

# The impact of hospitalization on oral health: a systematic review

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## Abstract

**Background:** Poor oral health of hospitalized patients is associated with an increased risk of hospital-acquired infections and reduced life quality.

**Objectives:** To systematically review the evidence on oral health changes during hospitalization.

**Data sources:** Cochrane library, Medline, OldMedline, Embase and CINAHL without language restrictions.

**Study eligibility criteria:** Observational longitudinal studies.

**Data appraisal and synthesis methods:** Two independent reviewers screened studies for inclusion, assessed the risk of bias and extracted data. Risk of bias was assessed using the Newcastle–Ottawa assessment scale. A narrative synthesis was conducted.

**Results:** Five before and after studies were included. The data suggest a deterioration in oral health following hospitalization with an increase in dental plaque accumulation and gingival inflammation and a deterioration in mucosal health.

**Limitations:** While before and after studies are at a general risk of bias, other specific study characteristics were judged to have a low risk of bias. However, methodological issues such as unvalidated outcome measures and the lack of assessor training limit the strength of the evidence.

**Conclusion:** Hospitalization is associated with a deterioration in oral health, particularly in intubated patients.

Key words: hospital-acquired infections; hospitalization; oral health; oral hygiene

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Maintenance of oral health is important for hospitalized patients. Oral health affects quality of life (Llewellyn & Warnakulasuriya 2003, Yu et al. 2008) and personal dignity and this impact appears to be more severe in medically compromised or hospitalized patients (Locker et al. 2002, Duke et al. 2005, Ingram et al. 2005, McMillan et al.

2005, Mulligan et al. 2008). Not surprisingly, poor oral health or dysfunction can also have a negative effect on nutritional status (Chai et al. 2006, Rauen et al. 2006, Gil-Montoya et al. 2008), while improvement of dental status increases the levels of nutritional markers (Wostmann et al. 2008).

Poor oral health and oral hygiene can also contribute to an increased incidence of hospital-acquired infections, particularly respiratory diseases (Shaw 2005, Azarpazhooh & Leake 2006). Furthermore, interventions that maintain or improve oral health can reduce the incidence of ventilator-associated pneumonia (Chan et al. 2007). Similarly, benefits from effective oral hygiene have also been documented for pneumonia in non-ambulatory (Scannapieco 2006) or elderly patients (Sjogren et al.

2008). Therefore, oral health requires management during in-patient care.

Although oral health can be maintained during hospitalization with proper training of the caregivers (Peltola et al. 2007), there are difficulties in the provision of adequate oral care in hospitals and institutional facilities. Barriers to effective oral care reported by caregivers include the low priority of oral care (Grap et al. 2003, Landstrom et al. 2009), fear of causing pain or injury to the patients (Jablonski et al. 2009), the perception that oral care does not provide significant benefits (Binkley et al. 2004, Jones et al. 2004), patients' resistive behaviours (Jablonski et al. 2009), inadequate nurse staffing (Grap et al. 2003) and lack of supplies (Jablonski et al. 2009). To encourage the provision of effective oral care,

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guidelines have been published with recommended protocols for hospitalized patients (Fiske et al. 2000, Department of Health 2003, Tablan et al. 2004, Department of Health 2007, NICE 2008). However, the adherence to oral health protocols is reported to be low (Grap et al. 2003, Rello et al. 2007).

While oral health status during hospitalization is clearly an important public health issue, no systematic review has been conducted to critically evaluate the research data on this topic. The aim of this systematic review was therefore to address the focused question: what is the effect of hospitalization on oral health?

## Methods

We considered as eligible longitudinal prospective observational studies in individuals of all ages being hospitalized that assessed changes of the following outcomes: tooth loss, any measures of periodontal health, dental caries and stomatological diseases. Intervention studies, cross-sectional studies, case reports and reviews were excluded. Studies reporting specifically on patients with psychiatric disorders or on patients receiving treatment with frequently observed oral complications (e.g. chemo- or radiotherapy) were excluded.

### Search strategy (Appendix 1)

The literature search for relevant articles was performed using Ovid MEDLINE and Ovid OLDMEDLINE (dating from January 1950 to January 2010), Cumulative Index to Nursing and Allied Health Literature (CINAHL) (dating from 1982 to January 2010), Cochrane Library (up to 2010) and EMBASE (dating from 1981 to January 2010). We designed a sensitive search strategy as we anticipated that coding for relevant search terms was not well developed. The bibliographies of all potentially relevant studies and review articles were also searched. Handsearching was performed in the following journals: *Community Dentistry and Oral Epidemiology*, *Gerodontology*, *Journal of Disability and Oral Health and Special Care in Dentistry*. No language restrictions were applied on the search. When necessary, we corresponded with the first authors of studies to elicit further information. One

reviewer (E. T.) scanned the titles and abstracts of the studies identified by the search. When a study seemed to meet the eligibility criteria or information was insufficient to exclude, full-text articles were obtained.

### Data extraction

Two reviewers (E. T., E. A.) independently screened all full-text articles. They also extracted data from the included studies in specially designed forms. Disagreements that could not be resolved were arbitrated by a third author (I. N.). Training of reviewers for screening, study eligibility and quality assessment was performed by an experienced systematic review methodologist (I. N.). The calibration of the examiners was made on five randomly selected studies included for full paper screening.

### Quality assessment

Studies were assessed by the two reviewers (E. T., E. A.) using the Newcastle–Ottawa scale for cohort studies (Wells et al. 2008). As we did not find studies with a non-exposed comparison group, we excluded the comparability section of the scale. In addition, we assessed whether a power calculation was reported for each study and, if so, the magnitude of a change that the study was powered to detect. Separately, we assessed the quality of the outcome assessment in terms of the validity of the measure of oral health and conduct/reporting of assessor training in the measure.

### Data synthesis

Pooling of data was based on the study design, population characteristics, types of oral hygiene measures used in the hospital units, setting characteristics of the studies and the outcomes measured. We anticipated substantial heterogeneity between studies and planned a narrative synthesis of data.

## Results

A total of 9689 potentially relevant review records were found. Nine thousand six hundred and fifty-two were excluded on the basis of their titles or abstracts and the full papers of 37 studies were finally included (Fourrier et al. 1998, Franklin et al. 2000, Dennesen et al. 2003, Munro et al. 2006, Prendergast et al. 2009) (Fig 1). Inter-examiner agreement for eligibility of included papers was 100%. The most common reasons for exclusion were no reported oral health outcomes or study design (e.g. intervention, cross-sectional or retrospective).

### Quality assessment

The agreement between reviewers on each aspect of the Newcastle–Ottawa scale was 100%. In all studies, the representativeness of the cohort was found to be adequate and the demonstration of outcomes of interest was made at baseline. Adequacy of follow-up was judged to be good in all studies, considering the healthcare setting, despite the dropouts encountered. This was based on the fact that the reasons for dropout were either death or discharge from the hospital unit (Franklin et al.

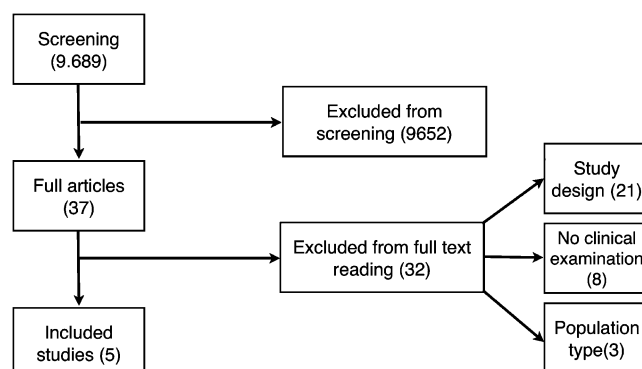


Fig. 1. Flowchart of inclusion of studies.

2000, Munro et al. 2006, Prendergast et al. 2009). The assessment of outcome was judged to be adequate for all studies in terms of the Newcastle–Ottawa criteria and the follow-up period was long enough for the assessment of dental plaque and gingival health changes. This period was arbitrarily defined as a minimum of 3–5 days (Eilers et al. 1988, Fitch et al. 1999), although too brief to detect either dental caries incidence or changes in periodontitis. The validity of the outcome measures was more problematic including the use of subjective indices based on visual analogue scale measurements (Munro et al. 2006), assessments of gingival health with tools designed for population epidemiology (Dennesen et al. 2003) and the use of partial recordings with indices not designed for this purpose (Fourrier et al. 1998). In addition, examiner training was reported in only one study (Prendergast et al. 2009).

#### Population characteristics

Four studies were located in ICU units (Fourrier et al. 1998, Franklin et al. 2000, Munro et al. 2006, Prendergast et al. 2009) and one investigated a mixed population of patients in ICU and a cardiosurgical ward (Dennesen et al. 2003). The population in three studies was intubated (Fourrier et al. 1998, Munro et al. 2006, Prendergast et al. 2009), while in two, the population was both intubated and not intubated (Franklin et al. 2000, Dennesen et al. 2003). One study investigated children only (Franklin et al. 2000), while the remainder reported on adult populations. The duration of the hospitalization ranged from 5 to 20 days (Table 1).

#### Oral care regime

There was marked variability in oral care protocols including sterile cloth drenched with 0.9% saline (Dennesen et al. 2003), rinsing with sterile water (Fourrier et al. 1998), foamsticks moistened with water (Franklin et al. 2000) and foam swabs or child toothbrushes with toothpaste, sterile water or normal saline (Prendergast et al. 2009). In one study, there were no details of the oral hygiene measures applied (Munro et al. 2006). The frequency of oral care provision ranged between two and six times per day.

#### Study setting

Two studies were based in the USA (Munro et al. 2006, Prendergast et al. 2009), one in the UK (Franklin et al. 2000), one in France (Fourrier et al. 1998) and one in the Netherlands (Dennesen et al. 2003).

#### Power calculation

Power calculation was reported in only one study (Franklin et al. 2000). The sample size was estimated to identify a difference of 10 plaque-covered surfaces significant at 5% with a power of 90% using a standard deviation of 15.0 for plaque on all tooth surfaces.

#### Dental plaque accumulation

Four out of the five included studies reported on the changes of dental plaque accumulation during the hospitalization period (Fourrier et al. 1998, Franklin et al. 2000, Munro et al. 2006, Prendergast et al. 2009). Each study used a different measure. In one study, no differences were observed during the observational period (Prendergast et al. 2009). Three studies reported increasing levels of plaque accumulation during hospitalization (Fourrier et al. 1998, Franklin et al. 2000, Munro et al. 2006), which was statistically significant in two (Fourrier et al. 1998, Franklin et al. 2000). The proportion of sites with abundant dental plaque (scores more than 2) increased from 23% at baseline to 93% at day 10 (Fourrier et al. 1998) and the other study showed a mean difference of 3.3% in the O'Leary index ( $p = 0.001$ ) (Franklin et al. 2000).

#### Gingival inflammation

Three studies reported on the levels of gingival inflammation during hospitalization using different indices (Franklin et al. 2000, Dennesen et al. 2003, Prendergast et al. 2009). Two of the studies found statistically significant increases in the severity of gingival inflammation [OAG median value changes from 1 at baseline to 2 at day 14 (Prendergast et al. 2009) and a mean difference of the sites presenting gingival inflammation of 1.4 ( $p = 0.006$ ) (Franklin et al. 2000)]. One study reported “no statistically significant changes,” although no data were presented (Dennesen et al. 2003).

#### Periodontal disease

One study reported on the severity of periodontal disease using an index of assessment of treatment needs, but found no statistically significant change (Dennesen et al. 2003). However, this index was designed for epidemiology and is insensitive to small changes over short durations of time (Holmgren 1994).

#### Caries incidence

Two studies assessed the incidence of dental caries in hospitalized patients and reported no statistically significant changes following hospitalization (Franklin et al. 2000, Munro et al. 2006).

#### Stomatological disease

Two studies evaluated the incidence of stomatological diseases (Dennesen et al. 2003, Prendergast et al. 2009). Both studies found a statistically significant increased incidence of mucositis intubated patients but not in non-intubated patients (Dennesen et al. 2003).

### Discussion

#### Statement of principal findings

The five included studies suggest that oral health deteriorates following hospitalization. Most studies were set in intensive care units including both intubated and non-intubated patients. Dental plaque accumulation and gingival and mucosal inflammation were the main oral health aspects affected in the examined populations and the findings were more evident in studies reporting on intubated patients (Franklin et al. 2000, Dennesen et al. 2003) (Table 2).

#### Strengths and weaknesses of the review

We conducted a sensitive search including multiple electronic databases without language restriction and supplemented by handsearching. However, we were only able to identify five eligible studies enrolling a total of 271 patients. We were unable to retrieve two papers for the full article reading. Their abstracts were unavailable in the databases and no records of the journals were found in the British Library. Other strengths of the review are that we appraised the methodological quality and risk of bias of included studies including the validity of the outcome measures in relation to oral health changes.

Table 1. Included study characteristics

Authors (type of study)	1. Participants: 2. Recruited 3. Age mean (range) 4. Dropouts 5. Dependency/intubated 6. Duration of hospitalization (observation period)	1. Type of oral care provided: 2. Personnel 3. Oral care regime 4. Frequency 5. Duration 6. Adherence assessed	1. Hospital department 2. Country	1. Type of oral care changes assessed (index used) 2. Assessor 3. Examiner training 4. Blinding	Quality assessment scoring
Prendergast et al. (2009) <sup>48</sup> (cohort study)	1. 45 patients 2. 49.16 years (18–85) 3. D0: 45 patients D10: 31 patients D10: 13 patients 4. Fully dependent (intubated) 5. 15.1 days (1–37) (12.8 days (1–31)) 1. 66 patients 2. 55 years (25–93) 3. D0: 66 patients D4: 37 patients D7: 21 patients 4. Fully dependent (intubated) 5. Not reported (4–7 days)	1. Nurse 2. Foam swabs or child toothbrush, toothpaste, sterile water or normal saline and lip lubricant. 3. Every 4–6 h 4. 5–10 min. 5. Yes (nurses' notes) 1. Not reported 2. Not reported 3. 2.58 times per day (0–7 range) 4. Not reported 5. Not reported	1. Neuroscience ICU 2. USA	1. Dental plaque accumulation, gingival inflammation, dental health (OAG index) 2. Nurses (3) 3. Yes 4. Yes	5/5
Munro et al. (2006) (cohort study)	1. 66 patients 2. 55 years (25–93) 3. D0: 66 patients D4: 37 patients D7: 21 patients 4. Fully dependent (intubated) 5. Not reported (4–7 days)	1. Not reported 2. Not reported 3. 2.58 times per day (0–7 range) 4. Not reported 5. Not reported	1. Respiratory ICU 2. USA	Dental plaque accumulation, gingival inflammation, gingival bleeding, purulence, candidiasis, calculus, caries, stain (Oral health assessment tool) Not reported Not reported Not reported 1. Periodontal disease (CPTN) and Oral mucositis (Quantitative scale of oral mucositis) 2. Dental hygienists (2) 3. Not reported 4. Not reported	5/5
Dennessen et al. (2003) (cohort study)	ICU: 24 patients CS: 20 patients ICU: 58 years (SD 18.6) CS: 61 years (41–77) Not reported ICU: intubated CS: intubated for < 12 h ICU: 20.4 days (SD 7.5) (14 days) CS: Not reported	ICU: Not reported CS: Not reported ICU: Sterile cloth drenched with NaCl 0.9% CS: Not reported ICU: Not reported CS: Not reported ICU: 2/day CS: Not reported Not reported	ICU and Cardiosurgery Ward, the Netherlands	1. Caries, missing, filled teeth (DMF index), dental plaque accumulation (O' Leary index), gingival inflammation (binary assessment), spontaneous gingival bleeding (binary assessment) 2. Author 3. Not reported 4. Not reported 1. Dental plaque accumulation (Plaque index from one tooth) 2. Not reported 3. Not reported 4. Not reported	5/5
Franklin et al. (2000) (cohort study)	1. 59 children 2. 4.8 (1–16) 3. 5 children 4. 12 children orally intubated. The rest nasally intubated or not intubated 5. 7.4 days (SD 6.2)	1. Nurses 2. Foam sticks moistened with water. Antiseptics and antifungals were used at the discretion of the nurses. 3. Every 4–6 h 4. Not reported 5. Not reported	1. Paediatric ICU 2. UK	1. Caries, missing, filled teeth (DMF index), dental plaque accumulation (O' Leary index), gingival inflammation (binary assessment), spontaneous gingival bleeding (binary assessment) 2. Author 3. Not reported 4. Not reported 1. Dental plaque accumulation (Plaque index from one tooth) 2. Not reported 3. Not reported 4. Not reported	5/5
Fourrier et al. (1998) (cohort study)	1. 57 patients 2. 49 years (18–83) 3. 29 patients 4. 44 patients intubated (77%) 5. 14 days (2–82) (15 patients for 5 days and 13 patients for 10 days)	1. Not reported 2. Not reported 3. Not reported 4. Not reported 5. Not reported	1. ICU 2. France	1. Dental plaque accumulation (Plaque index from one tooth) 2. Not reported 3. Not reported 4. Not reported	5/5

Key: "D0, D1, D4, D5, D7, D10": Baseline, Day 1, Day 4, Day 5, Day 7, Day 10.

CU, intensive care unit; CS, cardiosurgical ward; OAG, oral assessment guide; CPTN, Community Periodontal Index for treatment needs; DMFT index, decayed, missed and filled teeth index.

Table 2. Reported results from included studies

Authors	Number of patients and duration of observation period	Dental plaque (index)	Gingival health (index)	Periodontal health (index)	Caries (index)	Stomatological disease incidence (index)	Other outcome measures
Prendergast et al. (2009)	D0: 45 patients D4: 31 patients D7: 19 patients D10: 11 patients Mean period: 12.8 days (SD 7.5)	Median values OAG: 1st–3rd quartile D0: 2 (2–2) D4: 2 (2–3) D7: 2 (2–3) D14: 2 (2–3)	Median values OAG: 1st–3rd quartile D0: 1 (1–1) D4: 2 (1–2)* D7: 1 (1–2) D14: 2 (2–3)*	Not reported	Not reported	Median values OAG: 1st–3rd quartile D0: 1 (1–2) D4: 2 (1–2)* D7: 1 (2–2)* D14: 2 (1–2)	Total score in median values OAG: 1st–3rd quartile D0: 12 (11–14) D4: 14 (13–15)* D7: 15 (12–17)* D10: 16 (14–17)*
Munro et al. (2006)	D0: 66 patients D4: 37 patients D7: 21 patients	Oral health assessment tool D0: 21.27 (SD 23.66) D4: 22.72 (SD 20.47) D7: 24.32 (SD 29.01)	No data presented	No data presented	No data presented	No data presented	Oral health assessment tool
Dennessen et al. (2003)	ICU: 24 patients for 20.4 days (SD 7.5) CS: 20 patients for 15 days	Not reported	CPITN No data presented “No changes” reported	CPITN No data presented “No changes” reported	Not reported	Median mucositis% subjects mucositis free ICU: D0: 2 (SD 3.2) D7: 79% D21: 19 (SD 5.9) D14: 12% CS: No D21: 0% mucositis found	Quantitative scale of oral mucositis 0–39 (health: 0) D0: 2 ± 3.2 D21: 19 ± 5.9
Franklin et al. (2000)	54 children for 7.5 days (SD 6.2)	O’Leary plaque index D0: 22.5% (SD 17.7) Discharge: 25.8% (SD 18.5) Mean difference: 3.3% 95% CI: 1–4.53 <i>p</i> : 0.001	Presence of gingival inflammation (yes/no) D0: 4.1 sites Discharge: 5.5 sites Mean difference: 1.4 sites 95% CI: 0.4–2.3 <i>p</i> : 0.006 Spontaneous gingival bleeding D0: 0.1 sites (SD 0.5) Discharge: 0.2 sites (SD 1.1) No statistically significant differences	Not reported	DMFT index D0: Primary teeth: 1.0 (SD 2.2) Permanent teeth: 1.2 (SD 1.9) Discharge: “No changes” reported	Not reported	
Fourier et al. (1998)	Group 1: 15 patients for 5 days Group 2: 13 patients for 10 days	Plaque index (one tooth) Group 1: D0: 1.1 (SD 0.7) D5: 1.6 (SD 0.7) Group 2: D0: 1.0 (SD 0.7) D5: 1.6 (SD 0.6)† D10: 2.0 (SD 0.4)‡	Not reported	Not reported	Not reported	Not reported	

\*Statistically significant from baseline.

†Statistically significant different ( $p < 0.05$ ).‡Statistically significant different ( $p < 0.001$ ).

Key: “D0, D1, D4, D5, D7, D10”: Baseline, Day 1, Day 4, Day 5, Day 7, Day 10.

ICU, intensive care unit; CS cardiosurgical ward; OAG, oral assessment guide; CPITN, Community Periodontal Index for Treatment Needs; DMFT index, decayed, missed and filled teeth index.

As most of the studies were conducted in intensive care units, the results cannot be extrapolated to other hospital settings. Other than intubation, differences with other settings could include the level of dependency of patients for oral care, ease of provision of oral care and availability of staff to provide such care.

The quality of the evidence included in the review was affected by a number of methodological issues. Firstly, there was marked heterogeneity in the oral care routines and, in addition, adherence to oral care was not reported in the majority of studies. Secondly, a wide variety of indices for assessing of oral health were used and their validity was not clear. Validity issues included the use of subjective indices based on visual analogue scale measurements (Munro et al. 2006), assessments of gingival health with epidemiological tools (Dennesen et al. 2003) and the use of partial recordings with indices not designed for this purpose (Fourrier et al. 1998). Furthermore, examiner training in this testing setting was reported in only one study (Prendergast et al. 2009). Study design also limits the strength of the conclusions. All studies were uncontrolled and changes in outcomes may simply relate to shifts in examiner characteristics over time or due to other effects such as changes in general health status. Therefore, this needs to be accepted as a limitation to the evidence. Calibration of an examiner to a gold standard with re-testing throughout the study might have helped counter any drift. The duration of follow-up was limited (to a maximum of 20 days) due to the nature of the hospitalization. Although this period was adequate for the detection of changes in some oral health outcomes such as dental plaque accumulation (Theilade et al. 1966) and gingival inflammation (Loe et al. 1965), longer observational periods are required for the detection of a change in periodontitis (Goodson et al. 1982) or dental caries occurrence (Pitts & Stamm 2004). Finally, power calculations were reported in only one study (Franklin et al. 2000), thus hindering the interpretation of the findings.

#### Strengths and weaknesses in relation to other reviews

We have not found other systematic reviews addressing this research question. However, a clinical effectiveness review was published in 1999 investigating oral care practices by nurses (Bowsheer et al. 1999). The published report is limited in

the details of methodology, making comparison difficult. However, the findings, even though published more than a decade ago, appear to hold true "This review confirms that current practice largely ignores the research evidence and is inadequate for ensuring optimum care. There is a clear need to develop and evaluate oral care protocols for hospitalized patients and to support nurses in their implementation."

#### Meaning of the review, possible explanations and implications for clinicians and policy makers

This review suggests that hospitalization is associated with a deterioration in oral health and this could have profound implications for health and well-being. On the basis of current evidence, a deterioration in oral health would be expected to increase the risk of hospital-acquired infections, increase care costs and have a negative impact on health-related quality of life.

We were not able to conclude whether this impact results from a low priority of oral care provision, the implementation of improper oral care regimes, from hospitalization per se or from a combination of factors. Guidelines for the provision of oral care in hospital settings have been published (Fiske, et al. 2000, Department of Health 2003, Tablan et al. 2004, Department of Health 2007, NICE 2008), although they provide limited detail for carers. Additional protocols/guidelines are therefore needed and should be based on the best available evidence with sufficient detail to guide carers and patients. Such development should include the breadth of relevant stakeholders such as nursing, medical and dental professionals as well as patients and address the different settings in which care will need to be provided such as units with fully dependent patients and those where patients are able to carry out oral hygiene themselves. More challenging will be implementation (Rello et al. 2007) and this will need to be planned together with the evaluation of success before introduction.

In terms of interventions, chemical plaque control was the regime of choice in three out of five included studies (Fourrier et al. 1998, Franklin et al. 2000, Dennesen et al. 2003). Although the clinical application of chemicals such as antiseptics seems straightforward, their effect against established dental plaque is

marginal due to its organization as a biofilm in which bacteria are considerably less sensitive to antimicrobial treatments than free-living planktonic bacteria (Pratten et al. 1998). This is corroborated by a systematic review of chlorhexidine for prevention of ventilator-associated pneumonia (VAP), which reported no effect on VAP incidence (Pineda et al. 2006). Therefore, mechanical removal or disruption of dental plaque will be needed such as can be achieved through toothbrushing.

#### Suggestions for further research

More robust evidence is needed to understand the impact of hospitalization on oral health. In particular, we recommend studies conducted in a wider range of hospital settings including outside of critical care units. There are many outcome measures that are validated in oral health research and these should be selected for hospital-based studies. Furthermore, training of examiners should be provided together and outcomes of training (such as agreement levels) reported. Where feasible, longer observational periods could be used to investigate other oral health outcomes such as dental caries and periodontitis.

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## Appendix 1: Search strategy for Ovid Medline

1. exp Hospitalization/
2. Hospital\*.mp.
3. exp Intensive Care Units/
4. Intensive care unit\*.mp.
5. Intensive care ward\*.mp.
6. ICU.mp.
7. Dental deposit\*.mp.
8. Dental plaque.mp.
9. Dental calculus.mp.
10. Plaque accumulation.mp.
11. Plaque score.mp.
12. exp Dental Health Surveys/
13. Periodontal index.mp.
14. Gingival index.mp.
15. DMF index.mp.
16. exp Oral Hygiene/
17. Oral hygiene.mp.
18. Oral clean\*.mp.
19. exp candidiasis, oral/or exp mucositis/exp oral hemorrhage/or exp periodontal diseases/or exp stomatitis/
20. Periodont\*.mp.
21. Periodontal attachment loss.mp.
22. Periodontal pocket\*.mp.

23. Gingival pocket\*.mp.
24. Probing depth\*.mp
25. Bleeding on probing.mp.
26. Gingival hemorrhage.mp.
27. Gingival hemorrhage.mp.
28. Gingival haemorrhage.mp.
29. Oral mucositis.mp.
30. Stomatitis.mp.
31. tooth diseases/or exp dental deposits/or exp dental calculus/or exp dental plaque/or exp smear layer/or exp tooth demineralization/or exp dental caries/
32. Dental caries.mp.
33. Tooth decay.mp.
34. Tooth demineralization.mp.
35. Tooth demineralization.mp.
36. Tooth decalcification.mp.
37. Tooth extraction.mp.
38. Tooth loss.mp.
39. exp Oral Health/
40. Oral health.mp.
41. or/1–6
42. or/7–40
43. 41 and 42

#### Search strategy for EMBASE

1. exp hospital patient/
2. exp hospitalization/
3. hospital\*.mp.
4. exp intensive care/or exp intensive care unit/
5. intensive care unit\*.mp.
6. Intensive care ward\*.mp.
7. ICU.mp.
8. exp tooth calculus/
9. exp tooth plaque/
10. exp mouth hygiene/
11. exp mouth disease/
12. periodontal disease/
13. exp periodontitis/
14. exp thrush/
15. exp stomatitis/
16. exp dental caries/
17. exp tooth extraction/
18. dental deposit\*.mp.
19. dental calculus.mp.
20. dental plaque.mp.
21. plaque accumulation.mp.
22. oral hygiene.mp.
23. oral clean\*.mp.
24. oral candidiasis.mp.
25. oral mucositis.mp.
26. stomatitis.mp.
27. periodont\*.mp.
28. gingiv\*.mp.
29. dental caries.mp.
30. tooth decay.mp.
31. tooth demineralization.mp.
32. tooth decalcification.mp.
33. tooth loss.mp.
34. tooth extraction.mp.

35. oral health.mp
36. DMF index.mp
37. plaque score.mp.
38. or/1–7
39. or/8–37
40. 38 and 39

#### Search strategy for CINAHL

1. (MH "Hospitalization+")
2. TX hospital\*
3. (MH "Intensive Care Units+")
4. TX intensive care unit\*
5. TX intensive care ward\*
6. TX ICU
7. (MH "Tooth Diseases+")
8. (MH "Mouth Diseases+")
9. (MH "Oral Hygiene+")
10. (MH "Oral Health")
11. TX dental deposit\*
12. TX dental calculus
13. TX plaque accumulation
14. TX periodont\*
15. TX gingiv\*
16. TX stomatitis
17. TX oral candid\*
18. TX oral mucositis
19. TX dental caries
20. TX tooth decay
21. TX tooth demineralization
22. TX tooth decalcification
23. TX tooth decalcification
24. TX tooth loss
25. TX tooth extraction
26. TX probing depth
27. TX bleeding on probing
28. TX gingival hemorrhage
29. TX gingival haemorrhage
30. TX plaque score
31. TX DMF index
32. TX oral clean\*
33. TX oral hygiene
34. TX oral health
35. or/1–6
36. or/7–33
37. 35 and 36

#### Modified quality assessment scale for cohort studies (based on the Newcastle–Ottawa scale)

(Note: A study can be awarded a maximum of one star for each numbered item with the selection and outcome categories.)

#### Selection

##### (1) Representativeness of the cohort:

- (a) truly representative of the average hospitalized patients in the community (\*)

- (b) somewhat representative of the average hospitalized patients in the community (\*)
- (c) selected group of users, e.g. nurses, volunteers
- (d) no description of the derivation of the cohort

##### (2) Ascertainment of exposure:

- (a) secure record (e.g. surgical records) (\*)
- (b) structured interview (\*)
- (c) written self-report
- (d) no description

##### (4) Demonstration that outcome of interest at baseline:

- (a) yes (\*)
- (b) no

#### Outcome

##### (1) Assessment of outcome:

- (a) independent blind assessment (\*)
- (b) record linkage (\*)
- (c) self-report
- (d) no description

##### (2) Was follow-up long enough for outcomes to occur:

- (a) yes (3–5 days for plaque and gingival changes)(\*)
- (b) no

##### (3) Adequacy of follow-up of cohorts:

- (a) complete follow-up – all subjects accounted for (\*)
- (b) subjects lost to follow-up unlikely to introduce bias – small number lost (subjects lost due to death or discharge from the hospital or unit) (\*)
- (c) no description of those lost or loss due to other reasons than death or discharge from the hospital/unit.
- (d) no statement

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**Clinical Relevance**

*Scientific rational for study:* Poor oral health is recognized as a potential risk factor for hospital-acquired infections. Therefore, a systematic review of the evidence for the effect of hospitalization on oral health is needed.

*Principal findings:* The evidence suggests that oral health deteriorates during hospitalization. However, few studies have investigated this question and the strength of evidence is limited.

*Practical implications:* Oral care during hospitalization needs to be

strengthened together with further research investigating oral health changes in different settings and factors that facilitate the provision of care.

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