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Published in:
Community Dentistry and Oral Epidemiology

DOI (link to publication from Publisher):
[10.1111/cdoe.12638](https://doi.org/10.1111/cdoe.12638)

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Publication date:
2022

Document Version
Accepted author manuscript, peer reviewed version

[Link to publication from Aalborg University](#)

Citation for published version (APA):
Overgaard, C., Bøggild, H., Hede, B., Bagger, M., Hartmann, L. G., & Aagaard, K. (2022). Improving oral health in nursing home residents: A cluster randomized trial of a shared oral care intervention. *Community Dentistry and Oral Epidemiology*, 50(2), 115-123. <https://doi.org/10.1111/cdoe.12638>

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"This is the peer reviewed version of the following article: Overgaard, C, Bøggild, H, Hede, B, Bagger, M, Hartmann, LG, Aagaard, K. Improving oral health in nursing home residents: A cluster randomized trial of a shared oral care intervention. *Community Dent Oral Epidemiol.* 2021; 00: 1– 9. which has been published in final form at [<https://doi.org/10.1111/cdoe.12638>]. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Use of Self-Archived Versions."

1 **Improving oral health in nursing home residents: A cluster randomized trial of** 2 **a shared oral care intervention**

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16 **Acknowledgements**

17 A grant from the Municipality of Aalborg, Denmark for part of this research is gratefully acknowl-
18 edged.

19 **Authors' contributions**

20 All authors contributed to the conception and design of the study. KA and LGN collected the data.
21 HB carried out the statistical data analysis and all authors contributed to the interpretation of the
22 study results. CO wrote the first draft of the manuscript with inputs from KA, BH and HB. All au-
23 thors critically revised the manuscript for important intellectual content and approved the final ver-
24 sion for publication.

25 **Conflict of interest**

26 CO, HB, KA and BH declare not conflict of interest. MG and LGN are employed at the Department
27 of Special Care Dentistry, Municipality of Aalborg. Funders and stakeholders had no role in study
28 design, analysis, interpretation of results, decision to publish, or preparation of the manuscript.

29

30 **Keywords**

31 Oral health, intervention, older people, nursing homes, randomized controlled trial

32 **Abstract**

33 Objectives

34 To compare a designated shared oral care intervention in a group of public nursing home residents
35 with a standard oral care program, focusing on levels of oral plaque and oral inflammation.

36

37 Methods

38 A cluster-randomized field trial was undertaken in 14 Danish public nursing homes. There were 145
39 participants included in the intervention group and 98 in the control group. We undertook a six-
40 month intervention based on the principle of situated interprofessional learning. The primary out-
41 comes were plaque and inflammation levels measured with the mucosal-plaque index (MPS); this
42 was assessed at baseline, after three and six months (end of intervention), and at follow-up (six
43 months post-intervention). The odds ratios (OR) and 95% confidence intervals (CI) were estimated
44 with ordinal regression.

45

46 Results

47 Socio-demographic characteristics and oral health status at baseline were comparable between the
48 two groups, with the exception of age: the intervention group were significantly younger than con-
49 trols (median 82 versus 87 years). After three and six months, those receiving the shared oral care
50 intervention had significantly lower plaque and inflammation than the control group. The adjusted
51 ORs for a reduction in MPS were 11.8 (CI:6.5–21.3) and 11.0 (CI: 5.8–20.9), respectively. At fol-
52 low-up, plaque levels and oral inflammation had approached the pre-intervention level, with no re-
53 maining statistically significant group differences.

54

55 Conclusions

56 The shared oral care intervention based on a situated learning perspective was effective in improv-
57 ing oral health among care home residents. However, after termination of the intervention, the ef-
58 fect quickly decreased. This confirms the challenges of achieving long-term improvement in oral
59 health in nursing home residents. An implementation strategy focusing on achieving changes at
60 both organizational and individual levels with persistent attention to oral healthcare seem required
61 for long-term improvement.

62 **Introduction**

63 Oral health has improved considerably among older citizens in middle- and high-income countries.
64 Hence, an increasing proportion of residents in nursing homes have preserved their natural dentition
65 after undergoing complex dental treatment throughout their life,¹ leaving them with greater and di-
66 verse need for daily oral care. For example, a Swedish study indicated that approximately 80% of
67 nursing home residents depend on assistance to carry out daily oral care.²

68
69 At the same time, increasing numbers of nursing home residents are diagnosed with dementia³ and
70 suffer from severe physical and or cognitive impairment. These diminish their ability to provide
71 sufficient daily oral self-care,⁴ but also may lead to rejection of professional assistance or inability
72 to cooperate.⁵ These and other barriers, such as lack of attendance, economic constraints, and com-
73 peting healthcare needs, also affect the provision of adequate dental treatment. This underlines the
74 need for prevention.^{5,6} Insufficient daily oral care influences the food intake, taste, and speech of
75 older people, and poor oral hygiene is associated with pain and poorer levels of wellbeing.^{7,8}

76
77 The importance of oral health in older people, including nursing home residents, is thus well estab-
78 lished, but maintaining good daily oral hygiene routines for nursing home residents presents a con-
79 siderable challenge.⁸ Health agencies in e.g. Denmark and United Kingdom recommend that nurs-
80 ing homes introduce policies and care plans to improve residents' oral hygiene and health.^{9,10}, but
81 the effectiveness of the traditional healthcare education of nursing home staff has been questioned.⁵
82 A 2016 Cochrane systematic review including 9 RCTs found evidence of insufficient strength to
83 draw robust conclusions about the effect of oral care interventions on residents' dental health, as as-
84 sessed by dental and denture plaque.¹¹ Furthermore, dentists have argued that oral health in older
85 people with natural dentition is "not on the radar".¹²

86
87 In Denmark, all nursing home residents are offered an oral health program,¹³ but this standard pro-
88 gram of daily oral hygiene has proved inadequate.¹⁰ A "shared oral care" intervention has therefore
89 been developed, based on recommendations by the Danish Health Authority¹⁰ and inspired by Lave
90 and Wenger's situated learning perspective,¹⁴ where learning about oral care is adjusted individu-
91 ally to the specific social interaction between the nursing home resident, nursing staff, and dental
92 staff. A comparison of the contents of the intervention and standard oral care program are shown in
93 Table 1.

94

95 The aim of this study was to investigate the efficacy of the shared oral care intervention, by compar-
96 ing the levels of dental plaque and oral inflammation in public nursing home residents receiving the
97 intervention with those of a comparable group receiving standard care. We hypothesized that the
98 nursing homes residents receiving shared oral care would have significantly lower levels of dental
99 plaque and inflammation in the oral mucosa than the controls.

100

101 **Methods**

102 Study Design

103 The study was a cluster randomized trial, initially including 15 public nursing homes from the same
104 large Danish municipality, each considered as a cluster (unit of randomization). For a nursing home
105 to be eligible, more than one-third of its residents needed to have a natural dentition. Residents with
106 dementia or suffering from other cognitive impairment were included based on their ability to coop-
107 erate during the intervention. Nursing homes were excluded if they specialized in care for residents
108 with psychogeriatric problems or drug addiction, had many short-term residents, already followed a
109 specific protocol on oral care, or currently took part in other comprehensive care innovation or qual-
110 ity development studies. Of 38 nursing homes, 15 from a mix of urban and rural settings were
111 deemed eligible and randomly allocated using the online tool www.randomization.com.¹⁵ One home
112 withdrew after randomization, but before any participants had been included. The CONSORT rec-
113 ommendations for cluster randomized trials were observed in the design, analysis, and reporting of
114 this study.¹⁶

115

116 Participants and recruitment

117 The trial was undertaken from August 2017 to August 2018. Recruitment was undertaken by two of
118 the authors. Residents were eligible if they met the following criteria: (1) age 65+; (2) at least one
119 natural tooth; (3) physically suitable for oral examination; (4) were expected to reside in the nursing
120 home during the entire study period; and (5) gave their informed consent to participate. Residents
121 with dementia or cognitive impairment were included if they were able to cooperate during the in-
122 tervention. Excluded from the trial were those who were; (1) day attendance only; (2) short-term
123 residents; (3) in a coma or terminally ill; or (4) expressing verbal or physical opposition to the oral
124 examination. Figure 1 shows a flowchart of the included nursing homes and participants. Character-
125 istics of the included nursing homes and residents is seen in Supplementary Table A.

126

127 Clinical measurements

128 The outcome variables were the levels of dental plaque and oral inflammation assessed by the mu-
129 cosal-plaque index (MPS)¹⁷, which is designed to assess oral care in older people. A pictorial man-
130 ual supports the assessment tool and recording uses a four-point scale for plaque accumulation (PS)
131 and a four-point scale for mucosal inflammation (MS). A total MPS score can be calculated as a cu-
132 mulative index by adding the two recordings. Scores can be summed to give the total MPS score;
133 this can range from 2 to 8.

134

135 The assessments were done at the nursing home by visual inspection of the oral cavity by a dentist
136 employed by the municipality, and using two dental mirrors and a portable light source. For the in-
137 tervention group, a joint assessment of each resident's physical and cognitive ability to perform suf-
138 ficient oral hygiene was undertaken at baseline by a care professional and a dentist.

139

140 Questionnaire-assisted interview

141 Data on age, gender, living conditions, results of a mini-mental state examination (MMSE),¹⁸ and
142 oral-health-related quality of life were collected using an interview questionnaire. This included
143 four interview questions focused on physical pain and physical disability from the validated
144 OHIP14¹⁹ and GOHAI²⁰ scales. (question nr. 3, OHIP14, and questions nr. 1, 2 and 12, GOHAI. As
145 the intervention addresses a complex problem and is likely to be affected by the local context where
146 it is applied, the project drew on the UK Medical Research Council's guidance on how to develop,
147 test, and evaluate complex interventions.²¹ Pilot and feasibility tests of the shared oral care interven-
148 tion were undertaken at a typical public nursing home in the same municipality. In cooperation with
149 management, nursing staff, and nursing home residents, the intervention and tools for data collec-
150 tion were tested and adjusted. The pilot test showed that due to the general cognitive and physical
151 impairment of residents, use of the full OHIP14¹⁹ and GOHAI²⁰ scales for data collection was inap-
152 propriate. Many of the residents found most questions in the two scales difficult to answer and some
153 meaningless or even threatening. Four questions from the OHIP14¹⁹ and GOHAI²⁰ scales were
154 identified as useful for the study purpose as well as possible and meaningful for the residents to an-
155 swer and subsequently use. Dental staff were trained in the use of the MPS index, and calibration
156 was undertaken to ensure the reliability of the clinical data.

157

158 Timing of measurements

159 Oral plaque and inflammation were assessed at baseline, three months, end of intervention, and at
160 follow-up six months post-intervention. If a participant had prostheses, these were examined for
161 plaque.

162

163 Ethics

164 Denmark has a universal, national, scientific ethics committee system, but according to Danish leg-
165 islation²², health research projects are only to be submitted for approval by the Danish, Scientific
166 Ethics Committee if the project includes human biological material. All other health research pro-
167 jects are solely based on informed consent by the participants. Danish legislation does not stipulate
168 universities, hospitals etc. to have their own ethics committees.

169

170 For this study, the Danish Scientific Ethics Committee was approached and testified in writing that
171 this project did not fall within the scope of the Committee's Act and approval by the Committee was
172 therefore not needed (Act No. 593 of 14/6/2011, cf. § 2, points 1–3).²² Written informed consent to
173 participation was obtained. For cognitively impaired residents, the closest relative or warden was
174 asked for deputy consent. The Municipality of Aalborg approved the study.

175

176 The study was notified to the Danish Data Protection Agency through XXX University's joint report
177 (trial registration number NCT03407339; protocol ID 2016-899/10-0250). This includes university
178 approval of participant information material and informed consent form to ensure agreement
179 with the Helsinki Declaration²³ and General Data Protection Regulation Legislation.²⁴ All data were
180 anonymized, treated confidentially, collected, and managed using Research Electronic Data Capture
181 (REDCap)²⁵.

182

183 Power calculation

184 Prior to the study, a power calculation was made using the program GPower (Universität Kiel).²⁶
185 Based on reductions in the MS-score ≥ 2 from 60% to 15% reported by an earlier Danish study²⁷,
186 and assuming an alpha of 0.05 and a power of 80%, a minimum sample size of 23 participants in
187 each group was estimated. Taking into account the cluster randomized design, an estimated 33%
188 drop-out rate due to the participants' frail condition and a median resident time of approximately
189 two years, we conservatively aimed to include at least 92 participants in each group.

190

191 Statistical analyses

192 Participants in the intervention and control groups were compared at baseline, using cross-tabula-
193 tion and chi-square tests for categorical variables and Kruskal–Wallis tests for ordinal and ratio-in-
194 terval scales, on account of the skewed distribution. Because the MPS is an ordinal-scaled variable,
195 the variables are described by their 25, 50 (median) and 75 percentile and total range. The group
196 lost to follow-up six months post-intervention was compared to those not lost, for baseline figures.
197 Only differences in age and the absence of dental pain were statistically significant. This was to be
198 expected, since mortality increases with age and dental pain may prevent oral care.

199

200 Changes were calculated in PS, MS, and MPS scores from baseline to the third and sixth months of
201 the intervention, and at the six-month follow-up. Differences between intervention and control nurs-
202 ing homes were estimated as odds ratios and 95% confidence intervals in ordinal logistic regression
203 model for a one-unit improvement in the intervention group. The changes were further adjusted for
204 age and sex in multivariable ordinal regression models to account for confounding factors with re-
205 spect to age and gender introduced by dropouts or difference in age at baseline. Further adjusting
206 was not attempted due to the number of missing data for potential confounding factors.

207

208 Analysis was conducted as intention-to-treat, but without imputation of the missing data resulting
209 from the losses to follow-up, using STATA version 14 (StataCorp, College Station, USA). The as-
210 sumption of proportional odds was verified. Since the sample was stratified by nursing home, stand-
211 ard errors were estimated using the survey prefix commands. No survey prefix exists for Kruskal-
212 Wallis test, but as the differences between survey and ordinary chi-square tests were negligible, this
213 is not judged to be of importance.

214

215 **Results**

216 Background data on the study sample by group are shown in Table 2. The groups did not show sta-
217 tistically significant differences in any variable, except for age, whereby the intervention group
218 members were younger. Overall, the study included an elderly population with approximately two-
219 thirds or more reporting no dental pain and no limitation of food intake. Just over half of the partici-
220 pants reported no biting or chewing problems. Drop-out analysis (Supplementary Table B) showed

221 that those lost to follow-up were older and were more likely to experience dental pain; otherwise,
222 the two groups were alike, including MS scores at baseline.

223

224 The recorded data on MS, PS, and MPS are summarized in Table 3 and show similar scores in the
225 intervention and control groups at baseline. Unchanged scores were seen for MS, PS, and MPS in
226 the control group, but these decreased in the intervention group after three and six months, then re-
227 turned almost to the baseline level at the follow-up, six months post-intervention.

228

229 The outcome of the intervention is shown in Table 4, where the odds for a one-unit decrease (im-
230 provement) in scores in the intervention group in relation to the odds of obtaining a one-unit de-
231 crease (improvement) in scores in the control group are expressed by the odds ratio (OR). The prob-
232 ability of an improved score for MS, PS, and MPS was approximately 10 times greater in the inter-
233 vention group than in the control group after three months of intervention, and approximately 9–10
234 times greater at the end of the six month intervention. However, at follow-up the odds were lower
235 than during the intervention, almost equal expressed by an OR at approximately 1 for MS. The PS
236 was still 2.5 times higher in the intervention group, with statistical significance.

237

238 **Discussion**

239 Principal findings

240 The intervention significantly reduced plaque and inflammation in the intervention group but at fol-
241 low-up, a relapse in the direction of the pre-intervention level was seen. A reduction in the median
242 MPS value from 6 to 4 was observed in the intervention group, which fulfill the criteria of an ac-
243 ceptable oral care intervention. The MPS index is developed to be applied in groups of individuals.
244 A MPS value of 2-4 is considered to be acceptable whereas higher scores are unacceptable.¹⁷ How-
245 ever, the score relapsed towards baseline level 6 month after terminating the intervention which un-
246 derlines the lack of sustainability of the intervention and thus the need for persistent attention to oral
247 healthcare.

248 Strengths and weaknesses of the study:

249 One strength of this study is its randomized controlled design as undertaking of a RCT is highly
250 challenging in populations of institutionalized, care-dependent older people, in terms of obtaining
251 informed consent and ensuring adherence to protocol. We used cluster randomizing, as in most

252 comparable studies.¹¹ While this is less optimal than individual random allocation of participants,
253 cluster randomization is still useful for minimizing the risk of confounding, if the effects of cluster-
254 ing (as in this case) are incorporated in the data analysis.¹⁶

255
256 Another strength is the application of gingival and mucosal condition as primary outcome
257 measures: these are more long-term measures than the amount of plaque, which is a momentary
258 measure of oral hygiene. Moreover, the intervention design and testing followed the recommenda-
259 tions for complex interventions,²¹ all data were collected by the same small team, and the compre-
260 hensive calibration of the MPS score ensured high reliability in the clinical data.

261
262 The study also has several limitations. We did not have access to medical records or data on the
263 general health, medication, disabilities, hospital (re-)admissions, etc. of the study population, and
264 we were thus unable to take into account all the factors that could affect the intervention. This may,
265 however, be outweighed by the study design, which would distribute potential confounders ran-
266 domly in the intervention and control group.

267
268 Strengths and weaknesses in relation to other studies, discussing particularly any differences in re-
269 sults

270 As Figure 1 shows, the drop-out at follow-up was high, due to the death of participants. Comparable
271 rates have been reported in similar studies,²⁸ reflecting the generally poor health among nursing
272 home residents.²⁹ Also the amount of missing data was considerable. Several residents developed
273 severe cognitive impairment during the study period, and were unable or unwilling to respond to
274 questions. This is reflected in the high proportion of missing data, despite our comprehensive pre-
275 testing of the data collection tools and data collection process. The higher level of missing data in
276 the intervention group is related to this but otherwise unexplained.

277
278 Overall, existing RCT studies of educational interventions in this field vary greatly in their care and
279 educational approaches, inclusion criteria, and outcome measures, with some studies using only
280 measures of nursing staff attitudes and knowledge³⁰, without health-oriented outcome measures¹¹.
281 Healthcare systems and the financing of oral healthcare differ. Some studies were limited by their

282 sample size,³¹ and others date back almost 20 years.³² Furthermore, highly care-dependent and cog-
283 nitively impaired nursing home residents, who may find it difficult to follow care instructions or
284 may resist support for oral care, were often excluded.^{11,31}

285

286 In this study, we took into account recommendations from the National Health Agency¹⁰ and prior
287 studies on educational oral health programs^{5,27}. The primary recommendations were implementing
288 an individual oral care plan and situated learning with individual instructions to residents and care
289 professionals. This intervention followed guidance on the development and evaluation of complex
290 interventions²¹ and was based on an explicit and strong theoretical base.¹⁴ Our findings are in line
291 with two more recent RCTs reporting the positive effect of different oral health education programs
292 on oral health-related variables,³⁴ one including ultrasound baths²⁸.

293

294 Meaning of the study: possible mechanisms and implications for clinicians or policymakers

295 The study shows that situated learning, shared responsibility, and interprofessional collaboration on
296 oral care can significantly improve oral health among nursing home residents, also among those
297 who are dependent on professional help for daily oral hygiene.

298

299 The concept of situated learning appears useful as a framework for interprofessional learning and
300 collaboration in nursing homes and applicable to practice. A positive effect was seen after only a
301 short intervention period but, as also shown previously,³⁴ this effect may vanish just as fast after the
302 intervention period ends and the continuous focus and collaboration on oral healthcare stops.

303

304 Improvement of oral health among nursing home residents remains a challenge. New care routines
305 are difficult to maintain in nursing homes, where staff may sometimes be overstretched and change
306 frequently. Furthermore, the complexity of caring for physically impaired and cognitively impaired
307 nursing home residents with major interrelating geriatric issues—such as rapid physical and neu-
308 rocognitive decline, comorbidities, noncompliance with medication, and falls³⁵ is a challenge to the
309 implementation of new oral care routines. The qualitative process evaluation³⁶ of the shared oral
310 care intervention has highlighted a number of such important barriers, and thus provides some ex-
311 planation of the rapid and almost total relapse six months after the end of this in-depth intervention.
312 The findings indicate that a continuous collaboration and coordination of preventive and shared oral

313 care on both an individual and organizational level are important mechanisms in order to secure a
314 lasting improvement of oral healthcare status in nursing homes.

315

316 The situated learning perspective was very suitable for implementing the intervention on an individ-
317 ual level and prompted development of new and improved care practices among the frontline per-
318 sonnel. For this change to occur, the more in-depth assessment of the residents need for support for
319 oral care and high visibility of a jointly developed care plan appears vital. However, implementa-
320 tion strategy on an organizational level is needed to secure coordination and collaboration between
321 municipality departments and different management levels.

322

323 Unanswered questions and future research

324 This study adds to our knowledge of how improved oral care for nursing home residents can be ob-
325 tained, but unanswered questions nonetheless remain. Future studies should include the impact of
326 improved oral health on general health, hospital admissions, and other features of nursing home res-
327 idents. The impact of the intervention on the burden of dental treatment should also be investigated.
328 Furthermore, an evaluation of cost-effectiveness is recommended.

329

330 **Conclusion**

331 This shared oral care intervention, based on principles of situated interprofessional learning, was
332 found to reduce plaque and inflammation in the intervention group. A relapse at follow-up in the
333 direction of the pre-intervention level shows, however, that long-term improvement in oral health
334 for nursing home residents calls for a systematic implementation strategy, and that persistent atten-
335 tion to oral healthcare needs seems to be needed.

336

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Table 1. Characteristics of the shared oral care intervention and standard oral care

	Shared oral care (intervention)	Standard oral care (control)
Education on oral health care	Prior to intervention, all staff members attended a lecture on oral health care, performed by the project dentist and a dental practitioner	E-learning is available
Assessment of oral hygiene	Mucosal Plaque Score (MPS) was recorded on each visit by the dental practitioners	Mucosal Plaque Score (MPS) is recorded at the start and end of the intervention
Cognitive and physical function level assessment related to oral care	Including all residents Residents with dementia /cognitive impairment were included based on their ability to cooperate. This was jointly assessed by the dental practitioner and a care professional close to the resident	No assessment
Type of support needed for sufficient oral care	Assessment of need for verbal and physical guidance, or full support, by dental practitioner and care professionals. The assessment was noted in an individual oral health care plan for all residents	Preliminary oral health care plan prepared. Instructions offered on request
Preventive oral care	Situated learning in oral care performed at specific time intervals over 6 months in the nursing home: Month 1–2: weekly Month 3–4: every 2 weeks Month 5–6: every 3 weeks Situated Learning is learning about oral care, adjusted to the specific social interaction between the nursing home resident, nursing staff, and dental staff	Adjustment of oral health care plan as required at patient examination
Individual oral care plan	The oral health care plan was based on resident's level of functioning and oral hygiene status at each visit (jointly assess by dental practitioner and care professional) and adjusted throughout the intervention period. Laminated version was placed in the residents bathroom and included instructions on tooth brushing, use of ID brushes, and cleaning of prosthetics to both the resident and the care professionals depending on the residents' need for support	Oral health care plan prepared based on assessment of what support is needed
Documentation	During intervention, all data (MPS) entered into internal diary/protocol by the dental practitioner. MPS reported in care professionals' journal system	Oral health care plan documented in dental and care professionals' journal

Figure 1. Flow chart of nursing home and participant inclusion
(submitted as a separate file)

Table 2. Baseline characteristics of participants in 14 nursing homes, randomized to intervention or control. Figures given as n and % or median (25-75 percentile) (marked with # in heading). Missing data in brackets (intervention/control)

	Intervention group		Control group		P-value
	n or median	% or 25-75 percentile ()	n or median	% or 25-75 percentile ()	
No of participants	145	100	98	100	
Gender: female	84	57.9	55	56.1	0.781
Age (years) #	82	(76-89)	87	(81-90)	0.004
Living alone (67/18)	62	79.5	62	77.5	0.763
MMSE (76/29) #	19	(14-23)	21	(15-24)	0.219
No dental pain (67/18)	66	84.6	75	93.8	0.073
No biting or chewing problems (67/18)	54	70.1	53	66.3	0.605
No limitation on food intake (67/18)	64	84.2	65	82.3	0.743
No feeling of teeth/gum sensitivity (67/18)	58	74.4	64	80.0	0.409
Denture upper jaw (4/0)	84	59.2	62	63.3	0.515
Denture lower jaw (4/0)	120	85.1	80	81.6	0.482
Level of physical function (4)					
Self-helped	43	31.0			
Partly dependent	53	38.1			
Dependent	43	31.0			
Cognitive function according to nursing staff (4)					
No cognitive impairment	36	25.5			
Light cognitive impairment	38	27.0			
Moderate cognitive impairment	40	28.4			
Severe cognitive impairment	27	19.2			

median (25-75 percentile)

Table 3. MS, PS, and MPS scores at baseline, after 3 months, 6 months (end of intervention period), and at follow-up (six-month post-intervention), divided by intervention or control group and described by median and (25-75 percentile); range given by low:high.

	MS* score		PS** score		MPS score	
	Intervention	Control	Intervention	Control	Intervention	Control
Baseline	3 (3-4) 2:4	3 (3-4) 2:4	3 (2-4) 1:4	3 (2-4) 1:4	6 (5-8) 2:8	6 (5-8) 2:8
3 months	2 (1-3) 1:4	3 (2-4) 1:4	2 (1-2) 1:4	3 (2-3) 1:4	4 (3-5) 2:7	6 (5-7) 2:8
6 months	2 (1-3) 1:4	3 (2-4) 1:4	2 (1-2) 1:4	3 (2-3) 1:4	4 (3-5) 2:7	6 (4-7) 2:8
Follow-up	3 (2-3) 1:4	3 (2-3) 1:4	2 (2-3) 1:4	3 (2-3) 1:4	5 (4-6) 2:8	6 (5-7) 2:8

*Criteria for mucosal score (MS)¹⁷(1) Normal appearance of the gingiva and oral mucosa, (2) Mild inflammation, (3) Moderate inflammation, (4) Severe inflammation

**Criteria for Plaque Score (PS) on teeth and dentures¹⁷(1) No easily visible plaque, (2) Small amounts of hardly visible plaque (3) Moderate amounts of plaque (4) Abundant amounts of confluent plaque

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Table 4. Intervention and changes in PS, MS, and MPS scores from baseline to 3 months, end of intervention and follow-up 6 months post intervention.

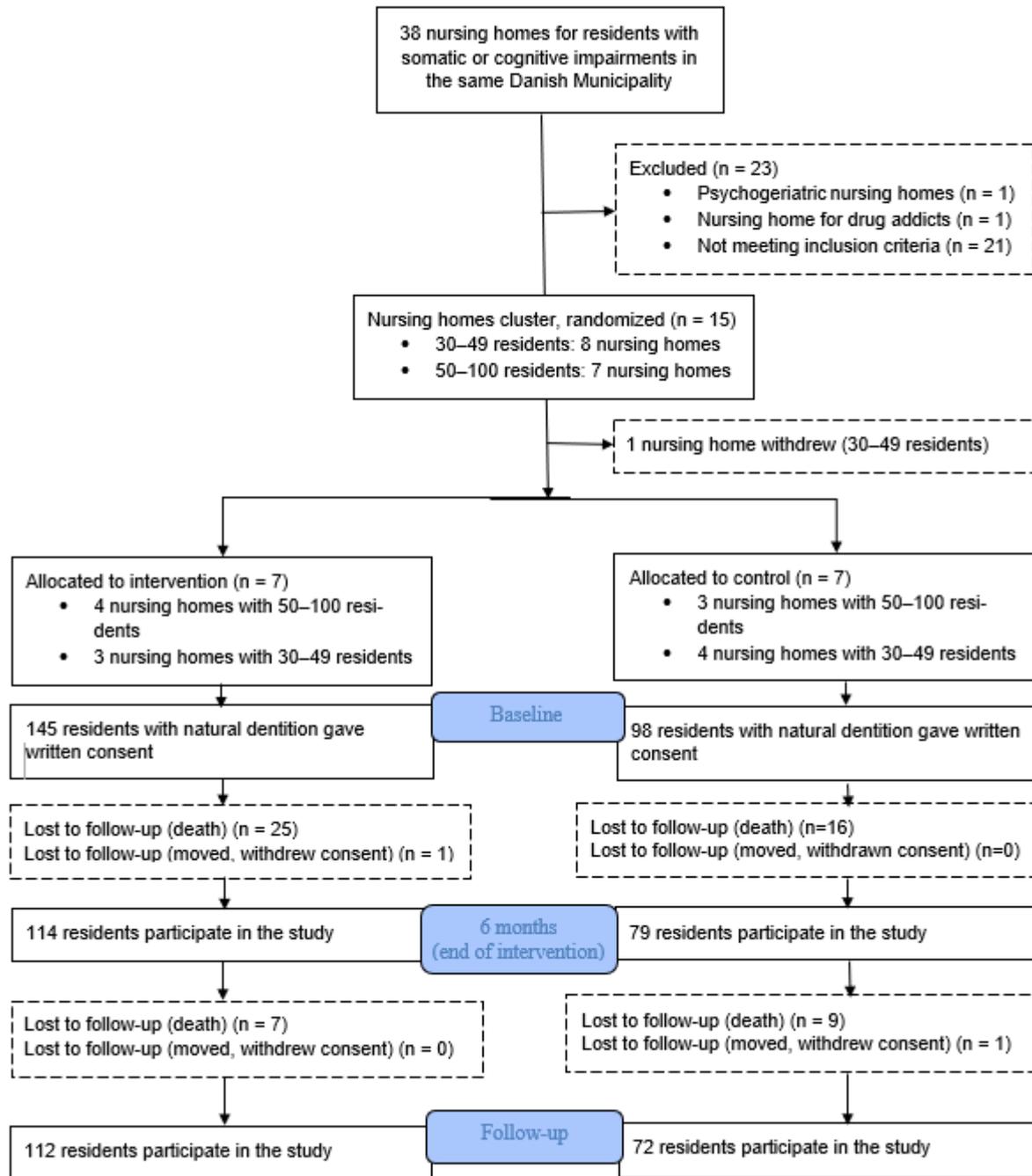
Baseline to		MS score	PS score	MPS score
3 months (128 I, 89 C)	OR (A)	9.02 (4.99–16.30)	10.58 (5.80–19.28)	11.56 (6.53–20.46)
	OR (B)	9.50 (5.18–17.43)	10.31 (5.58–19.06)	11.79 (6.52–21.32)
End of intervention (114 I, 79 C)	OR (A)	8.86 (4.57–17.17)	8.46 (4.61–15.52)	11.15 (5.99–20.75)
	OR (B)	9.10 (4.61–17.96)	8.37 (4.43–15.83) *	11.02 (5.81–20.91)
6 months post-intervention (98 I, 64 C)	OR (A)	1.06 (0.58–1.93)	2.47 (1.34–4.53)	1.67 (0.96–2.92)
	OR (B)	1.09 (0.59–2.03)	2.40 (1.29–4.47)	1.68 (0.95–2.99)

Estimated OR and 95% confidence intervals for a unit decrease in PS, MS, and MPS explained by belonging to the intervention instead of the control nursing home groups, results of ordinal regression models. Model A is unadjusted; model B adjusted for age and gender. I and C is the number of residents at the intervention and control nursing home included in the analyses and deviate due to missing data

*Failed to meet assumption of proportional odds

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Figure 1. Flow chart of nursing home and participant inclusion



SUPPLEMENTARY MATERIAL

Supplementary Table A: Characteristics of included nursing homes and residents

	Maximal number of residents	N with natural dentition / N included (%)	Nursing home characteristics
Intervention group			
1	45	25/19 (76%)	Under conversion into dementia nursing home
2	46	31/18 (58%)	Somatic Dementia section
3	66	35/24 (69%)	Somatic
4	72	39/25 (64%)	Somatic Dementia section
5	100	59/28 (47%)	Somatic Dementia section
6	36	23/9 (39%)	Dementia nursing home
7	83	40/22 (55%)	Somatic Dementia section
Control group			
8	75	48/21 (44%)	Somatic Dementia section
9	72	33/14 (42%)	Somatic Dementia section
10	50	29/17 (59%)	Somatic
11	45	31/19 (61%)	Somatic
12	25	17/6 (35%)	Somatic Dementia section
13	30	23/12 (52%)	Somatic Dementia section
14	48	22/9 (41%)	Somatic Dementia section

Supplementary Table B

Baseline characteristics of participants in 14 nursing homes, by retention in study and loss to follow-up. Figures given as n and % or median (p25-p75) (marked # in heading).

	Retention		Lost to follow-up, (from baseline to 6 months post-intervention)		P-value
	n	%	n	%	
No of participants (missing in brackets)	184	100	59	100	
Gender - female	109	59.2	30	50.9	0.257
Age (years) #	83	(81–97)	87	(81–91)	0.007
Living alone (59/26)	99	79.2	26	75.8	0.669
MMSE (73/32) #	20	(15–24)	21	(13–24)	0.824
No dental pain (59/26)	115	92.0	26	78.8	0.029
No biting or chewing problems (60/26)	84	67.7	23	69.7	0.830
No food intake limitations (61/27)	103	83.7	26	81.3	0.737
No feeling of sensitivity around teeth/gums (59/26)	96	76.8	26	78.8	0.809
Denture upper jaw (3/1)	70	38.5	24	41.4	0.692
Denture lower jaw (3/1)	27	14.9	12	20.7	0.301
MS (2/1) #	3	(2–4)	3	(2–3)	0.520
PS (2/1) #	3	(3–4)	3	(2.75–4)	0.954
MPS (2/1) #	6	(5–8)	6	(5–8)	0.716

*included in study from baseline, including three participants without baseline measurement of MPS

median (p25–p75)