Effectiveness of interventions for preventing people with dementia exiting or getting lost

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Abstract

Background and objectives. People with dementia are at risk of exiting premises unsupervised, eloping or getting lost, potentially leading to harmful or distressing consequences. This review aimed to estimate the effectiveness of interventions for preventing people with dementia from exiting or getting lost.

Design and Methods. A systematic review of English sources was undertaken. Healthcare (EMBASE, BNI, Medline, PubMed, CINAHL, PsycINFO, AMED, HTA, CENTRAL) and grey literature (OpenGrey) databases were searched using prespecified search terms. Additional studies were identified by hand-searching bibliographies of relevant reviews and included studies. Wide inclusion criteria were set to capture a range of intervention types. Data extraction and risk of bias assessment were completed independently by two reviewers. Methods were preregistered on PROSPERO.

Results. Individual and overall risk of bias was too high for statistical meta-analyses. A narrative synthesis was therefore performed. Twenty-five studies with 814 participants were included, investigating a range of nonpharmacological interventions aiming to prevent exiting, facilitate retrieval, educate participants, or a combination of these. Seventeen (68%) of the included studies had critical risks of internal bias to outcomes, providing no useful evidence for the effectiveness of their respective interventions. The remaining eight (32%) studies had serious risks of bias. Narrative synthesis of results yielded no overall robust evidence for the effectiveness of any interventions.

Discussion and implications. No evidence was found to justify the recommendation of any interventions included in this review. Future studies should focus on high quality, controlled study designs.

Keywords

Alzheimer’s disease; wandering; missing incidents.

Introduction

Spatial navigation symptoms (i.e. disorientation, getting lost) are core features of dementia, as the underlying brain systems are affected in the disease (Coughlan, Laczó, Hort, Minihane & Hornberger, 2018; Chiu et al., 2004). Consequently, people with dementia are at risk of getting lost in unfamiliar and familiar environments without carers' knowledge of their whereabouts (Yatawara et al., 2017). Reports estimate that 30-70% of people with dementia become lost at least once during the course of the disease, often unpredictably during routine tasks and with few antecedents (Bowen et al., 2011; Kwok et al., 2010; McShane et al., 1998; Pai & Lee, 2016). Becoming lost can be highly distressing for people with dementia and their carers (Kwok et al., 2010). Extreme cases may result in injury or death (Woolford, Weller & Ibrahim, 2017), the risk of which increases with age, length of time missing and season (Bantry White & Montgomery, 2014).

Informal carers may respond to the increased risk of people with dementia becoming lost by monitoring them more closely, which may result in a reduced sense of freedom of the care recipient (McShane et al., 1998). Moreover, multiple incidents of getting lost have been shown to increase the chances of informal carers institutionalising the person with dementia (McShane et al., 1998), who may express resistance to this and a desire to stay in their own home (van der Roest et al., 2007). Lost people with dementia can also incur large costs to law enforcement and other community search and rescue services due to retrieval efforts (Bowen et al., 2011). As getting lost is a prevalent problem for people with dementia, their carers, and the wider community, there is a need to investigate effective interventions to safeguard against it.

Recommendations from published literature and public health guidelines suggest a wide range of strategies and techniques to prevent people with dementia becoming lost including caregiver planning, out-of-sight door bolts, tracking devices and more (see https://alz.org/help-support/caregiving/stages-behaviors/wandering; Bowen et al., 2011; Pai & Lee, 2016). However, the effectiveness of these interventions remains unclear without systematic evaluation. Previous reviews have reported on interventions aimed at reducing 'wandering' (Robinson et al., 2007; Hermans et al., 2007). However, the term wandering is complex, with conceptual and operational definitions regarding it as a syndrome of locomotive behaviours (e.g. pacing, lapping) with possible associated outcomes such as exiting (also known as 'eloping') or getting lost (Algase, Moore, Vandeweerd, & Gavin-Dreschnack, 2007). Strategies and interventions aiming to mitigate harm or adverse consequences ~~are~~ have often been tailored to one type of wandering-related behaviour (such as pacing), but studies have often assessed their effectiveness with nonspecific outcome measures (see Robinson et al., 2007). Furthermore, interventions for reducing 'behavioural and psychological symptoms of dementia (BPSD)' often include 'wandering' amongst a list of diverse presentations. These are imprecise approaches for investigating specific wandering-related concepts, including the most potentially dangerous outcomes of wandering: the risk of people with dementia becoming lost, or leaving premises unattended ('exiting') that may lead to them becoming lost (Rowe et al., 2012). Neither exiting nor getting lost, as specific and problematic outcomes, have been the subject of any systematic reviews of intervention studies. Therefore, evidence-based recommendations cannot currently be made for safeguarding against their associated risks.

Filling this gap is important due to the prevalence and potential consequences of these behaviours, as mentioned above. A review of the evidence is also timely given that

recent technological advancements have yielded a wide range of tracking and alarm devices claiming to alleviate incidents or consequences of people with dementia becoming lost (Pulido Herrera, 2017). We therefore systematically reviewed the literature to determine whether evidence does exist for the effectiveness of these or any other interventions in preventing people with dementia specifically from becoming lost, or exiting as a precursor to this.

Review question

How effective are interventions which aim to prevent, reduce frequency or decrease adverse consequences of people with dementia exiting or becoming lost?

METHODS

Protocol and registration

Methods for this systematic review followed guidelines from the Centre for Reviews and Dissemination (2008), reporting standards from Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, Moher et al., 2009; Liberati et al., 2009) and AMSTAR 2—a critical appraisal tool for systematic reviews of healthcare interventions (Shea et al., 2017). The review was pre-registered on the International Prospective Register of Systematic Reviews (PROSPERO, CRD42018097229, https://www.crd.york.ac.uk/PROSPERO/) with details of the review question, search strategy, eligibility criteria, and methodological assessment. Details of data synthesis were not provided beforehand, except that they would follow methodology from CRD and that a meta-analysis was planned.

Eligibility criteria

Primary research studies of any design were included, except for case studies due to their very low generalisability. This broad criterion was set to allow an overview of a diversity of intervention types from studies reporting on their effectiveness. However, effectiveness of interventions was assessed against high quality designs for intervention studies. Studies with people who had a diagnosis of dementia of any age, gender or disease severity were included. The study could have been undertaken in any care setting (i.e., hospital, care or community). Studies looking exclusively at mild cognitive impairment and any other non-dementia groups were excluded. Studies were included if they examined any intervention, treatment or tool aimed at reducing or preventing wandering behaviours, exiting, elopement, getting lost, missing incidents or adverse consequences of these. Studies of interventions for improving wayfinding in controlled environments were excluded because they were not directly related to exiting or getting lost. Studies without control groups were included. However, the risk of bias for uncontrolled studies was assessed against high-quality controlled trials. The main outcomes of interest were any measure of, or incidence of, exiting (including 'eloping'), ~~eloping~~ or getting lost (including 'missing incidents'). Studies were excluded if they measured 'wandering' without inclusion of the above measures, or conflated with agitation, pacing or some other behaviour. Studies could also have included assessment of the consequences of the intervention or lack thereof, such as: Accidents; injuries; falls; fractures; deaths; activity in daily tasks; quality of life, anxiety, or distress of the person with dementia or their carer(s); carer burden; institutionalisation. Only English records were included as resource limitations prevented translation of non-English records.

Searching and information sources

Search terms and databases are documented in Table 1. This included online databases of published and grey literature (from inception to March 2019: the date of the most recent search update), bibliographies from included studies, and bibliographies from relevant reviews and other secondary sources found from systematic searching of databases. A list of these latter papers can be found in Table S3.

Study Selection

LEM extracted all search results and performed an initial screening of titles and abstracts using the eligibility criteria above ~~erring on the side of over-inclusion~~. A second screening of titles and abstracts was performed by LEM and VP independently, with reasons for exclusions provided. This process was briefly piloted for consistency ~~of reasons for exclusion~~ and refined accordingly. Potential inclusions from either LEM or VP were eligible for full text eligibility screening. Full texts were then assessed for final eligibility by LEM and VP independently. This process was first piloted for consistency and refined accordingly. Disagreements during the full selection process were resolved through discussion and arbitration by MH where necessary. Decisions on eligibility of full texts were recorded (supplementary spreadsheet, available for review as separate document).

Authors were contacted if more information was required to assess eligibility of articles. Papers were excluded if no reply was received before the cut-off date for data extraction (March 2019).

Data collection process

Preregistered data items were included in a data extraction form. The form was piloted on two studies and refined accordingly. LEM and VP extracted data independently before

comparing for consistency with disagreements resolved by discussion. Study characteristics were collected alongside assessment of reporting quality, risk of internal bias and risk of external bias (see supplementary spreadsheet for full data extraction and risk of bias assessment).

Appraisal of individual studies

An unblinded critical appraisal of each included study was undertaken by LEM and VP in duplicate, with disagreements resolved by discussion. The assessment was split into three parts: internal validity (risk of bias), external validity (representativeness, or external selection bias), and reporting quality. Although some critical appraisal scales cover all three of these areas, an adapted combination of tools was used to emphasise risk of bias and to avoid conflating the three areas into an overall score or rating (Liberati et al., 2009).

Internal validity

Cochrane's Risk Of Bias In Non-randomized Studies of Interventions tool (ROBINS-I; Sterne et al., 2016) was used as a basis for assessing internal validity. Cochrane's revised risk of bias tool for randomized trials (RoB 2; Higgins et al., 2016) was also used for assessing risk of bias in included randomized controlled trials (RCTs). RoB 2 ratings were adapted for comparison with the ROBINS-I. For example, whereas ROBINS-I allows for risk of bias ratings from 'low', through 'moderate', to 'serious' and 'critical'; the RoB 2 uses 'low', 'some concerns', and 'high' risks of bias. The RoB 2 'low' ratings were kept as 'low'; 'some concerns' was adapted to either 'moderate' or 'serious' risk of bias depending on details; and 'high' was adapted to 'serious' risk of bias in all domains except confounding, where there was potential for 'critical' risk (Higgins et al., 2016).

The RoB 2 tool has additional considerations for crossover trials (Higgins et al., 2016). These were used to inform risk of bias assessments of within-subject designs. For example, within-subject designs are susceptible to carryover effects of interventions and period effects from changes in study or background conditions over time. Additionally, the risk of bias due to confounding in single-group within-subject studies was partially assessed based on whether the study included just reversal (e.g. ABA) or also reintroduction (e.g. ABAB) of the intervention. The former accounts for confounding variables that may have influenced changes from A to B, but the latter is required to determine whether effects can be replicated (Cox, 2016). Single-group within-subject studies that reintroduced the intervention were deemed to have lower risk of bias due to confounding than reversal alone (Cox, 2016). Similarly, risk of bias due to confounding in these study designs was partially assessed based on potential effects of intervention ordering, which are usually controlled in crossover trials by design (Higgins et al., 2016). Finally, all within-subject designs were marked down for confounding due to period effects unless they accounted for underlying trends over time; this study design is considered inappropriate when investigating intervention effects on people who have progressive or unstable conditions such as dementia (Higgins et al., 2016).

Uncontrolled before-after studies (e.g. AB) were deemed to automatically have a critical risk of bias for any intervention effect, as all study-related and background factors become confounding factors (Cox, 2016; Armstrong, Waters & Doyle, 2011). However, these study designs were also automatically assigned a low risk of bias for many other domains because there could be no imbalance between intervention and control conditions.

Table S1 in the supplementary material compares bias domains across tools and study designs.

Studies with an overall critical risk of bias were excluded from any synthesis (Sterne et al., 2016). Risk of bias for remaining studies was taken into account in the evidence synthesis.

External validity

External validity was assessed based on risk of external selection bias, using the relevant subsection of the Downs and Black scale (1998). Each of the three items could be rated 'yes', 'no', or 'unclear'. Studies with 'no' or 'unclear' for all three items were given a high risk of external selection bias. Conversely, studies that were rated yes for all three items were given a low risk. Those with a mixture of yes's and no's were either given a rating of moderate or high risk, depending on details.

Reporting quality

Reporting quality was assessed separately from internal and external validity using the relevant subsection of the Downs and Black scale (1998). This is an 8-point subscale consisting of seven questions covering clarity of descriptions of: aims/hypotheses, participants, confounders, interventions, outcome measures, withdrawals, and adverse events (see supplementary spreadsheet). Each study was given a total score between 1 and 8, with lower scores indicating lower reporting quality.

Synthesis of results

One or more meta-analyses of intervention effects were planned, but studies were too heterogeneous in outcomes and intervention types, and risks of bias were too high. A narrative synthesis was undertaken instead, informed by published guidelines (CRD, 2008; Popay et al., 2006). This consisted of the following steps:

1. Theory development of intervention effects.

2. Tabulation and grouping of study characteristics.
3. Comparing direction and magnitude of effects of similar interventions, taking risk of bias into consideration alongside study characteristics.
4. Assessment of robustness of synthesis (overall level of evidence, critical reflection of methods of synthesis, comparison to other reviews).

RESULTS

Study selection

Twenty-five studies met the eligibility criteria and were included in the review. Figure 1 details the inclusions and exclusions from the search strategy. A list of excluded full texts and reasons for exclusions can be found in the supplementary spreadsheet.

Study characteristics

A summary of characteristics of included studies can be found in Table 2.

Study designs

Figure 3b shows total included study designs. The most common design was the uncontrolled before-after study (n = 11). Two further studies (Horvath, Hardy & Trudeau, 2007; Bantry White, Montgomery & McShane, 2010) were classed as uncontrolled after-only (UAO, also known as 'post-test-only') designs. Five studies employed a within-subject design with reversal of the intervention (e.g. ABA). Two further studies included reintroduction of the intervention (e.g. ABAB). Two unblinded randomized controlled trials (URCTs; Rowe, Greenblum, Boltz & Galvin, 2009; Shalek, Richeson & Buettner, 1999) and one nonrandomized controlled trial were included (Levy-Storms, Cherry, Lee & Wolf, 2017). One

study employed an observational cross-sectional design across groups of different intervention users (Chen & Leung, 2012). This is referred to as a controlled after-only (CAO) study to highlight comparison to other study designs. One study had an unclear design (Moore & Daley, 2014).

Participants

Eight-hundred and fourteen ~~814~~ reported participants were involved in the 25 included studies (median=20). Of these, six included carer-care recipient dyads as participants (total *n*=299), one reported staff as participants (Cohen-Mansfield et al., 1997) and the remainder included people with dementia only as participants. Two studies reported total residents in care units without reporting the number of affected individuals (Chafetz, 1990; Sherman et al., 1999).

Eight studies reported an unspecified diagnosis of dementia. Five did not report details on diagnosis but were included because the setting or context was dementia-specific. Twelve studies reported specific diagnoses of dementia, with totals of 232 Alzheimer's disease, 15 vascular or multi-infarct dementia, 1 frontotemporal dementia, 3 Parkinson's disease, 13 mixed dementia, 36 'other types of dementia' (or equivalently nonspecific), 1 'early onset' and 1 no diagnosis. Four of these studies included only participants with Alzheimer's disease (total n = 150). Disease severity was reported sparsely and heterogeneously (see supplementary spreadsheet).

Interventions and theory of intervention effects

Figure 2 shows a theoretical model of effects and outcomes of interventions included in this review. The model represents an as-usual pathway to exiting or becoming lost, with included interventions being linked to the section of the pathway in which they intervene. The effects

of these interventions are also represented, discerned through stated and interpreted intervention actions from reading individual studies. This was used to form four superordinate groups of interventions for this review:

- Most included studies investigated interventions for **preventing exits** from supervised locations. This is illustrated in figure 2 with all interventions with rightward arrows towards the outcome 'prevent exit'. This is the most preventative type of strategy to stopping people with dementia from becoming lost or coming to harm.
- Another superordinate grouping was for interventions with rightward arrows towards the terminal outcome '**retrieval**; reduce negative consequences' in figure 2. These are distinct aims from preventing exits, as they assume that the person with dementia is already outside supervised or safe premises.
- **Educational** interventions may vary considerably but tend to target several types of strategies for the carer to employ. Therefore, they are represented in figure 2 as affecting other interventions and intervention effects.
- The final grouping of interventions was for those that used a combination of approaches for a combination of effects, referred to in this review as **multicomponent and multi-aim** interventions (not represented in figure 2)

These four superordinate groups were further subdivided by type of intervention, represented in figure 2 as individual interventions within boxes. These groupings and categorisations were used to order studies in Table 2 and the results and synthesis of intervention effects.

Outcome measures

Primary. Twenty-four studies (92%) included measures consistent with eligibility for primary outcome measures for this review: measures of exiting, eloping or getting lost. Substantial diversity in reported outcome measurements was found.

The most commonly reported type of metric was an absolute measure (e.g. total, mean, frequency) of exits, exit attempts or door approaches (n = 11). For other exit prevention interventions, authors reported proportional metrics of exit attempts (Hewawasam, 1996; Mayer & Darby, 1991), duration of exit-seeking behaviour (Cohen-Mansfield & Werner, 1998), exits plus injuries (Rowe et al., 2009), or the Eloping Behavior subscale of the Algase Wandering Scale (Shalek et al., 1999; Traynor et al., 2018).

Two studies measured an outcome directly related to getting lost: Lau et al. (2018) measured missing incidents per year and average searching time before and after their intervention. Levy-Storms et al. (2017) included a likert-style self-report scale of frequency of getting lost.

Secondary. Two studies with interventions aiming to facilitate retrieval measured caregiver feelings and views only (Pot, Willemse & Horjus, 2012; Bantry White et al., 2010).

Settings

Fifteen studies were undertaken exclusively in institutional settings, twelve of which were set in one specific nursing home, care unit or other inpatient facility. Two studies were across two different care units (Traynor et al., 2018; Cohen-Mansfield & Werner, 1998); one was across 21 different nursing homes (Cohen-Mansfield et al., 1997).

Seven studies were undertaken in domestic or community settings; two studies (Roberts, 1999; Bass et al., 2007) were across a mixture of settings. Generally, interventions designed to

facilitate retrieval were in community settings, as were multi-aim and multicomponent interventions.

All studies with interventions designed to prevent exiting (*n* = 18) were in institutional settings except for two in community settings (Moore & Daley, 2014; Rowe et al., 2009).

Publication status

Twenty-three studies were published in peer-reviewed journals; two studies (Horvath et al., 2007; Bass et al., 2007) were published in the same book. Grey literature included one unpublished Masters dissertation (Hamilton, 1993) and one online registered trial report (Moore & Daley, 2014).

Appraisal of included studies

A summary table of critical appraisal results by study can be found in Table 3. Reasons for risk of bias judgements and individual reporting quality scores can be found in the supplementary spreadsheet.

Internal validity (risk of bias)

Seventeen studies (68%) were judged to have an overall critical risk of bias, eight (32%) a serious risk of bias, and one (4%) did not have enough information to inform a risk of bias judgement (Figure 3a; percentages total over 100% because one study had different risk of bias across intervention effects [Namazi, Rosner & Calkins, 1989]). No studies had an overall rating of moderate or low risk of bias.

Thirteen studies had a critical risk of confounding due to an uncontrolled design. Twenty-two studies had designs that accounted for internal selection bias (UBA, RCT, WS). All study designs with independent or within-subject control conditions (n = 12) had a serious or

critical risk of bias due to deviation from intended interventions. This was mainly due to the absence of blinding of participants and staff to intervention status without mitigation against risk of imbalanced co-interventions, as well as risks of carryover effects for within-subject designs. Additionally, there was no blinding of outcome assessors to intervention status across studies. This affected risk of bias differently depending on details of the outcome measurements. No studies had an available preregistered analysis and could not be rated low risk for selection of reported results (Higgins et al., 2016; Sterne et al., 2016).

External validity

Nineteen (76%) studies were rated high for risk of external selection bias, mainly due to small samples in singular institutional settings. Five (20%) studies were rated moderate for risk of external selection bias. All five of these were deemed to have representative settings, facilities and staff, but a lack of clarity on the representativeness of included participants. One study was rated potentially low for external selection bias due to explicit comments on the representativeness of the sample for the area based on demographic characteristics (Horvath et al., 2007). However, this study had an overall critical risk of bias for internal validity, limiting its external validity.

Reporting quality

Reporting quality across items is represented in Figure 3d. The item most commonly marked down on was clarity of distribution of principal confounders. Reporting sufficiency of other items varied. Full details can be found in the supplementary spreadsheet.

Results and synthesis of intervention effects

Studies with an overall critical risk of bias were not included in any analysis to avoid overemphasising results that provide no useful evidence. For the remaining studies (*n* = 8), a statistical meta-analysis was avoided for the following reasons:

- The risk of bias in included studies was too high (all serious);
- The reported study outcome measures were too diverse;
- Interventions were too diverse.

Results of eligible studies were narratively synthesised, examining intervention effects and relevant features within and across studies where possible and appropriate.

Results and syntheses are categorised by intervention type, informed by the theoretical model of intervention action (Figure 2). Graphical representations of effects across studies or outcomes were not attempted to avoid providing misleading results.

Interventions aiming to prevent exiting

Visual barriers for preventing exiting

Ten studies tested the effectiveness of interventions that modified the environment to disguise the exit door or deter people with dementia from interacting with it. These barriers were purely visual; they made no physical barrier to opening the door.

Grid patterns. The most common intervention overall was the use of grid patterns on or near the exit door. Four of the six studies (Hamilton, 1993; Hussian & Brown, 1987; Namazi, Rosner & Calkins, 1989; Roberts, 1999) were judged as having overall critical risks of bias and therefore provided no useful evidence for effectiveness. The results of the two remaining

studies were inconsistent, with one study finding no intervention effect (Chafetz, 1990), and the other a large effect (Hewawasam, 1996; reviewers' analysis, see supplementary spreadsheet). Although Hewawasam's (1996) study reduced risk of confounding through a stronger study design than Chafetz (1990), both reports had serious risks of bias in multiple domains (Table 3). Therefore, one result cannot clearly take precedence over the other and the effectiveness of grid patterns on exit-seeking behaviour is inconclusive.

Covering the exit door. Five studies examining the effect of covering the entire exit door or features of it had critical risks of bias (Dickinson et al., 1995, 1998; Kincaid & Peacock, 2003; Namazi et al., 1989; Roberts, 1999), with one providing unclear results (Moore & Daley, 2014). Results from one study (Namazi et al., 1989) suggest covering the exit doorknob may reduce exiting compared to no-intervention baseline conditions. However, no statistical analysis was attempted, and no measures of spread were provided for reviewers to perform calculations themselves. Therefore, this study does not provide sufficient evidence for the effectiveness of this strategy.

Mirror on the exit door. The effectiveness of a mirror on the exit door for reducing exiting is unclear due to problematic studies: One study reported a reduction in percentage of exit-door approaches resulting in door contacts but did not provide a base rate of absolute exit-door approaches, obscuring results necessary to determine effectiveness (Mayer & Darby, 1991. One other study reported using a mirror on the exit door but had a critical risk of bias and very brief reporting of results (Roberts, 1999).

Indoor alarms and tracking systems for preventing exiting

Three papers reported using alarm and tracking/tagging systems to alert caregivers to exit attempts by people with dementia. Two of these were too problematic in both internal

validity and reporting quality to provide any useful evidence (Connell & Sanford, 1998; Altus et al., 2000). Rowe and colleagues (2009) reported an unblinded, randomised, controlled trial of the effect of a home security system and bed occupancy sensor on the likelihood of unattended exits and home injuries ('adverse events'). In their primary analyses, they found no significant intervention effect, although the study had serious risks of bias in all domains of the RoB 2 tool. They did find an intervention effect when analysing based on intervention fidelity, but this is open to additional bias caused by per-protocol analysis (Ranganathan, Pramesh & Aggarwal, 2016). Effectiveness of this intervention is therefore inconclusive.

Distracting or occupying the person with dementia to prevent exiting

Five studies evaluated interventions to prevent exiting through occupying or distracting people with dementia. Two studies (Connell & Sanford, 1998; Traynor et al., 2018) had an overall critical risk of bias. The interventions in the remaining three studies were substantially different from each other and therefore their effects were not synthesised.

Corridor scenes. Cohen-Mansfield and Werner (1998) examined the effect of two corridor 'scenes' on the duration of a number of behaviours including exit-seeking. They found no significant difference in exit-seeking duration between conditions, but there was a serious risk of bias in multiple domains mainly due to possible contamination effects between the two corridors and risk of selective reporting of results.

Service dog. Results from Sherman (1999) suggest the effectiveness of a trained service dog for reducing exit attempts in an Alzheimer's special care unit, despite risks of bias in measurement of outcomes and reporting of results.

Air mat therapy. Shalek, Richeson and Buettner (2004) reported a significant reduction in the Eloping Behavior subscale of the Algase Wandering Scale before versus after the intervention for the intervention group in an unblinded RCT. However, no comparison was made between intervention and control groups' scores and so the effectiveness of the intervention cannot be determined.

Multicomponent strategies to prevent exiting

One study tested the effect of introducing multiple changes (camouflaged exit doors, a new wandering path, private bedrooms, and an outdoor patio) on exiting ~~a combination of strategies to prevent exiting~~ (Mazzei, Gillan & Cloutier, 2014), rated as having an overall critical risk of bias.

Interventions aiming to facilitate retrieval

Although preventing exits is a strategy for preventing people with dementia from becoming lost (see Figure 2), some interventions aim to facilitate safety and rapid location once a person with dementia has become lost. Two studies reported on carers' views following use of GPS devices for people with dementia (Bantry-White et al., 2010; Pot et al., 2012). Both studies had overall critical risks of bias. No evidence of the effectiveness of GPS devices on any primary or secondary outcomes can therefore be concluded.

Educational interventions

Both studies examining exclusively educational interventions (Cohen-Mansfield et al., 1997; Levy-Storms et al., 2017) had overall critical risks of bias.

Multi-aim and multicomponent interventions

Three studies were categorised as multi-aim studies, meaning they used a combination of exit prevention, retrieval facilitation, or education (Chen & Leung, 2012; Horvarth et al., 2007; Lau et al., 2018). For example, Lau and colleagues (2018) investigated an individualised programme involving, among other features, education, environmental modification for preventing exits, and GPS devices for facilitating retrieval. All three studies in this category ~~of these~~ were rated as having overall critical risks of bias.

DISCUSSION

Summary of evidence

Overall, there is insufficient evidence to determine the effectiveness of any interventions for preventing people with dementia exiting or getting lost. Grading systems for overall level of evidence were deemed unnecessary as risk of bias was so high. Although we assessed external selection bias, its relevance to our conclusions is slight as internal validity was so low.

For preventing exits, most studies had too high risk of bias to contribute to evidence synthesis. Only two studies investigating grid patterns were not at critical risk of bias. These studies had inconsistent results, possibly due to imbalanced co-interventions and selective reporting. Results from individual studies suggest potential support for a mirror on the door, a trained service dog, and covering features of the door for preventing exiting from institutional settings. However, due to the overall serious risks of internal bias and low external validity results should be considered preliminary and not robust evidence for effectiveness.

No studies met minimum risk of bias requirements (i.e. not at critical risk of bias) for providing useful evidence for the effectiveness of interventions for facilitating the retrieval of people with dementia who had become lost, or preventing the negative consequences of these events (e.g. GPS tracking).

Assumptions and robustness of synthesis

This is the first systematic review to focus specifically on interventions for preventing people with dementia from exiting or becoming lost. Study designs, risks of bias and reporting shortcomings mean that all outcomes were found to be highly problematic. However, some key assumptions that led to this conclusion are important to discuss.

Firstly, the synthesis was partially based on groupings and categories determined by our theoretical model of intervention effects. This model represented the pathway to exiting or getting lost, and the effects of interventions for preventing these. For example, the first step along the pathway was a 'desire to explore or exit', with relevant interventions reducing this desire and ultimately preventing exit attempts. This understanding may, in fact, be imprecise or simplistic. However, for this review, the model is not meant to thoroughly represent all antecedent and consequent factors in getting lost (see Rowe et al., 2015 for a more comprehensive discussion on this), or all steps in logic models of included interventions. Rather, we aimed to summarise and highlight different routes to preventing exits and getting lost from included interventions. Although the model was used to structure the narrative synthesis, threats to internal validity were so great that different assumptions would not have yielded different conclusions. Nevertheless, the model may provide a useful basis for future work aiming to develop new interventions.

As mentioned, the main factor preventing evidence synthesis in this review was risk of bias of individual studies. We included weaker study designs and assessed them against high quality trials to highlight the problems with existing literature for concluding intervention effectiveness. However, it is possible that our bespoke assessment of risk of bias for these studies led to conservative conclusions. Indeed, other systematic reviews (Fleming & Purandare, 2010; Hodgkinson et al., 2007; Jensen & Padilla, 2017; Letts et al., 2007; Padilla et al., 2007) have concluded moderate evidence for the effectiveness of environmental modification strategies on reducing exiting based on several of the same included studies as this review. However, these reviews included the results of other systematic reviews (i.e., each other) as the highest 'levels of evidence', often without methodological appraisal of primary research. This runs the risk of compounding and propagating biased findings. Indeed, when methodological appraisal was undertaken (Fleming & Purandare, 2010) authors used a checklist by Forbes (1998) that may have been interpreted as giving a 'moderate' rating for uncontrolled before-after studies. In contrast, we assumed that studies without a control group or comparator condition were at critical risk of bias due to confounding. It is well-established that an uncontrolled study cannot isolate the effect of the intervention under investigation (Armstrong et al., 2011).

We also assumed that potential carryover effects and intervention order effects may have existed for within-subject investigations. These effects may seem intuitively unlikely for environmental modification interventions for people with memory impairments, but their absence cannot be assumed without further evidence. Moreover, no studies suffered from risk of carryover or intervention-order effects alone—all controlled studies had at least serious risk of bias in two or more domains.

Conclusions and future directions

This review highlights a mismatch between the scale of the issue of getting lost and the evidence for strategies to mitigate against it. Indeed, most included studies are small-scale or preliminary and not appropriate for estimating intervention effectiveness. Therefore, high quality RCTs, NRCTs and crossover trials are urgently needed for further investigation of any intervention for people with dementia exiting, eloping or getting lost.

For institutional interventions that affect an entire inpatient unit (e.g., environmental modification, service dog), cluster randomized or crossover trials may be most appropriate. However, the practical and resource-related barriers to multi-site studies may be off-putting for many potential investigators working at specific clinical sites. For research looking to maximise internal validity without the need for generalizability (e.g. looking to reduce exiting on a specific ward), the use of within-subject designs with repeated reversal and reintroduction of interventions would reduce many common risks of confounding. However, investigators must also consider mitigation of carryover effects and bias due to unblinded outcome measurement. An additional strategy might be the use of an interrupted time series analysis to account for trends over time due to, for example, changes in disease progression (Sterne et al., 2016).

Despite several papers on the use of global positioning systems (GPS) for people with dementia who may become lost (see Pulido Herrera, 2017 for a review), only two studies with critical risks of bias came near to quantifying any intervention effects, neither of which examined an eligible primary outcome measure for this review. Therefore, perhaps surprisingly, there is no evidence for the effectiveness of GPS tracking devices for helping with retrieval of a lost person with dementia. Although the use and utility of GPS technology

is so widespread (Pulido Herrera, 2017), its effectiveness for supporting people with dementia cannot be assumed: Devices often rely on a minimum level of technological aptitude that people with dementia or their carers may not have. This has implications for ethical considerations surrounding the use of tracking technology: Evidence of the effectiveness of tracking devices is necessary to counterbalance concerns of stigma and breaching privacy (McShane et al., 1998; Nicolle, 1998; Hughes & Louw, 2002). Observational studies may be a good starting point for building evidence of the effectiveness of GPS as many dyads already use them (Pulido Herrera, 2017). For experimental studies, ensuring intervention fidelity and usability is imperative before starting expensive RCTs.

One key strategy not included in this review is that of retrieval and missing incident initiatives or programmes. For example, in the US, the Alzheimer's Association's Safe Return® program (https://alz.org/help-support/caregiving/safety/medicalert-safe-return) facilitates the engagement of law enforcement and community services to help speed the retrieval of people with dementia. One report stated that the program had facilitated the recovery of 11,200 people at the time of writing (2007), with a 99% success in safely returning those enrolled (Bass, Rowe & Moreno, 2007). In addition, the US has Project Lifesaver (https://projectlifesaver.org/) and Silver Alerts for missing persons with dementia. Other countries have similar programmes, such as Dementia Australia's version of Safe Return (https://www.dementia.org.au/resources/safe-return) and the currently-trialled Purple Alert mobile application from Alzheimer Scotland (http://purplealert.org.uk/). Although studies of the effectiveness of these programmes could not be found for inclusion in this review, they may play a crucial role in efforts to reduce the impact of people with dementia getting lost in the community. Detailed and systematic evaluations of these initiatives could reveal promising avenues for their implementation elsewhere.

Further implications

The absence of evidence for the effectiveness of interventions in this review implies an inability of practitioners and policy-makers to form evidence-based decisions or guidelines regarding strategies for preventing people with dementia becoming lost or exiting. Hesitancy in recommending strategies or technologies to individuals, dyads or institutions should be taken, particularly when large financial costs may be incurred. With the increasing prevalence of dementia, the issue and negative consequences of people with dementia getting lost will only continue to grow without effective mitigation. We hope this consideration will galvanise practitioners and researchers into thorough investigations of promising interventions to help safeguard people with dementia against becoming lost.

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Captions for Tables and Figures

Table 1. Search strategies

Table 2. Summary characteristics of included studies

Table 3. Summary of critical appraisal ratings.

Figure 1. PRISMA flow diagram of inclusions and exclusions.

Figure 2. Model of intervention effects and actions. Green boxes represent ultimate aims of interventions. Orange boxes represent interventions. Orange arrows represent general or varying effects of educational interventions.

Figure 3. Summary charts from critical appraisal. (A) total risk of bias ratings per domain and overall. (B) overall risk of bias by study design: (C) external validity by individual question score and overall risk of bias. (D) reporting quality total points per question: N=0, Y=1 except for the confounders question where partially = 1, Y = 2.

Table 1. Search strategies.

Databases/ Source(s)	Search terms/ details
EMBASE, BNI, Medline, PubMed, CINAHL, PsycINFO, AMED, HTA	dement* OR alzheimer* OR frontotemporal OR lewy OR corticobasal OR "primary progressive aphasia" OR "posterior cortical atrophy" AND tag* OR track* OR alarm* OR device* OR technolog* OR electronic OR GPS OR restrain* OR lock* OR barrier* OR snoezelen OR aromatherapy OR music OR therap* OR manag* OR prevent* OR interven* OR treat* OR independence OR RFID OR radiofrequency OR "radio frequency" OR environment* AND wander* OR walk* OR exit* OR elop* OR orientation OR disorientation OR navigat* OR lost OR wayfind* OR ambulat* OR "unexplained absence" OR abscond*
CENTRAL, OpenGrey (SIGLE)	Same as above but with the following in place of their respective truncations: Dementia; alzheimer; tag; track; alarm; device; technology; restrain; lock; barrier; therapy; manage; prevent; intervention; treat; environment; wander; walk; exit; elopement; navigation; wayfinding; ambulation; abscond.
Bibliographies from included studies (*n* =26)	See Table 2 for list and details of included studies.
Bibliographies from reviews and secondary sources (*n* = 20)	See Table S3 for list of reviews and sources.

* indicates truncated searched term.

Table 2. Summary characteristics of included studies

Study (ctry)	Funding	Group	Type of int.	Setting	Ppts.[d] (F)	Diagnoses	Design	Summary of intervention	Control condition	Outcome measure	Time-frame	Dropouts	Results	Int. RoB	Ext. RoB	Rep. qlty
Chafetz, 1990. (USA)	U. of Texas SW	Prevent exits	Visual barriers (grid)	Inst.	1 care unit w/ 30 (28)	65% AD, 13% MID, 22% MxD	WS: ABA	B: grid tape parallel to door C: grid plus reduced medication	No-grid baselines (A)	Freq. of door buzzes and staff stops	A1: 3 wks B: 1 wk C: 1 wk A2: 2 wks.	0	Sig. diff. between conditions but no intervention effect.	Ser.	High	6
Hewawasam, 1996 (UK)	BSc dissertation	Prevent exits	Visual barriers (grid)	Inst.	1 care unit w/ 10 (7)	4 AD, 1 PD, 5 OTD	WS-R: ABACA	B: horizontal grid patterns in front of exit door. C: vertical grid patterns.	No-grid baselines (A)	Mean door contacts per condition	A1: 3wks; all else 1 wk each. 7 wks total	0	Sig. reduction for grid conditions vs none, d = 1.21, p = .004; [e]	Ser.	High	5
Mayer & Darby, 1991 (UK)	NI	Prevent exits	Visual barriers (other)	Inst.	1 ward w/ 9 (8)	6 AD, 3 MID	WS-R: ABC daily alt.	B: full-length mirror on door C: reversed mirror on exit door	No-grid baselines (A)	% door approach resulting in contact	Two weeks, ints. cycled daily	0	No mirror: 76.2%, reversed mirror: 51%, mirror: 35.7%	Ser.	High	5
Cohen-Mansfield & Werner, 1998 (USA)	National Inst. on Aging	Prevent exits	Occupy / distract	Inst.	2 units w/ 27 (21) 19 vs 8.	56% AD; 24% OTD; 16% VD; 4% MxD.	WS: ABCA / ABAC	2 different 'scenes' in 2 different corridors of same unit.	No-scene baseline conditions.	Duration of exit-seeking behaviour	Four 2-wk phases per corridor.	0	No difference between conditions.	Ser.	High	6
Sherman, 1999 (USA)	NI	Prevent exits	Occupy / distract	Inst.	1 63-bed unit	NI	WS-R: ABBAB	Trained service dog guided residents away from doors, distracted residents.	WS; A1: pre-dog baseline, A2: dog at vet.	Exit attempts	A1: 2wks; B1: 4 wks; B2: 2wks 6 mths later; A2: 4 wks; B3: 4 wks.	0	Sig. reduction from A1 (120) to B1 (5), p < 0.01; Sig. reduction between A2 (28) and B3 (2), p < 0.05.	Ser.	High	4
Shalek et al., 2004 (USA)	American Therapeutic Recreation Fdtn.	Prevent exits	Occupy / distract	Inst.	1 nurs. home w/ 20 (15)	9 AD; 8 UnD; 2 VD; 1 EOD.	URCT	10x10 ft air mat therapy, 3-4 ppts at one time.	Regular recreation program	'Eloping behavior' subscale of Algase Wandering Scale.	Intervention: 60 min, 5 days per wk, 2 wks.	1 (int. arm)	Int. arm sig. diff. before and after, $t(8)$=2.27, p=.05; Ctrl arm 'no sig. diff.'	Ser. [a]	High	5
Rowe et al., 2009 (USA)	Nat. Inst. For Nurs. Research, Night Alert System	Prevent exits	Alarm / tagging	Com.	53 PwD-carer dyads	All AD or OTD	URCT	Home security system + bed occupancy sensor: info. to carer on location of PwD.	No intervention	No. adverse events (exits + injuries)	Follow-up at months 2, 3, 4, 5, 6, 8, 10 and 12	20	No sig. intervention effect in survival analysis	Ser. [a]	Mod.	6

Namazi, Rosner & Calkins, 1989 (USA)	The Cleveland Fdtn.	Prevent exits	Visual barriers (grid + other)	Inst.	1 care unit w/ 9 (5)	AD	WS: ABCD EAFG H	Grid patterns (B-D), doorknob covered (E, F), doorknob painted (G, H)	No-grid baselines (A)	Total exits per condition	NI	0	No statistical testing; cloth concealment had no exits; others unclear	Ser./ Crit.	High	5
Hussian & Brown, 1987 (USA)	NI	Prevent exits	Visual barriers (grid)	Inst.	1 ward w/ 8 (0)	PDD	WS: ABCD EA	Horizontal & vertical grid patterns on floor in front of door.	No-grid baselines (A)	Count when grid pattern crossed	Overall 2 months, NI on each condition	0	Potentially small drop, no statistical analysis.	Crit.	High	5
Hamilton, 1993 [c] (USA)	Inst. of Business Designers Fdtn, Lackawanna Leather Co.	Prevent exits	Visual barriers (grid)	Inst.	1 care unit w/ 12 (6)	4 AD, 2 SenD 1 MID 1 SDAT 1 PD 1 OBS	UBA: ABC	B: grid w/ black floor tape; C: grid w/ red floor tape.	None	Total exit attempts per condition	4 wks total: 1 wk per condition w/ 1 wk break between B and C	1	No significant difference between conditions.	Crit.	High	4
Dickinson et al., 1995; 1998 (USA)	NI	Prevent exits	Visual barriers (other)	Inst.	1 care unit w/ 7 (2)	5 AD or OTD; 1 no diagnosis; 1 PD.	UBA: ABCD	B: closed mini-blind covering door window; C: cloth barrier over panic bar. D: B+C.	None	Total exit attempts per condition	7 wks total: 1 wk per condition, 1 wk between.	0	B 'marginally sig.'; C sig. (W = 15.5, p < .001); D sig. (W = 11, p < .01). [b]	Crit.	High	5
Kincaid & Peacock, 2003 (USA)	U. of N. Carolina	Prevent exits	Visual barriers (other)	Inst.	1 care unit w/ 12 (10)	'dementia'	UBA: AB	A: no mural; B: wall mural painted over exit doorway	None	Mean door-testing behaviours	6 wk for pre- and post-intervention	0	Reduction d =0.82, p = 0.024.	Crit.	High	5
Roberts, 1999 (UK)	Fdtn. of Nurs. Studies	Prevent exits	Visual barriers (grid + other) + structured day	Com. / Inst.	20 (NI)	NI	UBA: ABCD	Mirrors; camouflage; floor grid patterns; structured day.	None	Subjective statements on change in exiting	Over 12 months	NI	Statements of success for all interventions.	Crit.	High	2
Traynor, et al., 2018 (AUS)	U. of Wollongong and Warrigal	Prevent exits	Occupy / distract	Inst.	4 care homes w/ 72	'dementia'	UBA: AB	Tailored, structured physical activity programme 3 x pw for 30 min over 16 wks.	None	'Eloping behavior' subscale of Algase Wandering Scale.	16 wks.	1	Sig. reduction post-intervention, t = -3.16, p = 0.002.	Crit.	Mod.	5

Altus et al., 2000 (USA)	National Inst. On Ageing	Prevent exits	Alarm / tagging	Inst.	1 unit w/ 4 (2)	NI	UBA: AB	'Mobile Locator': user wears transmitter. Caregiver with receiver.	None	Mean no. exit attempts per ppt.	19 wk baseline, 15 wk post-intervention	0	0.5 exit attempts per wk at baseline, 0 after intervention. Intervention not used.	Crit.	High	3
Connell & Sanford, 1998 (USA)	Dpt. of Veteran Affairs	Prevent exits	Alarm / tagging	Inst.	1 unit w/ 3 (NI)	NI	UBA: ABC	A: loud and aversive alarm; B: less aversive, verbal alarm C: access to outdoor space.	None	Freq. of actual and attempted exits + staff response times	NI	0	Reduction from A to B for 2 ppts. No decline between A and C.	Crit.	High	4
Mazzei, Gillan & Cloutier, 2014 (CAN)	None	Prevent exits	Multicomponent	Inst.	1 ward w/ 6 (2)	1 MxD; 4 MxD + BPSD; 1 FTD;	UBA	Camouflage murals on exits; circular wandering path; private bedrooms; outdoor patio.	None	No. door-testing behaviours per ppt.	3 months pre-int., 3 months post-int.	0	Reduction: mean diff. pre-post (95% CI) = 13.33 (-6.07, 32.74). [e]	Crit.	High	5
Bantry White et al., 2010 (IRL/UK)	NI	Facilitate retrieval	GPS	Com.	10 family carers of PwD	Dementia unspecified	UAO	GPS tracking device.	None	Questionnaire results of carer opinions.	NI	0	9/10 peace of mind from int.; 3/10 gave independence; 2/10 added to things to do; 1/10 it reassured PwD.	Crit.	High	5
Pot et al., 2012	NI	Facilitate retrieval	GPS	Com.	33 PwD-carer dyads	For PwD: 57% AD, 43% OTD	UBA	Tracking device combining GPS and General Packet Radio Service, worn on belt.	None	Feelings of role-overload (SPPIC) and worry (NTAWS)	Three months of use, meas. before and after.	5	Reduction in role-overload, d = -0.25, p = 0.13; Reduction in worry, d = -0.32, p = 0.08.	Crit.	High	6
Cohen-Mansfield et al., 1997 (USA)	National Inst. on Aging	Educate	Educational	Inst.	21 nursing homes w/ 174 staff.	NI	UBA: ABB	Education on dementia basics, problem behaviours; types of wandering; management strategies.	None	Counts of exit-seeking behaviours	Assess. A: 1 wk pre-int., B1: 1 wk post-int., B2: 4-wks post-int.	71	Not sig., no more info.	Crit.	Mod.	3

Levy-Storms et al., 2017 (CAN/ USA)	The Doctor's Company	Educate	Educational	Com.	60 (NI) PwD-carer dyads	AD	NRCT	One 2hr educational counselling session, with optional follow-up session.	Ad hoc control group of withdrawals.	Likert-type scale of freq. of getting lost.	1 month after final session.	13	Reduction for caregivers completing 1 or 2 sessions vs controls, mean diff.=0.72, p<0.05	Crit.	High	3
Horvath et al., 2007 (USA)	NI	Multi-aim	Multi-component	Com.	62 PwD-carer dyads	All AD	UAO / qual.	Home safety assessment, consultation, and recommendations.	None	Caregiver statements	6-month follow-up	10	60/62 dyads stated the assessment and information were very helpful.	Crit.	Low	3
Chen & Leung, 2012 [c] (TWN)	Ntnl. Science Counsel, Tatung U.	Multi-aim	Various	Com.	37 (21) PwD; NI for carers	Dementia unspecified	CAO	Reported use of ID cards; ID bracelets; GPS;	No intervention	Self-repot no. times lost + lost distance.	NI	0	No diff. in times lost; Lost distance greater for no int. vs ints.; Lost distance greater for GPS vs ID card/bracelet.	Crit.	High	5
Lau, Chan & Szeto, 2018 (HKG)	NI	Multi-aim	Multi-component	Com.	54 (29) PwD	Dementia diagnosis w/ DSM-5	UBA: ABB	Individualised programme: education, devices, skill training, env. mod., referral to services, change routines.	None	Missing incidents pa; search time (hrs); Carer burden (ZBI-C)	3- and 12-month follow-ups	10	Reduction in missing incidents, searching time, and carer burden at 3 and 12 months ($p \leq .001$).	Crit.	High	5
Moore & Daley, 2014 [c] (USA)	Dpt. of Veteran Affairs	Prevent exits	Visual barriers (other)	Com.	19 (2)	'Alz-like diagnosis' from ICD-9	Unclear: crossover or WS.	B: floor cover; C: door cover.	Unclear	No. door approaches & pass-throughs.	14 days per condition.	0	Unclear	Unclear	Mod.	5

Note: Not all data items are reported; included columns were informed by AMSTAR (Shea et al., 2017). Full characteristics of included studies can be found in the supplementary spreadsheet.
a, These studies were assessed using the RoB 2 tool in conjunction with ROBiNS-I. **b,** authors used inappropriate test + sample size too low for critical values of appropriate test (Wilcoxon signed-rank). **c,** grey literature. **d,** this is for participants enrolled. N of participants included in analysis is this figure minus dropouts.**e,** reviewer analysis, see supplementary spreadsheet.
Key. **Designs**: WS, Within-Subjects study designs (A = baseline/no intervention condition; all other letters = intervention condition); WS-R, Within-Subject study with Reintroduction of intervention; NRCT, Non-Randomized Controlled Trial; UBA, Uncontrolled Before-After study; URCT, Unblinded Randomised Controlled Trial; CAO, Controlled After-Only study. **Diagnoses:** PwD, people with dementia; AD, Alzheimer's disease; MID, Multi-infarct dementia; MxD, Mixed dementia; PDD, primary degenerative dementia; PD, Parkinson's disease; OTD, 'other' types of dementia; SenD, 'senile dementia'; SDAT, 'senile dementia of the Alzheimer's type; VD, vascular dementia; EOD, early-onset dementia (unspecified); FTD, frontotemporal dementia; OBS, organic brain syndrome; UnD, unclassified dementia; BPSD, behavioural and psychological symptoms of dementia. **Risk of bias:** RoB, Risk of Bias; Ser., Serious risk of bias; Crit., critical risk of bias. **Countries:** IRL, Ireland; CAN, Canada; HKG, Hong Kong; TWN, Taiwan. **Measures:** NTAWS, Night Time Activity Worry Scale; SPPIC, Self-Perceived Pressure from Informal Care scale; ZBI-C, Zarit burden interview, Chinese edition; ICD, International Classification of Disease; DSM, Diagnostic and Statistical Manual of Mental Disorders. **Settings:** Inst., Institutional setting; Com., community setting. NI, No information.

Table 3. Summary of critical appraisal ratings of individual studies.

Included study	Risk of bias due to...								Representativeness of...				Reporting quality score
	Confounding	Selection of participants	Classification of interventions	Deviations from intended interventions	Missing data	Measurement of outcomes	Selection of reported results	Overall risk of internal bias	Asked participants	Prepared participants	Staff, facilities etc.	Overall risk of external bias	
Chafetz, 1990	S	L	L	S	L	M	M	S	N	N	N	H	6
Hewawasam, 1996	M	L	L	S	L	M	S	S	N	N	N	H	5
Mayer & Darby, 1991	M	L	L	S	L	M	S	S	N	N	N	H	5
Cohen-Mansfield & Werner, 1998	M	L	L	S	L	S	S	S	N	N	N	H	6
Sherman, 1999	M	L	L	S	L	S	S	S	N	N	N	H	4
Shalek et al., 1999	M	L	L	S	M	S	S	S	N	N	N	H	5
Rowe et al., 2009	S	L	L	S	S	S	S	S	U	U	Y	M	6
Namazi, Rosner & Calkins, 1989	S/C	L	L	S	L	M	S	S/C	N	N	N	H	5
Hussian & Brown, 1987	C	L	L	S	L	M	M	C	N	N	N	H	5
Hamilton, 1993	C	L	L	L	L	L	M	C	N	N	N	H	4
Dickinson et al., 1995; 1998	C	L	L	L	L	L	M	C	N	N	N	H	5
Kincaid & Peacock, 2003	C	L	L	L	L	L	M	C	N	N	N	H	5

Roberts, 1999	U	L	L	U	L	U	C	C	N	N	N	H	2
Traynor et al., 2018	C	L	L	L	L	L	M	C	Y	U	Y	M	5
Altus et al., 2000	C	L	L	L	L	L	U	C	N	N	N	H	3
Connell & Sanford, 1998	C	L	L	L	L	L	M	C	N	N	N	H	4
Mazzei et al., 2014	C	L	L	L	L	L	M	C	N	N	N	H	5
Bantry-White et al., 2010	C	U	L	L	L	L	C	C	N	N	Y	H	5
Pot et al., 2012	C	L	L	L	L	L	M	C	N	N	Y	H	6
Cohen-Mansfield et al., 1997	C	L	L	L	L	L	M	C	Y	U	Y	M	3
Levy-Storms et al., 2017	C	C	L	C	S	S	M	C	N	N	Y	H	3
Horvath et al., 2007	C	L	L	L	L	L	C	C	U	Y	Y	L	3
Chen & Leung, 2012	C	S	M	S	L	S	S	C	N	N	U	H	5
Lau et al., 2018	C	L	L	L	L	L	M	C	N	N	Y	M	5
Moore & Daley, 2014	U	L	L	U	L	U	S	U	U	U	Y	M	5

Key

C	Critical risk of internal bias	S	Serious risk of internal bias	L	Low risk of bias (internal or external)
H	High risk of external bias	M	Moderate risk of bias (internal or external)	Y	Yes (likely representative)
N	No (likely unrepresentative)	U	Unclear risk of bias or representativeness		

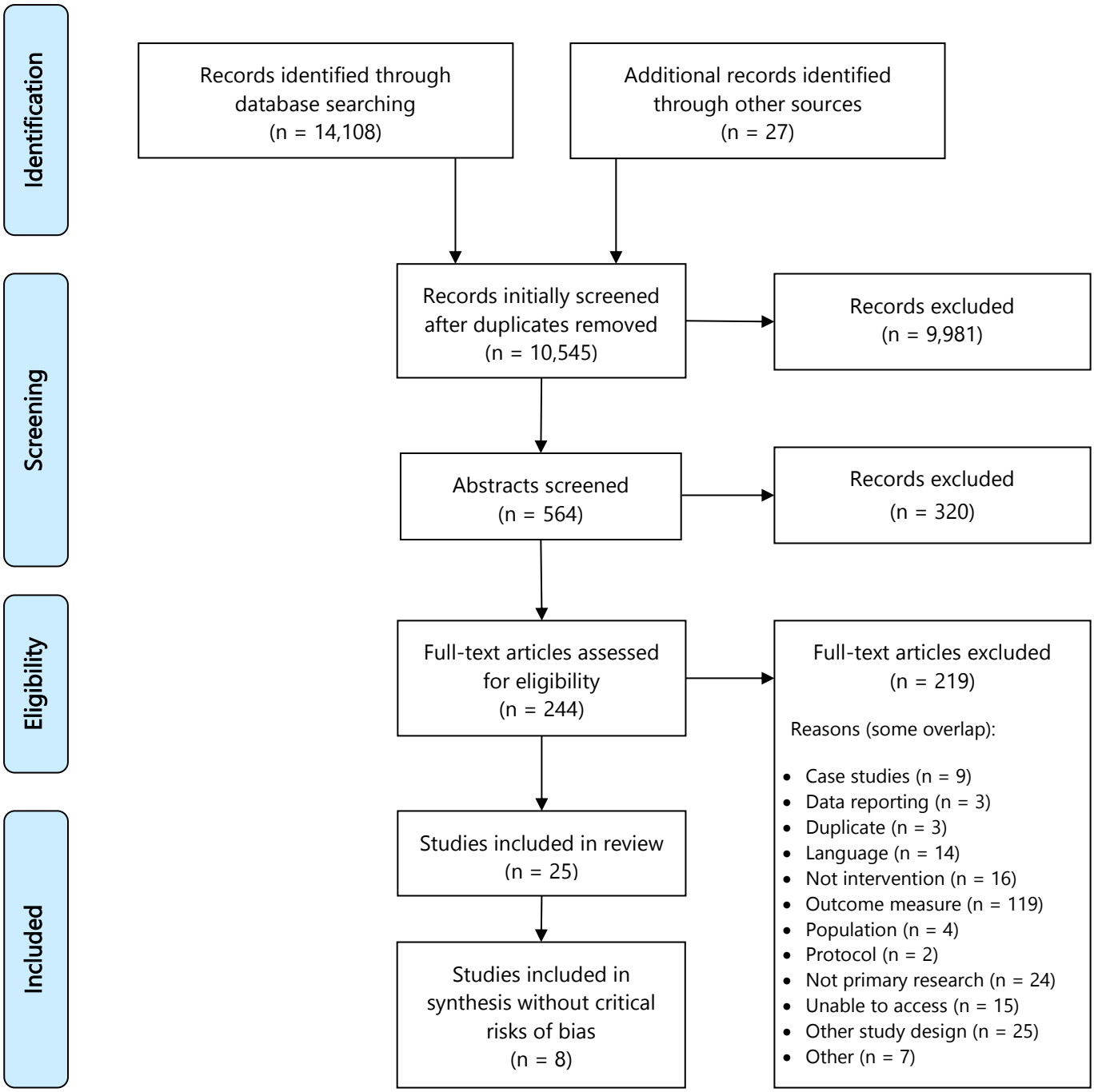


Figure 1. PRISMA flow diagram of inclusions and exclusions.

Figure 2. Model of intervention effects and actions. Green boxes represent ultimate aims of interventions. Orange boxes represent interventions. Orange arrows represent general or varying effects of educational interventions.

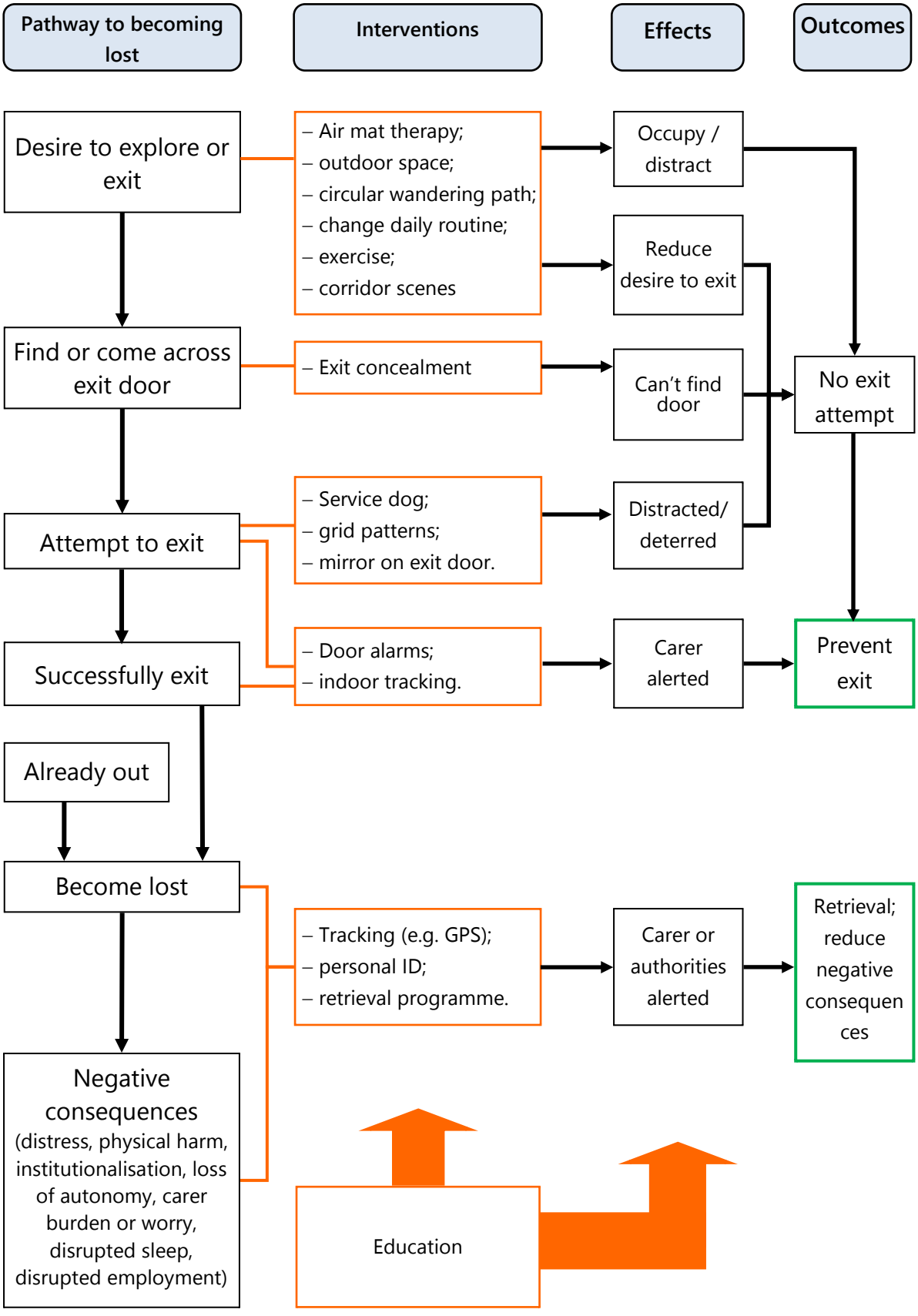
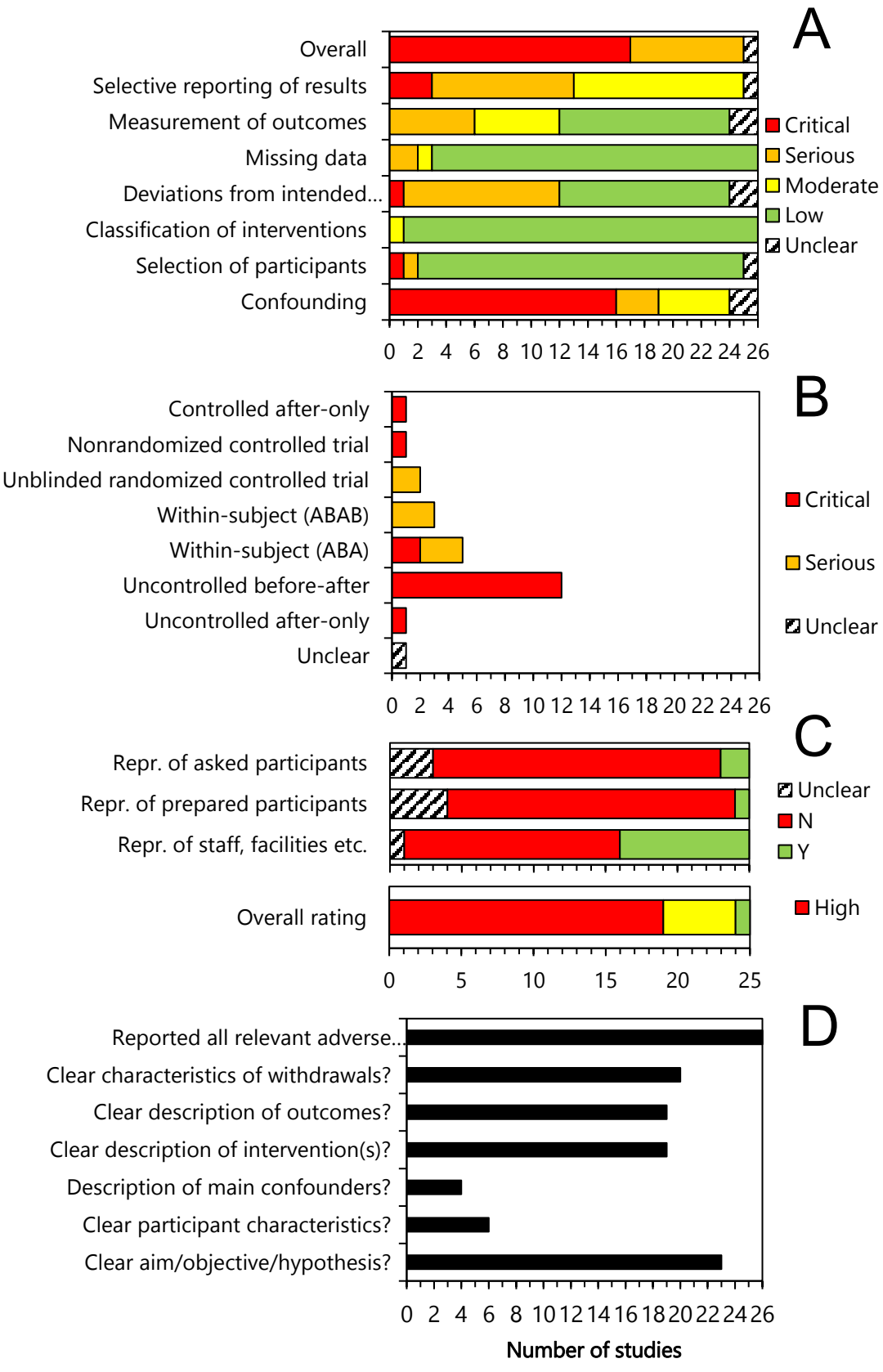


Figure 3. Summary charts from critical appraisal. (A) total risk of bias ratings per domain and overall. (B) overall risk of bias by study design: (C) external validity by individual question score and overall risk of bias. (D) reporting quality total points per question: N=0, Y=1 except for the confounders question where partially = 1, Y = 2.



Supplementary material

Table S1. Comparison of bias domains across tools and study designs.

ROBINS-I: non-randomised, controlled studies	RoB 2: randomised, controlled trials incl crossover trials	Uncontrolled before-after studies	Single group within-subject designs
Bias due to confounding	Bias from randomization process	Effect of non-intervention feature of the study or background factor	Period effects Effect of intervention ordering Reintroduction of intervention(s)
Bias in selection of participants	NA[a]	NA[a]	NA[a]
Bias in classification of interventions	NA[a]	NA[a]	NA[a]
Bias due to deviations from intended interventions	Bias due to deviations from intended interventions	NA[a]	Carryover effects Deviation from intended interventions
Bias due to missing outcome data	Bias due to missing outcome data	NA[a]	Bias due to missing outcome data between conditions.
Bias in measurement of the outcome	Bias in measurement of the outcome	NA[a]	Bias in measurement of outcome
Bias in selection of the reported results	Bias in selection of the reported results	Bias in selection of reported results	Bias in selection of reported results

a, domains of bias not applicable to the study design were automatically rated as low risk. This table was informed by the Cochrane Collaboration (Sterne et al., 2016; Higgins et al., 2016).

Table S2. PRISMA checklist.

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title page
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Abstract page
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	1-2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	2
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	2-3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3-4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4 & Table 1
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4 & Table 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4-5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5

Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5-8
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	NA
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	8
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	9-13 and Table 2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	13-14 and Table 3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	15-19
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	15-19
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			

Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	19
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	20-21
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	21-24
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Title page

Table S3. Citations for hand-searched bibliographies of reviews and secondary sources.

- Bossen, A. L., Kim, H., Steinhoff, A., Strieker, M., & Williams, K. (2015). Emerging roles for telemedicine and smart technologies in dementia care. *Smart Homecare Technology and TeleHealth*, *2015*(3), 49–57. https://doi.org/10.2147/shtt.s59500
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- Hermans, D., Htay, U.H., Cooley, S. J. (2007). Non-pharmacological interventions for wandering of people with dementia in the domestic setting. *Cochrane Database of Systematic Reviews*, *1,* Art. No.: CD005994. https://doi.org/10.1002/14651858.CD005994.pub2.
- Hurley, A. C., Gauthier, M. A., Horvath, K. J., Harvey, R., Smith, S. J., Trudeau, S., … Duffy, M. (2004). Promoting safer home environments for persons with Alzheimer's disease: The Home Safety/Injury Model. *Journal of Gerontological Nursing*, *30*(6), 43–51. https://doi.org/10.3928/0098-9134-20040601-09
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- Lucero, M. (2002). Intervention strategies for exit-seeking wandering behavior in dementia residents. *American Journal of Alzheimer's Disease & Other Dementiasr*, *17*(5), 277–280. https://doi.org/10.1177/153331750201700509

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- Mangini, L., & Wick, JeannetteY. (2017). Wandering: Unearthing New Tracking Devices. *The Consultant Pharmacist*, *32*(6), 324–331. https://doi.org/10.4140/tcp.n.2017.324
- Ng, Q. X., Ho, C. Y. X., Koh, S. S. H., Tan, W. C., & Chan, H. W. (2017). Doll therapy for dementia sufferers: A systematic review. *Complementary Therapies in Clinical Practice*, *26*, 42–46. https://doi.org/10.1016/j.ctcp.2016.11.007
- Peetoom, K. K. B., Lexis, M. A. S., Joore, M., Dirksen, C. D., & De Witte, L. P. (2014). Literature review on monitoring technologies and their outcomes in independently living elderly people. *Disability and Rehabilitation: Assistive Technology*, *10*(4), 271–294. https://doi.org/10.3109/17483107.2014.961179
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Supplementary spreadsheet (available for review as a separate document). Full data extraction spreadsheet, risk of bias assessments, full text exclusions and reviewers' analysis of two included studies. See README tab in the spreadsheet for more details.