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Original article

# Impaired oral health status on admission is associated with poor clinical outcomes in post-acute inpatients: A prospective cohort study

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SUMMARY

*Background & aims:* Oral health is an integral part of nutrition and rehabilitation. The purpose of this study was to investigate the impact of impaired oral health status on clinical and functional outcomes in post-acute in-hospital rehabilitation.

*Methods:* We conducted a prospective cohort study of hospitalized patients undergoing rehabilitation at a 225-bed post-acute rehabilitation hospital in Japan. All newly admitted patients were eligible to enroll during the two-year research period. Oral health status was evaluated on admission using the Revised Oral Assessment Guide (ROAG). Nutritional status, assessed using the Mini Nutritional Assessment-Short Form; activities of daily living, assessed by Functional Independence Measure motor scores; home discharge; all-cause in-hospital mortality; and length of hospital stay were measured as clinical and rehabilitation outcomes. Multivariate analyses were used to determine whether the ROAG score on admission was associated with these outcomes at discharge.

*Results:* Of the 1066 patients enrolled, 1056 were included in the final analysis. The mean age was 70 ± 17 years. Fifty-two percent of patients were women. Stroke (21.7%) and musculoskeletal disorders (30.5%) were the most common reasons for admission. Slight or moderate to severe oral health problems were detected in 609 (57.7%) and 163 (15.4%) patients, respectively. Eighteen patients died during hospitalization. The ROAG score at admission was independently associated with Functional Independence Measure motor scores at discharge ($P = 0.022$), home discharge ($P = 0.005$), in-hospital mortality ($P = 0.039$), and length of hospital stay ($P = 0.045$), after adjusting for potential confounders.

*Conclusions:* Impaired oral health status may be associated with rehabilitation outcomes in hospitalized patients. Early detection of oral health problems and treatment by dental professionals, or through cooperation between medical and dental professionals, should be implemented in these patients.



## 1. Introduction

Oral health is a crucial and often neglected aspect of healthy aging. Oral diseases or impaired oral health status constitute a major public and clinical health challenge, particularly among physically disabled, demented, institutionalized, or hospitalized older adults [1,2]. Frail and care-dependent older adults, especially hospitalized patients, are at a risk of impaired oral health status owing to physical and cognitive decline, as well as malnutrition and disease-related general fatigue, which affect daily oral hygiene [3].

Impaired oral health status is common in hospitalized patients. The proportion of hospitalized older patients with oral health problems is >80.0% [4]. Furthermore, 71.0% of hospitalized rehabilitation patients [5] and 91.0% of hospitalized acute care patients [6] are reported to suffer from impaired oral health. Periodontal disease is observed in all hospitalized patients and elderly home-care recipients [7,8]. Some degree of oral health problems is

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detected in 73.8% of hospitalized patients wearing dental prostheses. An association between the necessity of repairing prostheses and reduced cognitive function is also reported [9]. Furthermore, a reduction in the number of residual teeth or deterioration of oral hygiene causes malnutrition, pain anywhere in the oral cavity, and aesthetic and functional oral health problems, resulting in a decline in quality of life associated with oral hygiene [10]. Therefore, oral health problems, oral hygiene associated with lifestyle habits, and medical treatment are important issues that cannot be separated, indicating the need for cooperation between medical and dental professionals [11].

Oral health problems are associated with poor clinical outcomes [12]. In hospitalized patients, oral health problems are associated with nutritional status and weight loss, independent of physical function at discharge [4,13–17]. In addition, patients with oral health problems are likely to suffer from dysphagia, malnutrition, and physical dependence [18,19]. In disease-related oral health, patients with stroke frequently experience oral health problems [4]. Periodontal disease is associated with diabetes mellitus [20], cardiovascular disease [21], atherosclerosis [22,23], rheumatoid arthritis [24], chronic kidney disease [25], pneumonia [26], and cerebral amyloid plaques [27]. Furthermore, chewing difficulties are associated with cognitive impairment [28].

However, despite the establishment of a relationship between oral health problems and several medical conditions, as well as the need for cooperation between medical and dental professionals, little is known regarding the impact of oral health problems on rehabilitation outcomes (activities of daily living [ADLs] at discharge, the likelihood of home discharge, all-cause in-hospital mortality, and the length of hospital stay [LOS]) of post-acute rehabilitation patients who require aggressive nutritional treatment and oral management [29,30]. In their retrospective study of approximately 100 older patients, Shiraishi, et al. [4] showed that poor oral status was associated with worse ADLs after several weeks of post-acute in-hospital rehabilitation.

The aim of this study was to investigate the impact of impaired oral health status on clinical and functional outcomes of post-acute rehabilitation patients.

## 2. Materials and methods

### 2.1. Study design and participants

We conducted a single-center prospective cohort study at a post-acute hospital with 135 convalescent rehabilitation wards in Kumamoto, Japan. The city has a population of approximately 750,000, with 30.0% of residents aged >65 years. The study commenced in April 2016, with enrollment ending in March 2017. The observation period was during hospitalization (i.e., from the date of admission to the date of discharge). All newly admitted patients were eligible to enroll in the study. The exclusion criteria were as follows: patients who did not consent to participate, patients with disturbance of consciousness, and patients who were hospitalized for only a few days to conduct medical examinations. Inpatients at our hospital were mainly divided into three categories: those with a stroke history, those with musculoskeletal diseases, and others. Among the participants, all stroke patients were transferred from the Stroke Care Unit of another acute hospital, and >90% of patients with musculoskeletal diseases and other diseases were also transferred from another hospital once they were medically stable. In Japan, a convalescent rehabilitation ward is covered by the national health insurance that provides comprehensive rehabilitation programs that are approved as reimbursable medical services [31]. The wards contribute to the restoration of physical function, improvements in ADLs, and reduction in the need for nursing care among elderly individuals with disabilities [32].

Informed consent was obtained from all participants or their legal guardians. The study was approved by the Institutional Review Board of Kumamoto Rehabilitation Hospital (Kumamoto, Japan) (approval no.: 90–150118). Research was conducted in accordance with the Declaration of Helsinki.

### 2.2. Measurements

Basic information regarding the study participant characteristics (age, sex, type of stoke, types of disease, etc.) was collected on admission. The nutritional status was assessed by experienced nurses on the day of hospitalization through an interview using the Mini Nutritional Assessment-Short Form (MNA-SF) [33]. Physical and cognitive levels were assessed by experienced physical and occupational rehabilitation therapists within 2 days after hospitalization using Functional Independence Measure (FIM) scores [34]. MNA-SF is a validated nutrition screening and assessment tool that utilizes an ordinal scale ranging from 0 to 14. Scores of 0–7, 8–11, and 12–14 indicate malnutrition, risk of malnutrition, and normal nutritional status, respectively.

### 2.3. Oral health assessment

Oral health status was evaluated using the Revised Oral Assessment Guide (ROAG), a standardized tool for the assessment of oral health and function [5,35,36]. The reliability and validity of the ROAG has been reported [33,34]. The ROAG comprises eight categories: voice, lips, mucous membranes, tongue, gums, teeth or dentures, saliva, and swallowing. Each category is described and rated from 1 (“normal”) to 3 (“severe oral health problems”). The sum of each score from the numerical and descriptive ratings gives a total score ranging from 8 to 24. Scores of 8, 9–12, and 13–24 were classified as “normal,” “slight to moderate,” and “severe” oral health status [32–34]. In this study, two experienced dental hygienists performed the oral assessments using the ROAG on the day of admission.

### 2.4. Outcomes

The primary outcome was a motor domain of the FIM score at discharge, representing one of the most common measurement tools for assessing ADLs. The FIM score is divided into a motor domain (FIM-motor) and a cognitive domain (FIM-cognitive). The FIM-motor domain includes 13 motor tasks (eating, grooming, bathing, upper body dressing, lower body dressing, toileting, bladder management, bowel management, bed-to-chair transfer, toilet transfer, shower transfer, locomotion [ambulatory or wheelchair level], and going up and down stairs). The FIM-cognitive domain includes five cognitive tasks (cognitive comprehension, expression, social interaction, problem solving, and memory). The tasks are rated on a seven-point ordinal scale ranging from total assistance to independence. The total FIM score ranges from 18 to 126, the FIM-motor domain from 13 to 91, and the FIM-cognitive domain from 5 to 35. Lower scores indicate lower abilities regarding ADLs. FIM scores were evaluated at admission (enrollment) and at discharge (end of observation) by trained physical and occupational rehabilitation therapists.

Secondary outcomes included (1) home discharge, (2) all-cause in-hospital mortality, and (3) LOS, which were considered clinical indicators of rehabilitation outcome. Home discharge, or returning home after hospital discharge, is considered an indicator of successful rehabilitation and is frequently used as an indicator of the quality of care [37]. All-cause in-hospital mortality was defined as

death owing to any cause during hospitalization. LOS was defined as the number of days from hospitalization date to discharge date.

To reduce bias, the dental hygienists, physical and occupational rehabilitation therapists, and other staff who assessed outcomes during the study period were independent from those involved in clinical decision-making for the treatment and care of the patients.

### 2.5. Sample size calculation

Data from our previous study [38] were extracted to determine the sample size. In our previous study [38], the FIM score of patients admitted to hospital was normally distributed with a standard deviation of 30.9. If the true difference in means between patients with and without oral health problems is 10, a sample size of ≥151 would be needed in each group to reject the null hypothesis with a power of 0.8 and an alpha error of 0.05. Accordingly, in the present study, data were collected for >1 year to obtain a minimum of 151 patients in each group. Assuming a 10.0% loss to follow-up rate, we aimed to enroll ≥332 patients.

### 2.6. Statistical analyses

Continuous variables were expressed as the mean (standard deviation) for parametric data and the median (25th to 75th percentiles [interquartile range]) for non-parametric data. The Student's *t*-test, Chi-square test, and Mann–Whitney *U* test were used to examine between-group differences (with or without oral health problems). Multiple linear regression analysis was used to determine which variables were independently associated with FIM-motor scores at discharge, home discharge, and LOS. The Kaplan–Meier method was used to compare the in-hospital mortality rates, and differences were evaluated using the log-rank test. Furthermore, adjusted hazard ratios were determined using Cox regression analysis to clarify whether the ROAG on admission was an independent predictor of in-hospital mortality after adjusting for potential confounders. The covariates selected to adjust for bias were age; sex; ROAG, MNA-SF, FIM-motor, and FIM-cognitive scores on admission; speech and swallowing therapy during hospitalization; LOS; and admission diagnosis (i.e., type of disease), all of which were reported to be clinically relevant for clinical outcomes in post-acute care settings [4,5,29,39].

All statistical analyses were conducted using Statistical Package for the Social Sciences for Windows, software version 21 (IBM Corp., Armonk, NY, USA). A $P < 0.05$ was considered statistically significant.

## 3. Results

During the study period, a total of 1066 patients were newly admitted, had met the inclusion criteria, and were further examined for eligibility. Of these, 10 patients were excluded due to a short LOS for the purpose of medical examination. Thus, 1056 patients were enrolled. The baseline characteristics of the enrolled patients are summarized in Table 1. The mean age was 70 ± 17 years. Fifty-two percent of patients were women. Stroke ($n = 229$; 21.7%) and musculoskeletal disorders ($n = 322$; 30.5%) were the most common reasons for admission. Of the 1056 patients examined, 609 (57.7%) and 163 (15.4%) patients had slight or moderate to severe oral health problems, respectively, based on the ROAG. Five hundred and three (47.6%) and 398 (37.7%) patients had malnutrition or were at risk of malnutrition, respectively. The median (interquartile range) FIM-motor and FIM-cognitive scores were 48 (23–74) and 30 (18–35), respectively. This suggests that a large number of patients were physically dependent. The total number of in-hospital death was 18 (1.7%). Of these, the cause of death was pneumonia (including aspiration pneumonia) in 12 (66.7%) patients, heart failure in 5 (2.8%), and malignancy in 1 (5.5%).

The Results of the bivariate analysis showed that all outcome parameters were significantly poorer in patients with oral health problems than in those without oral health problems (Table 1). Patients with oral health problems were significantly older (73 ± 16 *vs.* 63 ± 19 years; $P < 0.001$), had significantly lower FIM-motor scores at discharge (75 [40–87] *vs.* 88 [84–90]; $P = 0.001$), had a significantly lower rate of home discharge (72.9% *vs.* 92.6%; $P < 0.001$), had a significantly longer LOS (53 [29–85] *vs.* 39 [20–59] days; $P < 0.001$), and had a significantly higher in-hospital mortality rate (18 ± 2.3% *vs.* 0 ± 0.0%; $P = 0.006$) than patients without oral health problems.

Tables 2 and 3 show the Results of the multivariate analyses for FIM-motor scores at discharge and the rate of home discharge after adjusting for potential covariates. There was no multicollinearity between the variables. Multivariate linear regression analysis showed that the ROAG score at admission was independently associated with FIM-motor scores at discharge (beta: −0.144, $P = 0.027$). Additionally, multiple logistic regression analysis showed that the ROAG score at admission was independently associated with home discharge (odds ratio: 0.84, 95.0% confidence interval: 0.752–0.952; $P = 0.025$). This suggests that the presence of oral health problems at admission is negatively associated with home discharge.

Kaplan–Meier curves of in-hospital mortality according to oral health problems are shown in Fig. 1. Patients with oral health problems had a significantly higher in-hospital mortality rate than patients without oral health problems (log-rank test, $P = 0.035$). Cox proportional hazards regression analysis showed that the ROAG score at admission was independently associated with in-hospital mortality after adjusting for potential covariates (hazard ratio: 1.14, 95.0% confidence interval: 1.084–1.851; $P = 0.039$) (Table 4).

Table 5 shows the Results of the multivariate analysis for LOS after adjusting for potential covariates. There was no multicollinearity between the variables. The analysis showed that the ROAG score at admission was independently associated with LOS (beta: 0.135, $P = 0.045$).

## 4. Discussion

In this study, we investigated the impact of impaired oral health status on clinical outcomes in post-acute hospitalized patients and highlighted three clinically significant findings: (1) oral health problems are associated with ADLs at discharge and the rate of home discharge, (2) oral health problems are associated with in-hospital mortality, and (3) oral health problems are associated with LOS.

Oral health problems are associated with ADLs at discharge and the rate of home discharge. In this study, >70.0% of patients presented with some degree of oral health problems on admission. Poor oral status could have direct effects on denture wearing, dental occlusion, chewing ability, and the consequent dysphagia, which could be the major cause of malnutrition. Furthermore, malnutrition and dysphagia have direct effects on functional recovery [29]. Therefore, the poor oral status might have indirect adverse effects on ADL recovery. Furthermore, reduced self-care ability may be an important factor affecting oral health problems in hospitalized patients because hospitalized adults, especially older adults, tend to experience further decline in physical and cognitive functions compared with those in other settings owing to new onset of an acute disease, exacerbation of chronic disease, and systemic inflammation. Oral health care is an important form of self-care, which is included in subcategories of basic ADL

**Table 1**
Patients' baseline characteristics on admission and clinical outcomes at discharge between groups with and without oral problems.

| | Overall N = 1056 | Without oral problems N = 284 | With oral problems N = 772 | p-value |
|---|---|---|---|---|
| **Baseline characteristics on admission** | | | | |
| Age, years, mean (SD) | 70 (17) | 63 (19) | 73 (16) | <0.001[a] |
| Sex, Man, n (%) | 507 (48.0) | 114 (40.1) | 393 (50.9) | 0.124[c] |
| Woman, n (%) | 549 (52.0) | 170 (59.9) | 379 (49.1) | |
| Admission diagnosis | | | | 0.094[c] |
| Stroke | | | | |
| Cerebral infarction, n (%) | 129 (12.2) | 26 (9.2) | 103 (13.3) | |
| Cerebral hemorrhage, n (%) | 77 (7.3) | 13 (4.6) | 41 (6.4) | |
| Subarachnoid hemorrhage, n (%) | 23 (2.2) | 7 (2.5) | 17 (2.7) | |
| Musculoskeletal disorders | | | | |
| Hip fractures, n (%) | 93 (8.8) | 36 (6.2) | 57 (7.4) | |
| Vertebral fractures, n (%) | 95 (9.0) | 41 (14.4) | 54 (7.0) | |
| Traumas, n (%) | 134 (12.7) | 65 (22.9) | 69 (8.9) | |
| Collagen diseases, n (%) | 52 (4.9) | 23 (8.1) | 29 (3.8) | |
| Decubitus, n (%) | 14 (1.3) | 2 (0.7) | 12 (15.5) | |
| Cardiovascular diseases | | | | |
| Cardiac diseases, n (%) | 70 (6.6) | 38 (13.4) | 32 (4.1) | |
| Peripheral arterial diseases, n (%) | 91 (8.6) | 37 (13.0) | 54 (7.0) | |
| Respiratory diseases | | | | |
| Pneumonia, n (%) | 85 (8.0) | 20 (7.0) | 65 (9.4) | |
| Respiratory diseases without pneumonia, n (%) | 61 (5.8) | 15 (12.7) | 46 (6.0) | |
| Neurodegenerative diseases, n (%) | 86 (8.1) | 30 (10.5) | 56 (7.3) | |
| Malignant diseases, n (%) | 46 (4.4) | 17 (5.9) | 29 (3.8) | |
| ROAG on admission | | | | |
| Score, median (IQR) | 10 (8–11) | 8 (8–8) | 10 (9–13) | – |
| Normal, n (%) | 284 (26.9) | 284 (100) | – | – |
| Slight problems, n (%) | 609 (57.7) | – | 609 (78.9) | |
| Moderate to severe problems, n (%) | 163 (15.4) | – | 163 (21.1) | |
| MNA-SF on admission | | | | |
| Score, median (IQR) | 9 (6–11) | 11 (10–12) | 8 (5–10) | <0.001[b] |
| Normal, n (%) | 155 (14.7) | 69 (24.2) | 80 (10.4) | <0.001[c] |
| At risk, n (%) | 503 (47.6) | 186 (65.4) | 306 (39.6) | |
| Malnutrition, n (%) | 398 (37.7) | 29 (10.4) | 386 (50.0) | |
| FIM on admission | | | | |
| Motor, score, median (IQR) | 48 (23–74) | 68 (44–82) | 38 (19–70) | <0.001[b] |
| Cognitive, score, median (IQR) | 30 (18–35) | 35 (31–35) | 26 (15–35) | <0.001[b] |
| **Rehabilitation therapy during hospitalization** | | | | |
| Rehabilitation[d], units/day, median (IQR) | | | | |
| Physical therapy (n = 1056) | 3.2 (2.4–4.5) | 3.2 (2.2–4.1) | 3.3 (2.3–4.1) | 0.511[b] |
| Occupational therapy (n = 767) | 1.8 (0.5–2.2) | 1.5 (0.6–2.4) | 1.6 (0.6–2.5) | 0.539[b] |
| Speech and swallowing therapy (n = 275) | 0.8 (0.2–1.0) | 0.6 (0.2–1.0) | 1.1 (0.5–1.6) | 0.041[b] |
| **Clinical outcomes at discharge** | | | | |
| FIM at discharge | | | | |
| Motor, score, median (IQR) | 83 (51–89) | 88 (84–90) | 75 (40–87) | 0.001[b] |
| Cognitive, score, median (IQR) | 33 (29–35) | 35 (34–35) | 31 (21–35) | 0.014[b] |
| Home discharge, n (%) | 826 (78.2) | 263 (92.6) | 563 (72.9) | <0.001[c] |
| Length of stay, day, median (IQR) | 45 (25–66) | 39 (20–59) | 53 (29–85) | <0.001[b] |
| In-hospital death, n (%) | 18 (1.7) | 0 (0.0) | 18 (2.3) | 0.006[c] |

ROAG: Revised Oral Assessment Guide, MNA-SF: Mini Nutritional Assessment-Short Form, FIM; Functional Independence Measure.
[a] *t*-test.
[b] Mann–Whitney *U* test.
[c] Chi-square test.
[d] Rehabilitation therapy performed during hospitalization (1 unit for 20 min).

**Table 2**
Multivariate regression analysis for FIM-motor at discharge.

| | B | SE | 95% CI of B | beta | p-value |
|---|---|---|---|---|---|
| Age | −.051 | .110 | −.271, .105 | −.122 | .114 |
| Sex | 2.458 | 2.667 | −2.799, 7.716 | .044 | .358 |
| ROAG on admission | −1.349 | .587 | −2.506, −.193 | −.144 | .027 |
| MNA-SF on admission | .597 | .366 | .119, 1.714 | .264 | .033 |
| Length of stay | .080 | .035 | −.081, .150 | .109 | .103 |
| FIM-Motor on admission | .349 | .070 | .211, .486 | .334 | <.001 |
| FIM-Cognitive on admission | .952 | .197 | .564, 1.340 | .323 | <.001 |
| Speech and swallowing therapy | .412 | .299 | −.121, .689 | .091 | .128 |
| Stroke | −.200 | 8.657 | −17.263, 16.863 | −.003 | .982 |
| Musculoskeletal disorders | 5.157 | 8.864 | −12.315, 22.629 | .080 | .561 |
| Collagen diseases | 9.666 | 12.535 | −15.041, 34.372 | .046 | .441 |
| Decubitus | 10.089 | 15.881 | −21.212, 41.391 | .034 | .526 |
| Cardiovascular diseases | −7.351 | 9.096 | −25.280, 10.578 | −.099 | .420 |
| Respiratory diseases | −1.325 | 8.899 | −18.866, 16.216 | −.018 | .882 |
| Neurodegenerative diseases | −2.091 | 10.147 | −22.091, 17.908 | −.016 | .837 |

ROAG: Revised Oral Assessment Guide, MNA-SF: Mini Nutritional Assessment-Short Form, FIM; Functional Independence Measure.

**Table 3**
Multiple logistic regression analysis for home discharge.

| | OR | 95% CI for OR | p-value |
|---|---|---|---|
| Age | .818 | .664, 1.016 | .229 |
| Sex | 1.244 | .695, 2.227 | .462 |
| ROAG on admission | .844 | .752, .952 | .025 |
| MNA-SF on admission | 1.186 | 1.049, 1.339 | .016 |
| Length of stay | 1.007 | .899, 1.015 | .210 |
| FIM-Motor on admission | 1.021 | 1.015, 1.337 | .010 |
| FIM-Cognitive on admission | 1.036 | .997, 1.077 | .098 |
| Speech and swallowing therapy | 1.109 | .579, 1.849 | .312 |
| Stroke | 1.930 | .316, 11.788 | .476 |
| Musculoskeletal disorders | 2.017 | .348, 13.547 | .407 |
| Collagen diseases | 2.182 | .148, 9.541 | .199 |
| Decubitus | .115 | .008, 1.933 | .137 |
| Cardiovascular diseases | .476 | .075, 3.137 | .449 |
| Respiratory diseases | .931 | .143, 6.156 | .948 |
| Neurodegenerative diseases | 3.160 | .406, 26.144 | .266 |

ROAG: Revised Oral Assessment Guide, MNA-SF: Mini Nutritional Assessment-Short Form, FIM; Functional Independence Measure; CI: confidence interval; OR: odds ratio.

**Table 4**
Cox proportional hazard model for in-hospital death.

| | HR | 95% CI for HR | p-value |
|---|---|---|---|
| Age | 1.114 | .961, 1.171 | .513 |
| Sex | .469 | .128, 1.715 | .252 |
| ROAG on admission | 1.135 | 1.084, 1.851 | .039 |
| MNA-SF on admission | .818 | .738, .972 | .027 |
| FIM-Motor on admission | 1.010 | .964, 1.058 | .680 |
| FIM-Cognitive on admission | .992 | .903, 1.088 | .858 |
| Speech and swallowing therapy | .709 | .379, 1.249 | .212 |
| Stroke | .100 | .008, 1.293 | .078 |
| Musculoskeletal disorders | .098 | .006, 1.636 | .106 |
| Collagen diseases | .021 | .002, 2.451. | .185 |
| Decubitus | 1.248 | .212, .5.121 | .298 |
| Cardiovascular diseases | .100 | .004, 2.402 | .156 |
| Respiratory diseases | .093 | .005, 1.879 | .122 |
| Neurodegenerative diseases | .358 | .015, 8.684 | .528 |

ROAG: Revised Oral Assessment Guide, MNA-SF: Mini Nutritional Assessment-Short Form, FIM; Functional Independence Measure; CI: confidence interval; HR: hazard ratio.

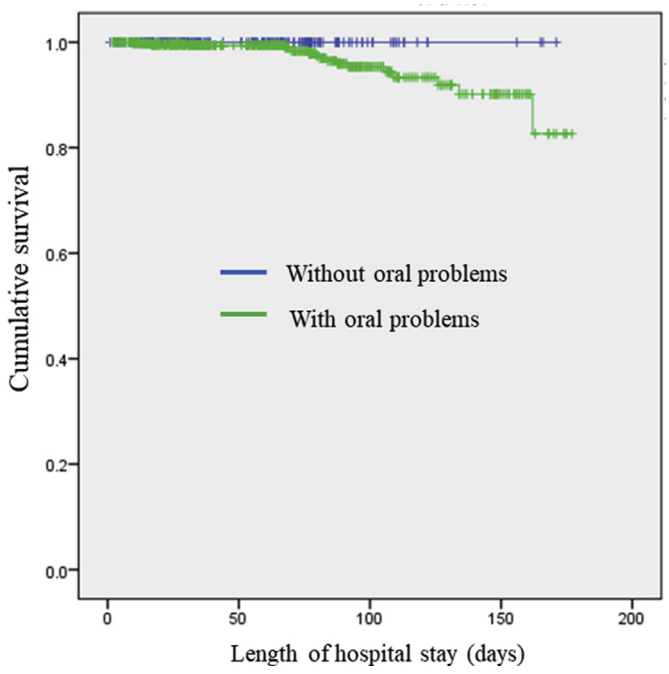


**Fig. 1. Kaplan–Meier curves of in-hospital mortality according to oral health problems.** Patients with oral health problems are represented by the green line and patients without oral health problems are represented by the blue line. Patients with oral health problems have a significantly higher in-hospital mortality rate than patients without oral health problems (log-rank test, $P = 0.035$). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.).

assessment, such as FIM and Barthel Index [40]. Factors contributing to reduced self-care ability may include physical dependency or disability due to aging, disease, sarcopenia, malnutrition, cognitive and psychological disorders, and socioeconomic factors [29]. Indeed, in the current study, many patients presented with impaired physical function as assessed by FIM-motor scores. Furthermore, the lower the FIM-motor and FIM-cognitive scores the more severe the oral health problems. Therefore, reduced self-care ability may be associated with oral health problems. Hence, it is necessary to facilitate oral management to enhance patient self-care ability or ADLs, because ADLs at discharge are associated with the rate of home discharge.

Sarcopenia and malnutrition often occur in post-acute settings [29,38] and are associated with poorer outcomes [41]. In this study, we show that oral health problems are associated with reduced ADLs at discharge, which can cause activity-related sarcopenia [41]. Therefore, it is necessary to monitor unnecessary bed resting, facilitate rehabilitation and nutrition management, and to prevent the onset of secondary sarcopenia (both nutrition and activity-related sarcopenia) and reduced physical function in hospitalized patients. We believe that such efforts will maximize the recovery of physical independency at discharge and lead to higher rates of home discharge. It is also necessary to monitor unnecessary *nil per os*, maintain oral intake as much as possible, provide adequate oral health care and treatment, and to prevent the onset of oral sarcopenia [42].

Oral health problems are associated with all-cause in-hospital mortality. Deterioration of oral hygiene increases the incidence of pneumonia and is associated with the onset or exacerbation of systemic diseases [43]. Indeed, in the current study, the commonest cause of death was pneumonia. Malnutrition and reduced physical and cognitive function, which are associated with oral health problems [44,45], increase mortality [46]. Furthermore, oral health problems have been reported to increase mortality, independent of systemic diseases [47–49]. For instance, patients with periodontal disease have a four times higher mortality rate than those with cardiovascular disease or pneumonia [50,51], and patients with greater dental treatment needs and signs of acute oral infection are at a higher risk of death [51]. According to a recent meta-analysis [52], the mortality rate of healthcare-associated pneumonia reduces when dental professionals intervene rather than nurses or caregivers. Therefore, early detection of oral health problems and, if required, appropriate oral health care and treatment by dental professionals are needed to attenuate oral health-related mortality in hospitalized rehabilitation patients.

Oral health problems are associated with LOS. Oral health problems can cause systemic diseases and worsen preexisting comorbidities. In this study, we show the association of oral health problems with reduced physical function during hospitalization and reduced rates of home discharge. Therefore, it is assumed that all of these factors are associated with the prolongation of LOS. Indeed, nursing care residents with oral health problems had longer LOS [53]. Considering the association between oral health problems and healthcare-related outcomes in hospitalized patients, cooperation between medical and dental professionals is needed. It is difficult to determine whether the collaboration is functioning adequately in clinical settings [54]. Building the collaboration is an urgent public health issue, especially in developed countries like Japan, which has an aging population.

**Table 5**
Multivariate regression analysis for length of stay.

| | B | SE | 95% CI of B | beta | p-value |
|---|---|---|---|---|---|
| Age | −.299 | .156 | −.606, .007 | −.096 | .056 |
| Sex | 5.186 | 3.685 | −1.937, 8.429 | .232 | .196 |
| ROAG on admission | 1.620 | .823 | 002, 3.237 | .135 | .045 |
| MNA on admission | −1.227 | .813 | −2.824, .371 | −.201 | .031 |
| FIM-Motor on admission | −.231 | .098 | −.424, −.037 | −.215 | .043 |
| FIM-Cognitive on admission | −.156 | .276 | −.699, .387 | −.042 | .573 |
| Speech and swallowing therapy | .812 | .599 | −.121, 1.689 | .091 | .428 |
| Stroke | 19.623 | 11.639 | −3.262, 42.507 | .238 | .133 |
| Musculoskeletal disorders | 8.923 | 11.755 | −14.190, 32.036 | .105 | .448 |
| Collagen diseases | 25.417 | 9.181 | −4.432, 55.266 | .114 | .125 |
| Decubitus | 2.571 | 11.878 | −38.478, 43.619 | .007 | .902 |
| Cardiovascular diseases | 4.792 | 8.100 | −18.999, 28.583 | .047 | .692 |
| Respiratory diseases | 4.178 | 5.039 | −1.492, 9.849 | .639 | .129 |
| Neurodegenerative diseases | −4.235 | 13.831 | −31.428, 22.959 | −.024 | .760 |

ROAG: Revised Oral Assessment Guide, MNA-SF: Mini Nutritional Assessment-Short Form, FIM; Functional Independence Measure; CI: confidence interval.

This study has several limitations. The first was that it was carried out at a single post-acute rehabilitation hospital, potentially limiting the generalization of the Results. Future studies are needed to determine whether similar findings can be obtained from multiple centers. Second, the effect of various interventions, such as nutrition therapy, food intake, and oral health care by dental professionals, was not investigated. Further studies are needed to investigate the clinical effects of nutritional support and oral management on clinical outcomes. Third, the direct effect of diseases, such as neurological disorders, on the oral health status was not investigated. Therefore, future high-quality multicenter observational and interventional studies are required to verify that oral management by dental professionals, and through cooperation between medical and dental professionals, enhances the recovery of not only oral health status, but also rehabilitation outcomes.

In conclusion, impaired oral health status may be associated with rehabilitation outcomes in post-acute hospitalized patients. Early detection of oral health problems and oral treatment by dental professionals, or through cooperation between medical and dental professionals, should be implemented in these patients. However, further studies are needed to validate our findings.

## Statement of authorship

AS and YY had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis, including and especially any adverse effects; HW contributed to the concept and design, data analysis, data interpretation, and drafting the manuscript; YT, SS and SJ contributed to the concept, data acquisition and data analysis. All authors revised the manuscript critically for important intellectual content and approved the final version of the manuscript.

## Conflict of interest

The authors declare no conflict of interest.

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