Review Article

Increasing Fluid Intake and Reducing Dehydration Risk in Older People Living in Long-Term Care: A Systematic Review

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ABSTRACT

Objective: To assess the efficacy of interventions and environmental factors on increasing fluid intake or reducing dehydration risk in older people living in long-term care facilities.

Design: Systematic review of intervention and observational studies.

Data Sources: Thirteen electronic databases were searched from inception until September 2013 in all languages. References of included papers and reviews were checked.

Eligibility Criteria: Intervention and observational studies investigating modifiable factors to increase fluid intake and/or reduce dehydration risk in older people ($\geq$65 years) living in long-term care facilities who could drink orally.

Review Methods: Two reviewers independently screened, selected, abstracted data, and assessed risk of bias from included studies; narrative synthesis was performed.

Results: A total of 4328 titles and abstracts were identified, 325 full-text articles were obtained and 23 were included in the review. Nineteen intervention and 4 observational studies from 7 countries investigated factors at the resident, institutional, or policy level. Overall, the studies were at high risk of bias due to selection and attrition bias and lack of valid outcome measures of fluid intake and dehydration assessment.

Reported findings from 6 of the 9 intervention studies investigating the effect of multicomponent strategies on fluid intake or dehydration described a positive effect. Components included greater choice and availability of beverages, increased staff awareness, and increased staff assistance with drinking and toileting. Implementation of the US Resident Assessment Instrument reduced dehydration prevalence from 3% to 1%, $P = .01$. Two smaller studies reported positive effects: one on fluid intake in 9 men with Alzheimer disease using high-contrast red cups, the other involved supplementing 13 mildly dehydrated residents with oral hydration solution over 5 days to reduce dehydration. Modifications to the dining environment, advice to residents, presentation of beverages, and mode of delivery (straw vs beaker; prethickened drinks vs those thickened at the bedside) were inconclusive.

Two large observational studies with good internal validity investigated effects of ownership; in Canada, for-profit ownership was associated with increased hospital admissions for dehydration; no difference was seen in dehydration prevalence between US for-profit and not-for-profit homes, although chain facilities were associated with lower odds of dehydration. This US study did not suggest any effect of staffing levels on dehydration prevalence.

Conclusions: A wide range of interventions and exposures were identified, but the efficacy of many strategies remains unproven due to the high risk of bias present in many studies. Reducing dehydration

prevalence in long-term care facilities is likely to require multiple strategies involving policymakers, management, and care staff, but these require further investigation using more robust study methodologies.

The review protocol was registered with the International Prospective Register of Systematic Reviews (http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42012003100).

Water-loss dehydration, when fluid output exceeds fluid input, leads to raised serum osmolality, common in older people living in long-term care facilities,[1] as demonstrated in our own study where 85 (46%) participants had impending or current dehydration (serum osmolality $\geq$295 mmol/kg).[2] Residents of long-term care facilities (which include residential care, long-term nursing care, and dementia care units) are particularly vulnerable to developing dehydration because they are more likely to experience cognitive and physical problems affecting their abilities to remember and obtain beverages. Anxiety about incontinence and toileting assistance often lead to a conscious reduction in fluid intake. This is complicated further by the physiological effects of aging, diminishing the thirst sensation and reducing the body's capacity to maintain an effective water-balance.

As dehydration in the elderly is associated with poor health outcomes,[3] including increased risk of disability and mortality,[4] prevention may improve health, functional status, and quality of life. Although drinking adequate fluids is the most effective method of preventing dehydration, this becomes complex for older people with a range of physical, cognitive, sensory, and behavioral needs.

Many articles describe ways of encouraging older people to drink more, but few studies, and only 1 systematic review, have evaluated their effectiveness.[5] The 2003 systematic review included 2 small (n = 39, n = 16) randomized crossover trials assessing the effectiveness of interventions to increase fluid intake in older people. Without reporting the validity or findings of these studies, the review concluded that fluids should be offered more frequently to bedridden older adults, and additional help provided when people were uncooperative or refused to drink.[5] The purpose of the current systematic review was to assess the effectiveness of interventions and environmental factors to increase fluid intake or hydration status in older people living in long-term care.

Methods

As recommended by the Cochrane Collaboration,[6] our review team independently duplicated screening, eligibility, data extraction, and validity assessments. A third reviewer arbitrated when disagreements were not resolved by discussion. Where a reviewer was also a study author, she was not involved in study selection or data extraction. Results were reported following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[7]

Search Strategy and Study Selection

We included intervention and observational studies involving older people ($\geq$65 years) living in residential, long-term nursing care, or specialist dementia units (together called long-term care facilities), who could drink orally. Studies examined an association between the intervention, or modifiable exposure, and hydration status and/or fluid intake (primary outcomes). Secondary outcomes with a likely link to dehydration (such as constipation, falls, urinary and upper respiratory tract infections, or death) were noted where a primary outcome was described.

DB developed and performed complex systematic searches using text and indexing terms to search 13 databases from inception until September 30, 2013, with no language restrictions. The full Medline (Ovid SP) search strategy was published with the protocol on Prospero[8] and adapted for Embase, PsychInfo (both OvidSP), CINAHL (EBSCO Host), British Nursing Index, CRD and Prospero, Cochrane CENTRAL, ISCRTN, ICTRP (WHO), Open Thesis, ProQuest Theses and Dissertations, and Kings Fund databases. Further searches were undertaken of key authors (>3 relevant publications) and references of included papers and reviews were checked.

Titles and abstracts were screened and full-text papers obtained if either reviewer considered it potentially eligible; full-text papers were grouped into studies and assessed for inclusion. Corresponding authors were contacted when papers were published in languages other than English or there were insufficient data to assess suitability for inclusion or outcomes.

Data Extraction, Risk of Bias, Quality Assessment, and Data Synthesis

We extracted bibliographic details and information on country, funding source, ethical approval, participants, study design, details of the intervention, and control or exposure and outcomes. For dichotomous outcomes we extracted numbers of participants, events, and odds ratios (ORs) or relative risks (RRs). For continuous outcomes we extracted number of participants, means and SDs of change in, or final readings of, outcomes in each treatment arm. *P* values were checked using reported data and these values reported if different.

Internal validity, evaluating the effects of systematic error, was assessed using the Cochrane Risk of Bias tool for intervention studies.[6] Each item was judged high or low risk of bias or "unclear" when there was insufficient evidence to judge.

The Newcastle-Ottawa Scales (NOS)[9] for cross-sectional and cohort studies were adapted for this review. Criteria were specified by 2 authors (DB, LH) and included definitions for dehydration and fluid intake assessment, whether age, gender, and frailty were controlled for and adequacy of follow-up (Web Table 6). Both scales had 8 items assessing 3 criteria: selection of participants, comparability of groups, and ascertainment of exposures and outcomes. Each item contained between 2 and 4 categories; those associated with the lowest risk of bias were starred. A maximum of 9 stars was achievable.

For all study types, risk of bias associated with assessment of dehydration status and fluid intake ascertainment was assessed, particularly whether fluid intake was assessed over 24 hours (to evaluate the effectiveness of the intervention on total fluid intake) or whether a valid assessment of dehydration had been used.

Studies were grouped according to type of intervention or exposure in narrative synthesis. The planned random effects meta-analysis, combining study estimates for similar effects of interest, was not possible due to the heterogeneity of interventions and outcomes.

Results

Selection of Studies

Electronic searches identified 4958 titles and abstracts with an additional 226 from reference lists and searches of key author's publications, totaling 5184. After removing 856 duplicates, 4328 titles and abstracts were screened, and full-text papers obtained for 325. Of these, 292 were excluded, 10 were related publications of included studies, and 23 studies (19 intervention, 4 observational) were included in this review (Figure 1). Most studies were based in North America (14 United States,[10–23] 3 Canada[24–26])' 4 in Europe (2 UK,[27,28] 1 Ireland,[29] 1 Germany[30]), and 2 in Asia (Japan,[31] Taiwan[32]. Characteristics of included studies are described briefly in Tables 1 and 2; and in further detail in Web Tables 1 and 2).

Risk of Bias, Validity, and Methodological Quality

In intervention studies, random sequence generation was adequate in 4 studies,[16,19,20,27,33] unclear in 4,[15,21,26,29] and inadequate in the remainder (where participants were recruited using nonrandom methods under the direction of facility or research staff,[11,18,23,24,28,31,32] using screening tests[10,22] or resident lists[13,30]; Figure 2). None clearly demonstrated adequate allocation concealment, although 7 were judged "unclear"[15,19–21,26,29,33] (3 of these were low risk for random sequence generation[19,20,33]). Blinding of

participants and those providing interventions, did not occur in any study. Only 4 studies[16,19,20,28] demonstrated low risk of attrition bias (reporting reasons for withdrawal, description of those withdrawing, and whether analysis was intention to treat), whereas 7 were unclear,[13,18,21,26,29,30,32] and the remaining 8 studies were judged high risk of bias.[10,11,15,22–24,31,33]

In the 4 observational studies, the composite NOS scores ranged from 4 to 9, and the 2 larger studies[12,25] both scored 8, indicating lower risk of bias. (Table 3) The 2 smaller studies[14,17] had higher risk of bias due to doubt about the representativeness of participants (neither fully described nonresponse) and ascertainment of exposures was unclear.

The method of assessing fluid intake or hydration status was judged low risk of bias in 4 studies,[14,20,22,25] high risk in 16,[10–13,15–19,21,23,24,26,28,32,33] and unclear in 3.[29–31] Of 4 studies judged low risk, 2 assessed serum osmolality,[20,22] 1 used *International Classification of Diseases, Ninth Revision* (ICD-9) codes only,[25] and 1 measured all fluid intake over 24 hours using referenced methodology with good interrater reliability ($r = 0.98$).[14] Of the 16 high-risk studies, 8 assessed fluid intake only,[11,15,17,19,23,24,26,33] 4 assessed dehydration status,[12,13,21,28] and 4 used a combination of both fluid intake and dehydration assessment.[10,16,18,32] Fluid intake assessments were judged high risk if they were conducted for part of the day or method of ascertainment was not considered to be accurate, whereas dehydration assessments were judged high risk if they had not been validated against serum osmolality in an elderly population (urine specific gravity [USG],[16,21,32] urine color,[16] dry eyes and mouth,[28] Resident Assessment Instrument Minimum Data Set [RAI-MDS] definitions,[12,13] and bioelectrical impedance analysis [BIA] to assess Total Body Water [TBW][16,18] or Total Body Resistance [TBR]).[10] In total, 6 studies assessed both fluid intake and dehydration,[10,16,18,20,22,32] but fluid intake was not fully reported in 4 of these[10,18,20,22] so risk of bias was assessed on the alternative reported measure. Just 6 studies reported results of any reliability checks between observers.[13–15,19,24,32]

Blinding of outcome assessors occurred in 2 studies (those using biochemical markers of dehydration[20,22]), but could have been feasible in other studies if incorporated into study designs. Only one study reported on all outcomes with reference to a published protocol.[28]

Findings (Further Details of Findings are Found in Web Table 3)

Drinking vessel characteristics

A randomized controlled trial (RCT) involving 24 UK nursing home residents with cognitive impairment found no effect of oral nutrition supplements given in the original bottle with a straw (n = 8) compared with being decanted into a glass (n = 16) on amount consumed (mean proportion imbibed using straws: 62%, SD 40% compared with 81%, SD 29% when using a glass, $P = .23$).[27,33]

Dunne et al[11] assessed the effect on fluid intake of high- and low-contrast colored tableware, compared with white, at lunch and supper for 10 days in 2 separate studies (a year apart) using a pretest-posttest design. Each involved 9 men with advanced dementia living in a US long-term care unit. Fluids were weighed and amounts consumed expressed as a percentage of amount served. In study 1, using high-contrast red tableware, the proportion drunk increased from a baseline mean of 54.4% (SD 36.6%) to 87.7% (SD 22.1%), $P = .02$. In study 2, 9 participants (including 5 from study 1), had the colors of their tableware manipulated as follows: white, high-contrast blue, white, low-contrast red, white, low-contrast blue, white, for 10 days each. Six participants completed the study. There were no statistically significant differences in mean fluid intake for any of the 3 colors when compared with white tableware in the period immediately before it ($P = .26$, 1.0, and .88, respectively).
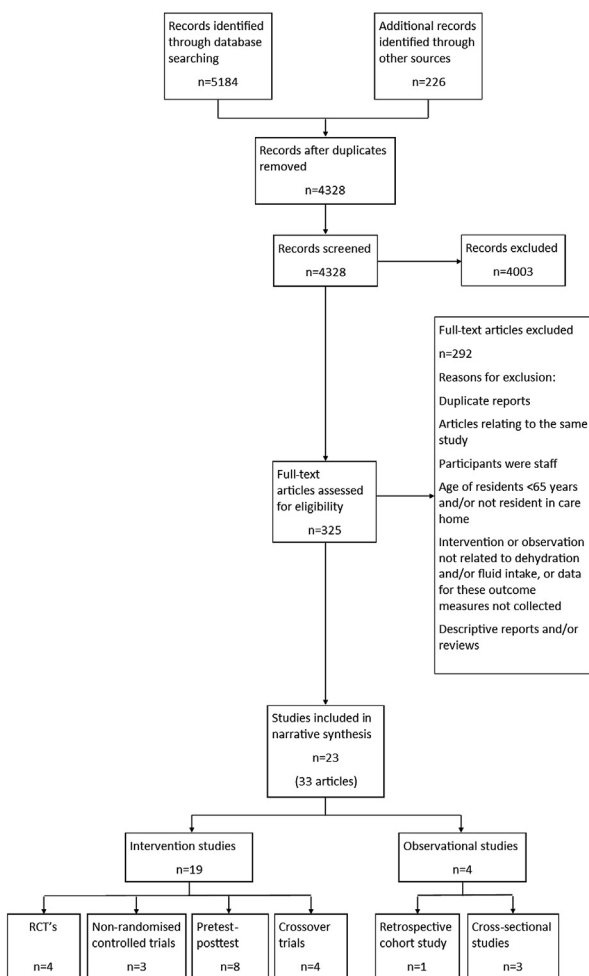

Fig. 1. Study flow diagram.

Table 1
Characteristics of Included Studies, Brief Outline of Intervention Studies

Author	Study Design	Participant Characteristics at Baseline	Intervention, Control, and Duration	Outcomes(s)
Allen,[27,33] 2011 UK	RCT	24 nursing home residents with cognitive impairment; **Group 1** = 8, **Group 2** = 16 Age, mean (SD): 86.3 (8.9) MMSE, mean (SD): 11.3 (9.7); range: 0−30	**Intervention, Group 1:** Straw inserted into ONS bottle **Intervention, Group 2:** ONS decanted into glass/beaker **Duration:** x3 per day, alternate days, 1 week	Proportion of ONS consumed/number of drinks served. **Method of assessment:** Amount of ONS consumed estimated as a proportion of amount served (0.1, 0.25, 0.5, 0.75, 1.0). Method of estimation not described.
Allison,[10] 2005 US	Pretest-posttest	281 residents of long-term care facilities *(substudy)*	**Intervention:** Senior facility staff evaluated participants and intervened with appropriate care if required (not described) to improve hydration **Duration:** 3−4 mo	Change in TBR. **Method of assessment:** Quantum II Bioimpedance Analyzer. Software: Cyprus Body Composition Software system - RJL Systems Equation: $TBW/(height^2/TBR) \times height/Resistance$.
Cleary,[24] 2008 Canada	Pretest-posttest	3 residents in long-term care facilities at risk of nutritional decline Age, mean: 92.7 MMSE, mean: 11.0	Regular seating plan instituted for this study at lunchtimes **Duration:** N/R, but 12 meals observed over nonconsecutive days	Change in percentage of fluids consumed at lunch, as a proportion of amount served (amount served N/R). **Method of assessment:** N/R.
Dunne,[11] 2004 US	Pretest-posttest	9 men with advanced AD living in long-term care; **Study 1** = 9, Age, mean: 82.7. MMSE, mean: 2.9 **Study 2** = 9 (includes 5 from study 1), Age, mean: 83.1. MMSE, mean: 3.2	**Study 1:** white tableware (control), high-contrast red tableware, white **Duration:** 30 d (10 d each) **Study 2 (1 year later):** white tableware, high-contrast blue (n = 9), white, low-contrast red (n = 7), white, low-contrast blue (n = 6), white **Duration:** 70 d (10 d each)	Change in mean percentage of fluid intake. **Method of assessment:** Food and fluid intake recorded every day for each participant at lunch Amount consumed expressed as a percentage of amount served. Amount served was weighed in ounces.
Fries,[13] 1997 US	Pretest-posttest	Nursing home residents, **Pre-RAI** = 2128; **Post-RAI** = 2088 (new cohort) >65 years: n = 3908 (92.1%)* Males: 1026 (23.3)* CPS: 31% intact; 35% moderate; 35% severe	**Intervention:** Implementation of RAI-MDS during 1990−1991	Change in baseline dehydration prevalence. Change in number of residents acquiring dehydration or improving during 6-month follow-up. **Method of assessment and definition of dehydration:** Dehydration present/absent as defined by the RAI-MDS, ≥2 criteria present from the following: Fluid intake <1.5 l/d Clinical signs of dehydration Fluid loss > fluid intake. Methods used to assess these N/R.
Holzapfel,[15] 1997 USA	RCTc	39 nursing home residents requiring complete feeding assistance Age, mean: 75 (95% ≥ 60 years) Males:3 (8%) Dementia diagnosis: n = 22 (56.4%)	**Intervention groups:** Feeding assistants sat for 2 wk, then stood for 2 wk, then crossed over. **Control:** Feeding assistants chose positions (positions chosen N/R) **Duration:** Lunch, Monday−Friday, 4 wk	Differences in mean fluid intake between groups on days 1, 5, 10, 15 and 20 (results presented as P value and t statistic only). Food and fluid consumed, at midday meal only, was recorded by the feeder using four predetermined categories of percentages (0−25%, 26−50%, 51−75%, 76−100%). Not known if this was measured or estimated. Fluid defined as being able to be consumed through a straw.
Kenkman,[28] 2010 UK	Cluster CCT	56 residents in residential care *(sub-study)*. **Intervention** = 30 MMSE, mean (SD): 19 (5.6) Number attempting chair-stands: 6 (20%) **Control** = 26 MMSE, mean (SD): 17 (6.2) Number attempting chair-stands: 4 (15.4%)	**Intervention:** Restaurant atmosphere, extended mealtimes, increased choice of foods, social experience, encouragement to eat, availability of drinks and snacks **Control:** "Usual care" (not described). **Duration:** 12 mo	Change in number of residents with dehydration. **Method of assessment and definition of dehydration:** Presence of either: Dry, furrowed tongue Dry mucous membrane Sunken eyes Methods used to assess these N/R
Lin,[32] 2013 Taiwan	Cluster CCT	74 incontinent nursing home residents. **Intervention** = 44 Age, mean (SD): 75.5 (12.7) Males: 14 (31.8%) SPMSQ, mean (SD): 5.4 (3.6) Barthel Index, mean (SD): 28.6 (24.4) **Control** = 30 Age, mean (SD): 74.7 (10.8)	**Intervention:** Advice to increase fluid intake to >1500 mL/d, unrestricted drinks choice **Control:** Unrestricted drinks, residents could choose type and amount. **Duration:** 6 wk	Change in mean fluid intake. **Methods of assessment:** Fluid input/output charts completed by facility staff, but methods of measuring fluids N/R.

McCormick,[29,38] 2006 Ireland	RCTc	Males: 15 (50) SPMSQ, mean (SD): 6.6 (3.2) Barthel Index, mean (SD): 32.2 (24.8) 11 long-term care residents with dysphagia Age, mean: 76 Males: 3 (27%) MMSE administered, N/R Barthel Index, mean: 0.4	***Wk 1−6:*** Group A received commercially prepared prethickened drinks, Group B received drinks thickened at bedside ***Wk 7−12:*** Group A: drinks thickened at bedside, Group B: commercially prepared prethickened drinks ***Duration:*** 12 wk	Difference in amount of thickened fluids consumed. ***Method of assessment:*** Daily assessment of total fluid intake using graduated cups.
Mentes,[16,39,40] 2000 US	Cluster RCT	49 nursing home residents. ***Intervention*** = 25 Age, mean (SD): 80.6 (10.3) Males: 11 (44%) MMSE, mean (SD): 22.0 (5.6) FIM, mean (SD): 79.4 (22.3) ***Control*** = 30 Age, mean (SD): 83.0 (9.2) Males: 11 (46%) MMSE, mean (SD): 24.6 (3.6) FIM, mean (SD): 112.2 (10.9)	***Intervention:*** Calculation of weight-based fluid intake goal. 75% of fluid goal to be drunk at mealtimes. Increased choice and availability of drinks, "sip-and-go" cups and tagging of charts and trays for "higher-risk" residents. ***Control:*** Routine care (not described). ***Duration:*** 8 wk	Change in urine color and USG. Change in fluid intake and number of residents achieving >75% of fluid goal. Change in TBW. ***Method of assessment:*** 1. Standard urine color chart 2. USG, assessed using Chemstrip Mini Urine Analyzer Weekly urine assessments. 3. 2x 24-h fluid intake records documented at baseline. During each week of the intervention a partial fluid intake record of drinks taken at mealtimes, medication and fluid rounds, was documented. Caffeinated and alcoholic beverages were excluded. Method of assessment N/R. 4. BIA-101 Quantum Analyzer (RJL systems, Clinton Township). Equations referenced. BIA conducted at baseline, wk 4 and 8.
Robinson,[18] 2002 US	Pretest-posttest	51 nursing home residents Age, mean: 83.5 Males: 8 (15.7%) Dependency n (%): Complete: 9 (17.6); Holds glass: 25 (49); Independent: 17 (33.3)	***Intervention (7 d/wk, 5 wk):*** Goal: to drink 8oz more fluids twice a day. Hydration assistant for fluid administration. Increased choice. Colorful beverage cart, jugs, and glasses ***Duration:*** 9 wk (includes 2 wk baseline and 2 wk follow-up)	Number of participants drinking extra 16oz/d. Change in TBW. ***Method of assessment:*** Fluid intake monitored mid-morning and afternoon only. Use of BIA to assess TBW, methods not described, and information regarding type of machine, and equations used N/R.
Schnelle,[19] 2010 US	RCT	112 nursing home residents with faecal and urinary incontinence ***Intervention*** = 58 Age, mean (SD): 85.8 (9.4) Males: 16% MMSE, mean (SD): 12.9 (8.4) Sit-to-stands, number performed, mean (SD): 3.6 (3.1) Walk/wheel distance, meters, mean (SD): 58.7 (50.3) ***Control*** = 54 86.1 (10.5) Males: 19% MMSE, mean (SD): 9.6 (8.4) Sit-to-stands, number performed, mean (SD): 2.1 (2.0) Walk/wheel distance, meters, mean (SD): 54.0 (55.8)	***Intervention:*** Research staff checked residents for incontinence, offered toileting assistance, choice of snack and drink, prompts to exercise. ***Control:*** Usual care (not described). ***Baseline and postintervention (1 wk each, both groups):*** Research staff offered toileting assistance and checked for UI and FI. ***Duration:*** 12 wk (weekdays, 7:00 AM−3:30 PM, 2 hourly)	Change in between-meal fluid intake. ***Method of assessment:*** Fluid intake assessed using validated photographic assessment method (Simmons et al, 2000).[43]
Simmons,[20] 2001 US	RCT	48 incontinent nursing home residents *(substudy)* ***Intervention*** = 23 Age, sex, and MMSE N/R for this sub-group ***Control*** = 15 Age, mean (SD): 86.3 (6.1) Males: 5 (33%) MMSE, mean (SD): 13.9 (6.5)	***Intervention:*** Usual care and x4 prompts to exercise per day and x4 prompts or help with toilet, changed if wet +: ***Phase 1 (wk 1−16):*** x4 verbal prompts to drink ***Phase 2 (wk 17−24):*** x8 verbal prompts to drink ***Phase 3 (wk 25−32):*** x8 verbal prompts to drink, increased choice of drinks and appropriate assistance provided. ***Control:*** Usual care (not described) ***Duration:*** 5 d/wk for 32 wk	Change in serum osmolality and BUN:creatinine ratio. ***Method of assessment:*** Venepuncture, methods N/R.
Spangler,[21] 1984 US	RCTc			

(continued on next page)

Table 1 (continued)

Author	Study Design	Participant Characteristics at Baseline	Intervention, Control, and Duration	Outcomes(s)
		16 nonambulatory nursing home residents with incontinence Age, range: 59–96 (mean, SD N/R) Males: 2 (12.5%)	**Intervention:** Research staff offered choice and help with cold drinks and toileting assistance every 1.5 h, 6:00 AM–9:00 PM. **Standard Care:** 3-hourly checks for soiling; no offers of drinks, but requests for drinks were met. **Duration:** 50 d (10 d baseline, 10 d each crossover period, 10 d standard care for both groups, 10 d when intervention delivered by facility staff to all participants)	Change in mean USG. **Method of assessment:** USG assessed using urinometer.
Tanaka,[31] 2009 Japan	Pretest-posttest	122 nursing home residents able to sit up and communicate need to defecate Age, mean: 85.2 (SD N/R) Males: 18 (14.8%) Dementia level, n (%): I (mild): 2 (1.7); II: 18 (14.9); III: 59 (48.8); IV: 42 (34.7) Dependence level, n (%): J1 and 2 (independent): 0 (0.0); A1: 7 (5.8); A2: 15 (12.4); B1: 28 (23.1); B2: 52 (43.0); C1: 7 (5.8); C3: 12 (9.9)	**Intervention:** Senior nurses received training then trained staff to increase fluid intake to 1500 mL/d by providing drinks early morning, between meals and bedtime, verbal and physical assistance and increased choice. Assistance provided with toileting and wet incontinence pads changed 2-hourly. Residents to remain out of bed for >6 h. **Duration:** 12 wk	Mean change in fluid intake. **Method of assessment:** 3-d mean fluid intake assessed at baseline and 12 wk. Methods N/R.
Taylor,[26] 2006 Canada	RCTc	31 residents with dysphagia living in extended care facilities Age, mean (SD): 85 (6.4) Males: 5 (16%)	**Intervention:** Five meals/d, matched to the 3 meals for energy content. **Group 1:** 5 meals/d for 4 d; **Group 2:** 3 meals/d for 4 d **4 wk later:** **Group 1:** 3 meals/d for 4 d; **Group 2:** 5 meals/d for 4 d **Duration:** 4 wk	Difference in fluid intake at mealtimes. **Method of assessment:** Fluid defined as any food usually drunk, or is liquid at room temperature before thickening. Food and fluids not provided by hospital staff were not weighed, but recorded as % consumed. This data N/R.
Welch,[22] 1996 US	Pretest-posttest	13 mildly dehydrated nursing home residents Age, mean: 89 (SD N/R) Males: 1 (8%)	**Intervention:** Oral hydration fluids offered when standard fluid intake was less than the weight-based calculated goal for daily fluid intake. Method of how increased fluids were promoted not described. **Duration:** 5 d	Change in serum biochemistry. Change in fluid intake. **Method of assessment:** Serum biochemistry assessed days 1, 3, 5. Fluid intake assessed daily, methods N/R.
Willms,[30] 2003 Germany	Pretest-posttest	70 residents requiring nursing care Age: 64–69: 5 (2.8%); 70–79: 36 (19.9%); 80–89: 82 (45.3%); 90–99: 57 (31.5%); >100: 1 (0.6%) Males: 24 (13.3%) Care levels, n (%): 1: 10 (14.7); 2: 37 (54.4); 3 (dependent): 21 (30.9)	**Baseline: 10 d** **Intervention (duration unknown):** Education for staff and residents. Provision of water fountains, drinks delivered at set times and increased choice of drinks taking into account color and taste. Increased assistance, such as physical help, thickening drinks and use of drinking aids. **Follow-up period: 10 d**	Change in mean fluid intake. **Method of assessment:** Fluid intake assessed daily by nursing home staff using calibrated containers. No information provided regarding time period (whole or part of day).
Zembrzuski,[23] 2006 US	CCT	82 residents of skilled nursing facilities **Intervention** = 48 Age, mean (SD): 88.04 (6.35) Males: 9 (18.8%) MMSE, mean (SD): 20.88 (5.99) **Control** = 34 Age, mean (SD): 85.76 (7.33) Males: 5 (14.7%) MMSE, mean (SD): 15.53 (9.18)	**Intervention:** Increased choice of drinks, increased assistance and monitoring; between-meal drinks offered at least twice daily for 30 d. **Control:** Routine care: general standard for offering drinks, drinks provided on request, increased drinks for "at-risk" residents. **Duration:** 30 d	Change in mean fluid intake. **Method of assessment:** Fluid intake observed over 12- h period for 3 d before study commencement and for 3 d at the end of the intervention using graduated cups.

AD, Alzheimer Disease; BIA, Bioelectrical Impedance Analysis; BMI, Body Mass Index; BUN, Blood Urea Nitrogen; DM, Diabetes Mellitus; CCF, Congestive Cardiac Failure; CCT, Controlled Clinical Trial; CPS, Cognitive Performance Scale; FIM, Functional Independence Measure; FI, Fecal Incontinence; Hb, Hemoglobin; MMSE, Mini Mental State Examination; Na, Sodium; N/R, Not Reported; ONS, Oral Nutritional Supplements; RAI-MDS, Resident Assessment Instrument–Minimum Data Set; RCT, Randomized Controlled Trial; RCTc, Randomized Controlled Crossover Trial; RIP, Rest in Peace (died); SPMSQ, Short Portable Mental Status Questionnaire; TBR, Total Body Resistance; TBW, Total Body Water; UI, Urinary Incontinence; USG, Urine Specific Gravity; UTI, Urinary Tract Infection.

*Reported as raw frequency and weighted percentages of the total population they represent (n = 121,337).

Table 2
Characteristics of Included Studies, Brief Outline of Observational Studies

Author	Study Design	Participant Characteristics at Baseline	Exposure(s) (Independent Variables)	Outcome Measure(s) (Dependant Variable/S)
Dyck,[12,41] 2006 US	Cross-sectional (2° analysis of RAI-MDS and OSCAR databases)	363,895 residents from 2951 nursing homes in 6 midwest states Age, mean (SD): 83.9 (7.9) Males: 99,612 (27.3%) Cognition and physical function N/R	Type of ownership (government-owned, not-for-profit, for-profit, chain facility) Reimbursement method Facility location (urban, rural) Case mix index Staffing: HRD by grade of staff (RN, LPN, CNA)	Risk of dehydration according to facility and staffing factors. ***Definition of dehydration:*** Dehydration present/absent, as defined by ICD-9-CM diagnostic code of 276.5, or as defined by the RAI-MDS J1c, ≥2 criteria present from the following: Fluid intake <1.5 l/day Clinical signs of dehydration Fluid loss > fluid intake. Methods used to assess RAI-MDS criteria N/R.
Gaspar,[14,42] 1999 US	Cross-sectional	99 residents from 3 nursing homes Age, mean: 85 (SD N/R) Males: 23 (23.2%) Able to respond to interview questions: 51 (51.5%) Norton score*, mean: 15 (SD N/R)	Number of ingestion sessions Who initiated the ingestion Place of ingestion Positioning of resident's upper body and head during feeding	Total water intake (from food and fluids). ***Method of assessment:*** Observations of food and fluid intake for 2x24-h periods during 1 wk. Coding manual used to code water content of foods and fluids.
McGregor,[25] 2006 Canada	Retrospective cohort Using British Columbia−linked health databases	43,065 hospital admissions from extended care facilities (representing 23,868 beds) between 01/04/1996−01/08/1999 Age, mean (SD): 82.3 (9.5) Males:14,757 (34.3%) Care level, n (%): I/II: 16,062 (37.3) III: 12,089 (28.1) Extended: 14,914 (34.6)	Not-for-profit facilities, n (%): 212 (70.4) For-profit facilities, n (%): 89 (29.6)	Risk of admission to acute unit from a care facility due to dehydration (primary diagnosis). ***Definition of dehydration:*** Dehydration present/absent, as defined by ICD-9-CM diagnostic code of 276.5
Reed,[17] 2005 US	Cross-sectional	326 residents diagnosed with dementia, from 10 nursing homes and 35 RC/AL† *(substudy)* Age, sex, degree of cognitive impairment and physical function N/R separately for substudy	Staff:resident ratio Type of staff training in hydration and nutrition Facility environment Facility type and ownership New model RC/AL v "traditional" model†	Risk of low fluid intake according to facility and staffing factors. ***Method of assessment and definition of dehydration:*** Low fluid intake defined as an intake of <8 fl oz, assessed over a single observed mealtime (method of assessment N/R).

CNA, Certified Nursing Assistant; HRD, Staffing Hours per resident per day; LPN, Licenced Practical Nurse; N/R, not reported; OSCAR, Online Survey, Certification and Reporting database; RAI-MDS, Resident Assessment Instrument−Minimum Data Set; NH, Nursing Homes; RC/AL, residential/assisted living facilities; RN, Registered Nurse.

*Norton Score used in this study to assess general physical and mental function, but it was validated to assess risk for development of pressure sores; possible scores range from 4−20. <9 = very high risk of developing pressure sores (due to impaired cognition, physical activity and bladder control); 10−13 = high risk; 14−17 = medium risk and 18−20 = low risk.

†Residential/assisted living facilities (RC/AL) are non-NH settings that provide room, board, and assistance with activities of daily living. New model RC/AL offers add-on services for residents requiring more care and/or nursing care.

Fig. 2. Risk of bias for intervention studies.

Drink characteristics

In Ireland, a crossover RCT involving 11 long-term care residents with dysphagia, compared fluid intake using commercially prepared prethickened drinks with drinks thickened by staff at the bedside.[29] During each 6-week intervention period, fluid intake, which was assessed at each drinking occasion, did not differ significantly (pre-thickened drinks, mean intake: 902 mL, SD 271; drinks thickened by staff, mean intake: 783 mL, SD 165, $P = .21$). Constipation rates were reported as not significantly different between groups (Web Table 4).

A US cross-sectional study (Reed et al[17]) with 326 participants living in 35 assisted-living facilities and 10 nursing homes, investigated the relationship between thickened drinks and low fluid intake (defined as ≤ 8 fluid ounces at a single meal, method of assessment not described). Adjusting for age, sex, ethnicity, marital status, number of comorbidities, cognitive status, and activities of daily living, there was no evidence that receiving thickened drinks, compared with nonthickened drinks, was associated with low fluid intake (OR 1.02, 95% confidence interval [CI] 0.38–2.75).

Physical and social setting for drinking

Adjustments to the eating and drinking environment may alter fluid intake. A clustered controlled clinical trial (CCT) involving 6 UK care homes evaluated a planned program of developments to improve the physical and social environment at mealtimes as well as increasing the availability and choice of drinks.[28] Risk of dehydration (defined as the presence or absence of a dry, furrowed tongue; dry mucous membrane; and/or sunken eyes) was unaltered by the intervention (RR 0.36; 95% CI 0.06–2.04, $P = .25$) in the 56 participants who completed the 1-year follow-up. Secondary outcomes are reported in Web Table 5.

Reed et al[17] assessed the association of environmental factors with low fluid intake. The odds of a low fluid intake were lower for participants eating in the dining room compared with their bedrooms (OR 0.18; 95% CI 0.06–0.63). Participants taking meals in dining rooms with fewer institutional features had lower odds of low fluid intake compared with participants eating in more institutionalized settings (OR 0.65; 95% CI 0.55–0.77). The odds of low fluid intake were not affected by number of residents in the dining area (OR 1.03; 95% CI 0.93–1.15), presence of family members (OR 1.22; 95% CI 0.46–3.2), or noise level (OR 0.92; 95% CI 0.44–1.89).

A Canadian study with 3 participants in a long-term care facility used a pretest-posttest design to investigate whether a set seating plan at lunchtime would improve food and fluid intake.[24] Study duration and whether the seating plan was maintained for meals other than those observed, was not reported. Fluid intake was assessed as percentage consumed of the amount served at lunchtime, but amounts served and method of assessment were not described. Mean fluid intake during nonintervention periods was 62.7% (SD 29.2%), and postintervention was 77.8% (SD 29.9%), $P = .53$.

Institutional factors

Four studies[12,13,17,25] investigated institutional factors: type of ownership and management, size of facility, staffing levels, and monitoring systems. Three studies were observational,[12,17,25] and 2 of these were secondary analyses of statewide datasets,[12,25] large robust studies with good internal validity.

Resident Assessment Instrument Minimum Data Set (RAI-MDS). A large US study investigated the effect of the compulsory implementation of the RAI-MDS from 1990 to 1991 using a pretest-posttest design.[13] Two separate cohorts were recruited from more than 250 nursing homes across 10 states in 1990 (n = 2128)

and 1993 (n = 2088) to assess whether implementation effected prevalence of dehydration at baseline and whether this was more or less likely to improve after 6-month follow-up. The odds of dehydration at baseline were significantly reduced after implementation of the RAI-MDS, compared with before (3% to 1%, P = .01; OR 0.35, 95% CI 0.21–0.57). (The prevalence of dehydration differs between the text and Table 2 in the article by Fries et al.[13] As prevalence is definitively described as n = 60 [3%] in the text, this figure is reported in this review.) However, for participants found to have dehydration at baseline, the odds of improving at the 6-month follow-up were decreased after RAI implementation (OR 0.06, P = .008), although the actual numbers of participants who remained in the study at 6 months were small (n = 2 and n = 4 for improvement pre/post implementation respectively).

Staffing. The relationships between staffing and dehydration were investigated in 2 US cross-sectional studies.[12,17] A secondary analysis using databases of the RAI-MDS and Online Survey Certification and Reporting (OSCAR; information regarding nursing homes, size, location, staffing, ownership), evaluated relationships between staffing and dehydration in 363,895 residents across 2951 nursing homes in 6 states. Dehydration was defined using a combination of RAI-MDS criteria and ICD-9 code for dehydration (E276.5). Adjusting for resident characteristics, stepwise logistic regression and generalized additive models explored linear and nonlinear relationships respectively. There was no evidence that staff grade or number of staffing hours had any effect on residents' dehydration levels, although the referent is unclear (Table 4).

In the United States, Reed et al,[17] after adjusting for several resident characteristics, found that the odds of a resident having a lower fluid intake were slightly reduced with low resident/staff ratios, although the number of staff (whether supervisory or direct-care) trained to detect and treat nutritional problems had no impact on fluid intake (Table 4).

Ownership and type of facility. Ownership was examined in 3 observational studies[12,17,25] (Table 4). McGregor et al,[25] conducting a retrospective cohort study, using the Canadian British Columbia Linked Health Database (includes administrative records for all publically funded health care services use and vital statistics for residents), investigated the influence of facility type and ownership on hospital admissions for dehydration among the 43,065 individuals admitted from long-term care facilities between April 1996 and August 1999. Rates of hospital admission with dehydration were greater from for-profit facilities compared with not-for-profit facilities after adjusting for age, sex, level of care, facility size, and hospitalization in the previous 30 days.[25] Of the 2 US studies, Dyck[12] found no difference in dehydration prevalence (after adjusting for "internal resident characteristics") and the smaller study by Reed et al,[17] using an outcome measure with a high risk of bias, found that residents from for-profit facilities had lower odds of a low fluid intake compared with residents living in not-for-profit facilities. All 3 studies conducted subgroup analyses to investigate associations between different types of for-profit and not-for-profit facilities (Table 4).

Size and location of facility. Neither McGregor et al[25] nor Reed et al[17] found that size of facility had an effect on the dependant variable, although their definitions of "large" and "small" facilities differed (Table 4). Dyck,[12] investigating geographical location, found marginally nonsignificant lower odds of dehydration in rural facilities (OR 0.9; 95% CI 0.81–1.0; P = .0595).[12]

Care aimed at increasing fluid intake. Ten studies investigated a range of factors specifically aimed at increasing fluid

Table 3
Risk of Bias, Observational Studies

Study Details	Ascertainment of Exposure	Case Definition of Dehydration	Representativeness of Cases* or Exposed Cohort†	Selection of Controls* or Nonexposed Cohort†	Definition of Controls* or Outcome Not Present at Start of Study†	Comparability of Cases and Controls	Same Methods Used to Ascertain Cases and Controls*	Nonresponse Rate* or Adequacy of Follow-up†	Follow-up Long Enough for Outcomes to Occur†	Number of Stars Achieved
Maximum number of stars achievable	1	1	1	1	1	2	1	1	1	9
Dyck, 2006[12,41] (Cross-sectional)	1	0	1	1	1	2	1	1	n/a	8
Gaspar, 1999[14,42] (Cross-sectional)	0	1	0	1	1	0	0	0	n/a	4
McGregor, 2006[25] (Retrospective cohort)	1	1	1	1	0	2	n/a	1	1	8
Reed, 2005[17] (Cross-sectional)	0	0	0	1	1	2	1	1	n/a	6

0 indicates high risk of bias, 1 or 2 indicates low risk of bias.
n/a indicates that the study is not being judged on this criteria.
*Applicable to cross-sectional studies only.
†Applicable to cohort studies only.
‡Applicable to cross-sectional studies only.

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Table 4
Institutional Factors and Their Association with Dehydration or Low Fluid Intake

Study Details	Characteristic	Referent/Comparison	Measure of Dehydration/Low Fluid Intake	OR/RR (95% CI)	Significant Effect?
Staffing					
Dyck,[12,41] 2006 US	*Grade of nurse:*		RAI-MDS record of dehydration, using MJ1c code or ICD-9 code E276.5		
	Registered Nurse, hours per resident per day	Unclear		OR: 1.07 (0.82–1.39)*	N
	Licensed Practical Nurse, hours per resident per day	Unclear		OR: 1.20 (0.97–1.48)*	N
	Certified Nursing Assistant, hours per resident per day	Unclear		OR: 0.95 (0.85–1.06)*	N
Reed,[17] 2006 US	*Number of staff trained to detect and treat nutritional problems (Nb by authors):*		Fluid intake ≤ 8 fl oz observed over a single meal		
	≥75% of supervisory staff	None in the facility		OR: 1.02 (0.89–1.16)†	N
	"some" supervisory staff	None in the facility		OR: 1.01 (0.94–1.08)†	N
	≥75% direct-care staff	None in the facility		OR: 0.99 (0.87–1.14)†	N
	"some" direct-care staff	None in the facility		OR: 0.99 (0.93–1.07)†	N
	Lower numbers of residents per staff member	Higher number of residents per staff member		OR: 0.95 (0.91–0.99)†	Y
Ownership and type of facility					
Dyck,[12,41] 2006 US	Chain facilities	Nonchain facilities	RAI-MDS record of dehydration, using MJ1c code or ICD-9 code E276.5	OR: 0.86 (0.77–0.96)*	Y
	Not-for-profit facilities	For-profit facilities		OR: 1.02 (0.91–1.15)*	N
McGregor,[25] 2005 Canada	For-profit facilities	Not-for-profit facilities	Hospital admission due to dehydration, using ICD-9 code E276.5	RR: 1.24 (1.08–1.43)‡	Y
	For-profit subgroups:				N
	Chain facilities	For-profit multisite facilities		RR: 0.93 (0.69–1.26)‡	N
	Chain facilities	For-profit single-site facilities		RR: 1.04 (0.74–1.45)‡	N
	Multisite facilities	For-profit single-site facilities		RR: 1.10 (0.84–1.45)‡	Y
	Not-for-profit subgroups:				
	Amalgamated to health authority	Facility attached to hospital		RR: 1.53 (1.18–1.96)‡	Y
	Single-site facilities	Facility attached to hospital		RR: 2.29 (1.83–2.88)‡	Y
	Multisite facilities	Facility attached to hospital		RR: 1.40 (1.01–1.94)‡	Y
	Single-site facilities	Amalgamated to health authority		RR: 1.49 (1.21–1.84)‡	Y
	Multisite facilities	Amalgamated to health authority		RR: 0.91 (0.66–1.26)‡	N
	Single-site facilities	Multisite facility		RR: 1.63 (1.23–2.17)‡	Y
Reed,[17] 2006. US	For-profit facilities	Not-for-profit facilities	Fluid intake ≤8 fl oz observed over a single meal	OR: 0.34 (0.22–0.53)†	Y
	Residential care or "traditional" type of assisted living facilities	Nursing homes		OR: 0.83 (0.44–1.55)†	N
	Residential care or "new model" type of assisted living facilities (residents require more care, including nursing care)	Nursing homes		OR: 0.46 (0.27–0.79)†	Y
Size and location of facility					
Dyck,[12,41] 2006 US	Rural facilities	Urban facilities	RAI-MDS record of dehydration, using MJ1c code or ICD-9 code E276.5	OR: 0.90 (0.81–1.00)*, P = .0595	N
McGregor,[25] 2005 Canada	Large facilities (*defined by authors*), >71.5 beds	Small facilities, ≤71 beds	Hospital admission due to dehydration, using ICD-9 code E276.5	RR: 0.95 (0.82–1.10)‡	N
Reed,[17] 2006 US	Small facilities(*defined by authors*), >16 beds	Nursing homes	Fluid intake ≤ 8 fl oz observed over a single meal	OR: 1.08 (0.48–2.45)†	N

CI, Confidence Interval; fl oz, Fluid Ounces; ICD-9, International Classification of Diseases, Ninth Revision; N, No; OR, Odds Ratio; RAI-MDS, Resident Assessment Instrument–Minimum Data Set; RR, Relative Risk; Y, Yes.
   *Adjusted for internal resident characteristics.
   †Adjusted for age, sex, ethnicity, marital status, number of comorbidities, cognitive status, and activities of daily living.
   ‡Adjusted for age, sex, level of care, facility size, and hospitalization in the 30 days before date used in the study.

intake or decreasing dehydration. Four investigated single interventions,[15,22,26,32] and 6 were multicomponent interventions.[10,14,16,18,23,30]

The effect of a feeding assistant's position (sitting or standing) was investigated in a US nursing home crossover RCT.[15] Thirty-nine residents were randomized to either a "control" group (feeding assistants chose their position) or 1 of 2 intervention groups in which residents were fed one way for 2 weeks, then crossed over and fed the other way for 2 weeks. Results were reported as the *t* statistic and *P* value between each group (sitting/standing, choice of feeder/sitting, choice of feeder/standing) for days 1, 5, 10, 15, and 20 of the 4-week study. Comparing sitting with standing groups only (as control group feeder positions were not reported), the feeding assistant's position had no significant effect on fluid intake (*P* values ranged from .533 to 1.0).

A 6-week nonrandomized cluster CCT involving 74 residents in 6 nursing homes investigated whether advice to increase fluid intake would reduce rates of asymptomatic bacteriuria.[32] The method of fluid intake assessment and nature of advice provided were not described, except that the choice of drinks was unlimited and fluid intake should exceed 1500 mL per day. On completion, there was no significant difference in mean fluid intake between intervention and control groups (intervention group: 1732 mL per day, SD 301, vs control group: 1548 mL per day, SD 558; *P* = .107), or rates of asymptomatic bacteriuria (Web Table 5).

Taylor and Barr[26] investigated the effect of 3 or 5 meals per day on energy and fluid intake in a crossover RCT involving 31 residents with dysphagia living in a Canadian extended care facility. Using a well-described method of fluid ascertainment at mealtimes, but relying on facility staff to record intake at other times, mean mealtime fluid intake was reported as increasing significantly (612 mL per day, SD 176, to 698 mL per day, SD 156; *P* = .003) with no decrease in between-meal fluid intake noted (but actual amounts not reported).

Welch et al[22] investigated how 13 mildly dehydrated US nursing home residents responded to an oral hydration solution in a 5-day study using a pretest-posttest design. Significant improvements were observed in serum osmolality (reported as decreasing from a baseline mean of 285.38 mOsm/kg, SD 1.73, to 278.77 mOsm/kg, SD 1.59, *P* < .001) and blood urea nitrogen (BUN; baseline mean 25.08 mg/dL, SD 2.78, decreasing to 21.62 mg/dL, SD 2.92, *P* = .002), but not mean fluid intake (baseline: 1588 mL per day, day 5: 1682 mL per day; SDs not reported).

Using a pretest-posttest design, Allison et al[10] described a management program in which senior staff from 26 US long-term care facilities evaluated 281 participants to assess whether a baseline BIA assessment of TBR greater than 550 ohm indicated dehydration. Staff were instructed to intervene with appropriate care (not described) following the BIA assessment. After 3 to 4 months, there was no clear effect on dehydration, reported as a fall in TBR in 70% of participants (610.2 ohm, SD 36.6, at baseline, to 478.4 ohm, SD 59.9), but with no effect in 30% of participants where they suggested that the intervention was not applied consistently (data not reported).

Mentes,[16] in a cluster RCT involving 49 participants from 4 US nursing homes, investigated the effect of an 8-week hydration program (increased choice and availabilty of drinks, staff training, identification of "at-risk" residents, and calculation of individual weight-based fluid goal) on reducing hydration-linked events. Significant baseline differences between intervention and control groups in functional ability (*P* < .001), confusion levels (*P* = .003), and USG (*P* = .002) were not adjusted for because of the small sample size, introducing bias. Methods for assessing fluid intake were not described, and mean fluid intakes following intervention were not reported, although the number of participants drinking more than 75% of their fluid intake goal were described as not being significantly different following the intervention (22, 88%, intervention group vs

20, 83%, control group, *P* = .64). There were no significant differences between groups on USG (*P* = .55), urine color (*P* = .24), BIA assessment of TBW (*P* = .28), or hydration-linked events (Web Table 5).

Robinson and Rosher[18] included 51 US nursing home residents to investigate the effectiveness of a 5-week hydration program (increased availability and choice of drinks, presented more attractively) aiming to increase fluid intake by 16 fluid ounces per day, to reduce dehydration and 6 related conditions (Web Table 4). Using a pretest-posttest design, research staff measured fluid intake at mid-morning and midafternoon drinks rounds and conducted weekly BIA assessments of TBW (methods not reported). Following the intervention, 27 (53%) residents always drank the extra 16 fluid ounces per day provided. Mean TBW data were poorly reported but the number of participants with TBW below the "standard" (not defined) dropped from 24 (47%) to 3 (6%), *P* = .001. Falls (*P* = .05), laxative use (*P* = .05), and number of bowel movements (*P* = .04) improved significantly, but urinary tract infections, upper respiratory tract infections, and skin breakdown demonstrated nonsignificant improvements (*P* > .05). Mental status changes were assessed but not reported (Web Table 4).

In another study using a pretest-posttest design, Willms et al[30] investigated the effects of a multicomponent intervention (education for staff and residents, increased help and provision of drinks) to improve fluid intake for 70 participants living in a German nursing home. Nursing staff used calibrated containers to assess fluid intake. Mean fluid intake increased significantly (from 956 mL per day, SD 413, to 1325 mL per day, SD 373; *P* < .0001).

In the United States, a CCT with 82 participants based in 4 skilled nursing home facilities, evaluated the effect of a multicomponent intervention (increased help and provision of drinks, closer monitoring of fluid intake) to increase fluid intake on postural hypotension and falls over 30 days.[23] Research staff assessed all fluid intake for 12 hours over 3 consecutive days at baseline and on completion using graduated cups. Mean fluid intakes for the intervention group were significantly higher than the control group (1577 mL per day, SD 66, vs 1063 mL per day, SD 274; *P* < .001).

Mean difference in both systolic and diastolic blood pressure from lying to standing improved significantly in the intervention group compared with the control group, but the number of participants falling was not significantly different between the 2 groups (Web Table 5).

A cross-sectional study in 3 US nursing homes with 99 participants investigated factors associated with inadequate water intake.[14] Food and fluid intake was observed over two 24-hour periods during 1 week, with low water intake (from food and drinks) defined as less than or equal to 1600 mL/m^2 body surface area. Unable to adjust for confounders (age, sex, frailty) because of small sample size, and considering the modifiable factors only (positioning of the resident's upper body, place of ingestion, number of ingestion sessions, and who initiated the ingestion), fewer ingestion sessions were correlated with inadequate water intake (r = 0.32, *P* < .01), but associations between water intake and positioning, place of ingestion, and who initiated the ingestion were not reported.

Care aiming to increase fluid intake, and including assistance with toileting. Four studies, recognizing the impact that anxiety about toileting may have on fluid intake, included increased toileting assistance within multicomponent interventions.[19–21,31]

Schnelle et al[19] included 112 US nursing home residents in a 12-week RCT comparing usual care with an intervention in which residents were prompted to void, exercise, and increase food and fluid intake every 2 hours between 7:00 AM–3:30 PM by research staff who also checked for incontinence and offered appropriate toileting assistance and choice of drinks. Assessing the amount imbibed as a

proportion of amount served, meal and between-meal fluid intake was recorded over 2 consecutive days at baseline and each month of the intervention. Only the results of between-meal fluid intake were reported (mean change from baseline, intervention group: +13.5 fluid ounces per day, SD 6.3; control group: +1.9 fluid ounces per day, SD 4.0; $P < .001$), but they stated that there was no decrease in mealtime fluid intake. Constipation rates improved significantly ($P < .001$; Web Table 5).

Simmons et al[20] involved 32 residents of 2 US nursing homes in a 32-week RCT to increase fluid intake. Usual care was compared with the intervention, delivered in 3 phases. In weeks 1 to 16, residents were prompted to exercise every 2 hours (7:00 AM–3:30 PM) by research staff, who checked for incontinence, and offered toileting assistance and drinks. This increased to 8 prompts a day in weeks 17 to 24, and in weeks 25 to 32, this was supplemented by an increased choice of drinks. Serum osmolality and BUN:creatinine ratio were assessed at baseline and 32 weeks. No significant differences were observed between groups following intervention, although both groups improved significantly compared with baseline (mean baseline serum osmolality, intervention group: 303.6, SD 9.1, vs 303.4, SD 8.5, control group, $P = .95$; 32-weeks mean serum osmolality, intervention group: 297.0, SD 10.8, vs 294.7, SD 11.9, control group, $P = .57$; mean baseline BUN:creatinine ratio, intervention group: 24, SD 4.6, vs 21.7, SD 6.1, control group, $P = .23$; 32-week mean BUN:creatinine ratio, intervention group: 22.9, SD 5.6, vs 23.8, SD 7.2, control group, $P = .71$). This study also assessed meal and between-meal fluid intake but these data were not fully reported.

In an earlier US study,[21] 16 nonambulatory nursing home residents were enrolled onto a 7-week crossover RCT to investigate whether increased help and availability with drinks, toileting, and incontinence care would decrease dehydration, assessed using USG (measured using a urinometer, dehydration defined as USG ≥22, units not described). After a baseline period when all residents received standard care (phase 1), residents were matched for dehydration and continence levels, then randomly assigned to 1 of 2 groups (A and B). The crossover periods were phases 2 and 3, when the intervention was delivered by research staff; phase 4 was a return to baseline, and in phase 5 the facility staff administered the intervention. The t tests for repeated measures were described as statistically significant ($P = .002$) between groups A and B for phases 2 and 3.

A more recent study using a pretest-posttest design based in 17 Japanese nursing homes with 122 participants, instituted a 12-week intervention (increased feeding assistance and availability of drinks, increased help with toileting and incontinence care, increased time out of bed). Fluid intake (assessed by facility staff, methods not reported) increased significantly (mean fluid intake, baseline, 881 mL per day, SD 264; post intervention, 1146 mL per day, SD 365, $P < .001$).[31]

Discussion

Nineteen intervention and 4 observational studies from 7 countries were included in this review. In intervention studies, 6 of the 9 multicomponent interventions demonstrated a trend toward increasing fluid intake, particularly if they included increased choice and availability of drinks, staff awareness, and increased assistance with drinking and toileting (Web Table 3). A reduction in dehydration prevalence was observed following the compulsory implementation of the RAI in the United States in 1990 to 1991.[13] The RAI is a comprehensive standardized tool designed to assess residents living in long-term care and to provide individualized care to promote functioning and prevent avoidable problems. Two small studies, both using pre-posttest designs, reported positive findings. Dunne et al[11] reported an increase in fluid intake in 9 men with Alzheimer

disease when using high-contrast red cups compared with white, although these findings were not repeated when using low-contrast red or high and low-contrast blue. Welch et al[22] provided oral hydration fluids to 13 mildly dehydrated nursing home residents over 5 days, resulting in improved serum biochemical indices. Advice to residents, modifications to the setting for ingestion and the way in which drinks were served (straw vs beaker[33]; prethickened drinks vs those thickened at the bedside[29]) were inconclusive. Two large observational studies with good internal validity investigated effects of ownership; in Canada, for-profit ownership was associated with increased hospital admissions for dehydration[25] and in the United States, no difference was seen in dehydration prevalence between for-profit and not-for-profit homes, although chain facilities were associated with lower odds of dehydration.[12] This study did not suggest any effect for staffing levels (grade of staff or staffing hours per day) on dehydration prevalence.

In contrast to the previous review,[5] we confined our review to residents living in long-term care, aiming to identify strategies applicable to these particular settings; older people living in the community are generally more independent and not so reliant on carers to provide drinks and assistance, whereas patients in acute hospitals face very different issues related to the cause of the admission and the acute illness. Even so, we identified 21 more studies than previously, and so identified many more interventions and exposures. The inclusion of observational studies enabled us to describe the effect of environmental and institutional factors, which had not been recognized previously.

However, the risk of bias was considerable in most studies, and so findings should be interpreted with care, with the efficacy of many strategies remaining unproven (Figure 2). Of particular concern was the lack of valid outcome measures of fluid intake and dehydration, validated in older people. We found that definitions of "fluids" varied, some studies defined fluids as those existing as liquids at room temperature, some considered fluids only if they were drunk, and in others, it was considered to be the water content of any fluids or foods imbibed. Similarly, different methods of assessing fluid intake were used, including use of graduated cups, weighing and estimating the proportion drunk from the amount served (but amount served was often not described). The period of time over which fluid intake was measured also varied, with fluid intake being measured at the point of intervention or at certain times of the day. Unless 24-hour fluid intake is recorded, evidence demonstrating that overall fluid intake has altered cannot be determined; it may simply increase at one time period at the expense of another. We recommend that validated methods of assessing fluid intake should be developed urgently. When considering dehydration, only biochemical markers (used in 2 studies[20,22]), have been validated in older people, whereas other clinical measures, including BIA assessments of TBW and TBR, urinary and mouth assessments, are unproven. We have recently completed and submitted a Cochrane Review that will report that clinical tests are ineffective in identifying dehydration in older people when compared with the reference standard of serum osmolality,[34,35] but we have identified a formula for serum osmolarity, calculated from routine biochemical parameters, that is a valid substitute for serum osmolality and thus a useful screening tool for dehydration.[2]

Conclusion

Although this review has been unable to demonstrate the effectiveness of many strategies because of the high risk of bias, our findings indicate that further investigations into dehydration prevention should be undertaken at the resident, institutional, and national policy levels. Further investigations of promising interventions at the resident and institutional levels, using high-quality adequately

powered RCTs with valid outcome measures, are required. We were particularly concerned about the lack of interventions to identify and target personal barriers to drinking, thus promoting person-centered care.[36] Although blinding at the level of intervention delivery is challenging, improved study designs, perhaps involving 3 arms ("usual care," intervention, and modified intervention) and more rigorous blinding of personnel at the different stages (random sequence generation, allocation, outcome assessment, and statistical analysis) may resolve some of the biases identified in this review. Further, robust cohort studies investigating the effects of national policies, home ownership, staffing levels, and training are required. Adequate research support has been recognized as a key challenge in developing high-quality research in nursing homes,[37] but this is what is required to improve fluid intake and hydration status in older care home residents.

Supplementary Data

Supplementary data related to this article can be found online at http://dx.doi.org/10.1016/j.jamda.2014.10.016.

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