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ORIGINAL RESEARCH

Sex-Specific Associations Between Oral Function Impairment and Clinical Outcomes in Hospitalized Older Adults: A Retrospective Observational Study

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Purpose: Oral functional impairment is a critical factor influencing clinical outcomes in hospitalized older adults. Notably, sex disparities in oral health on clinical outcomes remain an often underappreciated aspect.This study aims to investigate the association between oral function, assessed using the bedside oral examination (BOE), and in-hospital mortality, with an emphasis on sex-specific differences.

Patients and Methods: A retrospective cohort study was conducted involving 1,141 patients aged 65 years and older who were admitted to a medical center in Taiwan between 2018 and 2023. The BOE was a standardized clinical tool that evaluated eight domains of oral health, including swallowing, lips, tongue, saliva, mucous membranes, gingiva, teeth or dentures, and oral odor. Patients were classified into normal, moderate, or severe oral impairment groups. Cox proportional hazards models and Kaplan–Meier survival analysis were used to examine mortality risk, with results stratified by sex.

Results: Overall, greater oral functional impairment was associated with higher in-hospital mortality and poorer physical, nutritional, and psychological status. In the sex-stratified analysis, severe oral impairment remained an independent predictor of mortality in male patients (hazard ratio 1.77, 95% confidence interval 1.05 to 2.99, p = 0.032), but not in female patients. Survival differences were statistically significant among men based on oral function levels, as shown by Kaplan–Meier curves (log-rank p = 0.014), while no significant difference was found among women (log-rank p = 0.376).

Conclusion: Severe oral functional impairment significantly predicts in-hospital mortality among older men, but not women. These findings underscore the importance of sex-specific approaches to risk assessment and intervention. Incorporating oral health screening into routine geriatric care, especially for men, may enhance early identification of high-risk patients and inform targeted strategies to improve clinical outcomes. Further research is warranted to understand the mechanisms underlying these sex differences.

Keywords: oral health, sex differences, in-hospital mortality, comorbidity, geriatrics, survival analysis

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Introduction

Oral function impairment, which includes deficits in chewing, swallowing, articulatory ability, tongue pressure, salivation, and dentition, has been increasingly recognized as an independent risk factor for adverse health outcomes and elevated mortality among older adults.[1–4] The concept of oral frailty, characterized by the accumulation of multiple oral functional deficits, is associated with physical decline, functional disability, and increased risk of death.[5–8] These findings highlight the clinical value of assessing oral function during hospitalization.[6–8] Common clinical presentations include dysphagia, reduced masticatory performance, xerostomia, tooth loss, and impaired speech, all of which can negatively affect nutritional status, systemic health, and overall quality of life.[1–8] One study reports a 2.6-fold increase in mortality among older adults with both swallowing impairment and poor oral health compared to those with preserved oral function and good oral hygiene.[9] A dose–response relationship has also been observed, with the risk of mortality rising in accordance with the number and severity of oral function deficits. Individuals presenting with three or more impairments have been found to have more than double the risk of death compared to those without such deficits.[5] Furthermore, the presence of cognitive impairment in combination with poor oral function may have a synergistic effect, further increasing mortality risk, particularly from cardiometabolic causes.[4,7] The bedside oral examination (BOE) is a revised assessment tool based on previously validated instruments, designed to evaluate eight key aspects of oral health: swallowing function, lips, tongue, saliva, mucous membranes, gingiva, teeth or dentures, and oral odor.[1,10] Incorporating BOE into routine assessments may enhance risk stratification and support the development of targeted, interdisciplinary interventions by identifying high-risk patients and optimizing care strategies, particularly in relation to predicting in-hospital mortality.[1–3,8]

Sex-related disparities in health are well documented, encompassing disease susceptibility, healthcare utilization, and clinical outcomes.[11–13] Underlying these differences are complex biological mechanisms, including hormonal, immunological, and genetic influences that shape aging and disease progression.[14,15] In addition, aging trajectories differ between men and women due to both biological and sociobehavioral factors.[16,17] Oral health reflects similar patterns: men generally demonstrate lower oral health literacy and poorer behaviors than women, while women more frequently report symptoms of temporomandibular disorders.[18,19] Moreover, prior research suggests that the relationship between oral health literacy and oral health–related quality of life may differ by sex.[20]

However, there are less studies to examine the sex disparities between BOE and clinical outcomes, such as mortality. This study investigates the association between oral function impairment, assessed using BOE, and clinical outcomes, with a focus on sex-specific differences in hospitalized older adults. By predicting in-hospital mortality based on stratified levels of oral function, the study aims to enhance understanding of geriatric oral health and inform sex-sensitive interventions to improve clinical outcomes.

Materials and Methods

Study Design and Participants

This retrospective observational study was conducted at a medical center from October 2018 to March 2023 in Taiwan. April 1 to December 31, 2023. Prior to statistical analysis, the research team performed data cleaning and coding. To ensure data completeness and analytical consistency, patients with missing information on key variables were excluded. A total of 1,368 participants were initially included in the study, with 1,141 participants remaining in the final analysis.[8]

The participants included in this study were patients aged 65 years and older who were hospitalized due to a non-disabling acute medical illness, but remained conscious, and retained functional capacity between October 1, 2018, and March 31, 2023. During the first three days of hospitalization, assessments of oral health, physical condition, and psychological status were conducted. These evaluations were conducted by trained geriatric nurses under the supervision of attending geriatricians, following a standardized protocol that remained consistent throughout the study period. Data were reviewed and entered into a secure electronic database by trained geriatric nurses within one week of patient discharge. To maintain consistency and ensure data comparability, all assessors received protocol-based training and participated in regular consensus meetings. Although inter-rater reliability was not formally assessed, all procedures were strictly standardized.

Measure – Oral Health

The BOE assessed eight key domains of oral health: swallowing, lips, tongue, saliva, mucous membranes, gingivae, teeth or dentures, and oral odor. Each domain was rated on a three-point scale, with higher scores indicating more severe dysfunction. The total BOE score ranged from 8 to 24, with higher scores reflecting poorer oral health status.[1]

The assessment began with the evaluation of swallowing function, which was observed during swallowing and by checking the gag reflex. A normal swallow was scored as 1, mild pain or difficulty as 2, and inability to swallow as 3. The lips were assessed for appearance: smooth, pink lips scored 1; dry or cracked lips scored 2; and ulcerated or bleeding lips scored 3. The tongue was evaluated for texture and color. A pink, moist tongue with visible papillae was scored as 1, a coated or shiny tongue with partial loss of papillae as 2, and a cracked, blistered, or bleeding tongue as 3. Saliva was assessed by gently touching the tongue and, optionally, the floor of the mouth with a tongue blade. Watery saliva was scored as 1, thick or sticky saliva as 2, and absence of saliva as 3. Mucous membranes were examined for color and moisture. Pink, moist membranes were scored as 1; red or coated membranes without ulcers as 2; and ulcerated or bleeding membranes as 3. Gingival health was inspected visually and, if necessary, by gentle palpation. Healthy, firm, pink gums were scored as 1; red or swollen gums with or without bleeding as 2; and gums that bled easily as 3. Teeth and dentures were assessed for cleanliness and integrity. Clean natural teeth or clean dentures in edentulous patients were scored as 1, localized debris as 2, and generalized debris or visible decay as 3. Finally, oral odor was evaluated by smelling the patient's breath. A normal odor was scored as 1, a mild to moderate foul odor as 2, and a strong foul odor as 3.[1]

Patients were divided into three groups according to their levels of oral functional impairment. Those with a BOE score of 10 or less were classified as having normal oral function, those with a score between 11 and 14 were classified as having moderate impairment, and those with a score of 15 or higher were classified as having severe impairment. The classification thresholds were based on prior literature using BOE in hospitalized adults.[8]

Measure – Variables Surrounding Physical and Psychological Assessment

Sociodemographic factors, including marital status, living arrangements, caregiving responsibilities, and behavioral habits, were collected from electronic medical records. Clinical data included diagnoses collected using ICD-9 codes, while comorbidities were quantified through the age-adjusted Charlson comorbidity Index (ACCI).[21] Anthropometric indicators, including body mass index (BMI), hand grip strength (HGS), the six-meter walk test (SMWT), and the timed up and go test (TUGT), were utilized for assessment.[8] HGS was measured using a dynamometer, with strength levels below 28 kg for men and 18 kg for women considered low.[22] A walking speed of less than 1 m/s in the SMWT suggested impaired mobility, while the TUGT was used to examine balance, coordination, and lower limb strength.[22]

Psychological well-being was assessed using the five-item geriatric depression scale (GDS-5), where a score of 2 or above indicated a potential risk for depression.[23] Functional ability was determined by the Barthel index for activities of daily living (ADL) and the Lawton scale for instrumental activities of daily living (IADL), with higher scores signifying greater independence.[24,25] Nutritional status was analyzed using the mini nutritional assessment (MNA), which had a maximum score of 30, with higher values reflecting better overall nutritional health.[26]

Primary Outcome

The main outcome evaluated was in-hospital death.

Statistical Analysis

Descriptive statistics were used to summarize demographic and clinical characteristics. Continuous variables are presented as mean ± standard deviation and were analyzed using either one-way analysis of variance (ANOVA) or the Kruskal–Wallis test, depending on data distribution. Categorical variables were reported as frequencies and percentages and evaluated by chi-square tests for comparison. To identify factors associated with in-hospital mortality, univariate and multivariate Cox proportional hazards regression models were applied, providing hazard ratios (HR) along with 95% confidence intervals (CI). Variables that showed significance in the univariate analysis were included in the multivariate analysis. Stratified analyses were carried out to assess sex-specific variations in predictive factors. Kaplan–Meier survival

curves were generated for male and female subgroups to visualize the association between oral function impairment and in-hospital survival. A p-value of less than 0.05 was considered statistically significant. All statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY). A post hoc power analysis was conducted using a two-tailed independent samples *t*-test. With an observed effect size of d = 0.207, sample sizes of 490 and 651 for the two groups, and a significance level of α = 0.05, the analysis yielded an achieved power of 0.933.

Ethical Considerations

The hospital's institutional review board (IRB) granted approval for this study (approval number: CE23207B). As this study was conducted retrospectively, the IRB granted a waiver for informed consent. All procedures followed the ethical guidelines set forth in the declaration of Helsinki.

Results

Table 1 showed that the study included 1,141 hospitalized patients aged 65 and older, with 490 women (42.9%) and 651 men (57.1%). The mean age was 82.0 ± 8.9 years, with men being older (83.5 ± 9.1) than women (80.0 ± 8.3, $p < 0.001$). Women had a higher mean BMI (25.4 ± 4.8 vs 24.0 ± 4.0, $p < 0.001$). Sex-based differences were evident in smoking, alcohol use, marital status, and living arrangements. Diagnostically, urinary tract infections were more frequent in women (21.0%), whereas pneumonia was more common in men (17.7%). The BOE revealed

Table 1 Characteristics of the Patients

	Total (n=1141)	Female (n=490)	Male (n=651)	*p* value
	Mean / N ±SD / (%)	Mean / N±SD / (%)	Mean / N±SD / (%)	
Age (year)	82.0±8.9	80.0±8.3	83.5±9.1	<0.001*
Body mass index (kg/m^2)	24.6±4.4	25.4±4.8	24.0±4.0	<0.001*
Smoke	43 (3.8%)	0 (0%)	43 (6.7%)	<0.001*
Drink	114 (10.0%)	15 (3.1%)	99 (15.2%)	<0.001*
Marry				<0.001*
Single/ Widowed/ Divorced	521 (45.7%)	326 (66.5%)	195 (30.0%)	
Married	620 (54.3%)	164 (33.5%)	456 (70.0%)	
Live				0.008*
Non-family/alone	194 (17.0%)	100 (20.4%)	94 (14.4%)	
Family	947 (83.0%)	390 (79.6%)	557 (85.6%)	
Care				0.463
Oneself	423 (37.5%)	188 (38.7%)	235 (36.5%)	
Others	706 (62.5%)	298 (61.3%)	408 (63.5%)	
Diagnosis				<0.001*
Urinary tract infection	196 (17.2%)	103 (21.0%)	93 (14.3%)	
Pneumonia	147 (12.9%)	32 (6.5%)	115 (17.7%)	
Cellulitis	115 (10.1%)	48 (9.8%)	67 (10.3%)	
Bacteremia	81 (7.1%)	40 (8.2%)	41 (6.3%)	
Acute pyelonephritis	48 (4.2%)	35 (7.1%)	13 (2.0%)	
Acute kidney failure	39 (3.4%)	19 (3.9%)	20 (3.1%)	
Type 2 diabetes mellitus	31 (2.7%)	13 (2.7%)	18 (2.8%)	
Prostatitis	25 (2.2%)	0 (0%)	25 (3.8%)	
Fracture of femur	22 (1.9%)	13 (2.7%)	9 (1.4%)	
Other	437 (38.3%)	187 (38.2%)	250 (38.4%)	
Bedside oral examination				<0.001*
Normal	471 (41.3%)	232 (47.3%)	239 (36.7%)	
Moderate	456 (40.0%)	180 (36.7%)	276 (42.4%)	
Severe	214 (18.8%)	78 (15.9%)	136 (20.9%)	

(*Continued*)

Table 1 (Continued).

	Total (n=1141)	Female (n=490)	Male (n=651)	*p* value
	Mean / N ±SD / (%)	Mean / N±SD / (%)	Mean / N±SD / (%)	
Physical and psychological assessment				
Age-adjusted Charlson comorbidity index	6.2±2.2	6.1±2.4	6.2±2.0	0.152
5-item Geriatric Depression Scale	1.3±1.3	1.2±1.3	1.3±1.3	0.482
Barthel index of activities of daily living	44.3±31.0	46.3±31.3	42.7±30.6	0.049*
Lawton instrumental activities of daily living	1.8±2.2	2.1±2.3	1.6±2.1	<0.001*
Mini-nutritional assessment	18.9±5.4	19.3±5.5	18.6±5.3	0.031*
Hand grip strength (kg)	15.8±8.0	12.5±5.7	18.3±8.5	<0.001*
Six-meter walk test (sec)	16.0±14.3	15.6±14.2	16.4±14.4	0.568
Timed Up and Go test (sec)	23.6±16.7	23.4±16.5	23.7±17.0	0.877
Length of stay (day)	11.4±8.1	10.9±7.6	11.8±8.4	0.156
In-hospital mortality	198 (17.4%)	66 (13.5%)	132 (20.3%)	0.003*

Note: *: p<0.05.
Abbreviations: N, Number of patients; ±SD, Plus or minus standard deviation; %, Percentage.

significant sex differences ($p < 0.001$), with normal oral health being more common in females (47.3% vs 36.7%), while moderate (36.7% vs 42.4%) and severe conditions (15.9% vs 20.9%) were more frequent in males. Significant differences were observed between females and males in the physical and psychological assessments. Males had lower scores on the ADL (42.7 ± 30.6 vs 46.3 ± 31.3, p=0.049), the IADL (1.6 ± 2.1 vs 2.1 ± 2.3, p<0.001), and the MNA (18.6 ± 5.3 vs 19.3 ± 5.5, p=0.031). Additionally, in-hospital mortality was significantly higher in males (20.3% vs 13.5%, p=0.003).

Patients were categorized into three levels of oral functional impairment (normal, moderate, and severe), with sex-specific characteristics and clinical outcomes summarized in Table 2 (females) and Table 3 (males). In female patients (Table 2), age

Table 2 Female-Specific Differences in Characteristics, Diagnosis, Physical and Psychological Parameters, and Clinical Outcomes Based on Oral Functional Impairment Levels

	Normal	Moderate	Severe	*p* value
	Mean / N±SD / (%)	Mean / N±SD / (%)	Mean / N±SD / (%)	
Age (year)	78.8±8.8	81.1±7.5	81.4±8.1	0.002*
Body mass index (kg/m^2)	25.6±4.4	25.5±4.9	24.4±5.5	0.193
Smoke	0 (0%)	0 (0%)	0 (0%)	-
Drink	10 (4.3%)	4 (2.2%)	1 (1.3%)	0.290
Marry				0.038*
Single/ Widowed/ Divorced	141 (60.8%)	129 (71.7%)	56 (71.8%)	
Married	91 (39.2%)	51 (28.3%)	22 (28.2%)	
Live				0.940
Non-family/alone	47 (20.3%)	38 (21.1%)	15 (19.2%)	
Family	185 (79.7%)	142 (78.9%)	63 (80.8%)	
Care				<0.001*
Oneself	114 (49.1%)	59 (33.5%)	15 (19.2%)	
Others	118 (50.9%)	117 (66.5%)	63 (80.8%)	
Diagnosis				0.163
Urinary tract infection	49 (21.1%)	34 (18.9%)	20 (25.6%)	
Pneumonia	7 (3.0%)	15 (8.3%)	10 (12.8%)	
Cellulitis	20 (8.6%)	20 (11.1%)	8 (10.3%)	
Bacteremia	16 (6.9%)	19 (10.6%)	5 (6.4%)	

(*Continued*)

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Table 2 (Continued).

	Normal	Moderate	Severe	*p* value
	Mean / N±SD / (%)	Mean / N±SD / (%)	Mean / N±SD / (%)	
Acute pyelonephritis	22 (9.5%)	9 (5.0%)	4 (5.1%)	
Acute kidney failure	9 (3.9%)	8 (4.4%)	2 (2.6%)	
Type 2 diabetes mellitus	7 (3.0%)	4 (2.2%)	2 (2.6%)	
Prostatitis	0 (0%)	0 (0%)	0 (0%)	
Fracture of femur	7 (3.0%)	6 (3.3%)	0 (0%)	
Other	95 (40.9%)	65 (36.1%)	27 (34.6%)	
Physical and psychological assessment				
Age-adjusted Charlson comorbidity index	5.9±2.5	6.4±2.2	6.3±2.3	0.001*
5-item Geriatric Depression Scale	0.9±1.1	1.4±1.4	1.7±1.4	<0.001*
Barthel index of activities of daily living	59.7±31.4	35.6±25.2	31.5±28.0	<0.001*
Lawton instrumental activities of daily living	2.7±2.5	1.5±1.7	1.9±2.6	<0.001*
Mini-nutritional assessment	21.1±5.1	18.2±5.1	16.5±5.7	<0.001*
Hand grip strength (kg)	13.7±5.6	11.3±5.5	10.9±5.8	<0.001*
Six-meter walk test (sec)	15.2±13.6	16.9±17.8	15.4±9.3	0.256
Timed Up and Go test (sec)	22.4±15.4	26.5±19.8	23.0±14.9	0.103
Length of stay (day)	9.8±6.3	11.8±9.0	12.1±7.6	0.002*
In-hospital mortality	21 (9.1%)	31 (17s.2%)	14 (17.9%)	0.025*

Note: *: p<0.05.
Abbreviations: N, Number of patients; ±SD, Plus or minus standard deviation; %, Percentage.

and care dependency showed significant differences across oral function groups. Marital status varied significantly, with fewer married individuals in the severe impairment group (p = 0.038). Physical and psychological functions, including ADL, IADL, MNA, HGS, and GDS-5 scores, also declined with worsening oral impairment (all p < 0.001). In-hospital mortality increased from 9.1% in the normal group to 17.9% in the severe group (p = 0.025). In male patients (Table 3), age, BMI, and care dependency differed significantly across the three oral function levels. A clear decreasing trend in BMI was observed with increasing severity of oral impairment (p = 0.003). Similar to females, physical and nutritional status indicators worsened with severity. Notably, in-hospital mortality rose sharply, reaching 34.6% in those with severe impairment (p < 0.001).

Table 4 presented the results of sex-stratified Cox proportional hazards models that examined predictors of in-hospital mortality. In univariate analyses, older age, higher ACCI, lower scores on ADL and IADL, poorer MNA, and poorer

Table 3 Male-Specific Differences in Characteristics, Diagnoses, Physical and Psychological Parameters, and Clinical Outcomes Stratified by Oral Function Impairment Levels

	Normal	Moderate	Severe	*p* value
	Mean / N±SD / (%)	Mean / N±SD / (%)	Mean / N±SD / (%)	
Age (year)	81.7±9.5	84.2±8.6	85.2±8.9	0.001*
Body mass index (kg/m^2)	24.8±3.9	23.7±4.0	23.1±4.1	0.003*
Smoke	19 (8.0%)	17 (6.2%)	7 (5.3%)	0.563
Drink	40 (16.7%)	39 (14.1%)	20 (14.7%)	0.702
Marry				0.346
Single/ Widowed/ Divorced	73 (30.5%)	88 (31.9%)	34 (25.0%)	
Married	166 (69.5%)	188 (68.1%)	102 (75.0%)	
Live				0.170
Non-family/alone	28 (11.7%)	48 (17.4%)	18 (13.2%)	
Family	211 (88.3%)	228 (82.6%)	118 (86.8%)	

(*Continued*)

Table 3 (Continued).

	Normal	Moderate	Severe	*p* value
	Mean / N±SD / (%)	Mean / N±SD / (%)	Mean / N±SD / (%)	
Care				<0.001*
Oneself	117 (49.0%)	89 (32.8%)	29 (21.8%)	
Others	122 (51.0%)	182 (67.2%)	104 (78.2%)	
Diagnosis				0.124
Urinary tract infection	40 (16.7%)	34 (12.3%)	19 (14.0%)	
Pneumonia	26 (10.9%)	57 (20.7%)	32 (23.5%)	
Cellulitis	30 (12.6%)	25 (9.1%)	12 (8.8%)	
Bacteremia	15 (6.3%)	20 (7.2%)	6 (4.4%)	
Acute pyelonephritis	5 (2.1%)	5 (1.8%)	3 (2.2%)	
Acute kidney failure	7 (2.9%)	6 (2.2%)	7 (5.1%)	
Type 2 diabetes mellitus	9 (3.8%)	8 (2.9%)	1 (0.7%)	
Prostatitis	12 (5.0%)	9 (3.3%)	4 (2.9%)	
Fracture of femur	1 (0.4%)	5 (1.8%)	3 (2.2%)	
Other	94 (39.3%)	107 (38.8%)	49 (36.0%)	
Physical and psychological assessment				
Age-adjusted Charlson comorbidity index	6.1±2.1	6.3±2.0	6.4±2.1	0.231
5-item Geriatric Depression Scale	0.9±1.2	1.4±1.3	1.7±1.4	<0.001*
Barthel index of activities of daily living	60.3±30.4	36.8±25.6	23.6±23.8	<0.001*
Lawton instrumental activities of daily living	2.5±2.4	1.1±1.5	1.0±1.8	<0.001*
Mini-nutritional assessment	21.0±4.9	18.1±4.7	15.4±5.2	<0.001*
Hand grip strength (kg)	20.6±8.5	17.0±8.0	15.8±8.4	<0.001*
Six-meter walk test (sec)	15.1±13.7	18.5±16.0	16.4±10.6	0.085
Timed Up and Go test (sec)	21.3±12.7	28.2±22.2	25.8±20.1	0.104
Length of stay (day)	10.4±7.6	12.2±8.9	13.3±8.6	<0.001*
In-hospital mortality	29 (12.1%)	56 (20.3%)	47 (34.6%)	<0.001*

Note: *: p<0.05.
Abbreviations: N, Number of patients; ±SD, Plus or minus standard deviation; %, Percentage.

performance on physical function tests, including HGS, SMWT, and TUGT, were significantly associated with increased mortality risk in both sexes. However, several of these variables lost statistical significance after adjustment in the multivariate models. Notably, among males, severe impairment on the BOE remained an independent predictor of in-hospital mortality (HR = 1.77, 95% CI: 1.05–2.99, p = 0.032), as did a higher ACCI (HR = 1.11, 95% CI: 1.02–1.20, p = 0.014).

Kaplan–Meier survival curves were plotted to illustrate the cumulative survival rate during hospitalization according to oral function impairment levels in male and female patients (Figure 1a and b). Among male patients, the survival difference across oral function groups was statistically significant (log-rank p = 0.014), whereas the difference was not significant in female patients (log-rank p = 0.376).

Discussion

Statement of Principal Findings

The findings of this study underscore the critical role of oral functional impairment in clinical outcomes for hospitalized older adults, highlighting significant sex-specific differences. In our study, sex-related variations are observed in terms of the impact of oral health on physical, psychological, and functional outcomes.[8] Men experience a decline in BMI as oral functional impairment worsened, while women show stronger associations with changes in marital status and the presence of comorbidities. Despite the fact that the men in this study are older and have more adverse physical and psychological assessment factors, oral functional impairment remains an independent predictor of poor clinical outcomes. This suggests that oral health exerts a unique and significant influence beyond these established risk factors. Severe

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Table 4 Exploring Predictors of in-Hospital Mortality

	Female				Male			
	Univariate		Multivariate		Univariate		Multivariate	
	HR (95% CI)	*p* value	HR (95% CI)	*p* value	HR (95% CI)	*p* value	HR (95% CI)	*p* value
Age	1.08 (1.05–1.11)	<0.001*	1.05 (0.94–1.17)	0.396	1.03 (1.01–1.05)	0.012*	1.02 (0.99–1.04)	0.136
Bedside oral examination								
Normal	1.00				1.00		1.00	
Moderate	1.45 (0.83–2.53)	0.190			1.32 (0.84–2.08)	0.223	1.16 (0.72–1.87)	0.537
Severe	1.42 (0.72–2.80)	0.310			1.96 (1.23–3.12)	0.005*	1.77 (1.05–2.99)	0.032*
Physical and psychological assessment								
Age–adjusted Charlson comorbidity index	1.15 (1.06–1.25)	<0.001*	1.02 (0.70–1.50)	0.901	1.12 (1.04–1.21)	0.003*	1.11 (1.02–1.20)	0.014
5–item Geriatric Depression Scale	0.92 (0.75–1.14)	0.465			1.00 (0.85–1.17)	0.985		
Barthel index of activities of daily living	0.98 (0.97–0.99)	<0.001*	0.97 (0.92–1.02)	0.260	0.99 (0.99–1.00)	0.021*	1.01 (1.00–1.02)	0.223
Lawton instrumental activities of daily living	0.63 (0.49–0.80)	<0.001*	0.51 (0.20–1.28)	0.149	0.84 (0.75–0.95)	0.005*	0.85 (0.72–1.00)	0.051
Mini–nutritional assessment	0.91 (0.87–0.95)	<0.001*	0.94 (0.71–1.24)	0.668	0.97 (0.94–1.00)	0.092		
Hand grip strength (kg)	0.92 (0.87–0.98)	0.014*	1.09 (0.87–1.38)	0.448	0.98 (0.96–1.01)	0.248		
Six–meter walk test (sec)	1.04 (1.02–1.06)	0.001*	1.03 (0.94–1.12)	0.528	1.00 (0.97–1.03)	0.805		
Timed Up and Go test (sec)	1.04 (1.02–1.06)	<0.001*	0.99 (0.92–1.08)	0.877	0.99 (0.96–1.02)	0.462		
Diagnosis								
Urinary tract infection	1.30 (0.69–2.45)	0.424			1.40 (0.80–2.44)	0.239		
Pneumonia	0.81 (0.24–2.67)	0.725			1.15 (0.73–1.81)	0.535		
Cellulitis	0.95 (0.39–2.30)	0.911			0.47 (0.19–1.18)	0.109		
Bacteremia	1.66 (0.78–3.54)	0.193			0.85 (0.42–1.71)	0.641		
Acute pyelonephritis	0.19 (0.03–1.42)	0.107			0.74 (0.18–3.03)	0.672		
Acute kidney failure	2.36 (0.91–6.13)	0.079			1.67 (0.67–4.21)	0.272		
Type 2 diabetes mellitus	–	–			2.42 (0.96–6.10)	0.061		
Prostatitis	–	–			1.90 (0.46–7.82)	0.376		
Fracture of femur	–	–			0.89 (0.28–2.86)	0.845		
Other	1.00				1.00			

Note: *: p<0.05.

Abbreviations: HR, hazard ratio; CI, confidence interval.

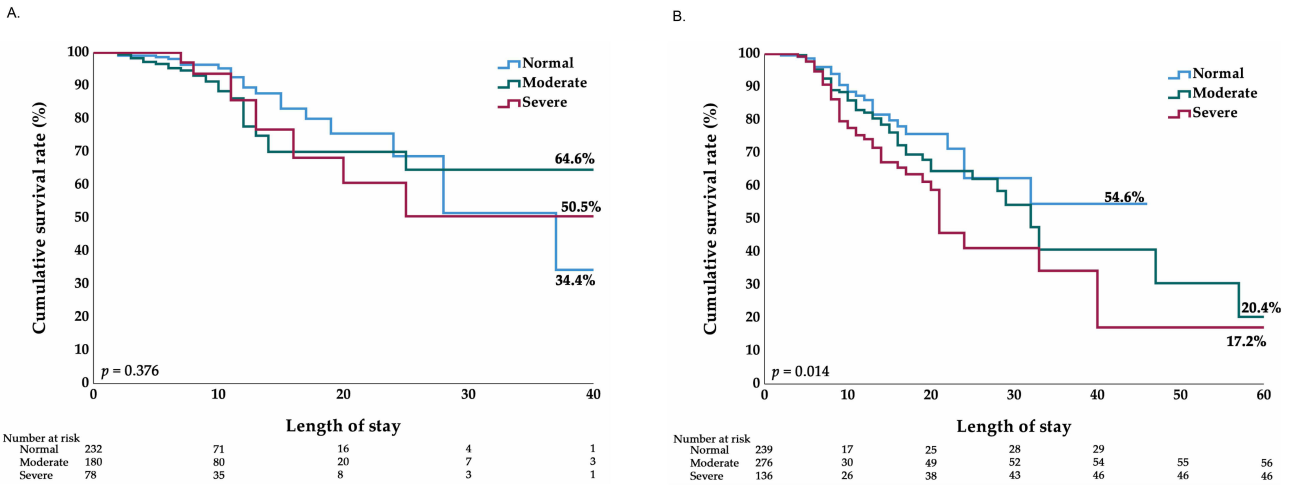

Figure 1 (**A**) Kaplan–Meier survival curves illustrating the cumulative survival rate by oral function impairment levels in female patients during hospitalization. The x-axis represents length of stay (days), and the y-axis represents cumulative survival (%).(**B**) Kaplan–Meier survival curves illustrating the cumulative survival rate by oral function impairment levels in male patients during hospitalization. The x-axis represents length of stay (days), and the y-axis represents cumulative survival (%).

impairment on the BOE is a strong predictor of in-hospital mortality in men but not in women. This sex-specific difference is further supported by Kaplan–Meier analysis, which shows a significant association between impaired oral function and reduced survival only in male patients. These findings highlight the differential vulnerability between sexes and emphasize the need for tailored, sex-specific approaches in geriatric care.

Strengths and Weaknesses in Relation to Other Studies

This study builds on existing research that highlights the critical role of oral health in overall health and functional independence among older adults.[2,3,8] Our findings advance this understanding by identifying distinct sex-specific predictors of in-hospital mortality. While prior studies have suggested that men experience poorer oral health outcomes,[12] our research offers specific evidence linking poor oral health to increased mortality risk in men. Notably, the ACCI also emerges as a strong predictor of in-hospital mortality in this group. The ACCI, recognized as a reliable, highly sensitive, and valid index under current clinimetric criteria for survival prediction,[27] further supports the significant role of oral health as a mortality predictor in men.

Both sex exhibit severe impairments associated with lower ADL scores, reduced IADL performance, poorer MNA results, and diminished HGS, but the specific associations differ by sex, as females show an increase in ACCI with worsening severity, suggesting a higher comorbidity burden, which may be related to hormonal factors such as estrogen fluctuations affecting gum inflammation.[12,28] Additionally, men are more likely to engage in smoking and alcohol consumption, which are risk factors for systemic diseases, while psychological factors such as depression and anxiety also vary by sex, with women reporting these symptoms more frequently, potentially impacting their hygiene practices.[12,28] Research has consistently shown a bidirectional relationship between mental health and oral health in older adults, as poor oral health can worsen depression and anxiety, while also affecting social interactions and facial aesthetics, which in turn impact overall well-being across physical, psychological, and social domains.[4,29–31] Moreover, the absence of a significant association between oral functional impairment and in-hospital mortality among female patients may reflect underlying sex-based differences in oral health trajectories prior to hospitalization. Although our study assesses oral function at admission, it is likely that pre-existing behaviors and access to preventive care influence the degree of impairment observed upon hospitalization. Prior studies have shown that older women are more likely to engage in preventive oral health behaviors and seek dental care more frequently than men.[32,33] These behaviors may have delayed the progression of oral dysfunction or mitigate its severity, potentially attenuating its immediate impact on clinical outcomes. In addition, Kotronia et al highlight that psychosocial buffers and health-seeking behaviors, more prevalent in women, may lessen the physiologic consequences of oral decline.[34] Therefore, while oral functional

impairment is measured post-admission, sex-specific differences in prior oral health maintenance may partially account for the observed variation in its prognostic value. Furthermore, consistent with previous research,[35,36] our findings demonstrate that BMI declines as oral functional impairment worsens in males. While a similar trend was observed in females, it does not reach statistical significance. A previous study conducted in Korea finds a positive relationship between being underweight and poor oral health in an older population,[35] underscoring the complex interplay between underweight status, low bone mineral density, and periodontal disease. This relationship may reflect a bidirectional link where poor oral health leads to nutritional deficiencies due to impaired chewing and eating capabilities, subsequently contributing to weight loss and lower BMI.[37] Conversely, being underweight and having low bone mineral density may exacerbate periodontal disease through weakened immune responses and reduced tissue repair capacity.[38–41] These findings indicate the need for integrated healthcare approaches that address oral health alongside nutritional and systemic health, particularly in older populations and especially in men, who appear to be more significantly affected by these associations.

Implications for Clinicians and Policymakers

Integrating oral health evaluations, such as the BOE, into routine geriatric assessments is crucial, especially for male patients. A feasible screening protocol may involve conducting a brief bedside oral assessment within the first 72 hours of hospitalization by trained nurses or geriatric care staff. Patients identified with moderate to severe impairment may be referred for further dental evaluation or receive targeted oral hygiene interventions. Policymakers should promote sex-sensitive protocols and oral health as a core element of geriatric care frameworks. These findings also highlight the value of personalized oral care strategies, as emphasized in recent literature to address the varying needs of older adults with differing functional, psychological, and social vulnerabilities.[42]

Strengths and Weaknesses of the Study

This study benefits from a large sample size and detailed analyses of sex-specific parameters, including oral health, comorbidities, and functional status. However, due to the retrospective design of this study, causality cannot be inferred. Differences in baseline demographics, such as higher BMI in women and greater prevalence of smoking and drinking in men, may have introduced bias. Unmeasured variables, including socioeconomic factors, could have further influenced outcomes. Additionally, certain potential confounding variables—such as access to dental care, oral health literacy, and socioeconomic status—are not assessed in this study. These factors may influence both oral health status and clinical outcomes and should be considered in future research. Moreover, while the BOE provides a quick and practical tool for bedside oral health assessment, it has limitations. It does not capture detailed periodontal or prosthodontic status, and its reliance on subjective clinical judgment may introduce variability, particularly when performed by different assessors. Future research may benefit from incorporating more comprehensive dental evaluations to complement BOE findings.

Unanswered Questions and Future Research

Future studies should investigate the biological mechanisms, such as inflammation and immune response, that underlie sex differences and their impact on oral health. Exploring the efficacy of tailored interventions addressing oral health and nutrition aimed at reducing mortality risks is vital. Additionally, longitudinal research is needed to establish causality and examine the role of oral health literacy and access to care in improving geriatric outcomes.

Conclusion

This study investigates the association between oral functional impairment and in-hospital mortality in older adults, with a specific focus on sex-based differences. Our findings demonstrate that severe oral functional impairment is an independent predictor of in-hospital mortality among men, but not women. These results underscore the importance of incorporating oral health assessments—such as the BOE—into hospital admission protocols to identify high-risk patients early and facilitate timely multidisciplinary interventions, particularly among male patients. Sex-specific approaches to risk stratification and care planning may improve clinical outcomes and promote more personalized geriatric care. Future

research should aim to elucidate the biological and social mechanisms underlying these sex disparities and evaluate the effectiveness of targeted interventions, which may ultimately contribute to more equitable and effective geriatric care.

Abbreviations

ACCI, age-adjusted Charlson comorbidity index; ADL, activities of daily living; BMI, body mass index; BOE, bedside oral examination; CI, confidence interval; GDS-5, five-item geriatric depression scale; HGS, hand grip strength; HR, hazard ratio; IADL, instrumental activities of daily living; IRB, institutional review board; MNA, mini-nutritional assessment; SMWT, six-meter walk test; TUGT, timed up and go test.

Data Sharing Statement

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the institutional review board of Taichung Veterans General Hospital (protocol code TCVGH-IRB CE23207B), which granted permission to access deidentified patient data for this retrospective study, thereby obviating the need for consent to participate.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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