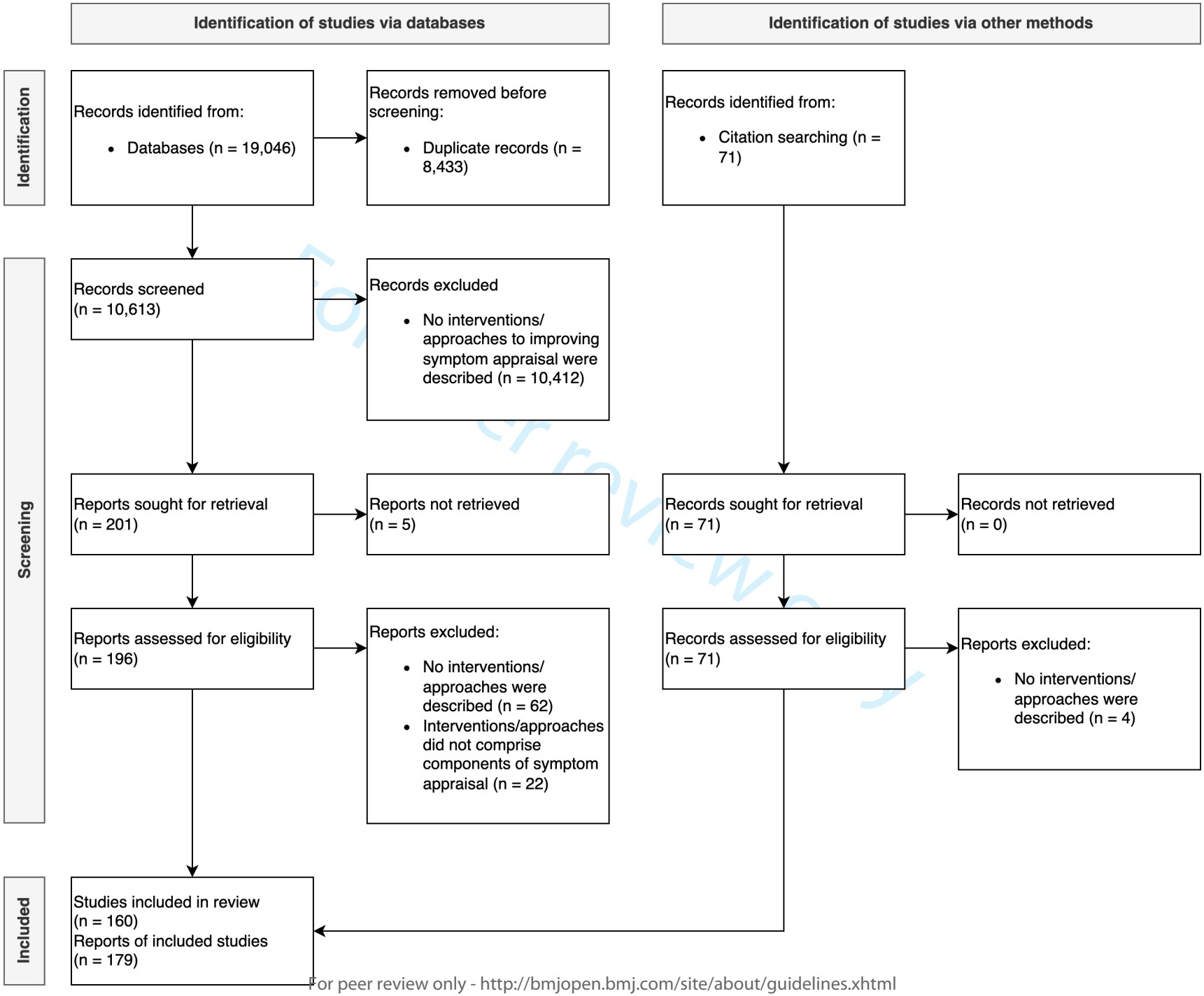
48. Matin SB, Wallingford A, Xu S, Ng N, Ho A, Vanosdoll M, et al. Feasibility of a mobile health tool for mothers to identify neonatal illness in rural Uganda: Acceptability study. JMIR mHealth and uHealth. 2020;8(2).
49. Craun AM, Deffenbacher JL. The effects of information, behavioral rehearsal, and prompting on breast self-exams. Journal of Behavioral Medicine. 1987;10(4):351-65.
50. Khokhar A. Short text messages (SMS) as a reminder system for making working women from Delhi Breast Aware. Asian Pac J Cancer Prev. 2009;10(2):319-22.
51. McLendon MS, Fulk CH, Starnes DC. Effectiveness of breast self-examination teaching to women of low socioeconomic class. JOGN Nurs. 1982;11(1):7-10.
52. Shepherd JH, McLnerney PA. Knowledge of breast self-examination in women in Sierra Leone. Curationis. 2007;30(4):38-44.
53. Stratton BF, Nicholson ME, Olsen LK, Mahoney BS, Warland RH. Breast self-examination proficiency: Attitudinal, demographic, and behavioral characteristics. Journal of Women's Health. 1994;3(3):185-95.
54. Brooks A, Predebon J, van der Zwan R. Perceptual strategies to improve skin cancer discriminations in naive observers. Public Health. 2001;115(2):139-45.
55. Butz AM, Syron L, Johnson B, Spaulding J, Walker M, Bollinger ME. Home-based asthma self-management education for inner city children. Public Health Nurs. 2005;22(3):189-99.
56. Hunt TN. Video Educational Intervention Improves Reporting of Concussion and Symptom Recognition. Athletic Training Education Journal (Allen Press Publishing Services Inc). 2015;10(1):65-74.
57. Bonovich L. Recognizing the onset of labor. J Obstet Gynecol Neonatal Nurs. 1990;19(2):141-5.
58. Ziadé N, Saad S, Al Mashaleh M, El Kibbi L, Elzorkany B, Badsha H, et al. Perceptions of patients with rheumatoid arthritis about self-assessment of disease activity after watching an educational video: a qualitative pilot study from the AUTO-DAS in Middle Eastern Arab countries project. Rheumatology International. 2021.
59. Dine JL, Austin MKS, Armer JM. Nursing education on lymphedema self-management and self-monitoring in a South African oncology clinic. Journal of Cultural Diversity. 2011;18(4):126-8.
60. Burgess CC, Bish AM, Hunter HS, Salkovskis P, Michell M, Whelehan P, et al. Promoting early presentation of breast cancer: development of a psycho-educational intervention. Chronic Illn. 2008;4(1):13-27.
61. Byrne S, Robles-Rodriguez E. Educational parties as a strategy to promote breast health awareness and screening in underserved female populations. Oncology nursing forum. 2009;36(2):145-8.
62. Gardner LE. Advanced Practitioner Provided Pre-Hospital Discharge Asthma Education: Walden University; 2016.
63. Brandt CL. Study of older adults' use of self-regulation for COPD self-management informs an evidence-based patient teaching plan. Rehabilitation nursing : the official journal of the Association of Rehabilitation Nurses. 2013;38(1):11-23.
64. Raczynski JM, Finnegan JR, Jr., Zapka JG, Meischke H, Meshack A, Stone EJ, et al. REACT theory-based intervention to reduce treatment-seeking delay for acute myocardial infarction. Rapid Early Action for Coronary Treatment. Am J Prev Med. 1999;16(4):325-34.
65. Green LW, Kreuter MW, Deeds S, Partridge K. Health Education Planning: A Diagnostic Approach: Mayfield Publishing Company; 1980.
66. Leventhal H, Nerenz D, Steele D. Illness representations and coping with health threats. In: A. Baum, SE Taylor, Singer J, editors. Handbook of psychology and health: social psychological aspects of health1984. p. 219-52.
67. Ajzen I. The theory of planned behavior. Organizational Behavior and Human Decision Processes. 1991;50(2):179-211.
68. Gollwitzer PM. Goal Achievement: The Role of Intentions. European Review of Social Psychology. 1993;4(1):141-85.
69. Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. Psychol Rev. 1977;84(2):191-215.
70. Rosenstock IM. Historical Origins of the Health Belief Model. Health Education Monographs. 1974;2(4):328-35.
71. Orem DE. Nursing: Concepts of Practice: McGraw-Hill; 1980.
72. Cameron LD, Leventhal H. The self-regulation of health and illness behaviour. New York, NY, US: Routledge; 2003.

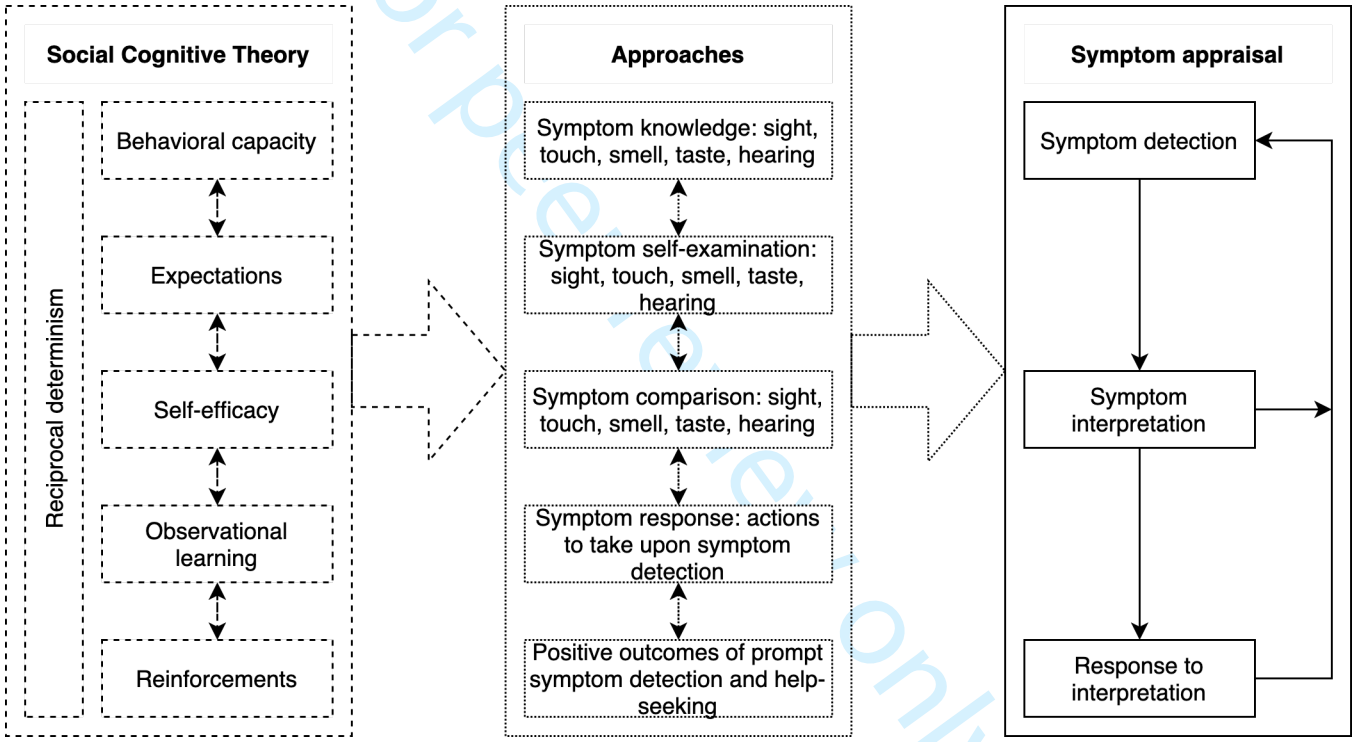
73. Parcel GS, Baranowski T. Social learning theory and health education. Health Educ. 1981;12(3):14-8.
74. Bandura A. Social foundations of thought and action: A social cognitive theory: Prentice-Hall, Inc; 1986.
75. Brandt CL. Description of the Self-regulation Process Used by Persons with Chronic Lung Disease and Its Relationship to Health-related Outcomes: University of Minnesota; 2005.
76. Perry CL, Baranowski T, Parcel GS. How individuals, environments, and health behavior interact: Social Cognitive Theory. In: Glanz K, Lewis FM, Rimer BK, editors. Health behavior and health education: Theory, research, and practice. San Francisco, CA: Jossey-Bass; 1990.
77. Cameron L, Leventhal EA, Leventhal H. Emotional and behavioral processes. In: Johnston M, Wallace L, editors. Stress and Medical Procedures: New York, NY: Pergamon; 1993. p. 7-30.
78. Bracht N. Health promotion at the community level. Thousand Oaks, CA, US: Sage Publications, Inc; 1990.
79. Rogers EM. Diffusion of innovations. New York; London: Free Press ; Collier Macmillan; 1983.
80. Novelli W. Applying social marketing to health promotion and disease prevention. In: Glanz K, Lewis FM, Rimer BK, editors. Health behavior and health education: theory, research and practice. San Francisco, CA: Jossey-Bass; 1990.
81. Riegel B, Dickson VV. A situation-specific theory of heart failure self-care. J Cardiovasc Nurs. 2008;23(3):190-6.
82. Lenz ER, Suppe F, Gift AG, Pugh LC, Milligan RA. Collaborative development of middle-range nursing theories: toward a theory of unpleasant symptoms. ANS Adv Nurs Sci. 1995;17(3):1-13.
83. Mishel MH. The measurement of uncertainty in illness. Nurs Res. 1981;30(5):258-63.
84. Mishel MH. Perceived uncertainty and stress in illness. Res Nurs Health. 1984;7(3):163-71.
85. Mishel MH. Uncertainty in illness. Image J Nurs Sch. 1988;20(4):225-32.
86. Mishel MH. Reconceptualization of the uncertainty in illness theory. Image J Nurs Sch. 1990;22(4):256-62.
87. Flanders NA. Analyzing teaching behavior. Reading, Mass.: Addison-Wesley Pub. Co.; 1970.
88. Redman BK. The Process of Patient Education: C.V. Mosby; 1984.
89. Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. Am J Public Health. 1999;89(9):1322-7.
90. Teuschl Y, Brainin M. Stroke education: discrepancies among factors influencing prehospital delay and stroke knowledge. International Journal of Stroke. 2010;5(3):187-208.
91. Glanz K, Rimer BK, Viswanath K. Health Behavior: Theory, Research, and Practice: Wiley; 2015.
92. Dingwall R. Aspects of Illness: Ashgate; 2001.
93. Alonzo AA. Everyday illness behavior: a situational approach to health status deviations. Soc Sci Med. 1979;13a(4):397-404.
94. Villeneuve E, Nam JL, Bell MJ, Deighton CM, Felson DT, Hazes JM, et al. A systematic literature review of strategies promoting early referral and reducing delays in the diagnosis and management of inflammatory arthritis. Ann Rheum Dis. 2013;72(1):13-22.
95. Murray J, Williams B. The Role of Images on Illness Behaviour: Interdisciplinary Theory, Evidence, and Ideas. Psychological Reports. 2020;0(0):0033294120945602.
96. Levie WH, Lentz R. Effects of Text Illustrations: A Review of Research. Educational Communication and Technology. 1982;30(4):195-232.

Figure legend/caption

Figure 1. PRISMA chart.

Figure 2. Proposed framework for improving symptom appraisal. Dashed boxes and arrows: concepts from Bandura's Social Cognitive Theory, dotted boxes and arrows: approaches to improving knowledge, skills, attitudes and beliefs about symptom appraisal using various formats including text, photos and videos, solid boxes and arrows: constructs from Whitaker's synthesis of symptom appraisal models. The up down arrows denote interacting relationship between different components.





Supplementary File 1. Development of literature search strategy

This literature review aims to identify approaches to improving symptom appraisal in the literature. We first performed a preliminary search in Medline using free-text terms for the two key concepts: symptom and appraisal, based on which we developed definitions of symptom and symptom appraisal and refined our search concepts and terms.

Various definitions of the term "symptom" have been proposed and adopted in the literature. Common features in different definitions are that a symptom is an indicator of bodily change/deviation from normality and that a symptom is a subjective perception of an individual(1-3). Based on these common features, we defined symptom as a subjective health state that departs from bodily normality, which may or may not be attributed as a manifestation of illness by an individual. This is based on the consideration that our focus starts from the onset of a bodily change/somatic information, regardless of whether it is detected, perceived or acted on by an individual.

Several concepts pertaining to symptom appraisal exist in the literature including illness representation(4, 5), symptom response(6), symptom attribution(7), symptom experience(3, 8-11), symptom interpretation(1), and symptom perception(2, 12, 13). In the synthesis of relevant concepts by Posey et al, symptom perception was defined as the belief about what a symptom means (cognitively and emotionally), appraisal of the symptom based on past and present knowledge and experience, and response or action based upon the meaning and appraisal of the symptom(14). In a more recent work synthesizing various symptom appraisal theories and models by Whitaker et al, symptom appraisal was defined as encompassing three main constructs: detection of a bodily change, interpretation of the bodily change and response to interpretation(15), the latter two coincide with the definition of symptom perception by Posey et al. We adopted the definition of symptom appraisal proposed by Whitaker et al for two reasons: first, it has a relatively broader meaning and second, it fits well with our study focus, namely the process starting before the detection of a bodily change to the point of decision making on whether or not to take action on the bodily change. We included the three main constructs (detection, interpretation and response) as well as other relevant concepts of symptom appraisal in the search terms (Table 1).

Our final search strategy contains three concepts: 1) symptom, 2) appraisal and 3) patient education. The concept of patient education was added in the search based on the consideration that our focus was approaches that had been developed to improve symptom appraisal among symptomatic patients instead of other populations such as healthcare professionals. Since there are no appropriate MeSH terms for the concept of appraisal, we adopted the MeSH terms for the combined concept of symptom appraisal, in consultation with a senior librarian with experience in medical literature search strategies. After Mesh Terms were selected, their corresponding controlled vocabularies in PsycInfo, Embase and Cumulative Index to Nursing and Allied Health Literature (CINAHL) were identified. We combined controlled vocabulary search in all fields and free-text search with proximity operators in title and abstract fields in Medline, PsycInfo and CINAHL. We performed a free-text search with proximity operators in title and abstract fields in Web of Science and Scopus where controlled vocabularies are not available.

Table 1. Literature search strategy

	Free-text terms	Controlled vocabularies					
		Medline	PsycInfo†	Embase‡	CINAHL	Web of Science	Scopus
Concept: symptom	symptom* OR somatic OR illness*	Diagnostic Self Evaluation OR Self Care	Self-Evaluation OR Self-Care	self evaluation OR self care agency OR self help	Self Assessment OR Self Care Agency OR Self-Management	-	-
Concept: appraisal	apprais* OR detect* OR recogni* OR						

	perce* OR interpret* OR attribut* OR respon* OR behav* OR experienc* OR report*						
Concept: patient education	educat* OR teach* OR instruct* OR train* OR learn*	Health Education	Health Education	health education	Health Education	-	-
Searching fields	Title and abstract	-	-	-	-	-	-
Proximity operators	-	adj5	adj5	NEAR/5	N5	NEAR/5	W/5

References

1. Teel CS, Meek P, McNamara AM, Watson L. Perspectives unifying symptom interpretation. Image J Nurs Sch. 1997;29(2):175-81.
2. van Wijk CM, Kolk AM. Sex differences in physical symptoms: the contribution of symptom perception theory. Soc Sci Med. 1997;45(2):231-46.
3. Dodd M, Janson S, Facione N, Faucett J, Froelicher ES, Humphreys J, et al. Advancing the science of symptom management. J Adv Nurs. 2001;33(5):668-76.
4. Leventhal H, Meyer D, Nerenz D. The common sense representation of illness danger. In: Rachman S, editor. Contributions to Medical Psychology: Pergamon Press; 1980. p. 7-30.
5. Leventhal H, Benyamini Y, Brownlee S, Diefenbach M, Leventhal EA, Patrick-Miller L, et al. Illness Representations: Theoretical Foundations. In: Petrie KJ, Weinman J, editors. Perceptions of Health and Illness: Current Research and Applications: Harwood Academic Publishers; 1997.
6. Sorofman B, Tripp-Reimer T, Lauer GM, Martin ME. Symptom self-care. Holist Nurs Pract. 1990;4(2):45-55.
7. Robbins JM, Kirmayer LJ. Attributions of common somatic symptoms. Psychol Med. 1991;21(4):1029-45.
8. The University of California San Francisco School of Nursing Symptom Management Faculty Group. A model for symptom management. . Image J Nurs Sch. 1994;26(4):272-6.
9. Lenz ER, Pugh LC, Milligan RA, Gift A, Suppe F. The middle-range theory of unpleasant symptoms: an update. ANS Adv Nurs Sci. 1997;19(3):14-27.
10. Armstrong TS. Symptoms experience: a concept analysis. Oncol Nurs Forum. 2003;30(4):601-6.
11. Henly SJ, Kallas KD, Klatt CM, Swenson KK. The notion of time in symptom experiences. Nurs Res. 2003;52(6):410-7.
12. Kolk AM, Hanewald GJ, Schagen S, Gijsbers van Wijk CM. A symptom perception approach to common physical symptoms. Soc Sci Med. 2003;57(12):2343-54.
13. Petersen S, van den Berg RA, Janssens T, Van den Bergh O. Illness and symptom perception: a theoretical approach towards an integrative measurement model. Clin Psychol Rev. 2011;31(3):428-39.
14. Posey AD. Symptom Perception: A Concept Exploration. Nursing Forum. 2006;41(3):113-24.
15. Whitaker KL, Scott SE, Wardle J. Applying symptom appraisal models to understand sociodemographic differences in responses to possible cancer symptoms: a research agenda. British Journal of Cancer. 2015;112(1):S27-S34.

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Page 4
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 3
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Supplementary File 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Pages 3-4
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Page 4
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Page 4
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 4
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 4
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	NA
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Page 4
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Page 4
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Page 4
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page 4
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	NA
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	NA
Certainty	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	NA

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
assessment			
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Page 4, Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	NA
Study characteristics	17	Cite each included study and present its characteristics.	Pages 14-15, Supplementary File 3
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Page 4
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	NA
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	NA
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Pages 4-5
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	NA
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	NA
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Pages 6-7
	23b	Discuss any limitations of the evidence included in the review.	NA
	23c	Discuss any limitations of the review processes used.	Page 7
	23d	Discuss implications of the results for practice, policy, and future research.	Pages 6-7, Supplementary File 4
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 3
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 3
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Page 8
Competing interests	26	Declare any competing interests of review authors.	Page 8
Availability of data, code and	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	NA

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
other materials			

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

Supplementary File 3. Characteristics of studies included in the synthesis

Study	Health conditions and symptoms	Study aims/design	Study population	Type and format of approaches	Constructs of symptom appraisal addressed	Summary of approaches or its component pertaining to symptom appraisal	Underlying theories/models	Evaluation of approaches
Cancer								
Dine et al, 2011(1)	BCLE	To describe a low-cost BCLE self-monitoring technique using case study analysis: interview with a key informant who initiated the program	Women affected by BCLE	Education sessions	Symptom detection (demonstration) and response	Education on comparison of a pre-cancer treatment (baseline) limb assessment to ongoing post-cancer treatment limb assessments • Demonstration of circumferential measurement • Utilization of tracing to assist in identifying anatomical landmarks for circumferential measurement • Observing for skin changes in case of potentially life-threatening infection	Nil	NA
Brailey et al, 1986(2)	Breast cancer	A quasiexperimental study to examine the effects of two health education intervention (group vs individual teaching) on health knowledge, beliefs, skill, and confidence in	Women employees from one business firm	Education sessions and materials (film, pamphlet)	Symptom detection (demonstration and hands-on practice)	Group teaching: • Introduction, film and discussion on breast cancer and BSE • Demonstration and hands-on practice of BSE • Education material on BSE Individual teaching: • Introduction and discussion on breast cancer and BSE • Demonstration and hands-on practice of BSE • Education material on BSE	Predisposing, Reinforcing, and Enabling Causes in Educational Diagnosis and Evaluation (PRECEDE) Model(3)	Frequency, skills and confidence in BSE; additional sources of information and perceived support; health knowledge; health beliefs; and prior experience with breast lumps or cancer in self or significant others assessed before and 4 months

		practicing BSE and to identify factors that influence the frequency of this practice						after the intervention
Burgess et al, 2008(4)	Breast cancer	Development of a psycho-educational intervention to promote early presentation of breast cancer among women	Women who were attending for or had recently received their final routine mammogram and women in the general population aged > 65 years	Education sessions and materials (booklet with graphics and illustrations using cartoon characters, photographs of symptoms)	Symptom detection (demonstration) and response (role modelling)	A booklet: • Absolute and relative risk of developing breast cancer (graphics) • Breast cancer symptoms and detection • Role-modelling: illustration of help-seeking • Action-planning upon symptom detection • Positive feelings for prompt help-seeking Radiographer-delivered interview (key components): • Photographs of early symptoms of breast cancer symptoms • Detections of breast changes using a silicone model • Reinforcing help-seeking for breast changes	Self-Regulation Theory(5), Theory of Planned Behavior(6), Implementation Intentions(7) and Social Cognitive Theory(8)	NA

Byrne et al, 2009(9)	Breast cancer	To evaluate whether participation in a community-based breast cancer education party would increase women's	Women in the general population	Education sessions and materials (pictures or illustrations)	Symptom detection (demonstration and hands-on practice) and response	Education programs/parties:
						• Gaming strategies: to increase knowledge related to breast cancer using pictures or illustrations
						  ○ Risk
						  ○ Prevention
						  ○ Early detection
						• Demonstration of BSE
							Nil	Reviewing of education materials, education sessions, conduction of education parties, data entry, contacting participants and

		participation in screening activities				○ Hands-on practice, palpation of breast models • Appointments for screening as appropriate		appointment for breast cancer screening
Craun et al, 1987(10)	Breast cancer	To study the effectiveness of the Health belief model in predicting BSE behavior and the effectiveness of training formats in altering BSE knowledge, attitudes and frequency using a 2 (information) x 2 (demonstration) x 2 (prompts) factorial design	Female college students	Education sessions and materials (pamphlet)	Symptom detection (demonstration and hands-on practice)	Training formats: • Information: ○ A lecture about breast cancer and BSE • Demonstration: ○ Demonstration and hands-on practice of BSE on a breast model • Prompt: ○ A pamphlet explaining the technique of BSE ○ Monthly reminders to practice BSE	Health Belief Model(11)	Knowledge of breast cancer, knowledge of BSE procedures, attitudes relevant to BSE behavior, cues associated with BSE and frequency of BSE assessed prior to, 1 month post, 3 months post and 6 months post intervention
Khokhar et al, 2009(12)	Breast cancer	To assess the effectiveness of short text messages (SMS) as a reminder system for regular practice of BSE	Women more than 20 years of age working for a private organization	Education sessions and materials (video clip and pamphlet)	Symptom detection (demonstration and hands-on practice)	Education program: • A talk on BSE • Demonstration and hands-on practice of BSE on breast model • A video clip on BSE • SMS reminders sent to each woman towards the end of her menstrual period that is the appropriate time to do BSE	Nil	Practice of BSE

						• Pamphlet on BSE		
McLendon et al, 1982(13)	Breast cancer	To assess the effect of one-to-one BSE teaching on retention of knowledge and accuracy of performance among subjects randomly assigned to control or experimental group	Women with low socioeconomic status from a family planning clinic	Education sessions (one-to-one)	Symptom detection (hands-on practice) and response	One-to-one instruction on BSE: • Description of steps • Hands-on practice • Help-seeking upon detection of any changes	Nil	BSE knowledge and practice and personal beliefs about BSE and breast cancer assessed pre and 2 months post instruction
Shepherd et al, 2007(14)	Breast cancer	To determine the effectiveness of knowledge regarding BSE education and its impact towards early detection of breast cancer using a descriptive-observational design	Women who attended the Breast Week	Education sessions and materials (multimedia: radio)	Symptom detection (demonstration) and response	Breast Week: • Advertisement of the Breast Week on radio programmes and in the communities • A radio discussion on breast cancer and BSE prior to the Breast Week • A call for women to undergo a free breast examination and routine teaching on how to examine their breasts • Women had their breasts examined and at the same time were taught what to observe for and when to report any abnormalities detected • Women were instructed to perform breast examination and where to seek help in	Orem's Self Care Nursing Model(15)	Direct observation of participants' skills in performing BSE (breast inspection, breast palpation and detection of abnormalities) using a checklist

						the event of any deviation from the normal		
Sorensen et al, 2005(16)	Breast cancer	To investigate the effect of a community-based BSE training program on women's knowledge, attitudes and behavior in relation to BSE	Women had and had not participated in the BSE training program	Education sessions (video)	Symptom detection (demonstration)	BSE training program: • A locally produced video • Individual instruction on breast models and the women's own breasts	Nil	Knowledge, attitude and behavior (frequency, technique and actions take upon detection of breast changes) of BSE
Stratton et al, 1994(17)	Breast cancer	To determine 1) BSE proficiency by observation and 2) reduction of BSE proficiency as a function of weeks post training	Women who responded to radio and newspaper advertisements for free BSE training	Education sessions and materials (film and booklet)	Symptom detection (demonstration)	One-on-one BSE (MammaCare) session: • BSE using women's own breast and a tissue-matched silicone breast model • Appropriate corrections in technique • A 45-min film reviewing the MammaCare method of BSE • Reminder stickers • A booklet, The MammaCare Method: Your Personal Manual	Nil	MammaCare evaluation of proficiency performance for self modelling, a tissue-matched silicon breast model and the Toronto Breast Self-Examination Instrument
Styrd et al, 1982(18)	Breast cancer	To stimulate employees to take an active interest in their own health care, to promote awareness as to the importance of performing	Female employees of a company	Education sessions and materials (film and publication)	Symptom detection (demonstration)	Education session: • An introduction to the need for practicing SSE • A discussion of basic anatomy and physiology of breast tissue, signs and symptoms of breast disease, statistical data on occurrence of breast cancer, and diagnostic techniques	Nil	BSE behavior assessed prior to, 3 months after and 1 year after the program

bmjopen-2022-064521 on 23 August 2022. Downloaded from

		routine BSE, to teach proper BSE technique, and to increase frequency of BSE among those already practicing it				used in the diagnosis of breast disease • The American Cancer Society (ACS) film, How to Examine Your Breasts, which discusses techniques used in SSE • Additional discussion of breast abnormalities, risk factors, and newer treatment methods Education material: • The ACS publication: How to Examine Your Breasts		
Luther et al, 1985(19)	Breast cancer and testicular cancer	To promote the concept of early detection of cancer to high school students by teaching the topics of breast and testicular self-examination	High school teachers, school nurses, and other interested community educators	Education sessions and materials (movies)	Symptom detection (demonstration)	Education packet: • The breast and testicular self-examination curriculum • Overhead transparencies to aid in teaching breast and testicle anatomy • Samples of written materials • Movies on breast and testicular self-examination • Breasts and testicle models Education workshop: • Background information about breast and testicular cancer • How to teach breast and testicular self-examination • How to use materials available to teach breast and testicular self-examination • Recovered breast and testicular cancer patients discussing their experiences	Nil	Teacher satisfaction; student self-exams, knowledge about BSE and TSE, and attitudes toward early cancer detection
Cornell et al,	Melanoma	To compare the ability of	Lay persons	Education materials	Symptom interpretatio	Online melanoma identification task using different training:	Nil	Sensitivity, specificity and

2015(20)		volunteers to distinguish between images of melanomas and mimics of melanoma using various training strategies	who visited the website created for the study in a 3-week period	(photographs)	n (comparison)	• Rule-based training using the written ABC criteria: 'D' for diameter of the ABC(D) criteria was excluded because the images used in the study were not presented as life size on the computer monitor
						• Image training: photograph of 80 melanoma, 300 seborrhoeic keratoses and 300 benign naevi
						  ○ Expert melanoma training set
						  ○ Expert benign training set
						  ○ Layperson-selected melanoma set
								accuracy in identification of melanoma

Robertson et al, 2014(21)	Melanoma	To compare image training using a 6 (experimental set of images) x 2 (benign class) x 3 (training method) design	Laypeople recruited from friends and family of staff, relatives of patients, and undergraduate students	Education materials (video and images of skin lesions)	Symptom interpretation (comparison)	Education materials:
						• A 3-min video: brief overview of skin cancer
						• Images of skin lesions with different experimental sets, benign class and training method (Control, ABC criteria, or Image)
						  ○ 42 'training' lesions (21 melanomas and 21 benign)
						  ○ 48 'test' lesions (12 melanomas and 36 benign)
							Nil	Diagnostic accuracy, sensitivity and specificity in distinguishing between melanomas and mimics of melanoma

Scott et al, 2012(22)	Oral cancer	To assess the immediate and short term effect of a theory-based intervention to	Patients aged between 45 and 65 years of age who	Education sessions and materials (leaflet)	Symptom detection (hands-on practice) and response	One-to-one plus leaflet instruction: • Assessing knowledge and understanding of detecting oral cancer early, and	Self-Regulation Theory(23, 24), Social Cognitive Theory(8)	Knowledge of oral cancer, anticipated delay for signs of oral cancer, perceived confidence to

		encourage early detection and presentation of oral cancer in the ‘‘at risk’’ population randomly assigned to control, leaflet or one-to-one instruction group	smoked and had no prior history of oral cancer			providing correct information where appropriate • Addressing barriers to seeking help • Outlining the procedure of mouth self-examination, and providing an opportunity for the participant to perform mouth self-examination with receipt of feedback		seek help, understanding of MSE, perceived confidence to perform MSE, likelihood of monthly MSE and emotion response to MSE assessed at baseline, post-intervention, and 1 month follow-up
Brooks et al, 2001(25)	Skin cancer	To investigate the use of simplified instructions to facilitate holistic assessment of skin lesions	Undergraduate psychology students	Education materials (pictures of skin lesions)	Symptom interpretation (comparison)	Experiment 1: a series of pictures of skin lesions • Harmless lesions: 1 freckle, 4 seborrhoeic keratoses and 5 compound naevi • Warning lesions: 10 dysplastic or atypical naevi • Cancerous lesions: 1 squamous cell carcinoma, 2 basal cell carcinomas, 2 nodular melanomas and 5 superficial spreading melanomas Experiment 2: 36 pair comparisons of the 9 representative lesions • Freckle • Compound melanocytic neavus • Seborrheic kerotosis • Dysplastic neavus • Basal cell carcinoma • Squamous cell carcinoma • Low risk superficial spreading melanoma	Nil	Discrimination between benign and malignant skin lesions assessed before and after exposure to education materials

						• Moderate risk superficial spreading melanoma • High risk superficial spreading melanoma		
Respiratory diseases								

Butz et al, 2005(26)	Asthma: persistent cough, wheeze and intercostal retractions	A cross-sectional analysis of asthma home management skills in parents and children enrolled in an ongoing randomized clinical trial of an asthma educational intervention	Families with children aged 2-8 years who have asthma	Education sessions	Symptom identification, interpretation (comparison) and response	Symptom identification/nebulizer educational intervention:
						• Symptom identification
						  ○ Review of early and late symptoms
						  ○ Comparison of normal breathing to breathing patterns during an acute asthma episode
						• Nebulizer use
							Model of Symptom Management(27)	Parents' ability to recognize symptoms and nebulizer-use technique using structured questionnaire and demonstration of nebulizer use

Collard et al, 2004(28)	Asthma	To investigate whether it is feasible to teach patients to recognise prodromal signs, whether patients will comply with instructions to act upon first symptoms using a single blind prospective randomised study	Children with moderate asthma according to the American Thoracic Society criteria	Education sessions	Symptom identification, interpretation (comparison) and response	Education sessions: • Information on asthma, symptoms, preventive measures, medication and asthma exacerbations • Individual prodromal signs which were identified together with the parents • Instructions on dose of inhaled corticosteroids when signs occurred	Nil	Primary outcomes: rate and severity of asthma attacks, frequency of disabilities, absence from school and parental absence from work due to asthma, registration of prodromal signs and compliance to self-treatment instructions; secondary outcomes: lung

								function and bronchial responsiveness

Gardner et al, 2016(29)	Asthma	A quality improvement project to address the need for information for parents and children with asthma	Children under the age of 18 who had been diagnosed with asthma, asthma exacerbation or status asthmaticus	Education sessions and materials (binder with large pictures)	Symptom recognition, interpretation (comparison) and response	An individualized asthma resource binder:
						• Basic asthma disease understanding
						• Medications and medication side effects
						• Symptoms and symptom control
						• Exacerbation recognition
						• Use of an asthma action plan
						An individualized teaching session:
						• Basic asthma pathophysiology
						• Medications
						  ○ Methods to improve medication compliance
						  ○ Demonstration of proper inhaler use
						• Symptom recognition and management: lifestyle change
						• Recognition of exacerbation: reflection on current hospitalization to identify early warning signs
						• Use of an asthma action plan: response when an exacerbation is recognized
							Health Belief Model(11)	(planned: hospital 30-day readmission rate (primary outcome), and satisfaction of physician and nurse, advanced practice providers, and residents)

Hendricson et al,	Asthma	Development of the patient education component,	Children aged 6 to 16 who had physician-	Education sessions and materials	Symptom recognition and response	Educational intervention on specific self-management skills using flip cards:	Social Learning Theory(31), Social	Parent and child subjective evaluation of educational

1996(30)		an individualized and bilingual program designed to reduce morbidity and improve quality of life among Hispanic children with chronic asthma	diagnosed asthma	(flip cards with illustrations, videotape, pamphlet)	(role modelling)	• Recognizing asthma symptoms before they get out of control • Correctly administering medicines as pre- scribed by the physician and managing side effects • Promptly recognizing and responding to acute asthma symptoms that require emergency care • Remaining calm and avoiding stress-inducing reactions when symptoms occur • Minimizing exposure to triggers (precipitating agents such as smoke, mold, animal hair) • Establishing appropriate levels of physical and social activities for the child • Communicating effectively with health care personnel Techniques incorporated into the intervention: • Role modelling: self-management behaviors (videotape) • Building self-efficacy: hands-on practice with inhalers and peak flow meters and role-playing for communication when symptoms occur • Contracting: written agreement	Cognitive Theory(32)	modules, attrition rate and parent impression 1 year after program completion
Brandt et al,	COPD exacerbatio	A qualitative study of self-	Patients with COPD	Education sessions	Symptom recognition,	COPD teaching plan: • Understanding COPD	Collaborative Model for	NA

2013(33)	n: increased breathless, cough, sputum, fever and fatigue; orthopnea; decreased activity tolerance; poor sleep; change in mental status	regulation in older adults with COPD and development of a theory and evidence-based teaching plan to build practical self-regulation skills in patients with COPD			interpretation (comparison) and response	• Everyday management strategies
						• Symptom monitoring/self-observation
						  ○ Keeping a symptom log until being familiar with baseline dyspnea and other symptoms
						  ○ Common signs and symptoms of an exacerbation
						• Exacerbation triggers and how to avoid them
						• Exacerbation recognition/self- judgment: daily symptom comparison, contrasting new or different symptoms with baseline characteristics
						• Management of exacerbations/self-reaction
							Self-Management of Chronic Disease(34)	

Cardiovascular diseases								

Davis et al, 2019(35)	ACS	To evaluate the feasibility and acceptability of a nurse-delivered education and skill-building intervention designed to improve symptom recognition and interpretation	Women aged 35 years and older who had been hospitalized with a definitive diagnosis of ACS	Education sessions and materials (pamphlet and pocket card)	Symptom recognition, interpretation (comparison) and response	Two face-to-face teaching sessions:
						• Symptom recognition and interpretation
						  ○ A standard pamphlet (Women, Heart Disease, and Stroke) and a pocket card (Know and Go: Heart Attack)
						  ○ Individualized education on symptom experience and actions taken, comorbid conditions
							Nil	Feasibility, acceptability and satisfaction with the intervention; knowledge, attitudes and beliefs about ACS symptoms

		in women with recurrent ACS symptoms using a single group pre-post-test design				that could mimic ACS symptoms, and misconceptions about ACS symptoms and care-seeking responses ○ A symptom monitoring notebook with instructions to document recurrent symptoms • Individualized action plan ○ Timely and appropriate care-seeking behavior for recurrent symptoms ○ Reinforcement of information from the first session		
Raczynski et al, 1999(36)	AMI: chest pain (primary symptom) and shortness of breath	Development of the theoretically-based Rapid Early Action for Coronary Treatment (REACT) intervention that addresses community organization, community education, professional education, and patient education	Community education: high-risk individuals, family members, and community residents; patient education: high-risk patients and their families	Education sessions and materials (flyers/brochures, posters, magnets and other "tokens"; video)	Symptom recognition and response (role modelling)	Community organization: • Engaging organizations and individuals in a collaborative effort to mobilize their resources and institutional structures to reduce AMI delay Community education: • Building awareness and knowledge about AMI and the problem of delay; • Recognizing AMI symptoms; • Modifying beliefs that may act as barriers to seeking treatment; • Building skills to improve behavioral intentions and actions; and	Social Cognitive Theory(37), Self-Regulatory Theory(38), Community Organization Theory(39), Diffusion of Innovation Theory(40), Social Marketing Theory(41)	NA

						• Increasing self-efficacy to respond rapidly to AMI symptoms Provider education: • Improving understanding of factors related to patient delay • Enhancing motivation to learn skills and intervene with patients • Enhancing patient-centred counselling • Impacting clinical practice Patient education: interpersonal + impersonal • Changing patients' knowledge, beliefs, attitudes, skills, behaviors, and self-efficacy regarding prompt action for AMI symptoms • Employment of patient-centered counselling, role-modelling, and behavioral rehearsal		
Jurgens et al, 2013(42)	HF: dyspenea and fatigue	To test the efficacy of a HF symptom training program on patients' self-care ability and particularly their ability to recognize and respond to changes in HF symptoms	Patients with a confirmed diagnosis of chronic HF	Education sessions and materials (booklet)	Symptom detection, interpretation (comparison) and response	HF symptom training intervention: • Weight scale • HF self-care booklet • Symptom profile: 3 symptoms with highest distress selected for clustering on symptom graph • Symptom burden at rest • Comparison of symptom burden after 6-min walk test with symptom burden at rest and discussion on symptom meaning and response	Theory of HF Self-Care(43), Theory of Unpleasant Symptoms(44, 45), Uncertainty in Illness Theory(46-49), Self-Regulation Theory(24)	Time to first event of HF hospitalization, emergency department admission for HF or HF-related cause and death (primary outcomes); HF symptom awareness and self-care assessed at

		using a randomized control trial				• Home visit to review symptom training		baseline and 3 months follow-up
Other health conditions								
Hunt et al, 2015(50)	Concussion	To determine if a concussion-education video developed for high school athletes would increase the reporting of concussive injuries and symptom recognition using a cross-sectional, between groups design	High school athletes aged 13 to 18 years	Education materials (video)	Symptom detection, interpretation (comparison) and response	Concussion education video addressing questions pertaining to head injuries or concussions: • What is a concussion? • How do concussions happen? • How do I know I have a concussion? • What are the signs and symptoms of concussion? • What is the importance of reporting my injury? • Whom should I report my injury to? • What is the difference between just getting hit in the head and having a concussion? • How are concussions managed? • When will I be able to play again?	Nil	Knowledge of concussion symptoms, assessed before and immediately after watching the education video
Bonovich et al, 1990(51)	Labor: contractions, vaginal discharge and amniotic fluid	To test the effectiveness of an intervention developed to meet the specific needs of clinic patients in recognizing the signs of true labor	Patients in their first uninterrupted pregnancies who had reached 30 weeks' gestation	Education sessions and materials	Symptom detection, interpretation (comparison) and response	Education material: • A printed list of instructions on how to detect signs of labor Education session: • Reinforcement of correct knowledge recall about labor patients gained prior to the intervention and provision of only necessary information to fill in knowledge gaps	Flanders' Analyzing Teaching Behavior(52), Redman's Principles of Patient Education(53)	Number of visits subjects made to labor and delivery by examining the registration records in the labor suite

		using an experimental design with one treatment group and one control group				• Instruction on distinguishing between Braxton Hicks contractions and contractions of active labor, changes in vaginal discharge (sights), distinguishing between involuntary urination and leaking of amniotic fluid (smell), and contraction pain and other senses (sensations)		
Eriksen et al, 2010(54)	Malaria	To develop a community intervention to improve first line case management of malaria in under-five children through primary caretakers in collaboration with local women groups and existing health centres and to evaluate its feasibility and effectiveness on anaemia, fever and malaria prevalence using a cluster-	Women leaders selected from village groups	Education sessions	Symptom detection, interpretation and response (role modelling)	Training of health workers • Theoretical training: lectures on principles of malaria case management including clinical diagnosis, treatment and follow-up • Practical training: management of suspected malaria cases in the outpatient department of the district hospital Training of women leaders • Theoretical training: same as training of health workers, with a focus on identifying fever cases that should be treated as suspected uncomplicated malaria or referred to health facilities as suspected severe malaria or other diseases requiring formal health care treatment • Practical training: observation of management of suspected malaria cases	Nil	Proportion of moderate/severe anaemia in children aged 6-59 months (primary outcome), proportions of measured fever, malaria prevalence and reported fever during the last 48 hours, mean malaria parasite densities, mean haemoglobin values and mean weight, assessed pre- and post-intervention

		randomised controlled effectiveness trial						

Matin et al, 2020(55)	Neonatal illness: lethargy, chest indrawing, convulsions and difficulty breastfeeding	To enable reliable and consistent assessment of neonates for identification of signs of illness to facilitate early referral of sick neonates, especially during the critical first week of life	Women who gave birth at the study hospital	Education apps/devices (audio, images of danger signs)	Symptom detection, interpretation (comparison) and response	A smartphone preloaded with an interactive app (the NeMo app):
						• Pictures, symbols, and audio recordings in the local language
						• 4 qualitative danger signs, images displayed for each sign: one showing a newborn exhibiting the danger sign and one showing a healthy infant
						  ○ Lethargy
						  ○ Chest indrawing
						  ○ Convulsions
						  ○ Difficulty breastfeeding
						A wearable sensing band (the NeMo band) that measures breathing rate
							Nil	Knowledge of danger signs assessed at baseline and after training, observation of device use, usage and impression of device assessed using quantitative scales and qualitative interviews, responses to danger sign triggers assessed through qualitative discussion

Ziadé et al, 2021(56)	RA: joint pain and swelling	To evaluate the perceptions of patients with RA about self-assessment of their disease activity using DAS-28 after watching the educational video	Adult patients with RA	Education materials (video)	Symptom detection (demonstration)	Education video: • A short introductory note about the assessment of disease activity in RA • A demonstration of the evaluation of each of the 28 joints for pain and swelling performed by a real patient with RA • An explanation about the final score calculation and the categorization into the disease activity levels	Nil	Perceptions about self-assessment of disease activity using semi-structured interview

BCLE: lymphedema secondary to breast cancer treatment, BSE: breast self-examination, COPD: chronic obstructive pulmonary disease, ACS: acute coronary syndrome, AMI: acute myocardial infarction, CHD: coronary heart disease, EMS: emergency medical system, ED: emergency department, MI: myocardial infarction, HF: heart failure, RA: rheumatoid arthritis, DAS: disease activity score

References

1. Dine JL, Austin MKS, Armer JM. Nursing education on lymphedema self-management and self-monitoring in a South African oncology clinic. Journal of Cultural Diversity. 2011;18(4):126-8.
2. Brailey LJ. Effects of health teaching in the workplace on women's knowledge, beliefs, and practices regarding breast self-examination. Research in Nursing & Health. 1986;9(3):223-31.
3. Green LW, Kreuter MW, Deeds S, Partridge K. Health Education Planning: A Diagnostic Approach: Mayfield Publishing Company; 1980.
4. Burgess CC, Bish AM, Hunter HS, Salkovskis P, Michell M, Whelehan P, et al. Promoting early presentation of breast cancer: development of a psycho-educational intervention. Chronic Illn. 2008;4(1):13-27.
5. Leventhal H, Nerenz D, Steele D. Illness representations and coping with health threats. In: A. Baum, SE Taylor, Singer J, editors. Handbook of psychology and health: social psychological aspects of health1984. p. 219-52.
6. Ajzen I. The theory of planned behavior. Organizational Behavior and Human Decision Processes. 1991;50(2):179-211.
7. Gollwitzer PM. Goal Achievement: The Role of Intentions. European Review of Social Psychology. 1993;4(1):141-85.
8. Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. Psychol Rev. 1977;84(2):191-215.
9. Byrne S, Robles-Rodriguez E. Educational parties as a strategy to promote breast health awareness and screening in underserved female populations. Oncology nursing forum. 2009;36(2):145-8.
10. Craun AM, Deffenbacher JL. The effects of information, behavioral rehearsal, and prompting on breast self-exams. Journal of Behavioral Medicine. 1987;10(4):351-65.
11. Rosenstock IM. Historical Origins of the Health Belief Model. Health Education Monographs. 1974;2(4):328-35.
12. Khokhar A. Short text messages (SMS) as a reminder system for making working women from Delhi Breast Aware. Asian Pac J Cancer Prev. 2009;10(2):319-22.
13. McLendon MS, Fulk CH, Starnes DC. Effectiveness of breast self-examination teaching to women of low socioeconomic class. JOGN Nurs. 1982;11(1):7-10.
14. Shepherd JH, McLnerney PA. Knowledge of breast self-examination in women in Sierra Leone. Curationis. 2007;30(4):38-44.
15. Orem DE. Nursing: Concepts of Practice: McGraw-Hill; 1980.
16. Sorensen J, Hertz A, Gudex C. Evaluation of a Danish teaching program in breast self-examination. Cancer Nursing. 2005;28(2):141-7.
17. Stratton BF, Nicholson ME, Olsen LK, Mahoney BS, Warland RH. Breast self-examination proficiency: Attitudinal, demographic, and behavioral characteristics. Journal of Women's Health. 1994;3(3):185-95.
18. Styrd AM. A breast self-examination program in an occupational health setting. Occup Health Nurs. 1982;30(4):33-5.
19. Luther SL, Sroka S, Goormastic M, Montie JE. Teaching breast and testicular self-exams: evaluation of a high school curriculum pilot project. Health Education. 1985;16(1):40-3.
20. Cornell E, Robertson K, McIntosh RD, Rees JL. Viewing Exemplars of Melanomas and Benign Mimics of Melanoma Modestly Improves Diagnostic Skills in Comparison with the ABCD Method and Other Image-based Methods for Lay Identification of Melanoma. Acta Dermato-Venereologica. 2015;95(6):681-5.
21. Robertson K, McIntosh RD, Bradley-Scott C, MacFarlane S, Rees JL. Image training, using random images of melanoma, performs as well as the ABC(D) criteria in enabling novices to distinguish between melanoma and mimics of melanoma. Acta Derm Venereol. 2014;94(3):265-70.
22. Scott SE, Khwaja M, Low EL, Weinman J, Grunfeld EA. A randomised controlled trial of a pilot intervention to encourage early presentation of oral cancer in high risk groups. Patient Education and Counseling. 2012;88(2):241-8.
23. Leventhal H, Meyer D, Nerenz D. The common sense representation of illness danger. In: Rachman S, editor. Contributions to Medical Psychology: Pergamon Press; 1980. p. 7-30.
24. Cameron LD, Leventhal H. The self-regulation of health and illness behaviour. New York, NY, US: Routledge; 2003.
25. Brooks A, Predebon J, van der Zwan R. Perceptual strategies to improve skin cancer discriminations in naive observers. Public Health. 2001;115(2):139-45.

26. Butz AM, Syron L, Johnson B, Spaulding J, Walker M, Bollinger ME. Home-based asthma self-management education for inner city children. Public Health Nurs. 2005;22(3):189-99.
27. University of California, San Francisco School of Nursing Symptom Management Faculty Group. A model for symptom management. Image J Nurs Sch. 1994;26(4):272-6.
28. Colland VT, van Essen-Zandvliet LE, Lans C, Denteneer A, Westers P, Brackel HJ. Poor adherence to self-medication instructions in children with asthma and their parents. Patient Education & Counseling. 2004;55(3):416-21.
29. Gardner LE. Advanced Practitioner Provided Pre-Hospital Discharge Asthma Education: Walden University; 2016.
30. Hendricson WD, Wood PR, Hidalgo HA, Ramirez AG, Kromer ME, Selva M, et al. Implementation of individualized patient education for Hispanic children with asthma. Patient Education & Counseling. 1996;29(2):155-65.
31. Parcel GS, Baranowski T. Social learning theory and health education. Health Educ. 1981;12(3):14-8.
32. Bandura A. Social foundations of thought and action: A social cognitive theory: Prentice-Hall, Inc; 1986.
33. Brandt CL. Study of older adults' use of self-regulation for COPD self-management informs an evidence-based patient teaching plan. Rehabilitation nursing : the official journal of the Association of Rehabilitation Nurses. 2013;38(1):11-23.
34. Brandt CL. Description of the Self-regulation Process Used by Persons with Chronic Lung Disease and Its Relationship to Health-related Outcomes: University of Minnesota; 2005.
35. Davis LL, McCoy TP. An Educational and Skill-Building Intervention to Improve Symptom Recognition and Interpretation in Women With Acute Coronary Syndrome: A Pilot Study. Dccn. 2019;38(1):29-37.
36. Raczynski JM, Finnegan JR, Jr., Zapka JG, Meischke H, Meshack A, Stone EJ, et al. REACT theory-based intervention to reduce treatment-seeking delay for acute myocardial infarction. Rapid Early Action for Coronary Treatment. Am J Prev Med. 1999;16(4):325-34.
37. Perry CL, Baranowski T, Parcel GS. How individuals, environments, and health behavior interact: Social Cognitive Theory. In: Glanz K, Lewis FM, Rimer BK, editors. Health behavior and health education: Theory, research, and practice. San Francisco, CA: Jossey-Bass; 1990.
38. Cameron L, Leventhal EA, Leventhal H. Emotional and behavioral processes. In: Johnston M, Wallace L, editors. Stress and Medical Procedures: New York, NY: Pergamon; 1993. p. 7-30.
39. Bracht N. Health promotion at the community level. Thousand Oaks, CA, US: Sage Publications, Inc; 1990.
40. Rogers EM. Diffusion of innovations. New York; London: Free Press ; Collier Macmillan; 1983.
41. Novelli W. Applying social marketing to health promotion and disease prevention. In: Glanz K, Lewis FM, Rimer BK, editors. Health behavior and health education: theory, research and practice. San Francisco, CA: Jossey-Bass; 1990.
42. Jurgens CY, Lee CS, Reitano JM, Riegel B. Heart failure symptom monitoring and response training. Heart & Lung. 2013;42(4):273-80.
43. Riegel B, Dickson VV. A situation-specific theory of heart failure self-care. J Cardiovasc Nurs. 2008;23(3):190-6.
44. Lenz ER, Suppe F, Gift AG, Pugh LC, Milligan RA. Collaborative development of middle-range nursing theories: toward a theory of unpleasant symptoms. ANS Adv Nurs Sci. 1995;17(3):1-13.
45. Lenz ER, Pugh LC, Milligan RA, Gift A, Suppe F. The middle-range theory of unpleasant symptoms: an update. ANS Adv Nurs Sci. 1997;19(3):14-27.
46. Mishel MH. The measurement of uncertainty in illness. Nurs Res. 1981;30(5):258-63.
47. Mishel MH. Perceived uncertainty and stress in illness. Res Nurs Health. 1984;7(3):163-71.
48. Mishel MH. Uncertainty in illness. Image J Nurs Sch. 1988;20(4):225-32.
49. Mishel MH. Reconceptualization of the uncertainty in illness theory. Image J Nurs Sch. 1990;22(4):256-62.
50. Hunt TN. Video Educational Intervention Improves Reporting of Concussion and Symptom Recognition. Athletic Training Education Journal (Allen Press Publishing Services Inc). 2015;10(1):65-74.
51. Bonovich L. Recognizing the onset of labor. J Obstet Gynecol Neonatal Nurs. 1990;19(2):141-5.
52. Flanders NA. Analyzing teaching behavior. Reading, Mass.: Addison-Wesley Pub. Co.; 1970.
53. Redman BK. The Process of Patient Education: C.V. Mosby; 1984.

54. Eriksen J, Mujinja P, Warsame M, Nsimba S, Kouyate B, Gustafsson LL, et al. Effectiveness of a community intervention on malaria in rural Tanzania - a randomised controlled trial. African Health Sciences. 2010;10(4):332-40.
55. Matin SB, Wallingford A, Xu S, Ng N, Ho A, Vanosdoll M, et al. Feasibility of a mobile health tool for mothers to identify neonatal illness in rural Uganda: Acceptability study. JMIR mHealth and uHealth. 2020;8(2).
56. Ziadé N, Saad S, Al Mashaleh M, El Kibbi L, Elzorkany B, Badsha H, et al. Perceptions of patients with rheumatoid arthritis about self-assessment of disease activity after watching an educational video: a qualitative pilot study from the AUTO-DAS in Middle Eastern Arab countries project. Rheumatology International. 2021.

Supplementary File 4. Application of the proposed framework to the development of a screening tool for autoimmune rheumatic diseases

In the proposed framework to improving symptom appraisal, Social Cognitive Theory (SCT) and main constructs of symptom appraisal, detection, interpretation and response to symptoms, were linked by approaches developed based on the six major concepts in SCT (*reciprocal determinism, behavioral capacity, expectations, self-efficacy, observational learning* and *reinforcements*)(1-3). We shall illustrate how the proposed framework and approaches could be incorporated into the development of screening tools using joint swelling and Raynaud's phenomenon (RP), a common and a distinctive symptom respectively seen in patients with audotimmune rheumatic diseases (ARDs), as examples.

Joint swelling may or may not be noticed, especially in the early stages of diseases when it is mild and not accompanied by other symptoms/signs. Knowledge of what joint swelling is, what a swollen joint looks like (sight) and how a swollen joint feels like (touch) using text (symptom knowledge) (*behavioral capacity*); and illustrations of the different appearance of a swollen joint and a normal joint using photos and different sensations when touching a swollen versus a normal joint using normal body sites for comparison can act as a prompt and allow an individual to notice their similar joint changes (symptom self-examination and comparison) (*behavioral capacity* and *self-efficacy*)(4). RP is characterized by the triphasic color change in digits (the skin of digits first turns white, then blue and finally red in the ischemic, deoxygenation and reperfusion phases, respectively) resulting from vasospasm and ischema in response to cold or emotional stimuli(5). While the dramatic color changes in digits are often not neglected, description of the color changes (sight) during an attack of RP using text (symptom knowledge) (*behavioral capacity*) and demonstration with cold water using short videos can help one confirm the presence or absence of RP (symptom self-examination and comparison) (*self-efficacy* and *observational learning*).

Following the detection of joint swelling and RP, individuals might attribute the meaning of these bodily changes first to situational factors such as cold weather based on their own knowledge (such as their own experience, self-education or observation from others)(6, 7), and only if the situational factors are insufficient to explain these bodily changes, to illness(8). Provision of the likely causes of joint swelling and RP (symptom knowledge) could thus allow one to make more appropriate attribution of their symptoms and in turn their response to the attribution (*behavioral capacity*). Depending on the meaning attributed to the detected symptoms/signs, individuals may decide to take no actions, self-monitor, self-manage, consult family or friends, or seek medical attention(3). Instruction on symptom response, namely, actions to take upon the detection of joint swelling and RP (such as reporting and help-seeking) (*behavioral capacity*), and demonstration of prompt symptom detection and response (*self-efficacy* and *observational learning*) and its positive outcomes (e.g., using video clips of role models) (*expectations* and *reinforcements*) could lead to more appropriate responses to one's symptoms/signs (on screening tools) and in turn facilitate early identification of potential cases in the population.

References

1. Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. Psychol Rev. 1977;84(2):191-215.
2. Bandura A. Social foundations of thought and action: A social cognitive theory: Prentice-Hall, Inc; 1986.
3. Whitaker KL, Scott SE, Wardle J. Applying symptom appraisal models to understand sociodemographic differences in responses to possible cancer symptoms: a research agenda. British Journal of Cancer. 2015;112(1):S27-S34.
4. Murray J, Williams B. The Role of Images on Illness Behaviour: Interdisciplinary Theory, Evidence, and Ideas. Psychological Reports. 2020;0(0):0033294120945602.
5. Hochberg M, Gravallese E, Silman A, Smolen J, Weinblatt M, Weisman M. Rheumatology: Elsevier; 2018.
6. Cacioppo JT, Andersen BL, Turnquist DC, Petty RE. Psychophysiological Comparison Processes: Interpreting Cancer Symptoms. In: Andersen BL, editor. Women with Cancer: Psychological Perspectives. New York, NY: Springer New York; 1986. p. 141-71.
7. Andersen BL, Cacioppo JT. Delay in seeking a cancer diagnosis: delay stages and psychophysiological comparison processes. Br J Soc Psychol. 1995;34 (Pt 1):33-52.
8. Robbins JM, Kirmayer LJ. Attributions of common somatic symptoms. Psychol Med. 1991;21(4):1029-45.

BMJ Open

Approaches to improving symptom appraisal: a systematic literature review

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2022-064521.R1
Article Type:	Original research
Date Submitted by the Author:	07-Jul-2022
Complete List of Authors:	Xiang, Ling; Singapore General Hospital, Department of Rheumatology and Immunology; National University of Singapore, Yong Loo Lin School of Medicine Yoon, Sungwon; Duke-NUS Medical School, Health Services and Systems Research Low, Andrea; Singapore General Hospital, Department of Rheumatology and Immunology; Duke-NUS Medical School Leung, Ying Ying; Singapore General Hospital, Department of Rheumatology and Immunology; Duke-NUS Medical School Fong, Warren; Singapore General Hospital, Department of Rheumatology and Immunology; Duke-NUS Medical School Lau, Tang Ching; National University of Singapore, Yong Loo Lin School of Medicine; National University Hospital, Department of Medicine Koh, Dow Rhoon; National University of Singapore, Yong Loo Lin School of Medicine; National University Hospital, Department of Medicine Thumboo, Julian; Singapore General Hospital, Department of Rheumatology and Immunology; Duke-NUS Medical School
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Rheumatology
Keywords:	Rheumatology < INTERNAL MEDICINE, RHEUMATOLOGY, MEDICAL EDUCATION & TRAINING

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Approaches to improving symptom appraisal: a systematic literature review

Ling Xiang,[1,2] Sungwon Yoon,[3] Andrea HL Low,[1,2,4] Ying Ying Leung,[1,2,4] Warren Fong,[1,2,4] Tang Ching Lau,[2,5] Dow Rhoon Koh,[2,5] Julian Thumboo.[1,2,4]

[1]Department of Rheumatology and Immunology, Singapore General Hospital, Singapore
[2]Yong Loo Lin School of Medicine, National University of Singapore, Singapore
[3]Health Services and Systems Research, Duke-NUS Medical School, Singapore
[4]Duke-NUS Medical School, Singapore
[5]Department of Medicine, National University Hospital, Singapore

Correspondence to: Julian Thumboo, Department of Rheumatology and Immunology, Singapore General Hospital, Academia Building, Level 4, 20 College Road, Singapore, 169856. Tel: (65) 6321 4028, Fax: (65) 6220 3321, Email: julian.thumboo@singhealth.com.sg.

Abstract

Objectives
Poor symptom appraisal (detection, interpretation and response to symptoms) plays a major role in prolonged pre-diagnosis interval in various health conditions. Theories and models have been proposed to study the symptom appraisal process but how they could be employed to improve symptom appraisal remains unclear. We therefore aimed to review approaches to improving symptom appraisal in the literature and to develop a theoretical framework that could guide the development of approaches to improving symptom appraisal among individuals in the general population.

Design
Systematic review.

Data sources
Medline, Web of Science, PsycInfo, Embase, CINAHL and Scopus were searched from inception to 30 March 2021.

Eligibility criteria
We included original articles in English in which approaches to improve the detection, interpretation or response to symptoms for symptomatic individuals were described. We excluded articles in which approaches were developed to improve symptom appraisal among healthcare professionals.

Data extraction and synthesis
A pre-defined data extraction form was used to extract the development, characteristics and evaluation of approaches to improving symptom appraisal. This formed the basis for the narrative synthesis.

Results
Of 19,046 publications identified from the literature search, 112 were selected for full text review and 29 approaches comprising provision of knowledge of symptoms/signs and additional components (e.g., symptom self-examination and comparison) for symptom appraisal were included in the synthesis. Less than half (41.4%) of these approaches were developed based on theories/models. Interestingly, despite the variety of theories/models adopted in developing these approaches, the components of these approaches were similar.

Conclusion
Symptom appraisal is an essential process in a patient's journey that can be targeted to facilitate early diagnosis but is largely unstudied. Building on the literature, we proposed a theoretical framework and approaches to improving symptom appraisal. This could facilitate early identification of a variety of health conditions in the general population.

Strengths and limitations of this study
- This systematic review was built on a comprehensive search strategy, which was developed and refined iteratively using multiple preliminary searches.
- A narrative analysis allowed for deeper insights into 1) the development, implementation and evaluation of approaches to improving symptom appraisal and 2) the adopted theories and models in the literature.
- A theory-based framework was proposed, which can provide guidance for the development of approaches to improving symptom appraisal.
- Only free-text search was conducted in Web of Science and Scopus, which do not have controlled vocabularies.

Introduction

Prolonged pre-diagnosis interval between symptom onset and diagnosis, also referred to as diagnostic delay, remains an unmet need among patients with various health conditions such as cancer and autoimmune rheumatic diseases (ARDs) and results in poor patient outcomes(1-8). Pre-diagnosis interval comprises largely the symptom appraisal interval between symptom onset and the first visit to healthcare professionals. Using the general model of total patient delay proposed by Andersen et al, symptom appraisal interval constituted the majority (more than 60%) of the total duration of delay among patients with various cancers(9). In a systematic review of pre-diagnosis interval among patients with rheumatoid arthritis (RA), the most common ARD, by Barhamain et al, symptom appraisal interval was found to be longer than intervals between the first visit to healthcare professionals and diagnosis (weighted average: 3.4 vs 2.1-2.9 months)(10).

Symptom appraisal is a process an individual undertakes when symptoms (bodily changes) are noticed till a decision is made on whether an action needs to be taken in response to the symptoms (bodily changes)(11). During the symptom appraisal interval, symptoms are being appraised and misperception of symptoms (bodily changes) may occur. Individuals may not perceive their symptoms as a health concern that requires prompt medical attention, and hence may not seek help from healthcare professionals or do so in a timely manner(12). Poor symptom appraisal has been shown to be a major cause of prolonged symptom appraisal interval and pre-diagnosis interval(13-17). In the meta-analysis by Petrova et al, poor symptom knowledge, wrong interpretation of symptoms, and negative beliefs about cancer were significantly associated with longer symptom appraisal/help-seeking intervals among patients with various cancers(16). In the systematic review by Stack et al, many patients with recent-onset RA reported that they were unaware of the significance of their symptoms before they were diagnosed and that they would have sought help earlier if they had more knowledge of RA and its symptoms(14).

It is thus important to develop approaches to improve symptom appraisal among symptomatic individuals in the general population to address the unmet need to shorten the pre-diagnosis interval. Many theories and models have been proposed to study the symptom appraisal process among patients with various chronic and acute health conditions(11, 18-27), however, how these theories and models could be employed to improve symptom appraisal remains unclear. We therefore aimed to review approaches to improving symptom appraisal in the literature, and to develop a theoretical framework that could guide the development of approaches to improving symptom appraisal among individuals in the general population to facilitate early diagnosis.

Methods

We conducted a systematic literature search of existing approaches developed to improve symptom appraisal among individuals with any health conditions. We first performed preliminary searches in Medline using the concepts of symptom and appraisal, based on which the definitions of symptom and symptom appraisal for use in this study were developed, and search terms for the concepts of symptom, appraisal and patient education were refined (Supplementary File 1)(11, 12, 18-20, 22-31). We performed the final literature search with the refined search terms in the following six electronic databases: Medline, Web of Science, PsycInfo, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Scopus. We included all articles published from inception to 30 March 2021.

This systematic review was registered with the PROSPERO International prospective register of systematic reviews (reference: CRD42021279500) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist was followed in the reporting (Supplementary File 2)(32).

Inclusion and exclusion criteria

One main reviewer (the first author) screened the title and abstract of all articles identified from the final literature search, with any uncertainty resolved by discussion with the other authors. We examined the references of all review articles to identify relevant publications. We included articles for full text review if they met the following three criteria: 1) original articles in which approaches (or their

components) to improving symptom appraisal were described, 2) approaches (or their components) aimed to improve the detection, interpretation or response to symptoms, and 3) approaches were developed for individuals with bodily changes/symptoms. We excluded articles in which approaches were developed to improve symptom appraisal among healthcare professionals such as medical trainees and nursing students.

Quality assessment

Quality assessment was conducted using the Joanna Briggs Institute (JBI) critical appraisal tools primarily by the first author, with any uncertainty resolved by discussion with the other authors(33, 34). A raw score was calculated for each of the selected studies by dividing the number of positive responses by the total number of applicable statements in the JBI critical appraisal tools. High risk of bias was defined as a raw score of 49% or lower, moderate risk of bias was defined as a raw score between 50% and 69%, and low risk of bias was defined as a raw score of 70% or above.

Data extraction and synthesis

Data on study design, participants, and the development, characteristics (type, format and components), and evaluation of approaches were extracted using a pre-defined data extraction form primarily by the first author, with any uncertainty resolved by discussion with the other authors. Due to the great heterogeneity in study design and outcome measures of the developed approaches, a narrative synthesis was performed.

Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting or dissemination of this research.

Results

Study selection

Among the 19,046 records identified from the final literature search, 10,613 were screened the title and abstract after removing duplicates, 196 were assessed for eligibility and 112 were included in the full text review (Figure 1). An additional 67 eligible records were identified from citation searching, yielding a total of 179 eligible publications from 160 unique studies.

After reviewing these 160 studies, we excluded 131 (81.9%) studies in which approaches comprised only provision of knowledge of symptoms/signs of a given health condition. We included the remaining 29 (18.1%) studies in which approaches comprised provision of both knowledge of symptoms/signs and additional components (such as demonstration and/or hands-on practice of self-examination and comparison of symptoms) to improve symptom appraisal in the synthesis (Table 1). This was based on the consideration that provision of knowledge (of symptoms/signs) alone might not be sufficient to produce the desired behavior (i.e., detection, interpretation and response to symptoms)(35), and that we aimed to develop similar approaches to help individuals recognize and respond promptly to their symptoms/signs.

Of these 29 studies, 13 were categorized as having low risk of bias(36-48), 10 were categorized as having moderate risk of bias(49-58), and 6 were unable to be assessed due to a lack of detailed evaluation of the developed approaches(59-64). The raw scores of these studies were shown in Supplementary File 3. We included all 29 studies in the synthesis as our focus was the development instead of the evaluation of approaches.

Table 1. Characteristics of studies included in the synthesis

Study	Health conditions	Type and format of approaches	Constructs of symptom appraisal addressed	Underlying theories/models
Cancer				
Dine et al, 2011(59)	BCLE	Education sessions	Detection (demonstration) and response	Nil
Brailey et al, 1986(36)	Breast cancer	Education sessions and materials (film, pamphlet)	Detection (demonstration and hands-on practice)	PRECEDE Model(65)
Burgess et al, 2008(60)	Breast cancer	Education sessions and materials (booklet with graphics and illustrations, photographs of symptoms)	Detection (demonstration) and response (role modelling)	SRT(66), TPB(67), Implementation Intentions(68) and SCT(69)
Byrne et al, 2009(61)	Breast cancer	Education sessions and materials (pictures or illustrations)	Detection (demonstration and hands-on practice) and response	Nil
Craun et al, 1987(49)	Breast cancer	Education sessions and materials (pamphlet)	Detection (demonstration and hands-on practice)	HBM(70)
Khokhar et al, 2009(50)	Breast cancer	Education sessions and materials (video clip and pamphlet)	Detection (demonstration and hands-on practice)	Nil
McLendon et al, 1982(51)	Breast cancer	Education sessions (one-to-one)	Detection (hands-on practice) and response	Nil
Shepherd et al, 2007(52)	Breast cancer	Education sessions and materials (multimedia: radio)	Detection (demonstration) and response	Orem's Self Care Nursing Model(71)
Sorensen et al, 2005(37)	Breast cancer	Education sessions (video)	Detection (demonstration)	Nil
Stratton et al, 1994(53)	Breast cancer	Education sessions and materials (film and booklet)	Detection (demonstration)	Nil
Styrd et al, 1982(38)	Breast cancer	Education sessions and materials (film and publication)	Detection (demonstration)	Nil
Luther et al, 1985(39)	Breast and testicular cancer	Education sessions and materials (movies)	Detection (demonstration)	Nil
Cornell et al, 2015(40)	Melanoma	Education materials (photographs)	Interpretation (comparison)	Nil
Robertson et al, 2014(41)	Melanoma	Education materials (video and images of skin lesions)	Interpretation (comparison)	Nil
Scott et al, 2012(42)	Oral cancer	Education sessions and materials (leaflet)	Detection (hands-on practice) and response	SRT(18, 72), SCT(69)

Brooks et al, 2001(54)	Skin cancer	Education materials (pictures of skin lesions)	Interpretation (comparison)	Nil
Respiratory diseases				
Butz et al, 2005(55)	Asthma	Education sessions	Identification, interpretation (comparison) and response	MSM(22)
Colland et al, 2004(43)	Asthma	Education sessions	Identification, interpretation (comparison) and response	Nil
Gardner et al, 2016(62)	Asthma	Education sessions and materials (binder with large pictures)	Recognition, interpretation (comparison) and response	HBM(70)
Hendricson et al, 1996(44)	Asthma	Education sessions and materials (flip cards with illustrations, videotape, pamphlet)	Recognition and response (role modelling)	SLT(73), SCT(74)
Brandt et al, 2013(63)	COPD	Education sessions	Recognition, interpretation (comparison) and response	Collaborative Model for Self-Management of Chronic Disease(75)
Cardiovascular diseases				
Davis et al, 2019(45)	ACS	Education sessions and materials (pamphlet and pocket card)	Recognition, interpretation (comparison) and response	Nil
Raczynski et al, 1999(64)	AMI	Education sessions and materials (flyers/brochures, posters, magnets and other “tokens”; video)	Recognition and response (role modelling)	SCT(76), SRT(77), CO(78), DIT(79), SMT(80)
Jurgens et al, 2013(46)	HF	Education sessions and materials (booklet)	Detection, interpretation (comparison) and response	Theory of HF Self-Care(81), TUS(28, 82), UIT(83-86), SRT(72)
Other health conditions				
Hunt et al, 2015(56)	Concussion	Education materials (video)	Detection, interpretation (comparison) and response	Nil
Bonovich et al, 1990(57)	Labor	Education sessions and materials	Detection, interpretation (comparison) and response	Flanders’ Analyzing Teaching Behavior(87), Redman’s Principles of Patient Education(88)
Eriksen et al, 2010(47)	Malaria	Education sessions	Detection, interpretation and response (role modelling)	Nil
Matin et al, 2020(48)	Neonatal illness	Education apps/devices (audio, images of danger signs)	Detection, interpretation (comparison) and response	Nil
Ziadé et al, 2021(58)	RA	Education materials (video)	Detection (demonstration)	Nil

ACS: Acute Coronary Syndrome; AMI: Acute Myocardial Infarction; BCLE: LymphEdema secondary to Breast Cancer Treatment; CO: Community Organization Theory; COPD: Chronic Obstructive Pulmonary Disease; DIT: Diffusion of Innovation Theory; HBM: Health Belief Model; HF: Heart Failure; MSM: Model of Symptom Management; Nil: no theories/models were adopted; PRECEDE: Predisposing, Reinforcing, and Enabling Causes in Educational Diagnosis and Evaluation; RA: Rheumatoid Arthritis; SCT: Social Cognitive Theory; SLT: Social Learning Theory; SMT: Social Marketing Theory; SRT: Self-Regulation Theory; TPB: Theory of Planned Behavior; TUS: Theory of Unpleasant Symptoms; UIT: Uncertainty in Illness Theory.

Characteristics of approaches included in the synthesis

Of the 29 studies included in the synthesis, 16 focused on cancer(36-42, 49-54, 59-61), 5 on respiratory diseases(43, 44, 55, 62, 63), 3 on cardiovascular diseases(45, 46, 64), and one each on other health conditions including concussion(56), labor(57), malaria(47), neonatal illness(48) and RA(58). Six were community-based studies engaging various parties (e.g., educators and women leaders) in the communities and employing different outreach efforts (e.g., flyers and radio advertisement)(37, 39, 47, 52, 61, 64), among which 2 involved training of both laypersons and health providers(47, 64). Five studies reported only the development of approaches(59, 60, 62-64), while the remaining 24 reported both the development and evaluation of approaches using quantitative and/or qualitative measures (Supplementary File 4)(36-58, 61).

The most common type of approaches was a combination of education sessions and education materials (n = 15), followed by education sessions alone (n = 8), education materials alone (n = 5), and education applications/devices (n = 1) (Table 2). The majority (n = 18) of these approaches utilized both text and audio visual aids or multimedia to describe and illustrate symptoms/signs. All approaches comprised provision of knowledge of target symptoms/sign, 14 comprised demonstration and/or hands-on practice of symptom self-examination, 12 comprised comparison or target symptoms/signs with symptoms/signs of other health conditions, and 3 comprised other components such as role modelling of the detection, interpretation and response to target symptoms/signs.

Table 2. Characteristics of approaches developed for various health conditions

	Cancer (n = 16)	**Respiratory diseases (n = 5)**	**Cardiovascular diseases (n = 3)**	**Other health conditions * (n = 5)**	**Total (n = 29)**
Type of approaches, n (%)					
Education sessions	4 (25.0)	3 (60.0)	0 (0.0)	1 (20.0)	8 (27.6)
Education materials	3 (18.8)	0 (0.0)	0 (0.0)	2 (40.0)	5 (17.2)
Education sessions and education materials	9 (56.3)	2 (40.0)	3 (100.0)	1 (20.0)	15 (51.7)
Education apps/devices	0 (0.0)	0 (0.0)	0 (0.0)	1 (20.0)	1 (3.5)
Format of approaches, n (%)					
Text	4 (25.0)	3 (60.0)	2 (66.7)	2 (40.0)	11 (37.9)
Audio visual aids	11 (68.8)	2 (40.0)	1 (33.3)	3 (60.0)	17 (58.6)
Multimedia	1 (6.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.5)
Components of approaches, n (%)					
Knowledge of symptoms/signs	16 (100.0)	5 (100.0)	3 (100.0)	5 (100.0)	29 (100.0)
Demonstration and/or hands-on practice of symptom self-examination	13 (81,3)	0 (0.0)	0 (0.0)	1 (20.0)	14 (48.3)
Symptom comparison	3 (18.8)	4 (80.0)	2 (66.7)	3 (60.0)	12 (41.4)
Other components: role modelling	0 (0.0)	1 (20.0)	1 (33.3)	1 (20.0)	3 (10.3)

Underlying theories/models adopted in the development of approaches, n (%)					
No	11 (68.8)	1 (20.0)	1 (33.3)	4 (80.0)	17 (58.6)
Yes	5 (31.3)	4 (80.0)	2 (66.7)	1 (20.0)	12 (41.4)

*Other health conditions included concussion (n = 1), labor (n = 1), malaria (n = 1), neonatal illness (n = 1), and rheumatoid arthritis (n = 1).

Theories/models adopted in the development of approaches

Despite the apparent similarity of components in the approaches, less than half (n = 12) were developed based on theories/models and a variety of theories/models were adopted in the development of these approaches (Table 2). The adopted theories/models could be grouped into four categories:

1) Health behavior theories/models, including Predisposing, Reinforcing, and Enabling Causes in Educational Diagnosis and Evaluation (PRECEDE) Model(65), Theory of Planned Behavior (TPB)(67), Social Cognitive Theory (SCT)(69, 74, 76), Health Belief Model (HBM)(70), Community Organization (CO)(78), Diffusion of Innovations Theory (DIT)(79), and Social Marketing Theory (SMT)(80);
2) Symptom appraisal theories/models, including Self-Regulation Theory (SRT)(18, 66, 72, 77), Model of Symptom Management (MSM)(22), and Theory of Unpleasant Symptoms (TUS)(28, 82);
3) Educational theories/models, including Social Learning Theory (SLT)(73), Flanders' Analyzing Teaching Behavior(87), and Redman's Principles of Patient Education(88);
4) Other theories/models, including Implementation Intentions(68), Orem's Self Care Nursing Model(71), Collaborative Model for Self-Management of Chronic Disease(75), Theory of Heart Failure Self-Care(81), and Uncertainty in Illness Theory (UIT)(83-86).

The most common theories/models underlying the approaches were SCT and SRT, adopted in 4 studies each(42, 44, 46, 60, 64), among which 3 studies adopted both SCT and SRT(42, 60, 64). The second most common theory/model was HBM, adopted in 2 studies(49, 62). The remaining theories/models were adopted in only 1 study(36, 44, 46, 52, 55, 57, 60, 63, 64).

Evaluation of the developed approaches

Evaluation of the developed approaches focused primarily on their effectiveness in the majority of these studies(36-43, 45-58), while the reach, adoption and implementation of these approaches were evaluated in 5 studies(39, 44, 45, 48, 61), based on the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework(89). The outcome measures included the following:

- Knowledge, attitudes and beliefs about the given health conditions and symptoms/signs (n = 11)(36, 39, 42, 43, 45, 46, 48, 49, 51, 55, 56);
- Skills, attitudes and practice of symptom self-examination via self-reporting (n = 8)(36-39, 42, 49-51), observation by examiners (n = 3)(48, 52, 53), or qualitative interview (n = 1)(58);
- Accuracy comparison of target symptoms/signs and those of other health conditions (n = 4)(40, 41, 54, 57);
- Confidence and delay in help-seeking (n = 3)(42, 46, 48);
- Severity of health conditions (n = 3)(43, 46, 47);
- Satisfaction of educators (n = 1)(39) and satisfaction of patients and caregivers via self-reporting (n = 2)(44, 45) or qualitative interview (n = 1)(48);
- Implementation of approaches such as reviewing of education materials and appointment-making for clinical screening services (n = 2)(44, 61).

Discussion

In this study, we reviewed existing approaches to improving symptom appraisal in the literature. Provision of symptom knowledge, self-examination and comparison as well as demonstration/illustration of symptom appraisal using role modelling were common approaches

identified from the literature search. We found significant heterogeneity in whether theories/models were employed and the choice of theories/models employed in the development of these approaches. Only a small number of studies involving provision of both knowledge of symptoms/signs and other approaches were found in the literature search, highlighting the need for such studies with the goal of improving symptom appraisal and reducing pre-diagnosis interval among individuals in the general population.

Approaches that were developed in the vast majority (81.9%) of studies identified from the literature search comprised only provision of knowledge of symptoms/signs of a given health condition. While knowledge acquisition is a precondition for performing symptom appraisal (a given behavior), knowledge alone does not lead to the desired behavior (symptom appraisal)(35). For example, in the literature review by Teuschl et al, a discrepancy was observed between the theoretical knowledge of and response to stroke symptoms, with only one-quarter to one-half of the patients who had been educated on stroke signs recognized their symptoms as stroke and in turn responding promptly(90). As such, only approaches comprising both provision of the required knowledge and skills and additional components to enable personal, behavioral and environmental factors for symptom appraisal were included in the synthesis.

Theories and models present a systematic way of understanding complex issues (including symptom appraisal) by specifying the interrelationships among associated factors, which could provide a holistic framework for developing, implementing and evaluating interventions to address such issues(91). In addition to symptom appraisal theories/models, health behavior theories/models were also commonly adopted in the development of approaches identified in the literature. Depending on the given health problem and its social context, health behavior theories/models at different levels could be adopted(91). Since all of the three main constructs of symptom appraisal (i.e., detection, interpretation and response to symptoms) are influenced by social environment such as access to health resources(92, 93), health behavior theories/models at interpersonal level (SCT) would be more appropriate for use in the context of symptom appraisal and was thus adopted more frequently compared to theories/models at individual/intrapersonal (e.g., HBM and TPB) or community level (e.g., CO and DIT)(67, 69, 70, 73, 74, 76, 78, 79). Health behavior theories/models at interpersonal level provide the psychosocial mechanisms through which personal cognitive, behavioral and environmental factors interactively influence a given behavior, while theories/models at individual/intrapersonal level do not address the environment that the person and behavior interact in and theories/models at community level focus more on the engagement of communities(67, 69, 70, 73, 74, 76, 78, 79). Multiple theories and models that complement each other are often adopted to guide the development of different components of a given approach. This was seen in half of the studies in which theories/models were adopted(42, 44, 46, 57, 60, 64). Of note, health behavior and symptom appraisal theories/models were adopted together in 3 of the 4 studies where they were used(42, 60, 64).

Building on these studies, we propose an integrated conceptual framework from the major concepts of SCT (*reciprocal determinism, behavioral capacity, expectations, self-efficacy, observational learning* and *reinforcements*) and main constructs of symptom appraisal (Figure 2), in which approaches were proposed based on SCT to improve symptom appraisal(11, 69, 74). *Reciprocal determinism*, the reciprocal interaction of person, environment and behavior, highlights the importance of a multi-pronged approach to enhance not only a given behavior (*behavioral capability* and *reinforcements*) but also its associated personal (*self-efficacy* and *expectations*) and environmental (*observational learning* and social support) influences (Table 3). To enhance the *behavioral capacity* to perform symptom appraisal, one must possess the knowledge of the target symptoms/signs (eg through sight, touch, hearing and scent/smell) and the skills of how to detect, interpret and respond to the target symptoms/signs. This could be achieved through provision of essential knowledge of target symptoms/signs (symptom knowledge), demonstration of symptom self-examination, illustration of differences between target symptom/signs and symptoms/signs of other health conditions (symptom comparison), and instruction on actions to take upon detection of target symptoms/signs (symptom response). *Expectations*, the anticipated consequences of symptom appraisal, could be enhanced by demonstration of positive outcomes of symptom appraisal, or more specifically, prompt symptom detection and help-seeking. The positive outcomes of symptom appraisal could also work as *reinforcements* of symptom appraisal behavior. *Self-efficacy*, the confidence of performing symptom appraisal, could be increased by adopting various formats such as text, photo and video to enhance the knowledge and skills (*behavioral capacity*) required for symptom

appraisal and by demonstrating symptom appraisal, namely symptom self-examination, comparison and response using role models, the latter could enhance symptom appraisal through *observational learning*.

Table 3. Proposed approaches to improving symptom appraisal

Concepts of the Social Cognitive Theory	Definition of the concepts	Approaches to improving symptom appraisal in screening tools
Reciprocal determinism	Dynamic and reciprocal interaction of person, environment and behavior	• Provision of knowledge and skills (person and behavior) and supportive environment required for symptom appraisal, e.g., social support
Behavioral capacity	Ability (knowledge and skills) to perform a behavior	• Provision of symptom knowledge (sight and touch etc) • Demonstration of symptom self-examination (sight and touch etc) • Illustration of symptom comparison: differences between target symptoms/signs and symptoms/signs of other conditions (sight and touch etc) • Instructions on symptom response, namely actions to take upon symptom detection
Expectations	Anticipated consequences of a behavior	• Demonstration of positive outcomes of prompt symptom detection and help-seeking
Self-efficacy	Confidence in one's ability to perform a behavior	• Adoption of various formats such as text, photo and video to enhance symptom knowledge, self-examination, comparison, and response • Demonstration of symptom self-examination, comparison and response using role models
Observational learning	Learning through observation e.g., modelling of behaviors	• Demonstration of symptom self-examination, comparison and response using role models
Reinforcements	Responses to a behavior that affect the likelihood of reoccurrence	• Demonstration of positive outcomes of prompt symptom detection and help-seeking

The proposed framework and approaches could be incorporated into the development of self-administered screening tools (Supplementary File 5), which are cost-effective in facilitating early disease identification in the general population(94). Many existing screening tools, however, might be too challenging for individuals with lower health literacy to answer as they often assess only the presence of target symptoms/signs of a given health condition without any explanations of what target symptoms/signs are and how these might look, feel etc. While providing a description/explanation of target symptoms/signs could, to some extent, aid comprehension and improve the accuracy of self-reporting on screening tools, many symptoms/signs cannot be easily explained using text and would require illustrations such as photos and videos. For example, the three phases of color changes in Raynaud's phenomenon (RP), a common symptom seen among patients with ARDs, could be illustrated more clearly in the form of video instead of text. Such illustrations could prompt symptomatic individuals to notice the deviations from normality and enhance symptom appraisal by providing the context for interpretation, extra-lingual information, clarifying examples and redundancy to aid comprehension of the text(95). In the literature review by Levie et al, increased understanding was observed in 98% of the experiments using different illustrations(96). Furthermore, other approaches such as demonstration of symptom self-examination and response using role models could be better illustrated using photos and videos.

There are three main limitations in this study. First, only free-text search was conducted in Web of Science and Scopus due to a lack of controlled vocabularies in these two databases. However, in consultation with a medical librarian with expertise in literature searches, a list of comprehensive free-text search terms were developed based on preliminary literature searches and both controlled vocabulary search and free-text search were used in other databases (Medline, PsycInfo, Embase and CINAHL), which would be sufficient to identify most of the important articles in the literature. Second, five reports identified in the literature search were unable to be retrieved, which might contain theories/models and approaches that differ from those reviewed in this study. However, based on their title and abstract, these reports comprise mainly self-examination of symptoms/signs of breast, skin and testicular cancer and macular degeneration, and similar approaches had been included in our review and synthesis. Finally, the proposed framework is conceptual and requires empirical data to support it. Qualitative interviews with patients with ARDs are planned in our future work to further validate the framework by understanding the experience of symptom appraisal and approaches that could help the patients detect, interpret and take prompt actions in response to symptoms/signs. A screening tool comprising approaches to improving symptom appraisal will then be developed. Furthermore, the proposed framework and approaches target mainly knowledge, skills, attitudes and beliefs about symptom appraisal (behavior) among symptomatic individuals (person). The environment with which person and behavior interact such as cultural beliefs, social support, healthcare system and healthcare professionals also plays an important role in promoting or inhibiting symptom appraisal among these individuals. These environmental factors, however, could not be easily incorporated into screening tools but rather into large-scale public health screening programmes, which is a potential focus for our future work.

Conclusion

Symptom appraisal is an essential process in a patient's journey that can be targeted to facilitate early diagnosis but is largely unstudied. Building on the literature, we propose a theoretical framework and approaches to improving symptom appraisal. This could facilitate early identification of a variety of health conditions in the general population.

Funding

This work was supported by the SingHealth Duke-NUS Academic Medicine Research Grant (grant reference: AM/HSR015/2021) and Goh Cheng Liang Rheumatology ARISE (Advancing Research and Innovation with Synergistic Expertise) Programme Fund (funding reference: N/A). The funders had no role in the design of the study and collection, analysis, and interpretation of data and in writing of this manuscript.

Acknowledgments

We would like to thank Ms Suei-Nee Wong, a senior librarian in the medical library of the National University Singapore, for her assistance in the development of literature search strategy.

Contributors

LX, AHLL, TCL, DRK and JT designed the search. LX conducted the search and narrative analysis. SY, AHLL, YYL, WF, TCL, DRK and JT contributed to the data interpretation and editing of the manuscript. LX drafted the manuscript. All authors read and approved the final manuscript.

Competing interests

None.

Data availability statement

All data relevant to the study are available on reasonable request to the corresponding author.

Research ethics approval

Not applicable.

References

1. Zhao SS, Pittam B, Harrison NL, Ahmed AE, Goodson NJ, Hughes DM. Diagnostic delay in axial spondyloarthritis: a systematic review and meta-analysis. Rheumatology. 2021;60(4):1620-8.
2. Lauritzen BB, Jensen JS, Gronhoj C, Wessel I, von Buchwald C. Impact of delay in diagnosis and treatment-initiation on disease stage and survival in oral cavity cancer: a systematic review. Acta Oncologica. 2021;60(9):1083-90.
3. Qu LG, Brand NR, Chao A, Ilbawi AM. Interventions Addressing Barriers to Delayed Cancer Diagnosis in Low- and Middle-Income Countries: A Systematic Review. Oncologist. 2020;25(9):e1382-e95.
4. Bello S, Afolabi RF, Ajayi DT, Sharma T, Owoeye DO, Oduyoye O, et al. Empirical evidence of delays in diagnosis and treatment of pulmonary tuberculosis: systematic review and meta-regression analysis. BMC Public Health. 2019;19(1):820.
5. Prior JA, Ranjbar H, Belcher J, Mackie SL, Helliwell T, Liddle J, et al. Diagnostic delay for giant cell arteritis - a systematic review and meta-analysis. BMC Medicine. 2017;15(1):120.
6. Jovani V, Blasco-Blasco M, Ruiz-Cantero MT, Pascual E. Understanding How the Diagnostic Delay of Spondyloarthritis Differs Between Women and Men: A Systematic Review and Metaanalysis. Journal of Rheumatology. 2017;44(2):174-83.
7. Getnet F, Demissie M, Assefa N, Mengistie B, Worku A. Delay in diagnosis of pulmonary tuberculosis in low-and middle-income settings: systematic review and meta-analysis. BMC Pulmonary Medicine. 2017;17(1):202.
8. Brasme JF, Morfouace M, Grill J, Martinot A, Amalberti R, Bons-Letouzey C, et al. Delays in diagnosis of paediatric cancers: a systematic review and comparison with expert testimony in lawsuits. Lancet Oncology. 2012;13(10):e445-59.
9. Andersen BL, Cacioppo JT. Delay in seeking a cancer diagnosis: delay stages and psychophysiological comparison processes. Br J Soc Psychol. 1995;34 (Pt 1):33-52.
10. Barhamain AS, Magliah RF, Shaheen MH, Munassar SF, Falemban AM, Alshareef MM, et al. The journey of rheumatoid arthritis patients: a review of reported lag times from the onset of symptoms. Open Access Rheumatol. 2017;9:139-50.
11. Whitaker KL, Scott SE, Wardle J. Applying symptom appraisal models to understand sociodemographic differences in responses to possible cancer symptoms: a research agenda. British Journal of Cancer. 2015;112(1):S27-S34.
12. Robbins JM, Kirmayer LJ. Attributions of common somatic symptoms. Psychol Med. 1991;21(4):1029-45.
13. Simons G, Mason A, Falahee M, Kumar K, Mallen CD, Raza K, et al. Qualitative Exploration of Illness Perceptions of Rheumatoid Arthritis in the General Public. Musculoskeletal Care. 2017;15(1):13-22.
14. Stack RJ, Shaw K, Mallen C, Herron-Marx S, Horne R, Raza K. Delays in help seeking at the onset of the symptoms of rheumatoid arthritis: a systematic synthesis of qualitative literature. Ann Rheum Dis. 2012;71(4):493-7.
15. Xiang L, Low AHL, Leung YY, Fong W, Gandhi M, Yoon S, et al. Interval between symptom onset and diagnosis among patients with autoimmune rheumatic diseases in a multi-ethnic Asian population. Int J Rheum Dis. 2021;24(8):1061-70.
16. Petrova D, Okan Y, Salamanca-Fernandez E, Dominguez-Lopez S, Sanchez MJ, Rodriguez-Barranco M. Psychological factors related to time to help-seeking for cancer symptoms: a meta-analysis across cancer sites. Health psychol. 2020;14(2):245-68.
17. Macdonald S, Macleod U, Campbell NC, Weller D, Mitchell E. Systematic review of factors influencing patient and practitioner delay in diagnosis of upper gastrointestinal cancer. British Journal of Cancer. 2006;94(9):1272-80.
18. Leventhal H, Meyer D, Nerenz D. The common sense representation of illness danger. In: Rachman S, editor. Contributions to Medical Psychology: Pergamon Press; 1980. p. 7-30.
19. Leventhal H, Benyamini Y, Brownlee S, Diefenbach M, Leventhal EA, Patrick-Miller L, et al. Illness Representations: Theoretical Foundations. In: Petrie KJ, Weinman J, editors. Perceptions of Health and Illness: Current Research and Applications: Harwood Academic Publishers; 1997.
20. Sorofman B, Tripp-Reimer T, Lauer GM, Martin ME. Symptom self-care. Holist Nurs Pract. 1990;4(2):45-55.
21. Cioffi D. Beyond attentional strategies: cognitive-perceptual model of somatic interpretation. Psychol Bull. 1991;109(1):25-41.
22. The University of California San Francisco School of Nursing Symptom Management Faculty Group. A model for symptom management. . Image J Nurs Sch. 1994;26(4):272-6.

23. Dodd M, Janson S, Facione N, Faucett J, Froelicher ES, Humphreys J, et al. Advancing the science of symptom management. J Adv Nurs. 2001;33(5):668-76.
24. Teel CS, Meek P, McNamara AM, Watson L. Perspectives unifying symptom interpretation. Image J Nurs Sch. 1997;29(2):175-81.
25. van Wijk CM, Kolk AM. Sex differences in physical symptoms: the contribution of symptom perception theory. Soc Sci Med. 1997;45(2):231-46.
26. Henly SJ, Kallas KD, Klatt CM, Swenson KK. The notion of time in symptom experiences. Nurs Res. 2003;52(6):410-7.
27. Petersen S, van den Berg RA, Janssens T, Van den Bergh O. Illness and symptom perception: a theoretical approach towards an integrative measurement model. Clin Psychol Rev. 2011;31(3):428-39.
28. Lenz ER, Pugh LC, Milligan RA, Gift A, Suppe F. The middle-range theory of unpleasant symptoms: an update. ANS Adv Nurs Sci. 1997;19(3):14-27.
29. Armstrong TS. Symptoms experience: a concept analysis. Oncol Nurs Forum. 2003;30(4):601-6.
30. Kolk AM, Hanewald GJ, Schagen S, Gijsbers van Wijk CM. A symptom perception approach to common physical symptoms. Soc Sci Med. 2003;57(12):2343-54.
31. Posey AD. Symptom Perception: A Concept Exploration. Nursing Forum. 2006;41(3):113-24.
32. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.
33. Tufanaru C, Munn Z, Aromataris E, Campbell J, Hopp L. Chapter 3: Systematic reviews of effectiveness. 2020. In: JBI Manual for Evidence Synthesis [Internet]. JBI. Available from: https://synthesismanual.jbi.global.
34. Lockwood C, Munn Z, Porritt K. Qualitative research synthesis: methodological guidance for systematic reviewers utilizing meta-aggregation. Int J Evid Based Healthc. 2015;13(3):179-87.
35. Bandura A. Health promotion by social cognitive means. Health Educ Behav. 2004;31(2):143-64.
36. Brailey LJ. Effects of health teaching in the workplace on women's knowledge, beliefs, and practices regarding breast self-examination. Research in Nursing & Health. 1986;9(3):223-31.
37. Sorensen J, Hertz A, Gudex C. Evaluation of a Danish teaching program in breast self-examination. Cancer Nursing. 2005;28(2):141-7.
38. Styrd AM. A breast self-examination program in an occupational health setting. Occup Health Nurs. 1982;30(4):33-5.
39. Luther SL, Sroka S, Goormastic M, Montie JE. Teaching breast and testicular self-exams: evaluation of a high school curriculum pilot project. Health Education. 1985;16(1):40-3.
40. Cornell E, Robertson K, McIntosh RD, Rees JL. Viewing Exemplars of Melanomas and Benign Mimics of Melanoma Modestly Improves Diagnostic Skills in Comparison with the ABCD Method and Other Image-based Methods for Lay Identification of Melanoma. Acta Dermato-Venereologica. 2015;95(6):681-5.
41. Robertson K, McIntosh RD, Bradley-Scott C, MacFarlane S, Rees JL. Image training, using random images of melanoma, performs as well as the ABC(D) criteria in enabling novices to distinguish between melanoma and mimics of melanoma. Acta Derm Venereol. 2014;94(3):265-70.
42. Scott SE, Khwaja M, Low EL, Weinman J, Grunfeld EA. A randomised controlled trial of a pilot intervention to encourage early presentation of oral cancer in high risk groups. Patient Education and Counseling. 2012;88(2):241-8.
43. Colland VT, van Essen-Zandvliet LE, Lans C, Denteneer A, Westers P, Brackel HJ. Poor adherence to self-medication instructions in children with asthma and their parents. Patient Education & Counseling. 2004;55(3):416-21.
44. Hendricson WD, Wood PR, Hidalgo HA, Ramirez AG, Kromer ME, Selva M, et al. Implementation of individualized patient education for Hispanic children with asthma. Patient Education & Counseling. 1996;29(2):155-65.
45. Davis LL, McCoy TP. An Educational and Skill-Building Intervention to Improve Symptom Recognition and Interpretation in Women With Acute Coronary Syndrome: A Pilot Study. Dccn. 2019;38(1):29-37.
46. Jurgens CY, Lee CS, Reitano JM, Riegel B. Heart failure symptom monitoring and response training. Heart & Lung. 2013;42(4):273-80.
47. Eriksen J, Mujinja P, Warsame M, Nsimba S, Kouyate B, Gustafsson LL, et al. Effectiveness of a community intervention on malaria in rural Tanzania - a randomised controlled trial. African Health Sciences. 2010;10(4):332-40.

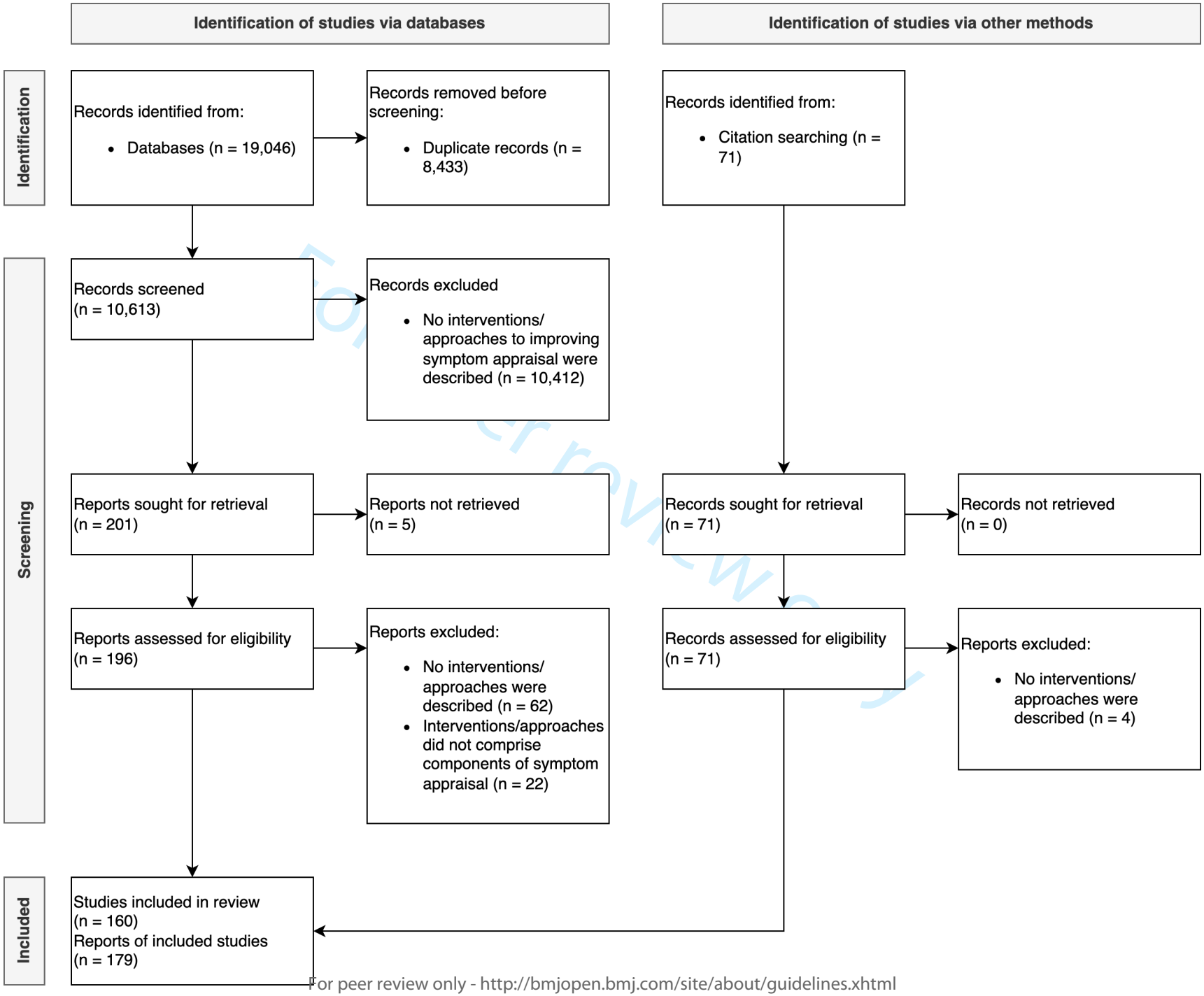
48. Matin SB, Wallingford A, Xu S, Ng N, Ho A, Vanosdoll M, et al. Feasibility of a mobile health tool for mothers to identify neonatal illness in rural Uganda: Acceptability study. JMIR mHealth and uHealth. 2020;8(2).
49. Craun AM, Deffenbacher JL. The effects of information, behavioral rehearsal, and prompting on breast self-exams. Journal of Behavioral Medicine. 1987;10(4):351-65.
50. Khokhar A. Short text messages (SMS) as a reminder system for making working women from Delhi Breast Aware. Asian Pac J Cancer Prev. 2009;10(2):319-22.
51. McLendon MS, Fulk CH, Starnes DC. Effectiveness of breast self-examination teaching to women of low socioeconomic class. JOGN Nurs. 1982;11(1):7-10.
52. Shepherd JH, McLnerney PA. Knowledge of breast self-examination in women in Sierra Leone. Curationis. 2007;30(4):38-44.
53. Stratton BF, Nicholson ME, Olsen LK, Mahoney BS, Warland RH. Breast self-examination proficiency: Attitudinal, demographic, and behavioral characteristics. Journal of Women's Health. 1994;3(3):185-95.
54. Brooks A, Predebon J, van der Zwan R. Perceptual strategies to improve skin cancer discriminations in naive observers. Public Health. 2001;115(2):139-45.
55. Butz AM, Syron L, Johnson B, Spaulding J, Walker M, Bollinger ME. Home-based asthma self-management education for inner city children. Public Health Nurs. 2005;22(3):189-99.
56. Hunt TN. Video Educational Intervention Improves Reporting of Concussion and Symptom Recognition. Athletic Training Education Journal (Allen Press Publishing Services Inc). 2015;10(1):65-74.
57. Bonovich L. Recognizing the onset of labor. J Obstet Gynecol Neonatal Nurs. 1990;19(2):141-5.
58. Ziadé N, Saad S, Al Mashaleh M, El Kibbi L, Elzorkany B, Badsha H, et al. Perceptions of patients with rheumatoid arthritis about self-assessment of disease activity after watching an educational video: a qualitative pilot study from the AUTO-DAS in Middle Eastern Arab countries project. Rheumatology International. 2021.
59. Dine JL, Austin MKS, Armer JM. Nursing education on lymphedema self-management and self-monitoring in a South African oncology clinic. Journal of Cultural Diversity. 2011;18(4):126-8.
60. Burgess CC, Bish AM, Hunter HS, Salkovskis P, Michell M, Whelehan P, et al. Promoting early presentation of breast cancer: development of a psycho-educational intervention. Chronic Illn. 2008;4(1):13-27.
61. Byrne S, Robles-Rodriguez E. Educational parties as a strategy to promote breast health awareness and screening in underserved female populations. Oncology nursing forum. 2009;36(2):145-8.
62. Gardner LE. Advanced Practitioner Provided Pre-Hospital Discharge Asthma Education: Walden University; 2016.
63. Brandt CL. Study of older adults' use of self-regulation for COPD self-management informs an evidence-based patient teaching plan. Rehabilitation nursing : the official journal of the Association of Rehabilitation Nurses. 2013;38(1):11-23.
64. Raczynski JM, Finnegan JR, Jr., Zapka JG, Meischke H, Meshack A, Stone EJ, et al. REACT theory-based intervention to reduce treatment-seeking delay for acute myocardial infarction. Rapid Early Action for Coronary Treatment. Am J Prev Med. 1999;16(4):325-34.
65. Green LW, Kreuter MW, Deeds S, Partridge K. Health Education Planning: A Diagnostic Approach: Mayfield Publishing Company; 1980.
66. Leventhal H, Nerenz D, Steele D. Illness representations and coping with health threats. In: A. Baum, SE Taylor, Singer J, editors. Handbook of psychology and health: social psychological aspects of health1984. p. 219-52.
67. Ajzen I. The theory of planned behavior. Organizational Behavior and Human Decision Processes. 1991;50(2):179-211.
68. Gollwitzer PM. Goal Achievement: The Role of Intentions. European Review of Social Psychology. 1993;4(1):141-85.
69. Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. Psychol Rev. 1977;84(2):191-215.
70. Rosenstock IM. Historical Origins of the Health Belief Model. Health Education Monographs. 1974;2(4):328-35.
71. Orem DE. Nursing: Concepts of Practice: McGraw-Hill; 1980.
72. Cameron LD, Leventhal H. The self-regulation of health and illness behaviour. New York, NY, US: Routledge; 2003.

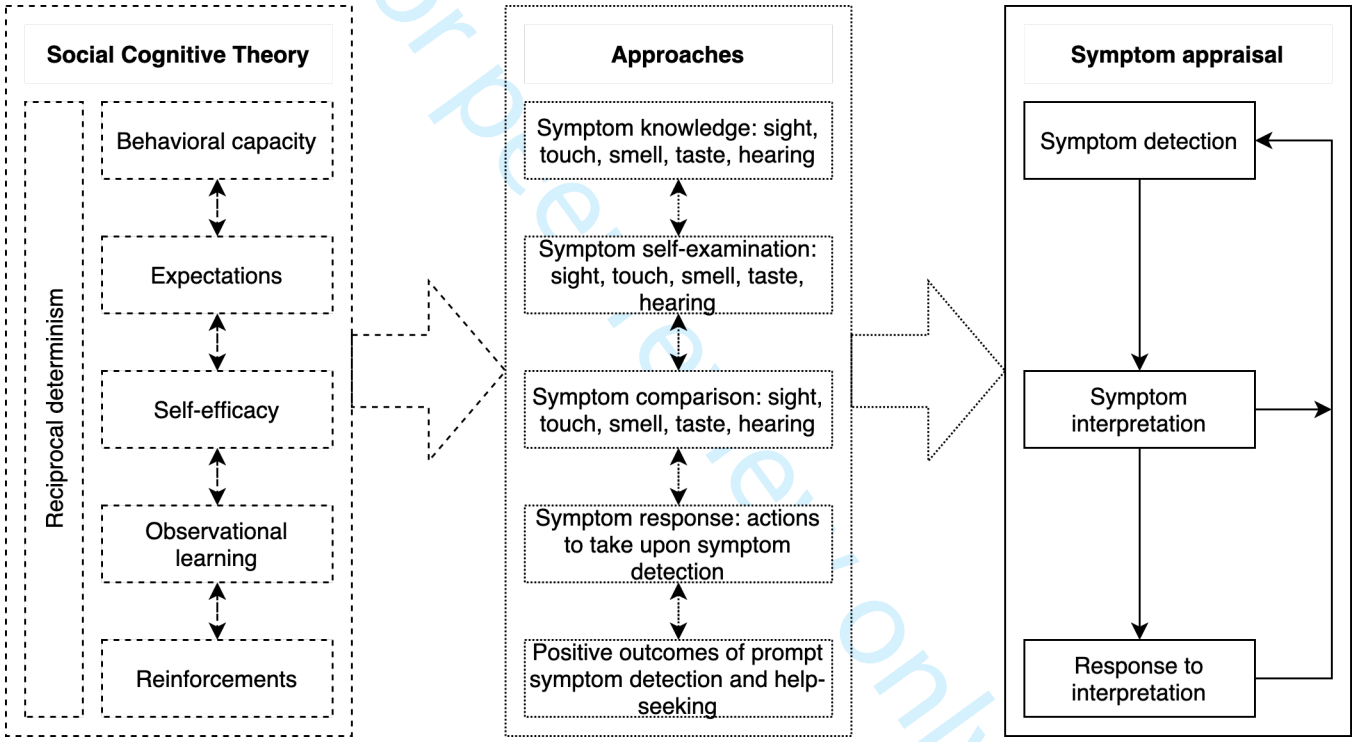
73. Parcel GS, Baranowski T. Social learning theory and health education. Health Educ. 1981;12(3):14-8.
74. Bandura A. Social foundations of thought and action: A social cognitive theory: Prentice-Hall, Inc; 1986.
75. Brandt CL. Description of the Self-regulation Process Used by Persons with Chronic Lung Disease and Its Relationship to Health-related Outcomes: University of Minnesota; 2005.
76. Perry CL, Baranowski T, Parcel GS. How individuals, environments, and health behavior interact: Social Cognitive Theory. In: Glanz K, Lewis FM, Rimer BK, editors. Health behavior and health education: Theory, research, and practice. San Francisco, CA: Jossey-Bass; 1990.
77. Cameron L, Leventhal EA, Leventhal H. Emotional and behavioral processes. In: Johnston M, Wallace L, editors. Stress and Medical Procedures: New York, NY: Pergamon; 1993. p. 7-30.
78. Bracht N. Health promotion at the community level. Thousand Oaks, CA, US: Sage Publications, Inc; 1990.
79. Rogers EM. Diffusion of innovations. New York; London: Free Press ; Collier Macmillan; 1983.
80. Novelli W. Applying social marketing to health promotion and disease prevention. In: Glanz K, Lewis FM, Rimer BK, editors. Health behavior and health education: theory, research and practice. San Francisco, CA: Jossey-Bass; 1990.
81. Riegel B, Dickson VV. A situation-specific theory of heart failure self-care. J Cardiovasc Nurs. 2008;23(3):190-6.
82. Lenz ER, Suppe F, Gift AG, Pugh LC, Milligan RA. Collaborative development of middle-range nursing theories: toward a theory of unpleasant symptoms. ANS Adv Nurs Sci. 1995;17(3):1-13.
83. Mishel MH. The measurement of uncertainty in illness. Nurs Res. 1981;30(5):258-63.
84. Mishel MH. Perceived uncertainty and stress in illness. Res Nurs Health. 1984;7(3):163-71.
85. Mishel MH. Uncertainty in illness. Image J Nurs Sch. 1988;20(4):225-32.
86. Mishel MH. Reconceptualization of the uncertainty in illness theory. Image J Nurs Sch. 1990;22(4):256-62.
87. Flanders NA. Analyzing teaching behavior. Reading, Mass.: Addison-Wesley Pub. Co.; 1970.
88. Redman BK. The Process of Patient Education: C.V. Mosby; 1984.
89. Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. Am J Public Health. 1999;89(9):1322-7.
90. Teuschl Y, Brainin M. Stroke education: discrepancies among factors influencing prehospital delay and stroke knowledge. International Journal of Stroke. 2010;5(3):187-208.
91. Glanz K, Rimer BK, Viswanath K. Health Behavior: Theory, Research, and Practice: Wiley; 2015.
92. Dingwall R. Aspects of Illness: Ashgate; 2001.
93. Alonzo AA. Everyday illness behavior: a situational approach to health status deviations. Soc Sci Med. 1979;13a(4):397-404.
94. Villeneuve E, Nam JL, Bell MJ, Deighton CM, Felson DT, Hazes JM, et al. A systematic literature review of strategies promoting early referral and reducing delays in the diagnosis and management of inflammatory arthritis. Ann Rheum Dis. 2013;72(1):13-22.
95. Murray J, Williams B. The Role of Images on Illness Behaviour: Interdisciplinary Theory, Evidence, and Ideas. Psychological Reports. 2020;0(0):0033294120945602.
96. Levie WH, Lentz R. Effects of Text Illustrations: A Review of Research. Educational Communication and Technology. 1982;30(4):195-232.

Figure legend/caption

Figure 1. PRISMA chart

Figure 2. Proposed framework for improving symptom appraisal
Dashed boxes and arrows: concepts from Bandura's Social Cognitive Theory, dotted boxes and arrows: approaches to improving knowledge, skills, attitudes and beliefs about symptom appraisal using various formats including text, photos and videos, solid boxes and arrows: constructs from Whitaker's synthesis of symptom appraisal models. The up down arrows denote interacting relationship between different components.





Supplementary File 1. Development of literature search strategy

This literature review aims to identify approaches to improving symptom appraisal in the literature. We first performed preliminary searches in Medline using free-text terms for the two key concepts: symptom and appraisal, based on which we developed definitions of symptom and symptom appraisal and refined our search concepts and terms.

Various definitions of the term "symptom" have been proposed and adopted in the literature. Common features in different definitions are that a symptom is an indicator of bodily change/deviation from normality and that a symptom is a subjective perception of an individual(1-3). Based on these common features, we defined symptom as a subjective health state that departs from bodily normality, which may or may not be attributed as a manifestation of illness by an individual. This is based on the consideration that our focus starts from the onset of a bodily change/somatic information, regardless of whether it is detected, perceived or acted on by an individual.

Several concepts pertaining to symptom appraisal exist in the literature including illness representation(4, 5), symptom response(6), symptom attribution(7), symptom experience(3, 8-11), symptom interpretation(1), and symptom perception(2, 12, 13). In the synthesis of relevant concepts by Posey et al, symptom perception was defined as the belief about what a symptom means (cognitively and emotionally), appraisal of the symptom based on past and present knowledge and experience, and response or action based upon the meaning and appraisal of the symptom(14). In a more recent work synthesizing various symptom appraisal theories and models by Whitaker et al, symptom appraisal was defined as encompassing three main constructs: detection of a bodily change, interpretation of the bodily change and response to interpretation(15), the latter two coincide with the definition of symptom perception by Posey et al. We adopted the definition of symptom appraisal proposed by Whitaker et al for two reasons: first, it has a relatively broader meaning and second, it fits well with our study focus, namely the process starting before the detection of a bodily change to the point of decision making on whether or not to take action on the bodily change. We included the three main constructs (detection, interpretation and response) as well as other relevant concepts of symptom appraisal in the search terms (Table 1).

Our final search strategy contains three concepts: 1) symptom, 2) appraisal and 3) patient education. The concept of patient education was added in the search based on the consideration that our focus was approaches that had been developed to improve symptom appraisal among symptomatic patients instead of other populations such as healthcare professionals. Since there are no appropriate MeSH terms for the concept of appraisal, we adopted the MeSH terms for the combined concept of symptom appraisal, in consultation with a senior librarian with experience in medical literature search strategies. After Mesh Terms were selected, their corresponding controlled vocabularies in PsycInfo, Embase and Cumulative Index to Nursing and Allied Health Literature (CINAHL) were identified. We combined controlled vocabulary search in all fields and free-text search with proximity operators in title and abstract fields in Medline, PsycInfo and CINAHL. We performed a free-text search with proximity operators in title and abstract fields in Web of Science and Scopus where controlled vocabularies are not available.

Table 1. Literature search strategy

	Free-text terms	Controlled vocabularies					
		Medline	PsycInfo†	Embase‡	CINAHL	Web of Science	Scopus
Concept: symptom	symptom* OR somatic OR illness*	Diagnostic Self Evaluation OR Self Care	Self-Evaluation OR Self-Care	self evaluation OR self care agency OR self help	Self Assessment OR Self Care Agency OR Self-Management	-	-
Concept: appraisal	apprais* OR detect* OR recogni* OR						

	perce* OR interpret* OR attribut* OR respon* OR behav* OR experienc* OR report*						
Concept: patient education	educat* OR teach* OR instruct* OR train* OR learn*	Health Education	Health Education	health education	Health Education	-	-
Searching fields	Title and abstract	-	-	-	-	-	-
Proximity operators	-	adj5	adj5	NEAR/5	N5	NEAR/5	W/5

References

1. Teel CS, Meek P, McNamara AM, Watson L. Perspectives unifying symptom interpretation. Image J Nurs Sch. 1997;29(2):175-81.
2. van Wijk CM, Kolk AM. Sex differences in physical symptoms: the contribution of symptom perception theory. Soc Sci Med. 1997;45(2):231-46.
3. Dodd M, Janson S, Facione N, Faucett J, Froelicher ES, Humphreys J, et al. Advancing the science of symptom management. J Adv Nurs. 2001;33(5):668-76.
4. Leventhal H, Meyer D, Nerenz D. The common sense representation of illness danger. In: Rachman S, editor. Contributions to Medical Psychology: Pergamon Press; 1980. p. 7-30.
5. Leventhal H, Benyamini Y, Brownlee S, Diefenbach M, Leventhal EA, Patrick-Miller L, et al. Illness Representations: Theoretical Foundations. In: Petrie KJ, Weinman J, editors. Perceptions of Health and Illness: Current Research and Applications: Harwood Academic Publishers; 1997.
6. Sorofman B, Tripp-Reimer T, Lauer GM, Martin ME. Symptom self-care. Holist Nurs Pract. 1990;4(2):45-55.
7. Robbins JM, Kirmayer LJ. Attributions of common somatic symptoms. Psychol Med. 1991;21(4):1029-45.
8. The University of California San Francisco School of Nursing Symptom Management Faculty Group. A model for symptom management. . Image J Nurs Sch. 1994;26(4):272-6.
9. Lenz ER, Pugh LC, Milligan RA, Gift A, Suppe F. The middle-range theory of unpleasant symptoms: an update. ANS Adv Nurs Sci. 1997;19(3):14-27.
10. Armstrong TS. Symptoms experience: a concept analysis. Oncol Nurs Forum. 2003;30(4):601-6.
11. Henly SJ, Kallas KD, Klatt CM, Swenson KK. The notion of time in symptom experiences. Nurs Res. 2003;52(6):410-7.
12. Kolk AM, Hanewald GJ, Schagen S, Gijsbers van Wijk CM. A symptom perception approach to common physical symptoms. Soc Sci Med. 2003;57(12):2343-54.
13. Petersen S, van den Berg RA, Janssens T, Van den Bergh O. Illness and symptom perception: a theoretical approach towards an integrative measurement model. Clin Psychol Rev. 2011;31(3):428-39.
14. Posey AD. Symptom Perception: A Concept Exploration. Nursing Forum. 2006;41(3):113-24.
15. Whitaker KL, Scott SE, Wardle J. Applying symptom appraisal models to understand sociodemographic differences in responses to possible cancer symptoms: a research agenda. British Journal of Cancer. 2015;112(1):S27-S34.

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Page 4
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 3
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Supplementary File 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Pages 3-4
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Page 4
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Page 4
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 4
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 4
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	NA
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Page 4
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Page 4
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Page 4
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page 4
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	NA
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	NA
Certainty	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	NA

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
assessment			
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Page 4, Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	NA
Study characteristics	17	Cite each included study and present its characteristics.	Pages 14-15, Supplementary File 3
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Page 4
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	NA
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	NA
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Pages 4-5
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	NA
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	NA
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Pages 6-7
	23b	Discuss any limitations of the evidence included in the review.	NA
	23c	Discuss any limitations of the review processes used.	Page 7
	23d	Discuss implications of the results for practice, policy, and future research.	Pages 6-7, Supplementary File 4
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 3
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 3
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Page 8
Competing interests	26	Declare any competing interests of review authors.	Page 8
Availability of data, code and	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	NA

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
other materials			

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

Supplementary File 3. Quality assessment using the Joanna Briggs Institute critical appraisal tools

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Raw score
Randomized controlled trials														
Bonovich 1990(1)	U	U	Y	U	N	NA	Y	NA	Y	Y	Y	Y	Y	64%
Butz 2005(2)	Y	Y	Y	U	N	U	Y	N	Y	Y	Y	Y	Y	69%
Craun 1987(3)	U	U	U	U	U	NA	NA	NA	Y	Y	Y	Y	Y	50%
Jurgens 2013(4)	Y	Y	Y	U	N	NA	Y	Y	Y	Y	Y	Y	Y	83%
Scott 2012(5)	Y	Y	Y	N	N	NA	Y	Y	Y	Y	Y	Y	Y	83%
Colland 2004(6)	Y	Y	Y	U	N	U	Y	Y	Y	Y	Y	Y	Y	77%
Eriksen 2010(7)	Y	NA	N	U	N	NA	Y	NA	Y	Y	Y	Y	Y	70%
Hunt 2015(8)	U	U	N	U	N	NA	NA	Y	Y	Y	Y	Y	Y	55%
McLendon 1982(9)	Y	U	N	U	N	U	Y	N	Y	Y	Y	Y	Y	54%
Quasi-experimental studies														
Brailey 1986(10)	Y	U	NA	Y	N	Y	Y	Y	Y					75%
Hendricson 1996(11)	Y	NA	NA	N	NA	NA	NA	Y	Y					75%
Shepherd 2007(12)	Y	NA	NA	N	N	NA	NA	Y	Y					60%
Brooks 2001(13)	Y	U	NA	Y	N	U	Y	Y	Y					63%
Cornell 2015(14)	Y	Y	NA	Y	N	NA	Y	Y	Y					86%
Davis 2019(15)	Y	NA	NA	N	Y	NA	NA	Y	Y					80%
Khokhar 2009(16)	Y	NA	NA	N	N	NA	NA	Y	Y					60%
Luther 1985(17)	Y	NA	NA	N	Y	NA	NA	Y	Y					80%
Matin 2020(18)	Y	NA	NA	N	Y	NA	NA	Y	Y					80%
Robertson 2014(19)	Y	N	NA	Y	N	NA	Y	Y	Y					71%
Sorensen 2005(20)	Y	N	NA	Y	N	NA	Y	Y	Y					71%
Stratton 1994(21)	Y	NA	NA	N	N	NA	NA	Y	Y					60%
Styrd 1982(22)	Y	NA	NA	N	Y	NA	NA	Y	Y					80%
Qualitative research														
Ziadé 2021(23)	Y	Y	U	U	Y	Y	U	N	Y	Y				60%

N: no, NA: not applicable, U: unclear, Y: yes.

Checklist for randomized controlled trials:
Q1. Was true randomization used for assignment of participants to treatment groups?
Q2. Was allocation to treatment groups concealed?

Q3. Were treatment groups similar at the baseline?
Q4. Were participants blind to treatment assignment?
Q5. Were those delivering treatment blind to treatment assignment?
Q6. Were outcomes assessors blind to treatment assignment?
Q7. Were treatment groups treated identically other than the intervention of interest?
Q8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?
Q9. Were participants analyzed in the groups to which they were randomized?
Q10. Were outcomes measured in the same way for treatment groups?
Q11. Were outcomes measured in a reliable way?
Q12. Was appropriate statistical analysis used?
Q13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?

Checklist for quasi-experimental studies:
Q1. Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?
Q2. Were the participants included in any comparisons similar?
Q3. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?
Q4. Was there a control group?
Q5. Were there multiple measurements of the outcome both pre and post the intervention/exposure?
Q6. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?
Q7. Were the outcomes of participants included in any comparisons measured in the same way?
Q8. Were outcomes measured in a reliable way?
Q9. Was appropriate statistical analysis used?"

Checklist for qualitative research:
Q1. Is there congruity between the stated philosophical perspective and the research methodology?
Q2. Is there congruity between the research methodology and the research question or objectives?
Q3. Is there congruity between the research methodology and the methods used to collect data?
Q4. Is there congruity between the research methodology and the representation and analysis of data?
Q5. Is there congruity between the research methodology and the interpretation of results?
Q6. Is there a statement locating the researcher culturally or theoretically?
Q7. Is the influence of the researcher on the research, and vice- versa, addressed?
Q8. Are participants, and their voices, adequately represented?
Q9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?
Q10. Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?"

References

1. Bonovich L. Recognizing the onset of labor. J Obstet Gynecol Neonatal Nurs. 1990;19(2):141-5.
2. Butz AM, Syron L, Johnson B, Spaulding J, Walker M, Bollinger ME. Home-based asthma self-management education for inner city children. Public Health Nurs. 2005;22(3):189-99.
3. Craun AM, Deffenbacher JL. The effects of information, behavioral rehearsal, and prompting on breast self-exams. Journal of Behavioral Medicine. 1987;10(4):351-65.
4. Jurgens CY, Lee CS, Reitano JM, Riegel B. Heart failure symptom monitoring and response training. Heart & Lung. 2013;42(4):273-80.
5. Scott SE, Khwaja M, Low EL, Weinman J, Grunfeld EA. A randomised controlled trial of a pilot intervention to encourage early presentation of oral cancer in high risk groups. Patient Education and Counseling. 2012;88(2):241-8.
6. Colland VT, van Essen-Zandvliet LE, Lans C, Denteneer A, Westers P, Brackel HJ. Poor adherence to self-medication instructions in children with asthma and their parents. Patient Education & Counseling. 2004;55(3):416-21.
7. Eriksen J, Mujinja P, Warsame M, Nsimba S, Kouyate B, Gustafsson LL, et al. Effectiveness of a community intervention on malaria in rural Tanzania - a randomised controlled trial. African Health Sciences. 2010;10(4):332-40.
8. Hunt TN. Video Educational Intervention Improves Reporting of Concussion and Symptom Recognition. Athletic Training Education Journal (Allen Press Publishing Services Inc). 2015;10(1):65-74.
9. McLendon MS, Fulk CH, Starnes DC. Effectiveness of breast self-examination teaching to women of low socioeconomic class. JOGN Nurs. 1982;11(1):7-10.
10. Brailey LJ. Effects of health teaching in the workplace on women's knowledge, beliefs, and practices regarding breast self-examination. Research in Nursing & Health. 1986;9(3):223-31.
11. Hendricson WD, Wood PR, Hidalgo HA, Ramirez AG, Kromer ME, Selva M, et al. Implementation of individualized patient education for Hispanic children with asthma. Patient Education & Counseling. 1996;29(2):155-65.
12. Shepherd JH, McLnerney PA. Knowledge of breast self-examination in women in Sierra Leone. Curationis. 2007;30(4):38-44.
13. Brooks A, Predebon J, van der Zwan R. Perceptual strategies to improve skin cancer discriminations in naive observers. Public Health. 2001;115(2):139-45.
14. Cornell E, Robertson K, McIntosh RD, Rees JL. Viewing Exemplars of Melanomas and Benign Mimics of Melanoma Modestly Improves Diagnostic Skills in Comparison with the ABCD Method and Other Image-based Methods for Lay Identification of Melanoma. Acta Dermato-Venereologica. 2015;95(6):681-5.
15. Davis LL, McCoy TP. An Educational and Skill-Building Intervention to Improve Symptom Recognition and Interpretation in Women With Acute Coronary Syndrome: A Pilot Study. Dccn. 2019;38(1):29-37.
16. Khokhar A. Short text messages (SMS) as a reminder system for making working women from Delhi Breast Aware. Asian Pac J Cancer Prev. 2009;10(2):319-22.
17. Luther SL, Sroka S, Goormastic M, Montie JE. Teaching breast and testicular self-exams: evaluation of a high school curriculum pilot project. Health Education. 1985;16(1):40-3.
18. Matin SB, Wallingford A, Xu S, Ng N, Ho A, Vanosdoll M, et al. Feasibility of a mobile health tool for mothers to identify neonatal illness in rural Uganda: Acceptability study. JMIR mHealth and uHealth. 2020;8(2).
19. Robertson K, McIntosh RD, Bradley-Scott C, MacFarlane S, Rees JL. Image training, using random images of melanoma, performs as well as the ABC(D) criteria in enabling novices to distinguish between melanoma and mimics of melanoma. Acta Derm Venereol. 2014;94(3):265-70.
20. Sorensen J, Hertz A, Gudex C. Evaluation of a Danish teaching program in breast self-examination. Cancer Nursing. 2005;28(2):141-7.
21. Stratton BF, Nicholson ME, Olsen LK, Mahoney BS, Warland RH. Breast self-examination proficiency: Attitudinal, demographic, and behavioral characteristics. Journal of Women's Health. 1994;3(3):185-95.
22. Styrd AM. A breast self-examination program in an occupational health setting. Occup Health Nurs. 1982;30(4):33-5.
23. Ziadé N, Saad S, Al Mashaleh M, El Kibbi L, Elzorkany B, Badsha H, et al. Perceptions of patients with rheumatoid arthritis about self-assessment of disease activity after watching an

educational video: a qualitative pilot study from the AUTO-DAS in Middle Eastern Arab countries project. Rheumatology International. 2021.

Supplementary File 4. Characteristics of studies included in the synthesis

Study	Health conditions and symptoms	Study aims/design	Study population	Type and format of approaches	Constructs of symptom appraisal addressed	Summary of approaches or its component pertaining to symptom appraisal	Underlying theories/models	Evaluation of approaches
Cancer								
Dine et al, 2011(1)	BCLE	To describe a low-cost BCLE self-monitoring technique using case study analysis: interview with a key informant who initiated the program	Women affected by BCLE	Education sessions	Symptom detection (demonstration) and response	Education on comparison of a pre-cancer treatment (baseline) limb assessment to ongoing post-cancer treatment limb assessments • Demonstration of circumferential measurement • Utilization of tracing to assist in identifying anatomical landmarks for circumferential measurement • Observing for skin changes in case of potentially life-threatening infection	Nil	NA
Brailey et al, 1986(2)	Breast cancer	A quasiexperimental study to examine the effects of two health education intervention (group vs individual teaching) on health knowledge, beliefs, skill, and confidence in	Women employees from one business firm	Education sessions and materials (film, pamphlet)	Symptom detection (demonstration and hands-on practice)	Group teaching: • Introduction, film and discussion on breast cancer and BSE • Demonstration and hands-on practice of BSE • Education material on BSE Individual teaching: • Introduction and discussion on breast cancer and BSE • Demonstration and hands-on practice of BSE • Education material on BSE	Predisposing, Reinforcing, and Enabling Causes in Educational Diagnosis and Evaluation (PRECEDE) Model(3)	Frequency, skills and confidence in BSE; additional sources of information and perceived support; health knowledge; health beliefs; and prior experience with breast lumps or cancer in self or significant others assessed before and 4 months

		practicing BSE and to identify factors that influence the frequency of this practice						after the intervention
Burgess et al, 2008(4)	Breast cancer	Development of a psycho-educational intervention to promote early presentation of breast cancer among women	Women who were attending for or had recently received their final routine mammogram and women in the general population aged > 65 years	Education sessions and materials (booklet with graphics and illustrations using cartoon characters, photographs of symptoms)	Symptom detection (demonstration) and response (role modelling)	A booklet: • Absolute and relative risk of developing breast cancer (graphics) • Breast cancer symptoms and detection • Role-modelling: illustration of help-seeking • Action-planning upon symptom detection • Positive feelings for prompt help-seeking Radiographer-delivered interview (key components): • Photographs of early symptoms of breast cancer symptoms • Detections of breast changes using a silicone model • Reinforcing help-seeking for breast changes	Self-Regulation Theory(5), Theory of Planned Behavior(6), Implementation Intentions(7) and Social Cognitive Theory(8)	NA

Byrne et al, 2009(9)	Breast cancer	To evaluate whether participation in a community-based breast cancer education party would increase women's	Women in the general population	Education sessions and materials (pictures or illustrations)	Symptom detection (demonstration and hands-on practice) and response	Education programs/parties:
						• Gaming strategies: to increase knowledge related to breast cancer using pictures or illustrations
						  ○ Risk
						  ○ Prevention
						  ○ Early detection
						• Demonstration of BSE
							Nil	Reviewing of education materials, education sessions, conduction of education parties, data entry, contacting participants and

		participation in screening activities				○ Hands-on practice, palpation of breast models • Appointments for screening as appropriate		appointment for breast cancer screening
Craun et al, 1987(10)	Breast cancer	To study the effectiveness of the Health belief model in predicting BSE behavior and the effectiveness of training formats in altering BSE knowledge, attitudes and frequency using a 2 (information) x 2 (demonstration) x 2 (prompts) factorial design	Female college students	Education sessions and materials (pamphlet)	Symptom detection (demonstration and hands-on practice)	Training formats: • Information: ○ A lecture about breast cancer and BSE • Demonstration: ○ Demonstration and hands-on practice of BSE on a breast model • Prompt: ○ A pamphlet explaining the technique of BSE ○ Monthly reminders to practice BSE	Health Belief Model(11)	Knowledge of breast cancer, knowledge of BSE procedures, attitudes relevant to BSE behavior, cues associated with BSE and frequency of BSE assessed prior to, 1 month post, 3 months post and 6 months post intervention
Khokhar et al, 2009(12)	Breast cancer	To assess the effectiveness of short text messages (SMS) as a reminder system for regular practice of BSE	Women more than 20 years of age working for a private organization	Education sessions and materials (video clip and pamphlet)	Symptom detection (demonstration and hands-on practice)	Education program: • A talk on BSE • Demonstration and hands-on practice of BSE on breast model • A video clip on BSE • SMS reminders sent to each woman towards the end of her menstrual period that is the appropriate time to do BSE	Nil	Practice of BSE

						• Pamphlet on BSE		
McLendon et al, 1982(13)	Breast cancer	To assess the effect of one-to-one BSE teaching on retention of knowledge and accuracy of performance among subjects randomly assigned to control or experimental group	Women with low socioeconomic status from a family planning clinic	Education sessions (one-to-one)	Symptom detection (hands-on practice) and response	One-to-one instruction on BSE: • Description of steps • Hands-on practice • Help-seeking upon detection of any changes	Nil	BSE knowledge and practice and personal beliefs about BSE and breast cancer assessed pre and 2 months post instruction
Shepherd et al, 2007(14)	Breast cancer	To determine the effectiveness of knowledge regarding BSE education and its impact towards early detection of breast cancer using a descriptive-observational design	Women who attended the Breast Week	Education sessions and materials (multimedia: radio)	Symptom detection (demonstration) and response	Breast Week: • Advertisement of the Breast Week on radio programmes and in the communities • A radio discussion on breast cancer and BSE prior to the Breast Week • A call for women to undergo a free breast examination and routine teaching on how to examine their breasts • Women had their breasts examined and at the same time were taught what to observe for and when to report any abnormalities detected • Women were instructed to perform breast examination and where to seek help in	Orem's Self Care Nursing Model(15)	Direct observation of participants' skills in performing BSE (breast inspection, breast palpation and detection of abnormalities) using a checklist

						the event of any deviation from the normal		
Sorensen et al, 2005(16)	Breast cancer	To investigate the effect of a community-based BSE training program on women's knowledge, attitudes and behavior in relation to BSE	Women had and had not participated in the BSE training program	Education sessions (video)	Symptom detection (demonstration)	BSE training program: • A locally produced video • Individual instruction on breast models and the women's own breasts	Nil	Knowledge, attitude and behavior (frequency, technique and actions take upon detection of breast changes) of BSE
Stratton et al, 1994(17)	Breast cancer	To determine 1) BSE proficiency by observation and 2) reduction of BSE proficiency as a function of weeks post training	Women who responded to radio and newspaper advertisements for free BSE training	Education sessions and materials (film and booklet)	Symptom detection (demonstration)	One-on-one BSE (MammaCare) session: • BSE using women's own breast and a tissue-matched silicone breast model • Appropriate corrections in technique • A 45-min film reviewing the MammaCare method of BSE • Reminder stickers • A booklet, The MammaCare Method: Your Personal Manual	Nil	MammaCare evaluation of proficiency performance for self modelling, a tissue-matched silicon breast model and the Toronto Breast Self-Examination Instrument
Styrd et al, 1982(18)	Breast cancer	To stimulate employees to take an active interest in their own health care, to promote awareness as to the importance of performing	Female employees of a company	Education sessions and materials (film and publication)	Symptom detection (demonstration)	Education session: • An introduction to the need for practicing SSE • A discussion of basic anatomy and physiology of breast tissue, signs and symptoms of breast disease, statistical data on occurrence of breast cancer, and diagnostic techniques	Nil	BSE behavior assessed prior to, 3 months after and 1 year after the program

		routine BSE, to teach proper BSE technique, and to increase frequency of BSE among those already practicing it				used in the diagnosis of breast disease • The American Cancer Society (ACS) film, How to Examine Your Breasts, which discusses techniques used in SSE • Additional discussion of breast abnormalities, risk factors, and newer treatment methods Education material: • The ACS publication: How to Examine Your Breasts		
Luther et al, 1985(19)	Breast cancer and testicular cancer	To promote the concept of early detection of cancer to high school students by teaching the topics of breast and testicular self-examination	High school teachers, school nurses, and other interested community educators	Education sessions and materials (movies)	Symptom detection (demonstration)	Education packet: • The breast and testicular self-examination curriculum • Overhead transparencies to aid in teaching breast and testicle anatomy • Samples of written materials • Movies on breast and testicular self-examination • Breasts and testicle models Education workshop: • Background information about breast and testicular cancer • How to teach breast and testicular self-examination • How to use materials available to teach breast and testicular self-examination • Recovered breast and testicular cancer patients discussing their experiences	Nil	Teacher satisfaction; student self-exams, knowledge about BSE and TSE, and attitudes toward early cancer detection
Cornell et al,	Melanoma	To compare the ability of	Lay persons	Education materials	Symptom interpretatio	Online melanoma identification task using different training:	Nil	Sensitivity, specificity and

2015(20)		volunteers to distinguish between images of melanomas and mimics of melanoma using various training strategies	who visited the website created for the study in a 3-week period	(photographs)	n (comparison)	• Rule-based training using the written ABC criteria: 'D' for diameter of the ABC(D) criteria was excluded because the images used in the study were not presented as life size on the computer monitor
						• Image training: photograph of 80 melanoma, 300 seborrhoeic keratoses and 300 benign naevi
						  ○ Expert melanoma training set
						  ○ Expert benign training set
						  ○ Layperson-selected melanoma set
								accuracy in identification of melanoma

Robertson et al, 2014(21)	Melanoma	To compare image training using a 6 (experimental set of images) x 2 (benign class) x 3 (training method) design	Laypeople recruited from friends and family of staff, relatives of patients, and undergraduate students	Education materials (video and images of skin lesions)	Symptom interpretation (comparison)	Education materials:
						• A 3-min video: brief overview of skin cancer
						• Images of skin lesions with different experimental sets, benign class and training method (Control, ABC criteria, or Image)
						  ○ 42 'training' lesions (21 melanomas and 21 benign)
						  ○ 48 'test' lesions (12 melanomas and 36 benign)
							Nil	Diagnostic accuracy, sensitivity and specificity in distinguishing between melanomas and mimics of melanoma

Scott et al, 2012(22)	Oral cancer	To assess the immediate and short term effect of a theory-based intervention to	Patients aged between 45 and 65 years of age who	Education sessions and materials (leaflet)	Symptom detection (hands-on practice) and response	One-to-one plus leaflet instruction: • Assessing knowledge and understanding of detecting oral cancer early, and	Self-Regulation Theory(23, 24), Social Cognitive Theory(8)	Knowledge of oral cancer, anticipated delay for signs of oral cancer, perceived confidence to

		encourage early detection and presentation of oral cancer in the ‘‘at risk’’ population randomly assigned to control, leaflet or one-to-one instruction group	smoked and had no prior history of oral cancer			providing correct information where appropriate • Addressing barriers to seeking help • Outlining the procedure of mouth self-examination, and providing an opportunity for the participant to perform mouth self-examination with receipt of feedback		seek help, understanding of MSE, perceived confidence to perform MSE, likelihood of monthly MSE and emotion response to MSE assessed at baseline, post-intervention, and 1 month follow-up
Brooks et al, 2001(25)	Skin cancer	To investigate the use of simplified instructions to facilitate holistic assessment of skin lesions	Undergraduate psychology students	Education materials (pictures of skin lesions)	Symptom interpretation (comparison)	Experiment 1: a series of pictures of skin lesions • Harmless lesions: 1 freckle, 4 seborrhoeic keratoses and 5 compound naevi • Warning lesions: 10 dysplastic or atypical naevi • Cancerous lesions: 1 squamous cell carcinoma, 2 basal cell carcinomas, 2 nodular melanomas and 5 superficial spreading melanomas Experiment 2: 36 pair comparisons of the 9 representative lesions • Freckle • Compound melanocytic neavus • Seborrheic kerotosis • Dysplastic neavus • Basal cell carcinoma • Squamous cell carcinoma • Low risk superficial spreading melanoma	Nil	Discrimination between benign and malignant skin lesions assessed before and after exposure to education materials

						• Moderate risk superficial spreading melanoma • High risk superficial spreading melanoma		
Respiratory diseases								

Butz et al, 2005(26)	Asthma: persistent cough, wheeze and intercostal retractions	A cross-sectional analysis of asthma home management skills in parents and children enrolled in an ongoing randomized clinical trial of an asthma educational intervention	Families with children aged 2-8 years who have asthma	Education sessions	Symptom identification, interpretation (comparison) and response	Symptom identification/nebulizer educational intervention:
						• Symptom identification
						  ○ Review of early and late symptoms
						  ○ Comparison of normal breathing to breathing patterns during an acute asthma episode
						• Nebulizer use
							Model of Symptom Management(27)	Parents' ability to recognize symptoms and nebulizer-use technique using structured questionnaire and demonstration of nebulizer use

Collan d et al, 2004(28)	Asthma	To investigate whether it is feasible to teach patients to recognise prodromal signs, whether patients will comply with instructions to act upon first symptoms using a single blind prospective randomised study	Children with moderate asthma according to the American Thoracic Society criteria	Education sessions	Symptom identification, interpretation (comparison) and response	Education sessions: • Information on asthma, symptoms, preventive measures, medication and asthma exacerbations • Individual prodromal signs which were identified together with the parents • Instructions on dose of inhaled corticosteroids when signs occurred	Nil	Primary outcomes: rate and severity of asthma attacks, frequency of disabilities, absence from school and parental absence from work due to asthma, registration of prodromal signs and compliance to self-treatment instructions; secondary outcomes: lung

								function and bronchial responsiveness

Gardner et al, 2016(29)	Asthma	A quality improvement project to address the need for information for parents and children with asthma	Children under the age of 18 who had been diagnosed with asthma, asthma exacerbation or status asthmaticus	Education sessions and materials (binder with large pictures)	Symptom recognition, interpretation (comparison) and response	An individualized asthma resource binder:
						• Basic asthma disease understanding
						• Medications and medication side effects
						• Symptoms and symptom control
						• Exacerbation recognition
						• Use of an asthma action plan
						An individualized teaching session:
						• Basic asthma pathophysiology
						• Medications
						  ○ Methods to improve medication compliance
						  ○ Demonstration of proper inhaler use
						• Symptom recognition and management: lifestyle change
						• Recognition of exacerbation: reflection on current hospitalization to identify early warning signs
						• Use of an asthma action plan: response when an exacerbation is recognized
							Health Belief Model(11)	(planned: hospital 30-day readmission rate (primary outcome), and satisfaction of physician and nurse, advanced practice providers, and residents)

Hendricson et al,	Asthma	Development of the patient education component,	Children aged 6 to 16 who had physician-	Education sessions and materials	Symptom recognition and response	Educational intervention on specific self-management skills using flip cards:	Social Learning Theory(31), Social	Parent and child subjective evaluation of educational

1996(30)		an individualized and bilingual program designed to reduce morbidity and improve quality of life among Hispanic children with chronic asthma	diagnosed asthma	(flip cards with illustrations, videotape, pamphlet)	(role modelling)	• Recognizing asthma symptoms before they get out of control • Correctly administering medicines as pre- scribed by the physician and managing side effects • Promptly recognizing and responding to acute asthma symptoms that require emergency care • Remaining calm and avoiding stress-inducing reactions when symptoms occur • Minimizing exposure to triggers (precipitating agents such as smoke, mold, animal hair) • Establishing appropriate levels of physical and social activities for the child • Communicating effectively with health care personnel Techniques incorporated into the intervention: • Role modelling: self-management behaviors (videotape) • Building self-efficacy: hands-on practice with inhalers and peak flow meters and role-playing for communication when symptoms occur • Contracting: written agreement	Cognitive Theory(32)	modules, attrition rate and parent impression 1 year after program completion
Brandt et al,	COPD exacerbatio	A qualitative study of self-	Patients with COPD	Education sessions	Symptom recognition,	COPD teaching plan: • Understanding COPD	Collaborative Model for	NA

2013(33)	n: increased breathless, cough, sputum, fever and fatigue; orthopnea; decreased activity tolerance; poor sleep; change in mental status	regulation in older adults with COPD and development of a theory and evidence-based teaching plan to build practical self-regulation skills in patients with COPD			interpretation (comparison) and response	• Everyday management strategies
						• Symptom monitoring/self-observation
						  ○ Keeping a symptom log until being familiar with baseline dyspnea and other symptoms
						  ○ Common signs and symptoms of an exacerbation
						• Exacerbation triggers and how to avoid them
						• Exacerbation recognition/self- judgment: daily symptom comparison, contrasting new or different symptoms with baseline characteristics
						• Management of exacerbations/self-reaction
							Self-Management of Chronic Disease(34)	

Cardiovascular diseases								

Davis et al, 2019(35)	ACS	To evaluate the feasibility and acceptability of a nurse-delivered education and skill-building intervention designed to improve symptom recognition and interpretation	Women aged 35 years and older who had been hospitalized with a definitive diagnosis of ACS	Education sessions and materials (pamphlet and pocket card)	Symptom recognition, interpretation (comparison) and response	Two face-to-face teaching sessions:
						• Symptom recognition and interpretation
						  ○ A standard pamphlet (Women, Heart Disease, and Stroke) and a pocket card (Know and Go: Heart Attack)
						  ○ Individualized education on symptom experience and actions taken, comorbid conditions
							Nil	Feasibility, acceptability and satisfaction with the intervention; knowledge, attitudes and beliefs about ACS symptoms

		in women with recurrent ACS symptoms using a single group pre-post-test design				that could mimic ACS symptoms, and misconceptions about ACS symptoms and care-seeking responses ○ A symptom monitoring notebook with instructions to document recurrent symptoms • Individualized action plan ○ Timely and appropriate care-seeking behavior for recurrent symptoms ○ Reinforcement of information from the first session		
Raczynski et al, 1999(36)	AMI: chest pain (primary symptom) and shortness of breath	Development of the theoretically-based Rapid Early Action for Coronary Treatment (REACT) intervention that addresses community organization, community education, professional education, and patient education	Community education: high-risk individuals, family members, and community residents; patient education: high-risk patients and their families	Education sessions and materials (flyers/brochures, posters, magnets and other "tokens"; video)	Symptom recognition and response (role modelling)	Community organization: • Engaging organizations and individuals in a collaborative effort to mobilize their resources and institutional structures to reduce AMI delay Community education: • Building awareness and knowledge about AMI and the problem of delay; • Recognizing AMI symptoms; • Modifying beliefs that may act as barriers to seeking treatment; • Building skills to improve behavioral intentions and actions; and	Social Cognitive Theory(37), Self-Regulatory Theory(38), Community Organization Theory(39), Diffusion of Innovation Theory(40), Social Marketing Theory(41)	NA

						• Increasing self-efficacy to respond rapidly to AMI symptoms Provider education: • Improving understanding of factors related to patient delay • Enhancing motivation to learn skills and intervene with patients • Enhancing patient-centred counselling • Impacting clinical practice Patient education: interpersonal + impersonal • Changing patients' knowledge, beliefs, attitudes, skills, behaviors, and self-efficacy regarding prompt action for AMI symptoms • Employment of patient-centered counselling, role-modelling, and behavioral rehearsal		
Jurgens et al, 2013(42)	HF: dyspenea and fatigue	To test the efficacy of a HF symptom training program on patients' self-care ability and particularly their ability to recognize and respond to changes in HF symptoms	Patients with a confirmed diagnosis of chronic HF	Education sessions and materials (booklet)	Symptom detection, interpretation (comparison) and response	HF symptom training intervention: • Weight scale • HF self-care booklet • Symptom profile: 3 symptoms with highest distress selected for clustering on symptom graph • Symptom burden at rest • Comparison of symptom burden after 6-min walk test with symptom burden at rest and discussion on symptom meaning and response	Theory of HF Self-Care(43), Theory of Unpleasant Symptoms(44, 45), Uncertainty in Illness Theory(46-49), Self-Regulation Theory(24)	Time to first event of HF hospitalization, emergency department admission for HF or HF-related cause and death (primary outcomes); HF symptom awareness and self-care assessed at

		using a randomized control trial				• Home visit to review symptom training		baseline and 3 months follow-up
Other health conditions								
Hunt et al, 2015(50)	Concussion	To determine if a concussion-education video developed for high school athletes would increase the reporting of concussive injuries and symptom recognition using a cross-sectional, between groups design	High school athletes aged 13 to 18 years	Education materials (video)	Symptom detection, interpretation (comparison) and response	Concussion education video addressing questions pertaining to head injuries or concussions: • What is a concussion? • How do concussions happen? • How do I know I have a concussion? • What are the signs and symptoms of concussion? • What is the importance of reporting my injury? • Whom should I report my injury to? • What is the difference between just getting hit in the head and having a concussion? • How are concussions managed? • When will I be able to play again?	Nil	Knowledge of concussion symptoms, assessed before and immediately after watching the education video
Bonovich et al, 1990(51)	Labor: contractions, vaginal discharge and amniotic fluid	To test the effectiveness of an intervention developed to meet the specific needs of clinic patients in recognizing the signs of true labor	Patients in their first uninterrupted pregnancies who had reached 30 weeks' gestation	Education sessions and materials	Symptom detection, interpretation (comparison) and response	Education material: • A printed list of instructions on how to detect signs of labor Education session: • Reinforcement of correct knowledge recall about labor patients gained prior to the intervention and provision of only necessary information to fill in knowledge gaps	Flanders' Analyzing Teaching Behavior(52), Redman's Principles of Patient Education(53)	Number of visits subjects made to labor and delivery by examining the registration records in the labor suite

		using an experimental design with one treatment group and one control group				• Instruction on distinguishing between Braxton Hicks contractions and contractions of active labor, changes in vaginal discharge (sights), distinguishing between involuntary urination and leaking of amniotic fluid (smell), and contraction pain and other senses (sensations)		
Eriksen et al, 2010(54)	Malaria	To develop a community intervention to improve first line case management of malaria in under-five children through primary caretakers in collaboration with local women groups and existing health centres and to evaluate its feasibility and effectiveness on anaemia, fever and malaria prevalence using a cluster-	Women leaders selected from village groups	Education sessions	Symptom detection, interpretation and response (role modelling)	Training of health workers • Theoretical training: lectures on principles of malaria case management including clinical diagnosis, treatment and follow-up • Practical training: management of suspected malaria cases in the outpatient department of the district hospital Training of women leaders • Theoretical training: same as training of health workers, with a focus on identifying fever cases that should be treated as suspected uncomplicated malaria or referred to health facilities as suspected severe malaria or other diseases requiring formal health care treatment • Practical training: observation of management of suspected malaria cases	Nil	Proportion of moderate/severe anaemia in children aged 6-59 months (primary outcome), proportions of measured fever, malaria prevalence and reported fever during the last 48 hours, mean malaria parasite densities, mean haemoglobin values and mean weight, assessed pre- and post-intervention

		randomised controlled effectiveness trial						

Matin et al, 2020(55)	Neonatal illness: lethargy, chest indrawing, convulsions and difficulty breastfeeding	To enable reliable and consistent assessment of neonates for identification of signs of illness to facilitate early referral of sick neonates, especially during the critical first week of life	Women who gave birth at the study hospital	Education apps/devices (audio, images of danger signs)	Symptom detection, interpretation (comparison) and response	A smartphone preloaded with an interactive app (the NeMo app):
						• Pictures, symbols, and audio recordings in the local language
						• 4 qualitative danger signs, images displayed for each sign: one showing a newborn exhibiting the danger sign and one showing a healthy infant
						  ○ Lethargy
						  ○ Chest indrawing
						  ○ Convulsions
						  ○ Difficulty breastfeeding
						A wearable sensing band (the NeMo band) that measures breathing rate
							Nil	Knowledge of danger signs assessed at baseline and after training, observation of device use, usage and impression of device assessed using quantitative scales and qualitative interviews, responses to danger sign triggers assessed through qualitative discussion

Ziadé et al, 2021(56)	RA: joint pain and swelling	To evaluate the perceptions of patients with RA about self-assessment of their disease activity using DAS-28 after watching the educational video	Adult patients with RA	Education materials (video)	Symptom detection (demonstration)	Education video: • A short introductory note about the assessment of disease activity in RA • A demonstration of the evaluation of each of the 28 joints for pain and swelling performed by a real patient with RA • An explanation about the final score calculation and the categorization into the disease activity levels	Nil	Perceptions about self-assessment of disease activity using semi-structured interview

BCLE: lymphedema secondary to breast cancer treatment, BSE: breast self-examination, COPD: chronic obstructive pulmonary disease, ACS: acute coronary syndrome, AMI: acute myocardial infarction, CHD: coronary heart disease, EMS: emergency medical system, ED: emergency department, MI: myocardial infarction, HF: heart failure, RA: rheumatoid arthritis, DAS: disease activity score

References

1. Dine JL, Austin MKS, Armer JM. Nursing education on lymphedema self-management and self-monitoring in a South African oncology clinic. Journal of Cultural Diversity. 2011;18(4):126-8.
2. Brailey LJ. Effects of health teaching in the workplace on women's knowledge, beliefs, and practices regarding breast self-examination. Research in Nursing & Health. 1986;9(3):223-31.
3. Green LW, Kreuter MW, Deeds S, Partridge K. Health Education Planning: A Diagnostic Approach: Mayfield Publishing Company; 1980.
4. Burgess CC, Bish AM, Hunter HS, Salkovskis P, Michell M, Whelehan P, et al. Promoting early presentation of breast cancer: development of a psycho-educational intervention. Chronic Illn. 2008;4(1):13-27.
5. Leventhal H, Nerenz D, Steele D. Illness representations and coping with health threats. In: A. Baum, SE Taylor, Singer J, editors. Handbook of psychology and health: social psychological aspects of health1984. p. 219-52.
6. Ajzen I. The theory of planned behavior. Organizational Behavior and Human Decision Processes. 1991;50(2):179-211.
7. Gollwitzer PM. Goal Achievement: The Role of Intentions. European Review of Social Psychology. 1993;4(1):141-85.
8. Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. Psychol Rev. 1977;84(2):191-215.
9. Byrne S, Robles-Rodriguez E. Educational parties as a strategy to promote breast health awareness and screening in underserved female populations. Oncology nursing forum. 2009;36(2):145-8.
10. Craun AM, Deffenbacher JL. The effects of information, behavioral rehearsal, and prompting on breast self-exams. Journal of Behavioral Medicine. 1987;10(4):351-65.
11. Rosenstock IM. Historical Origins of the Health Belief Model. Health Education Monographs. 1974;2(4):328-35.
12. Khokhar A. Short text messages (SMS) as a reminder system for making working women from Delhi Breast Aware. Asian Pac J Cancer Prev. 2009;10(2):319-22.
13. McLendon MS, Fulk CH, Starnes DC. Effectiveness of breast self-examination teaching to women of low socioeconomic class. JOGN Nurs. 1982;11(1):7-10.
14. Shepherd JH, McLnerney PA. Knowledge of breast self-examination in women in Sierra Leone. Curationis. 2007;30(4):38-44.
15. Orem DE. Nursing: Concepts of Practice: McGraw-Hill; 1980.
16. Sorensen J, Hertz A, Gudex C. Evaluation of a Danish teaching program in breast self-examination. Cancer Nursing. 2005;28(2):141-7.
17. Stratton BF, Nicholson ME, Olsen LK, Mahoney BS, Warland RH. Breast self-examination proficiency: Attitudinal, demographic, and behavioral characteristics. Journal of Women's Health. 1994;3(3):185-95.
18. Styrd AM. A breast self-examination program in an occupational health setting. Occup Health Nurs. 1982;30(4):33-5.
19. Luther SL, Sroka S, Goormastic M, Montie JE. Teaching breast and testicular self-exams: evaluation of a high school curriculum pilot project. Health Education. 1985;16(1):40-3.
20. Cornell E, Robertson K, McIntosh RD, Rees JL. Viewing Exemplars of Melanomas and Benign Mimics of Melanoma Modestly Improves Diagnostic Skills in Comparison with the ABCD Method and Other Image-based Methods for Lay Identification of Melanoma. Acta Dermato-Venereologica. 2015;95(6):681-5.
21. Robertson K, McIntosh RD, Bradley-Scott C, MacFarlane S, Rees JL. Image training, using random images of melanoma, performs as well as the ABC(D) criteria in enabling novices to distinguish between melanoma and mimics of melanoma. Acta Derm Venereol. 2014;94(3):265-70.
22. Scott SE, Khwaja M, Low EL, Weinman J, Grunfeld EA. A randomised controlled trial of a pilot intervention to encourage early presentation of oral cancer in high risk groups. Patient Education and Counseling. 2012;88(2):241-8.
23. Leventhal H, Meyer D, Nerenz D. The common sense representation of illness danger. In: Rachman S, editor. Contributions to Medical Psychology: Pergamon Press; 1980. p. 7-30.
24. Cameron LD, Leventhal H. The self-regulation of health and illness behaviour. New York, NY, US: Routledge; 2003.
25. Brooks A, Predebon J, van der Zwan R. Perceptual strategies to improve skin cancer discriminations in naive observers. Public Health. 2001;115(2):139-45.

26. Butz AM, Syron L, Johnson B, Spaulding J, Walker M, Bollinger ME. Home-based asthma self-management education for inner city children. Public Health Nurs. 2005;22(3):189-99.
27. University of California, San Francisco School of Nursing Symptom Management Faculty Group. A model for symptom management. Image J Nurs Sch. 1994;26(4):272-6.
28. Colland VT, van Essen-Zandvliet LE, Lans C, Denteneer A, Westers P, Brackel HJ. Poor adherence to self-medication instructions in children with asthma and their parents. Patient Education & Counseling. 2004;55(3):416-21.
29. Gardner LE. Advanced Practitioner Provided Pre-Hospital Discharge Asthma Education: Walden University; 2016.
30. Hendricson WD, Wood PR, Hidalgo HA, Ramirez AG, Kromer ME, Selva M, et al. Implementation of individualized patient education for Hispanic children with asthma. Patient Education & Counseling. 1996;29(2):155-65.
31. Parcel GS, Baranowski T. Social learning theory and health education. Health Educ. 1981;12(3):14-8.
32. Bandura A. Social foundations of thought and action: A social cognitive theory: Prentice-Hall, Inc; 1986.
33. Brandt CL. Study of older adults' use of self-regulation for COPD self-management informs an evidence-based patient teaching plan. Rehabilitation nursing : the official journal of the Association of Rehabilitation Nurses. 2013;38(1):11-23.
34. Brandt CL. Description of the Self-regulation Process Used by Persons with Chronic Lung Disease and Its Relationship to Health-related Outcomes: University of Minnesota; 2005.
35. Davis LL, McCoy TP. An Educational and Skill-Building Intervention to Improve Symptom Recognition and Interpretation in Women With Acute Coronary Syndrome: A Pilot Study. Dccn. 2019;38(1):29-37.
36. Raczynski JM, Finnegan JR, Jr., Zapka JG, Meischke H, Meshack A, Stone EJ, et al. REACT theory-based intervention to reduce treatment-seeking delay for acute myocardial infarction. Rapid Early Action for Coronary Treatment. Am J Prev Med. 1999;16(4):325-34.
37. Perry CL, Baranowski T, Parcel GS. How individuals, environments, and health behavior interact: Social Cognitive Theory. In: Glanz K, Lewis FM, Rimer BK, editors. Health behavior and health education: Theory, research, and practice. San Francisco, CA: Jossey-Bass; 1990.
38. Cameron L, Leventhal EA, Leventhal H. Emotional and behavioral processes. In: Johnston M, Wallace L, editors. Stress and Medical Procedures: New York, NY: Pergamon; 1993. p. 7-30.
39. Bracht N. Health promotion at the community level. Thousand Oaks, CA, US: Sage Publications, Inc; 1990.
40. Rogers EM. Diffusion of innovations. New York; London: Free Press ; Collier Macmillan; 1983.
41. Novelli W. Applying social marketing to health promotion and disease prevention. In: Glanz K, Lewis FM, Rimer BK, editors. Health behavior and health education: theory, research and practice. San Francisco, CA: Jossey-Bass; 1990.
42. Jurgens CY, Lee CS, Reitano JM, Riegel B. Heart failure symptom monitoring and response training. Heart & Lung. 2013;42(4):273-80.
43. Riegel B, Dickson VV. A situation-specific theory of heart failure self-care. J Cardiovasc Nurs. 2008;23(3):190-6.
44. Lenz ER, Suppe F, Gift AG, Pugh LC, Milligan RA. Collaborative development of middle-range nursing theories: toward a theory of unpleasant symptoms. ANS Adv Nurs Sci. 1995;17(3):1-13.
45. Lenz ER, Pugh LC, Milligan RA, Gift A, Suppe F. The middle-range theory of unpleasant symptoms: an update. ANS Adv Nurs Sci. 1997;19(3):14-27.
46. Mishel MH. The measurement of uncertainty in illness. Nurs Res. 1981;30(5):258-63.
47. Mishel MH. Perceived uncertainty and stress in illness. Res Nurs Health. 1984;7(3):163-71.
48. Mishel MH. Uncertainty in illness. Image J Nurs Sch. 1988;20(4):225-32.
49. Mishel MH. Reconceptualization of the uncertainty in illness theory. Image J Nurs Sch. 1990;22(4):256-62.
50. Hunt TN. Video Educational Intervention Improves Reporting of Concussion and Symptom Recognition. Athletic Training Education Journal (Allen Press Publishing Services Inc). 2015;10(1):65-74.
51. Bonovich L. Recognizing the onset of labor. J Obstet Gynecol Neonatal Nurs. 1990;19(2):141-5.
52. Flanders NA. Analyzing teaching behavior. Reading, Mass.: Addison-Wesley Pub. Co.; 1970.
53. Redman BK. The Process of Patient Education: C.V. Mosby; 1984.

54. Eriksen J, Mujinja P, Warsame M, Nsimba S, Kouyate B, Gustafsson LL, et al. Effectiveness of a community intervention on malaria in rural Tanzania - a randomised controlled trial. African Health Sciences. 2010;10(4):332-40.
55. Matin SB, Wallingford A, Xu S, Ng N, Ho A, Vanosdoll M, et al. Feasibility of a mobile health tool for mothers to identify neonatal illness in rural Uganda: Acceptability study. JMIR mHealth and uHealth. 2020;8(2).
56. Ziadé N, Saad S, Al Mashaleh M, El Kibbi L, Elzorkany B, Badsha H, et al. Perceptions of patients with rheumatoid arthritis about self-assessment of disease activity after watching an educational video: a qualitative pilot study from the AUTO-DAS in Middle Eastern Arab countries project. Rheumatology International. 2021.

Supplementary File 5. Application of the proposed framework to the development of a screening tool for autoimmune rheumatic diseases

In the proposed framework to improving symptom appraisal, Social Cognitive Theory (SCT) and main constructs of symptom appraisal, detection, interpretation and response to symptoms, were linked by approaches developed based on the six major concepts in SCT (*reciprocal determinism, behavioral capacity, expectations, self-efficacy, observational learning* and *reinforcements*)(1-3). We shall illustrate how the proposed framework and approaches could be incorporated into the development of screening tools using joint swelling and Raynaud's phenomenon (RP), a common and a distinctive symptom respectively seen in patients with audotimmune rheumatic diseases (ARDs), as examples.

Joint swelling may or may not be noticed, especially in the early stages of diseases when it is mild and not accompanied by other symptoms/signs. Knowledge of what joint swelling is, what a swollen joint looks like (sight) and how a swollen joint feels like (touch) using text (symptom knowledge) (*behavioral capacity*); and illustrations of the different appearance of a swollen joint and a normal joint using photos and different sensations when touching a swollen versus a normal joint using normal body sites for comparison can act as a prompt and allow an individual to notice their similar joint changes (symptom self-examination and comparison) (*behavioral capacity* and *self-efficacy*)(4). RP is characterized by the triphasic color change in digits (the skin of digits first turns white, then blue and finally red in the ischemic, deoxygenation and reperfusion phases, respectively) resulting from vasospasm and ischema in response to cold or emotional stimuli(5). While the dramatic color changes in digits are often not neglected, description of the color changes (sight) during an attack of RP using text (symptom knowledge) (*behavioral capacity*) and demonstration with cold water using short videos can help one confirm the presence or absence of RP (symptom self-examination and comparison) (*self-efficacy* and *observational learning*).

Following the detection of joint swelling and RP, individuals might attribute the meaning of these bodily changes first to situational factors such as cold weather based on their own knowledge (such as their own experience, self-education or observation from others)(6, 7), and only if the situational factors are insufficient to explain these bodily changes, to illness(8). Provision of the likely causes of joint swelling and RP (symptom knowledge) could thus allow one to make more appropriate attribution of their symptoms and in turn their response to the attribution (*behavioral capacity*). Depending on the meaning attributed to the detected symptoms/signs, individuals may decide to take no actions, self-monitor, self-manage, consult family or friends, or seek medical attention(3). Instruction on symptom response, namely, actions to take upon the detection of joint swelling and RP (such as reporting and help-seeking) (*behavioral capacity*), and demonstration of prompt symptom detection and response (*self-efficacy* and *observational learning*) and its positive outcomes (e.g., using video clips of role models) (*expectations* and *reinforcements*) could lead to more appropriate responses to one's symptoms/signs (on screening tools) and in turn facilitate early identification of potential cases in the population.

References

1. Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. Psychol Rev. 1977;84(2):191-215.
2. Bandura A. Social foundations of thought and action: A social cognitive theory: Prentice-Hall, Inc; 1986.
3. Whitaker KL, Scott SE, Wardle J. Applying symptom appraisal models to understand sociodemographic differences in responses to possible cancer symptoms: a research agenda. British Journal of Cancer. 2015;112(1):S27-S34.
4. Murray J, Williams B. The Role of Images on Illness Behaviour: Interdisciplinary Theory, Evidence, and Ideas. Psychological Reports. 2020;0(0):0033294120945602.
5. Hochberg M, Gravallese E, Silman A, Smolen J, Weinblatt M, Weisman M. Rheumatology: Elsevier; 2018.
6. Cacioppo JT, Andersen BL, Turnquist DC, Petty RE. Psychophysiological Comparison Processes: Interpreting Cancer Symptoms. In: Andersen BL, editor. Women with Cancer: Psychological Perspectives. New York, NY: Springer New York; 1986. p. 141-71.
7. Andersen BL, Cacioppo JT. Delay in seeking a cancer diagnosis: delay stages and psychophysiological comparison processes. Br J Soc Psychol. 1995;34 (Pt 1):33-52.
8. Robbins JM, Kirmayer LJ. Attributions of common somatic symptoms. Psychol Med. 1991;21(4):1029-45.