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What do we know about strategies to manage dementia-related wandering? A scoping review

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Abstract Three of five persons with dementia will wander, raising concern as to how it can be managed effectively. Wander-management strategies comprise a range of interventions for different environments. Although technological interventions may help in the management of wandering, no review has exhaustively searched what types of high- and low-technological solutions are being used to reduce the risks of wandering. In this article, we perform a review of gray and scholarly literature that examines the range and extent of high- and low-tech strategies used to manage wandering behavior in persons with dementia. We conclude that although effectiveness of 49 interventions and usability of 13 interventions were clinically tested, most were evaluated in institutional or laboratory settings, few addressed ethical issues, and the overall level of scientific evidence from these outcomes was low. Based on this review, we provide guidelines and recommendations for future research in this field.

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1. Introduction

The rates of cognitive impairment are on the rise worldwide as our world population ages. In 2016, 46.6 million people globally were living with dementia, and this number is projected to increase to 75 million by 2030 [1]. As a result, the already high economic burden of $818 billion in 2015 has been estimated to have increased to $1 trillion by 2018. These staggering numbers have led to the establishment of more than 30 national dementia strategies worldwide as nations begin to work together to transform dementia care and support [2].

One significant concern for persons with dementia and their family caregivers is becoming lost when alone or in unfamiliar environments [3,4]. This behavior is often indicative of wandering. Wandering has been defined as "a syndrome of dementia-related locomotion behavior having repetitive, frequent, temporally disoriented nature that is manifested in lapping, random, and/or pacing patterns some of which are associated with eloping, eloping attempts, or getting lost unless accompanied" [5]. It can be either an aimless or purposeful behavior [5], and its severity can be affected by rhythm disturbances [6], spatial disorientation and visual-perceptual deficits [7], physical [8] and social [9] environments, or changes in personality and behavior patterns [10]. A more recent definition of wandering also includes critical wandering, the type of wandering that results in older adults to elope with no orientation to time and place. Indeed, critical wandering is what exposes persons with dementia to the potential dangers that is of concern to caregivers [11].

More than 60% of persons with dementia will wander. The consequences of wandering vary from minor injuries [12], to high search and rescue costs and death [13]. If not found within 24 hours, up to half of those who wander and get lost will suffer serious injury or death [14]. Wandering behavior also significantly impacts the care and economic

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burden of family caregivers. For example, caregivers have been found to experience increases in emotional distress and potential civil tort claims and regulatory penalties [15]. The severity of these outcomes has gained attention from caregivers and first responders alike [16] and raises questions about how the adverse outcomes associated with wandering can be managed, and whether managing this behavior can have an influence on improving the stressors that result from caring for a person with dementia [17].

Early interventions to manage wandering included physical restraints and medications [18]; however, use of such strategies have been in decline due to unwanted side effects [19] and negative consequences such as poor physical and social functioning [20]. High tech strategies, such as wearable global positioning system (GPS)–enabled devices [21], and low-tech strategies, such as visual barriers [22], offer options for mitigating risks while allowing a person with dementia with a degree of autonomy. These strategies may therefore be a preferred approach over restraints and medications [23]. Wander-management technologies may extend the time a person with dementia can live in a community and provide peace of mind to caregivers [21,22,24]. Although such strategies are more available to consumers, only one review [25] has been conducted to examine what existing interventions for wandering are being used, and whether their effectiveness has been tested in laboratory or community settings. This review, however, only included high-tech solutions, excluding several key strategies, such as door murals and distractions, which may also help with managing this behavior. Although that review presents state of the evidence to support these interventions, it excluded potential vital reviews and studies that fall outside of this focus, limiting the scope of all available solutions within the scholarly and gray literature.

The current review serves as an extension from Neubauer et al. [25] where only high-tech solutions used to manage dementia-related wandering behavior, and only studies evaluating their usability or effectiveness were included. Therefore, the purpose of this review was to identify the range and extent of all wander-management strategies, their product readiness level, and all associated outcomes. This information provides evidence for caregivers and clinicians when they select strategies to manage wandering in persons living with dementia.

2. Methodology

2.1. Design

This is a scoping literature review based on Daudt, van Mossel, and Scott's (2013) [26] modification of Arksey and O'Malley's (2005) [27] methodology. The original Arksey and O'Malley's methodology [27] includes six steps: (1) determine the research question; (2) identify the applicable studies; (3) study selection; (4) chart data; (5) collect, summarize, and report the results; and (6) consultation exercise (optional). Daudt, van Mossel, and Scott's (2013) [26] modification of this methodology involves an interprofessional team in step (2), and in step (3) uses a three-tiered approach to cross-check and select the articles.

2.2. Data sources and search strategy

We examined peer-reviewed and gray literature published between January 1990 and November 2017. Peer-reviewed literature studies were searched in six databases: EMBASE, CINAHL, Ovid Medline, PsycINFO, Web of Science, and Scopus. These databases were searched using the following terms identified in the title, abstract, or key words: (physical barrier* OR barrier* OR lock* OR low tech* OR nonpharmacological OR therap* OR exercise OR distraction OR pet therap* OR home modification* OR door mural* or signage OR identification information OR ID card* OR bracelet* OR jewelry OR technolog* OR gerontechnology OR telemonitoring OR telesurveillance OR telehealth OR assistive technology OR GPS OR sensor* OR mobile device OR application OR apps OR radio frequency telemetry OR radio frequency identification OR tracking OR surveillance OR alarms OR tagging OR electronic OR restraints) AND (wander* OR walk* OR sundowning OR escape OR restlessness OR pacing OR exit* OR missing OR stay OR benevolent wandering OR critical wandering OR noncritical wandering) AND (dementia OR Alzheimer's Disease OR cognitive disorders). Gray literature was searched in eight databases: Google, CADTH grey matters, Institute of Health Economics, Clinicaltrials.gov, The University of Alberta Grey Literature Collection, ProQuest Dissertations & Theses Global, National Guidelines Clearinghouse, and Health on the NET Foundation were searched for strategies developed to address wandering in persons with dementia—(dementia) AND (wander* OR elope OR sundowning OR critical wandering OR benevolent wandering OR noncritical wandering) (nonpharmacological OR therap* OR exercise OR distraction OR low tech* OR home modification OR technology OR tech* OR GPS OR RFID OR mobile applications OR iOS OR android OR wifi) (Appendix A).

2.3. Studies selection process

Articles were exported to a reference manager where duplicate articles were excluded. Two authors (N.A.N. and P.A.-K.) first screened the titles and abstracts, reviewed the full text of all potential articles, and extracted the data (Fig. 1). Disagreements were resolved by consensus. Where disagreements were unresolved, the third reviewer (A.M.C.) provided input. To determine agreement between raters, 20% of the selected articles were extracted and compared. The level of agreement between the raters was high, that is, average agreement for abstracts 96% (298/310) (average κ score of 0.87, $P < .000$), and 97% (198/204) average agreement for full papers (overall κ score of 0.91, $P < .000$). For included articles, reviewers first extracted

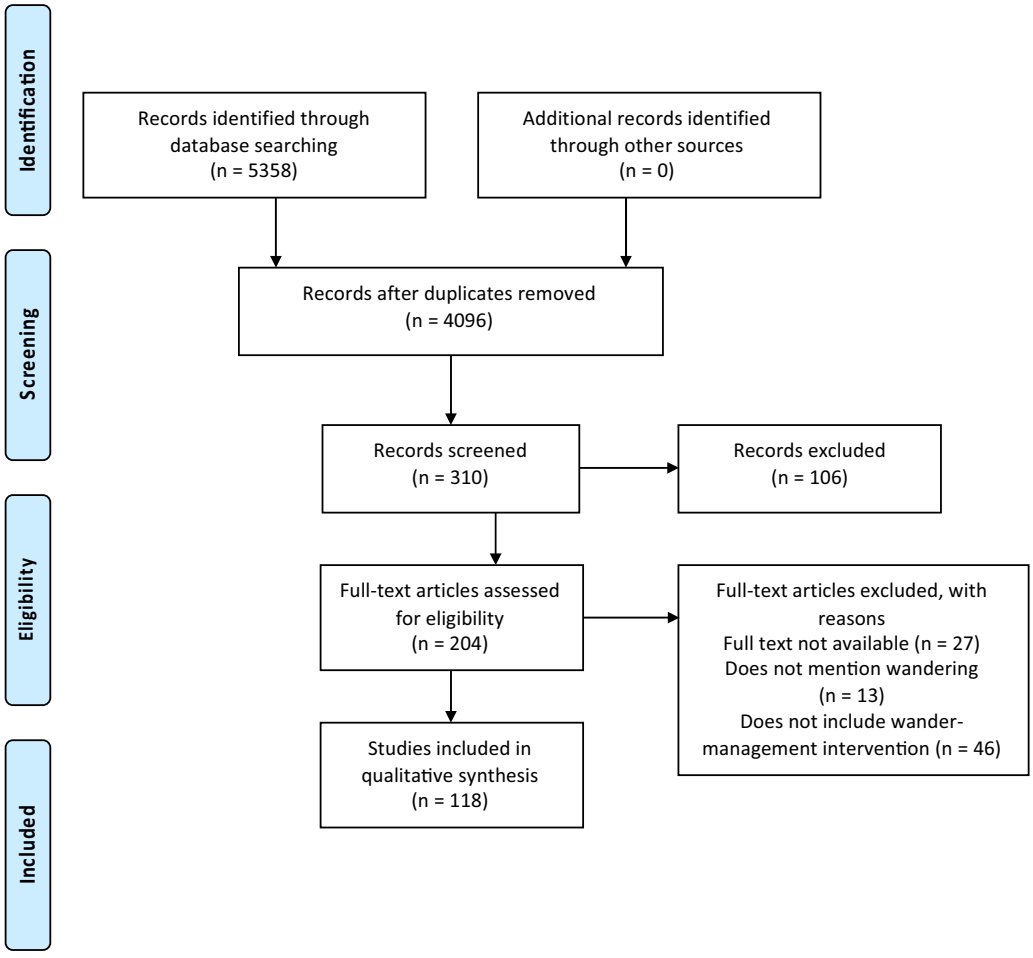


Fig. 1. Scholarly reviewed literature article search results.

author initials, citation, and whether the study was eligible for review. If a study was considered ineligible for data extraction, the reason for exclusion was reported (Fig. 1).

2.3.1. Inclusion criteria

1. Studies that
   a. address wander-management strategies in the home or supportive care environments for persons with dementia or cognitive decline regardless of whether it was embedded in an environment, was worn, or was implemented as a form of therapy.
   b. address critical or noncritical wandering in older adults with dementia.
   c. include strategies that support independence and address outcomes associated with wandering, regardless of level of development.
2. Clinically oriented studies that included only persons with dementia over age 50 years.
3. Studies published in any language and available in full text in peer-reviewed journals or conference proceedings from electronic abstract systems.
4. Studies that used any type of study design or methodology, with positive or negative results.
5. Studies that used lower and higher complexity technologies for wander management such as GPS and door murals.
6. Studies published in books or book chapters and conference proceedings.
7. For gray literature: were websites suggesting or selling strategies to address dementia-related wandering.

2.3.2. Exclusion criteria

1. Abstracts or studies that were not available.
2. Publications that did not provide adequate information for categorizing the study (e.g., participant characteristics).

2.4. Bias control

The procedure of Neubauer et al. [25] was followed to address bias. By including any language, multiple databases, and data types, we conducted a thorough search, to achieve a high level of sensitivity [28]. Inclusion of studies with positive and negative results addressed publication bias [29]. Inclusion of studies registered in electronic abstract systems

served as the first "*quality filter*" and ensured a degree of scientific level of conceptual methodological rigor [30]. Studies published before 1990 were not included because most development of wander-management strategies occurred later [17,31]. The use of two pairs of raters during the selection for relevant articles, and a third and fourth rater when there was disagreement, minimized rater-bias that may have arisen from the subjective nature of applying the inclusion and exclusion criteria.

2.5. Publications review and data abstraction

Peer-reviewed articles were examined for the following attributes: features of wander-management strategies (i.e., strategy type, specifications, cost, product readiness level) and characteristics of research (i.e., clinical implications, sample size, participant characteristics, level of clinical evidence of outcomes). Gray literature was reviewed for features of wander-management strategies (i.e., strategy type, specifications, cost, device features). Two raters individually extracted data from articles.

2.5.1. Features of wander-management strategies

(a) **Strategy type.** Refers to the name and strategy used to manage wandering. Primary categories identified include high tech [32] (e.g., locating, alarms/surveillance, wandering detection, wayfinding belt, distraction/redirection, and locks/barriers) and low tech [32] (e.g., exercise, distraction/redirection, locks/barriers, physical restraints, community, signage, wayfinding, supervision, education, and other).

(b) **Product readiness level (PRL).** Assesses the maturity of evolving products during their development. We used the PRL [33] in which nine levels are used and ranged from PRL1 (basic principles observed) to PRL9 (actual system proven in operational environment).

2.5.2. Characteristics of research conducted in wander-management strategies

(a) **Type of study, design of the study, level of clinical evidence, and outcomes in the studies regarding wander-management strategies.** Studies were classified into four types, including strategy- and clinical-oriented studies, usability, program-oriented, review, or a combination of them. Study design was categorized using the McMaster assessment of study appraisal [34,35]. An adaptation of the modified Sackett criteria proposed by Teasell et al., (2013) [36] was used to determine the level of evidence provided by the clinical-oriented studies. Using this criterion, raters assigned a level of evidence for a given technological intervention based on a seven-level scale. Quality of the randomized controlled trials (RCTs) was measured by the Physiotherapy Evidence Database (*PEDro*) scale [37]. The PEDro scale has 11 criteria, 10 being the maximum score that a trial can achieve. Scores of 9–10 are considered "excellent" quality; 6–8 indicates "good" quality; 4–5 are "fair" quality; and below 4 is "poor" quality [38]. As the field of wander-management technologies is diverse, we assessed the levels of evidence across three device categories: mobile locator, sensor and alarm, and wayfinding. Data on sample size, experiment length, study strategy (i.e., clinical, usability, combined), study design (i.e., qualitative or quantitative research method), main outcomes of the study, and data collection location (i.e., home, community, facility) were collected.

(b) **Ethical concern associated with the implementation of the wander-management strategy.** Refers to the ethical concerns that were addressed regarding the implementation or use of the wander-management strategy. Examples of concerns include but not limited to protecting privacy, dignity, and autonomy of the person with dementia.

2.6. Data analysis

Data analysis was conducted by one person (N.A.N.). Due to the diversity of the included articles, a qualitative approach was used, where content analysis was performed on the extracted data highlighted (in bold) previously. Descriptive statistics (i.e., averages and standard deviations [SDs]) were calculated for diversity of the technology specifications, strategy cost, and PRL across the included wander-management strategies, in addition to participant age, number of participants from the included studies, and study length.

3. Results

The initial search identified 4096 peer-reviewed studies; 118 studies were included in the data-abstraction phase and final analysis (2.9%, 118/4096) (Fig. 1). Most studies (68.6%, 59/86) were excluded because they did not meet inclusion criteria 1a, 1b, 1c, or all three. Other reasons for exclusion from the final data-abstraction phase were that studies were not available (31.4%, 27/86).

For the gray literature, 130 strategies from 44 commercial websites, 1 dissertation website, 5 self-help websites, 8 Alzheimer's-specific websites, and 1 online magazine were included in the data-abstraction phase and final analysis. All met inclusion criteria (7), that is, were websites suggesting or selling strategies to address dementia-related wandering.

Studies containing high-tech–only strategies were characterized by low journal impact factor (i.e., Source Normalized Impact per Paper mean 0.94, SD 0.59; 95% confidence interval [0.79, 1.08]) and were published in journals located in Q1 (13 studies), Q2 (16 studies), Q3 (5 studies), and Q4 (6

studies) journal quartile per SCImago Journal Rank classification [39]. Studies containing low-tech–only strategies were characterized by low journal impact factor (i.e., Source Normalized Impact per Paper mean 0.99, SD 0.51; 95% confidence interval [0.84, 1.14]) and were published in journals located in Q1 (19 studies), Q2 (16 studies), Q3 (6 studies), and Q4 (2 studies) journal quartile per SCImago Journal Rank classification [39]. Studies containing both high- and low-tech strategies were characterized by low journal impact factor (i.e., Source Normalized Impact per Paper mean 0.99, SD 0.82; 95% confidence interval [0.58, 1.40]) and were published in journals located in Q1 (4 studies), Q2 (7 studies), and Q3 (1 studies) journal quartile per SCImago Journal Rank classification [39].

Regarding design [34,35], seven high-tech studies were of qualitative design [phenomenology (4) and grounded theory (3)], 21 were of quantitative design [cross-sectional design (10), single-case design (4), case study (3), before-after design (1), randomized controlled trial (1), randomized pre-post (1), and descriptive (1)], and 9 were reviews [systematic review (4) and other review (5)]. Low-tech strategies included two studies that were of qualitative design [grounded theory (2)], 14 were of quantitative design [cross-sectional design (4), case study (4), single-case design (2), retrospective (1), pretest-posttest (1), ABA descriptive design (1), and randomized controlled trail (1)], and 17 were reviews [systematic review (10), Cochrane review (1), and other review (6)]. Publications containing both high- and low-tech strategies included two studies that were of qualitative design [phenomenology (2)], 4 were of quantitative design [cross-sectional design (1), single-case design (1), randomized controlled trail (1), and case study (1)], and 4 were reviews [systematic review (2), Cochrane review (1), and other review (1)] (Table 1).

Included peer-reviewed literature came from 20 countries, with over half of the studies being conducted in the USA (58%, 47/118) and the UK (16%, 19/118). Similarly, for the gray literature, strategies were found to originate from 7 countries, with almost 80% of the technologies being from the USA and UK (75% USA, 12% Canada, and 7% UK). Publication year of the included peer-reviewed literature varied, with wander-management strategy publications appearing in the early 1990s, and the total number of publications increasing over the last 27 years. A trend was evident pertaining to the type of strategy being published, where there has been a predominant focus on high- versus low-tech strategies over the last decade.

3.1. Features of wander-management technologies

3.1.1. Wander-management strategy—type used and strategy specifications

A total of 183 high-tech strategies (109 from peer-reviewed and 74 from gray literature) and 143 low-tech strategies (85 from peer-reviewed and 58 from gray literature) were included in this scoping review and included 6 subcategories of high-tech strategies and 14 subcategories of low-tech strategies. The most commonly used high-tech subcategories from the scholarly literature were locating strategies (i.e., GPS, radio frequency, Bluetooth, and Wi-Fi; 71.6%, 78/109) and alarm and sensors (i.e., motion and occupancy sensors, monitors, and optical systems; 19.3%, 21/109). The most commonly used high-tech subcategories from the gray literature were also locating technologies (i.e., GPS and radio frequency; 63.5%, 47/74) and alarm and sensors (i.e., motion sensors; 35.1%, 26/74) (Fig. 2). The most commonly used low-tech subcategories from the scholarly literature were distraction/redirection strategies (i.e., doll therapy, music therapy, mirrors in front of exit doors, visual barriers such as cloth on exit doors or door murals, and the integration of purposeful activities such as chores and crafts; 35.3%, 30/85), exercise groups (i.e., walking; 12.9%, 11/85), and identification strategies (i.e., ID cards, labels, and the Safe Return Program; 8.2%, 7/85) (Fig. 2). The most commonly used low-tech subcategories from the gray literature were distraction/redirection strategies (i.e., visual barriers, planning meaningful activities, animal therapy; 25.9%, 15/58), locks/barriers (i.e., door locks; 15.5%, 9/58), and identification strategies (i.e., Safe Return and Medic Alert; 12.1%, 7/58) (Fig. 2).

3.1.2. Product readiness level

For the peer-reviewed articles, two were in the analytical and experimental critical functions phase (PRL3), and 21 were either in development and testing phases in laboratory, or validated in relevant environments (PRL 4 and 5), or the technologies were in demonstration or pilot phase (PRL6). The remaining 31 articles contained strategies either prototypes near or planned in an operational system or were mature strategies in which actual systems operated over the full range of expected conditions (PRL9) (Table 1). A total of 19 high-tech articles, 34 low-tech articles, and 11 articles containing both high- and low-tech strategies could not be classified using the PRL scale. Primary reasons were due to the high number of review articles included in this study, in addition to many strategies that were proposed but not evaluated. Articles containing both high- and low-tech solutions were found to have the highest technology readiness level (PRL9), in comparison with high-tech–only articles with an average PRL7 and low-tech–only strategies with an average PRL7.

3.2. Descriptive analysis of studies

3.2.1. Characteristics of the research conducted in wander-management technologies

(a) ***Participant characteristics, sample size, length, and location of included studies.*** Participants of the included studies had a mean age of 75 years (SD

Table 1
Positive and negative outcomes per type of strategy (high tech vs. low tech) (n = 118) of scholarly literature

Strategy type	No. of studies (%)		Avg. no. of participants	Design of study	Level of evidence	Type of study	Product readiness level (PRL)	PEDro scale
	Negative or mixed outcomes	Positive outcomes						
High-tech strategy	26 (43%)	32 (52%)	51 ± 77	Cross-sectional design (1), single-case design (4), case study (3), RCT (1), randomized pre-post (1), descriptive (1), before-after design (1), phenomenology (4), grounded theory (3), systematic review (4), other review (5), N/A (24)	Conflicting	Strategy-oriented (32), usability (5), clinical-oriented (15), strategy- and clinical-oriented (1), review (8)	6.8 ± 1.9	N/A
Low-tech strategy	13 (31%)	21 (50%)	110 ± 365	Cross-sectional design (4), single-case design (2), case study (4), retrospective (1), pretest-posttest (1), ABA descriptive design (1), RCT (1), grounded theory (2), systematic review (1), Cochrane review (1), other review (6), N/A (9)	Conflicting	Strategy-oriented (1), technology- and clinical- oriented (22), program-oriented (1), review (17), N/A (1)	6.8 ± 2.1	5 (1 study)
Contains both high- and low-tech strategies	9 (60%)	4 (27%)	113 ± 195	Single-case design (2), case study (1), RCT (1), phenomenology (2), systematic review (2), Cochrane review (1), other review (1), N/A (2)	Conflicting	Clinical-oriented (9), review (4), N/A (2)	9 ± 0	N/A

NOTE. Three of 61 high-tech, 8/42 low-tech, and 2/15 articles that contained both high- and low-tech strategies did not evaluate the effectiveness of wander-management strategies and only proposed potential strategies. Therefore, outcomes of these included articles could not be provided. Level of evidence according to Sackett criteria proposed by Teasell et al. [36].

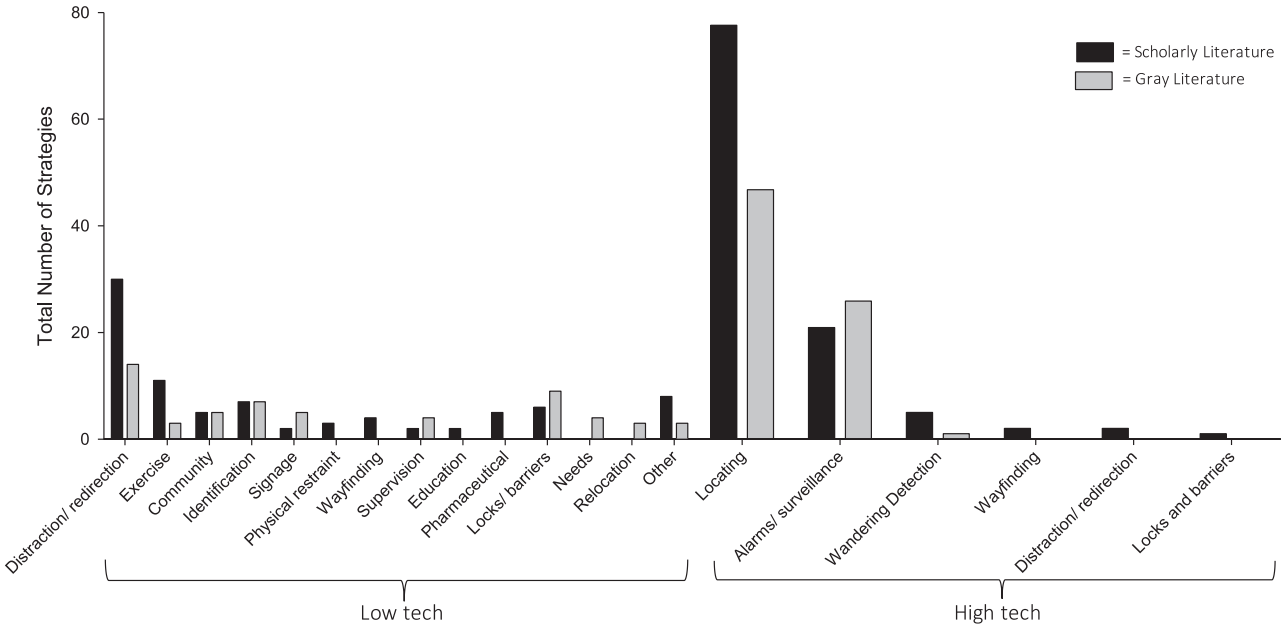


Fig. 2. Number of strategies that were high (n = 183) and low (n = 142) tech.

9.7). The age ranged from 23 to 90 years for caregivers and 60 to 103 years for persons with dementia, with a high dispersion in the number of participants (i.e., mean of n = 217 and SD = 77.2). Although all peer-reviewed articles included persons with dementia, only 19 articles (16%, 19/118) specified their underlying degree of dementia and level of cognitive decline. Almost 43% (38/88) of the included clinically oriented studies were small trials with a total number of participants less than 50 (i.e., mean of n = 10.8; SD 10.0), whereas the remaining trials can be described as medium-large (i.e., >50) with a mean of n = 200.5 (SD 338.0). No mean differences were found across low- and high-tech strategy studies for small and medium-large trials ($P > .05$). Of the 88 included clinical studies, 29 did not report sample size and therefore were not included in the aforementioned calculations. Fourteen studies involved caregivers; however, only seven reported the relationship between the individual with dementia and caregiver. The most common type of family caregiver was a combination of children and spouse (18.6%), followed by spouse only (17.7%), and children (16.7%). Professional caregivers, search and rescue workers, and nurses were also included, making up nearly half of the reported involved stakeholders (40.3%). Forty-three of the studies reported the ratio of male-to-female dementia clients and caregivers. The average total number of females included in this review was 60 (SD 27), whereas the average total number of males included in this review was 39 (SD 36). Only 11 of the 118 studies reported ethnicity of participants. Of these, two were 100% Caucasian, five were more than 70% Caucasian, four were 100% Asian, and five contained <25% for Latino, African American, and African Caribbean decent. The lengths of the included studies varied (mean 4.8 months; SD 11.5). Only 57 of the 118 studies (48%) reported the location of the study. The setting of tests for the included studies ranged from long-term care (43.9%), community (26.3%), laboratory (10.5%), home (7.0%), hospital (5.3%), assisted living (3.5%), and outdoor environments (3.5%).

(b) ***Wander-management strategy outcomes.*** Effectiveness of wander-management strategies was measured using 96 outcome variables across the 118 studies. Of these, 76.0% (73/96) of the outcome variables were different. When breaking down the studies by technology complexity, high-tech–only studies used 60 outcome variables across 61 included studies, with 71.7% (43/60) of the outcome variables being different; low-tech–only studies used 20 outcome variables across 42 included studies, with 75.0% (15/20) being different; and studies containing both high- and low-tech strategies included 16 outcome variables across 15 studies, with 93.8% (15/16) being different. The outcome variables for high-tech strategies included perceived effect of the technology on the well-being of the user (e.g., level of caregiver burden, satisfaction, depression, mood, daytime fatigue); perceived usability of the device by the user

(e.g., ease of use, comfort, confidence in the use of the device, perceived usefulness, concerns/problems); and the reliability, functionality, and accuracy of the device (e.g., number of errors, alarm frequency, time to find wanderer, number of unattended exits, and number of nighttime injuries) (Table 2). For the measures used to assess the proposed outcome variables, 50 measures were reported, and of these, 74% (37/50) were different. The most commonly used approaches were Likert scales (3/50), interviews (5/50), observations (3/5), and true positive/negative rate (5/50).

The outcome variables for low-tech strategies included wandering prevalence/frequency, attempted door testing/exiting/entries, total time seated, number of aggressive events, restlessness, and success facilitating return of the missing person (Table 3). For the measures used to assess the proposed outcome variables, 17 measures were reported, and of these, 76% (13/17) were different. The most commonly used approaches were time between door testing/exiting (4/17) and observations (3/17). Finally, the outcome variables for studies that included low- and high-tech strategies included effectiveness of the intervention, experience and advise using the different strategies, acceptability related to the intervention, distance of wandering, and agitation and irritability (Tables 2 and 3). For the measures used to assess the proposed outcome variables, 16 measures were reported, and of these, 88% (14/16) were different. The most commonly used approaches were interviews (2/16) and observations (2/16).

For the overall outcomes, 48.3% (57/118) of the included peer-reviewed literature showed advantages of wander-management strategies in terms of managing wandering in persons with dementia. Forty-eight of the 118 studies reported negative or nonsignificant differences, but positive versus negative outcomes were not significantly different ($P > .05$). When separating the number of positive and negative or mixed outcomes by technology complexity, 52% (32/61) of the high-tech strategies, 50% (21/42) of the low-tech strategies, and 27% (4/15) of the studies that included both low- and high-tech strategies demonstrated positive results. Thirteen studies did not include results that evaluated wander-management strategies; therefore, they were not included in calculations. The above indicates that although the implementation of strategies to manage the adverse outcomes associated with wandering is promising, there is significant room for improvement and requires further investigation. Table 1 shows the number of studies classifying the positive and negative outcomes per device type, in addition to details on the total number of participants and study design types.

(c) ***Evidence of the clinical outcomes.*** The level of scientific evidence of the clinical-oriented studies that

Table 2
High-tech main outcomes of scholarly literature

Strategy subtype	Main outcome(s)
Locating	RFID device had great potential for locating the wanderer quickly with localization ranging from 5 to 60 meters (3). Locating devices increased confidence and peace of mind of caregivers (3) and provided perceptions of reassurance and enhanced independence for the person with dementia. GPS was found to be more time effective in finding a missing person with dementia than RF. Overall, users were satisfied with locator devices and found them to be useful and acceptable. Electronic tagging was found to be a preferred option by users; however, it was highlighted that there is a need to tailor the device to the user's needs and send better alerts (2). Ethical issues, such as coercing persons with dementia to use locating devices (2), concerns over the device conveying the user as frail as sick (2), removing the person with dementia of their dignity, and worries over privacy and security were conveyed.
Alarms/surveillance	Wide variability among commercial alarm products such as alarm sound pressure levels, power consumption, frequency, and force measurement data for pressure activated systems and pull tab alarms. Most devices were too sensitive leading to false alarms. Results raise a need to link multiple products into one system to meet the variable needs of the users. Devices focused on ongoing surveillance at home for persons with dementia are needed so could be quickly adopted. Technologies that alter the appearance of the home or resemble medical devices will not be adopted by this population.
Wandering detection	Wandering detection devices had an excellent detection performance and low false alarm rate (smaller than 0.07). Wandering detection devices raise potential to contribute toward improved safety by identifying attempts to elope and successful exits and will facilitate the examination of trigger events for intensive wandering.
Wayfinding	Results of study are promising, and individuals with mild dementia are capable of following vibrotactile signals. Attention capture needs to be included. The device is not functionally relevant to those who have progressed to moderate stages.
Distraction/redirection	Interactive wall was experienced positively by wandering elders, and installation was an improvement in attracting persons with dementia than old empty environments.

Abbreviations: RFID, radio-frequency identification; GPS, global positioning system; RF, radio frequency.

Table 3
Low-tech main outcomes of scholarly literature

Strategy subtype	Main outcome(s)
Music therapy	Shows as a promising alternative to decrease the length of wandering. Music therapy was found to increase the amount of time seating more than reading therapy (2x the time seated) (4)
Doll therapy	Caregivers felt that there were clear benefits of using doll therapy in reducing wandering; however, some studies were subjective and anecdotal in nature, questioning the true effectiveness of this strategy.
Exercise programs	Were found to reduce wandering behaviors (2); however, no evidence was found in randomized trails. Demonstrated less aggressive incidents (30%) and nighttime wandering decreased.
Mirror in front of exit door	A mirror was found to reduce exit attempts by 50% (1), and 40% (1), and saw general decreases in successful exiting.
Blind/cloth barriers	Barriers on an exit door (i.e., covering the door knob or using black tape/cloth to alter the exit door) were found to be more effective (96%) than horizontal mini-blinds on the window panels on exit doors (44%). Combined methods reduced attempts by 88%. Changing floor patterns were least effective. Cloth barriers were also found to be more effective than staff-redirected entries without the visual barrier present and demonstrated high treatment acceptability.
Door mural	Door testing behaviors were reduced by 42%.
Signage	Studies were found to be underpowered and not convincing where no evidence was generally found. Those implementing signage need to take into consideration the downward gaze of the person with dementia.
Differential reinforcement	Results indicated a significant decrease in wandering with reductions ranging from 65% to 80%. Differential reinforcement techniques ranged from lack of attention for two participants, availability of sweet food for one, and sensor stimulation for another.
Distraction	Methods of distraction included providing activities for the person with dementia after meals (chores, crafts, watching videos, singing songs, etc.), and to encourage pottering. Self-stimulator products, however, are needed when staff are unavailable to direct the activities. Strategies, however, were only proposed, but its effectiveness was never evaluated.
Silver Alert	Massive variation from one state to the next on procedures. There is a limitation on available knowledge about the program (costs, effectiveness, etc.)
Safe Return Program	Proposed but effectiveness was not evaluated
Aromatherapy	Rubbing lotion with lavender, geranium, rosemary, and mandarin oils into skin of the person with dementia decreased anxiety and wandering.
Reality orientation	Strategy was suggested in the literature, but its effectiveness was not evaluated.
Lighting conditions/noise level/temperature	No effects of temperature on wandering prevalence were found. Higher noise in rooms indicated increased levels of wandering. Lighting conditions influenced wandering prevalence, where microslated glazed windows with bronze microslats coated in black were found to decrease wandering incidents, whereas brighter lighting was found to cause more wandering.
Pharmaceutical strategies	Risperidone demonstrated reductions in wandering but did not specify by how much. Alprazolam and Fasudil also indicated decreases in wandering behavior.
Locked units and physical restraints	Perceived as effective; however, it is not used by a majority of facilities (only used by 28% of facilities)

evaluated wander-management strategies using quantitative methods was low. Regarding the level of scientific evidence for the studies that evaluated high-tech strategies, only one article incorporated an RCT design [13]; however, details were not explained. Ten papers used a cross-sectional design. All studies were at a level of evidence 5, and results indicated that high-tech strategies have great potential for locating the wanderer quickly; however, many devices do not follow to their claims, which could in part be due to the low quality of effectiveness testing. GPS locating devices consistently demonstrated superior accuracy to radio frequency devices. Family caregivers were perceived significantly more important in the decision-making process than figures outside of the family. Four studies used a single-case study design without a baseline phase, also at a level of evidence 5, indicating that individuals with mild dementia are capable of following vibrotactile signals, that wandering detection devices can contribute toward improved safety by identifying attempts to elope by setting up alarms and sensors, and that locating devices demonstrate promise as a novel and competent healthcare approach in the case of dementia scenarios. Seven studies used qualitative approaches, which cannot be assessed using Sackett's criteria [36].

Regarding low-tech strategies, only one study incorporated an RCT design. This RCT [40] achieved a PEDro score of 5, with a level of evidence 2, where adapted exercise games (i.e., active activities with a softball) significantly decreased agitated behaviors, such as searching or wandering behaviors (54%, $P < .05$), whereas escaping restraints had no significant change (40%, $P = .07$). Four articles used a cross-sectional design with a level of evidence 5, and results indicated that lighting conditions had no effect on disruptive behaviors such as door testing/exiting, and few persons with dementia who exercises in ways other than walking may influence sundown syndrome and sleep quality. Four studies used a single-case study design with a baseline phase and had a level of evidence 4, indicating

that cloth barriers reduced entry into restricted areas with a high treatment acceptability, music therapy can increase the amount of time seated by the persons with dementia, and highlighted the need to educate caregivers that all persons with dementia are at risk of getting lost, regardless of whether they have exhibited the risky behavior in the past. Early education would allow caregivers to adopt preventative measures to reduce these impending risks. One study used a pretest-posttest design, with a level of evidence of 4. Results demonstrated the effectiveness of integrating a wall mural painted on the entrance of doorways, through the reduction of door testing behaviors exhibited by the participants. Two articles used qualitative methods, which cannot be assessed using Sackett's criteria [36].

Regarding studies that included high- and low-tech solutions, one study included an RCT design [41]; however, the details were not explained. Results from this study highlighted that most devices presently used by family caregivers do not comprise new technology but rather use established items, such as baby monitors, and home modifications that are recommended by an occupational or physical therapist. There was level 5 evidence from two case study [42,43] designs indicating that no evidence of benefit from exercise or walking therapies were found, that tracking devices and home alarms and sensors both effectively detected wandering and locating lost patients in uncontrolled, nonrandomized studies, and that IC tag monitoring system needed further improvement for clinical use.

(d) ***Usability and strategy acceptance.*** Of the peer-reviewed studies, 12% (13 studies) aimed to study the usability and acceptance of wander-management strategies. Of these, nine (69%, 9/13) examined acceptance of high-tech solutions and 4 (31%, 4/13) examined acceptance of low-tech solutions. Overall acceptability and usability of these strategies were high among participants. For example, one study found that most respondents agreed that the use of locator devices was superior to existing search methods and would improve quality of life of caregivers and persons with dementia, that they were appropriate devices, and that they could operate the device successfully [24]. Those who were more inclined to use wander-management technologies were older adults who had been lost once or more (89%) or who had been diagnosed with mild dementia and had a history of being lost (73%) [44]. For low-tech solutions, cloth barriers, for example, were found to have high treatment acceptability [22]. Low-tech solutions were also seen as strategies that have already been implemented within a person's home, in part due to their affordable nature, and as established strategies that result from professional recommendations from occupational and physical therapists [41].

(e) Although the acceptability of certain strategies was high, others did not have the same result. Locator devices used by Yung-Ching & Leung (2012) [44], for example, were met with resistance. Barriers toward the implementation of wander-management strategies are suggested to be partly related to caregivers' acceptance of the suggestions, which they often perceive as not necessary or that they would not work in their situation. In addition to acceptance of wander-management strategies, barriers on the use of high-tech strategies include concerns about damaging the device, cost of equipment, difficulties in using the strategy, false alarms caused by the device, uncomfortable wear of the device, inaccuracy of the coordinates for locator devices, forgetting to wear the device, and concerns about privacy and stigmatization. Device esthetics was also considered important in purchase consideration [44]. Barriers on the use of low-tech strategies include participants not being aware of the strategy (e.g., mirrors and grids on doors), not enough staff to implement the strategy (e.g., exercise programs), poor product design, unavailability or lack of cooperation, issues with building codes (i.e., locked door strategies), and the implementation of the strategy being challenging due to raised ethical concerns (i.e., doll therapy being seen as demeaning and patronizing).

(f) ***Ethical concerns associated with the implementation of the wander-management strategy.*** Of the 118 articles, 36 reported using an approach or policy to guarantee privacy of the individuals that used wander-management technologies. High-tech strategies comprised the greatest percentage of concerns (92%), with low-tech strategies only including 8% of the highlighted ethical issues (Table 4). This in part may be due to high-tech solutions involving devices that track or monitor persons with dementia, instilling concerns over privacy and security [45].

4. Discussion

This review examined the range and extent of all possible strategies used to manage wandering behavior in persons with dementia. We included 118 studies (of 4096) and 130 strategies from the gray literature. Overall, 183 high- and 143 low-tech strategies were included, with the majority (59.5%) of the strategies being derived from the scholarly literature. The percentage of strategies derived from scholarly and gray literature differs from that of Neubauer et al. [25] where most strategies were from the gray literature. This is in part due to the addition of low-tech solutions and studies that do not evaluate the usability or effectiveness of the wander-management strategies to the current review. Of the 296 strategies, there were 183 high- and 143 low-tech solutions. Of these, there were six different

Table 4
Ethical concerns associated with wander-management strategies

Strategy type	Ethical concern to the use of the wander-management strategy
High tech	There are concerns over control and restraint (i.e., tagging like a criminal). Electronic tagging can be viewed as stigmatizing, demeaning, and an invasion of privacy and removes one's dignity. There are concerns of data leakage for locator devices. It is suggested that locator devices do not increase autonomy but just assists in finding the person with dementia sooner. Locating devices raise issues as to who benefits, and there is a conflict of interest between the caregiver and the person with dementia, need formal agreements from all involved. Little attention has been placed on the perspective of the person with dementia on locator devices.
Low tech	Doll therapy was demeaning and patronizing. There is a need for procedural safeguards of Silver Alert to protect privacy. The role of mental health providers in activation of Silver Alerts should be more thoroughly explored.

subcategories of high- and 14 different subcategories of low-tech strategies, with locating strategies, alarms and sensors, and distraction/redirection strategies were the most common. Of the 118 included studies, less than half (48.3%) evaluated the usability or effectiveness of the strategies.

Only 16% were clinically tested in home or community settings, and 25% were tested in formal care settings. In addition, all testing locations took place in urban settings. The lack of real-world evaluation raises question about the degree of effectiveness of the proposed wander-management strategies, and whether users are able and willing to adopt these solutions. In addition, rural regions were significantly underrepresented, leaving out a significant cohort, which may have presented different and necessary views by caregivers on the use and integration of these interventions in their communities [46]. An increased focus on usability testing in home-based rural and urban settings and the use of user-centered and participatory design approaches would enable real users to identify problems with existing strategy designs, which could enhance adoption and acceptance of wander-management strategies [47].

Aside from a lack of usability testing and user-centered approaches of wander-management strategies, available solutions were difficult to find and were vastly scattered across the gray literature. Most high-tech solutions were available through an array of commercial websites selling the technology. Two websites, tech.findingyourwayontario.ca and alzstore.com, were the only websites containing strategies from multiple companies. Low-tech solutions were primarily suggested in Alzheimer's-specific websites such as through the Alzheimer Association; however, little information was provided on where or how to access these strategies. In addition, no website provided an in-depth description of all available low- and high-tech wander-management strategies. These findings help to support difficulties caregivers and persons with dementia may face when trying to choose a strategy that works best for their individual needs. A guideline available through different mediums and locations is therefore necessary to simplify this information for a population that is often time constrained due to their caregiving responsibilities [48].

Although the mass diversity of wander-management strategies may be promising in terms of having multiple options to help serve the unique needs of persons with dementia and their caregivers, only 13% of studies (15/118) in this review included high- and low-tech strategies together. Even fewer (2%; 2/118) compared their effectiveness. This raises the question whether certain high- and low-tech strategies are more effective than others, and if various combinations of wander-management strategies are necessary to meet the unique needs of persons with dementia and their family caregivers. Some persons with dementia, for example, wander inside and outside of their homes [49], whereas some may only wander in one of these settings. In terms of living arrangements, there are a growing number of persons with dementia who are living at home alone in the community, changing the scope of how one might care for these individuals [50]. When looking at the diverse context of those affected by dementia, income levels, perceptions of risk associated with wandering behavior, culture, and beliefs may all play key roles in the successful adoption of wander-management strategies [46]. These factors, however, have yet to be evaluated within the present literature.

In addition to examining the range and scope of high- and low-tech wander-management strategies in this review, we wanted to identify their level of product readiness, and to characterize the present evidence on the implementation of such interventions. Overall, most peer-reviewed articles described strategies in which they were prototypes that were planned in an operational setting. This signifies the positive state of wander-management strategies in that most have been tested in a relevant environment and are in the process of being deployed in operational environments. Despite the potential advantages of using high- and low-tech strategies to manage wandering, only 52% (61/118) of the studies could be evaluated using the PRL scale because many studies were only proposing the strategy. With 194 different high- and low-tech strategies being included in the scholarly literature alone, this highlights the sheer infancy of present strategies that are being used to manage wandering. Further research in this area is therefore required because of the low percentage of strategies that could be evaluated using the PRL scale.

Mixed outcomes were found for both high- and low-tech strategies, where positive outcomes were found for 52% of the included high-tech strategies and 50% for the low-tech strategies. Overall, the use of nonconstraining strategies provided promise to facilitate persons with dementia to support independence and enable them to engage in meaningful activities, such as walking and remaining engaged within their community [51]. For high-tech strategies, locating technologies, such as GPS and RFID devices, were suggested to have great potential for locating wandering persons with dementia quickly, provides increased confidence and peace of mind of caregivers, and was found to be a preferred option by users. The implementation of alarms and surveillance strategies were also promising. Issues, however, such as cost, over sensitivity, appearance, privacy, stigma, and the need to combine multiple products to meet the variable needs of users, are to be considered. For low-tech interventions, strategies such as door murals, methods of distraction, visual barriers, exercise programs, and therapies (i.e., doll and music therapy) all demonstrated reductions in wandering and exit seeking behaviors. Conflicting evidence, however, was found across all strategies, and scientific rigor was repeatedly mentioned as being poor quality [52]. This raises questions on the feasibility and effectiveness of the adoption of these strategies in formal and community-based settings. Aside from the outcomes that measured caregivers' perceptions on strategies to manage wandering, like the findings of Neubauer et al. [25], none of the included studies addressed the needs and opinions of persons with dementia, more specifically those with mild dementia. Although addressing the concerns of family caregivers is important, the end outcome of these strategies is to ensure the safety of persons with dementia at risk of getting lost. The involvement of both caregivers and persons with dementia in the design and implementation of wander-management strategies is therefore critical to enable enhanced user satisfaction, adherence, and inevitably improved safety and quality of life of persons with dementia.

The significant variation of included outcomes, participant type, assessment tools, study duration, testing settings, and study design may have influenced the mixed outcomes of the high- and low-tech wander-management strategies. Intervention implementation, for example, ranged from 25 minutes to 1 year, with most (78%) being only applied for 3 months or less. The high variation and short study length indicates a need to determine a duration that is best suited for strategy development and evaluation. Longitudinal field studies are also required to identify the long-term impact of each wander-management strategy, and there remains a critical need for standardized outcomes to compare the effectiveness of strategies to manage wandering. Other measures based on models such as the Technology Acceptance Model [53] and the Unified Theory of Acceptance and Use of Technology [54] are necessary to ensure strategies are designed in a way that take into consideration factors that are essential to user adoption. The level of scientific evidence provided by clinical-oriented studies that used quantitative methods is low as the highest level per Sackett criteria [36] was 2, with most studies containing at level of evidence of 4 or less for both high and low tech included studies. Thus, there is a need for more RCT studies to increase the level of evidence of wander-management strategies for persons with dementia.

Finally, there is a gap in the literature with respect to privacy and ethics of persons affected using wander-management strategies. There has been no approach or recommendations published to address ethical issues. Future studies on privacy versus safety, the influence of stigma, and conflicts of interest between caregivers and persons with dementia need to be further explored.

4.1. Limitations of this review

We could only quantitatively assess the strength of studies that used RCTs (using PEDro scale); as far as we know there is no standardized scale that determines the quality of either quantitative or qualitative non-RCT studies. Although there are tools and guidelines available for performing a critical appraisal of research literature, the result was a proxy measure of quality. Without a scale, comparison of the relative quality of the included studies was not possible.

5. Future research and conclusions

From this review, we can conclude that many high- and low-tech strategies exist to manage the negative outcomes associated with wandering in persons with dementia. There is a general agreement that wander-management strategies can reduce risks associated with wandering, while enabling persons with dementia with a sense of freedom and independence. Further research could determine the factors that may influence intervention adoption and demonstrate the efficacy of high- and low-tech wander-management strategies.

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Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.dadm.2018.08.001.

RESEARCH IN CONTEXT

1. Systematic review: We conducted an extensive search on gray and scholarly literature databases. Three levels of screening were employed, that is, title screening, abstract screening, and full-text screening.
2. Interpretation: We identified six categories of high-tech and 14 subcategories of low-tech strategies that can be used by caregivers and persons with dementia. Although wander-management strategies were believed to mitigate the risks associated with wandering, few addressed ethical issues, few were evaluated in community settings, and the overall scientific evidence from these outcomes was low. Available solutions were scattered across the gray literature and difficult to find.
3. Future directions: Rigorous research is required to demonstrate the efficacy of high- and low-tech wander-management strategies and their feasibility in urban and rural community-dwelling environments. A guideline is also necessary to simplify all possible strategy types and to allow stakeholders to choose wander-management strategies based on their individual needs.

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