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Multimorbidity patterns and prevalence among geriatric patients in Japanese hospital dentistry

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Abstract

Background This study aimed to determine the prevalence of multimorbidity of a hospital dental patients with high rates of aging in Japan and to identify multimorbidity patterns in older patients (aged 65 years and older) through cluster analysis. As the population ages, the number of patients with multimorbidity is rising, highlighting the need for efficient allocation of dental resources and collaboration with other healthcare professionals. However, the prevalence and patterns of multimorbidity in older dental patients have not yet been reported. Such data could support standardized approaches to systematizing dental care.

Methods A retrospective survey was conducted on 1,011 patients in the Dental and Oral Surgery Department of Acute Care Hospital from April to October 2022, examining 17 types of chronic diseases per patient. For patients aged 65 years and older, cluster analysis using the non-hierarchical k-means method was applied to identify multimorbidity patterns.

Results The prevalence of multimorbidity was 61.4% among all patients and 86.5% among those aged 65 years and older. Cluster analysis revealed five distinct multimorbidity patterns in patients aged 65 and older, each defined by specific combinations of chronic diseases. Additionally, low independence in daily activities and high nursing care needs were associated with two particular multimorbidity patterns: a combination of stroke, digestive disease, hypertension, neurological disease, and a combination of cardiovascular disease, digestive disease, and metabolic disease.

Conclusions This study identified the prevalence and specific patterns of multimorbidity among older hospital dental patients, providing essential insights for dental professionals to enhance service provision and manage complex multimorbidity cases.

Keywords Multimorbidity, Hospital dental clinic, Nursing care intensity, Cluster analysis

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Background

Multimorbidity refers to the presence of two or more chronic diseases in an individual, differing from comorbidity, which refers to the combined effects of additional conditions on the index condition in an individual [1]. Studies have reported that 64.9% of individuals aged 65 years have multimorbidity [2, 3]. Global population projection models suggest that the proportion of people aged 65 years and older will be substantial across many regions [4]. Additionally, the prevalence of multimorbidity tends to increase with age. Patients with multimorbidity often need frequent, complex health service interactions, which can compromise safety due to fragmented care, increased unplanned hospitalizations, complications, and increased patient burden [5, 6, 7]. These issues pose significant public health concerns that warrant further attention.

Oral diseases are a global health priority, particularly among aging populations [8, 9]. Addressing multimorbidity is standard in dentistry and oral health care, yet system reforms, new training and care models are necessary [11]. Prior research in dentistry has emphasized the importance of incorporating chronic oral conditions into the category of chronic diseases within the framework of multimorbidity [12]. Studies exploring multimorbidity in individuals with periodontal disease have identified associations with hypertension, obesity, arthritis, and diabetes [13]. However, there is limited literature on a specialized care model for efficiently distributing and providing dental services to patients with highly complex multimorbidity.

The management of multimorbidity is largely based on single-disease clinical guidelines [2]. Currently, there are no reliable evidence-based guidelines for multimorbidity management [14]. Consequently, further research is needed to evaluate the effectiveness of the current treatment and support systems for individuals with multimorbidity [15]. Identifying and providing targeted services to patients in need of treatment and care may offer a viable solution [5]. To date, numerous studies have explored multimorbidity patterns in the general and older populations, revealing common multimorbidity patterns among cardiovascular, metabolic, gastrointestinal, psychiatric, and musculoskeletal diseases [16, 17, 18, 19, 20]. However, no studies have specifically examined multimorbidity patterns in older dental patients.

In Japan, which has a universal health insurance system for both medicine and dentistry, there are 67,899 dental clinics, while there are 1,867 dental clinics that are part of hospital departments [21] (hereafter referred to as hospital dental clinics). Hospital dental clinics often receive referrals from nearby dental clinics for patients with systemic diseases or patients who are hospitalized in other departments of the hospital. Therefore, hospital dental clinic tends to concentrate older patients with systemic diseases.

The aim of this study is to clarify the prevalence of multimorbidity in patients of hospital dental clinics and the patterns of multimorbidity in patients aged 65 and over in Japan, a country that is experiencing the fastest rate of population aging in the world. Another aim is to provide information to dentists and their assistants who will be responsible for treating complex multimorbidity who are expected to increase in number in the future.

Methods

Study population and definition of multimorbidity

Data were collected from a retrospective medical record survey of 1,011 patients who visited the Dental and Oral Surgery Department of the Japan Communication Healthcare Organization (JCHO) Kobe Central Hospital between April and October 2022. The following basic information was gathered: sex, age, daily living environment (home, hospital/nursing home), patient status at the time of hospital dental treatment (inpatient or outpatient), number of medications used, presence or absence of collaboration with institutions other than the referring one, and hospital dental treatment category (dental and oral surgical treatment, non-invasive treatment, oral care management during hospitalization). Inpatient in the "patient status at the time of hospital dental treatment" section means that the patient is hospitalized for the treatment of a medical condition and does not include patients hospitalized for a dental condition. Collaboration with institutions other than the referring one means the sharing of health information of each patient with medical institutions (doctors or dentists of other hospitals) other than the referring one for the purpose of ascertaining medical conditions prior to treatment at a hospital dental clinic or passing the information on to another dental clinic from the hospital dental clinic.

Hospital dental treatment in this study includes most of the general dental treatment and oral surgical treatments permitted for Japanese dentists. Dental and oral surgical treatments refer invasive treatment (e.g. dental caries treatment, endodontic therapy, periodontal disease treatment, extraction of third molars, the removal of tumors from the jawbone and oral soft tissues, trauma care). While non-invasive treatment refers to the examination and treatment of oral medicine conditions such as temporomandibular disorders, facial pain, and the oral manifestations of systemic and infectious diseases. Oral care management during hospitalization is professional oral care by dental hygienists under the direction of a dentist to patients admitted to other departments of the hospital and hygiene education for patients and nurses.

Aoki (2018) classified chronic diseases into 17 categories for use in Japan [16], including hypertension,

diabetes, dyslipidemia, stroke, cardiac disease, chronic respiratory disease, digestive disease, kidney disease, urological disease, arthritis, rheumatism, lumbar disease, neurological disease, mental disease, endocrine disease, malignancy, vision abnormalities, and skin disease. Identification of each patient's chronic diseases was recorded in the electronic medical records shared by the hospital's medical and dental departments, based on information completed by the patient themselves in questionnaires, as well as information completed by the hospital's doctors based on objective diagnostic criteria, and information provided by doctors at other hospitals.

For inpatients, the primary diagnosis for admission, degree of independence for disabled elderly, and the nursing care intensity scores were also recorded. The degree of independence in daily living for disabled elderly is an index used to assess the health status and care requirements among older individuals in Japan [22]. This scale indicates the functional abilities and independence of older individuals in their daily life, and it is classified into four stages: independent, house-bound, chair-bound, and bed-bound. In this study, the chair-bound and bed-bound classifications were defined as low independence, while the others were defined as high independence.

Nursing Care Intensity was developed as a management indicator to measure the amount of nursing care required by inpatients [23], and has been used for the past 20 years to assess the level of disability of patients in acute care wards in Japan. It has also been established as one of the evaluation indices for use as a standard for determining medical fees. The B-items of Nursing care intensity assess the patient's activities of daily living, including repositioning, transfer, oral hygiene, eating, dressing, undressing, instruction, and risky behavior, with total scales ranging from 0 to 12, with higher scores indicating greater severity. In this study, for each patient during hospitalization, the highest one-day value on B-item was extracted for each patient.

Statistical analyses

Multimorbidity was defined as the presence of two or more chronic diseases. To statistically compare each item between the 0–1 disease group and multimorbidity group, a chi-square test was performed for nominal variables, and Student's t-test was performed for continuous variables. To examine multimorbidity patterns, factor analysis using the principal component method was employed, with promax rotation to ascertain the number of clusters. Based on these findings, a non-hierarchical cluster analysis (k-means method) was used to identify multimorbidity patterns. Statistical analyses were performed using SPSS statistical software (Excel Bell Curve). P value of < 0.05 was considered to indicate a statistically significant difference.

Ethical considerations

This study was conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Japan Community Health Care Organization Kobe Central Hospital, approval number [330] and the University of Hyogo, approval number [2023-0008]. The need for individual informed consent was waived by the IRB due to the retrospective nature of the study and the use of anonymized data, in accordance with [relevant national regulation or guideline, e.g., the Japanese Ethical Guidelines for Medical and Health Research Involving Human Subjects]. Patient consent was obtained through the facility's opt-out process.

Results

Characteristics of hospital dental patients and prevalence of multimorbidity

Survey data from 1,011 patients are presented in Table 1. Among them, 621 (61.4%) patients had multimorbidity. The remaining patients were divided into two categories: those with no chronic diseases ($n = 235$, 23.2%) and those with one chronic disease ($n = 155$, 15.3%). The prevalence of multimorbidity was analyzed focusing on the inversion of the ratio of 0–1 disease to multiple diseases among patients aged 50–64 and 65 years, the prevalence of multimorbidity was analyzed; 546 (86.5%) patients aged 65 years and older (631 patients) had multiple diseases, while 292 (93.0%) of the 314 patients aged 80 years and older had multiple diseases.

There was a notable sex difference, with 65.1% of males and 58.4% of female patients exhibiting multiple diseases. The number of chronic diseases per patient ranged from zero to nine, with an average of 2.5. The mean age of the subjects was 64.5 years, and a total of 366 patients (36.2%) resided in external care facilities, while 401 (39.7%) were inpatients of other department at the hospital. The number of medications used ranged from zero to 19 with an average of 4.0. A total of 112 patients (11.1%) were using more than 10 medications. In 115 patients (11.4%), hospital dentists collaborated with institutions other than the referring one to share medical or dental information necessary to hospital dental treatment of the patient. Dental and oral surgical treatments (466 cases) were most prevalent, followed by inpatient oral care (380 cases). Significant differences in sex, age, living environment, patient condition, number of medications used, and information sharing were observed when comparing patients with 0–1 disease to those with multimorbidity.

The distribution of chronic diseases among all patients (Table 2, left) showed that hypertension and digestive diseases affected over 30% of all patients, while the six less prevalent diseases accounted for less than 10% of all cases.

Table 1 Characteristics of patients with Multimorbidity compared to those with 0–1 chronic conditions

	total	0-1chronical condition	multimorbidity	*p*-value
Overall	1011	390(38.6)	621(61.4)	
Sex				
Male	453(44.8)	158(34.9)	295(65.1)	0.03*
Female	558(55.2)	232(41.6)	326(58.4)	
Age				
Average (year)	64.5	44.4	77.1	< 0.01**
<50	253(25.0)	234(92.5)	19(7.5)	< 0.01*
50–64	127(12.6)	71(56.0)	56(44.0)	
65–80	317(31.4)	63(20.0)	254(80.0)	
80≦	314(31.0)	22(7.0)	292(93.0)	
Living environment				
Home	645(63.8)	354(54.9)	291(45.1)	< 0.01*
Hospital, nursing home	366(36.2)	36(10.0)	330(90.0)	
Patient status				
Inpatient	401(40.0)	56(14.0)	345(86.0)	< 0.01*
Outpatient	610(60.0)	334(54.8)	276(45.2)	
Number of concurrent medications				
Average	3.98	0.61	6.09	< 0.01**
0	306(30.3)	285(93.1)	21(6.9)	< 0.01*
1-4	315(31.2)	91(28.9)	224(71.1)	
5-9	278(27.5)	14(5.0)	264(95.0)	
≧10	112(11.0)	0(0)	112(100)	
Collaboration with any additional institution				
No	896(88.6)	371(41.4)	525(58.6)	< 0.01*
Yes	115(11.4)	19(16.5)	96(83.5)	
Hospital dental treatment category				
Dental and oral surgical treatment	466(46.1)	252(54.1)	214(45.9)	
Non-invasive treatment	165(16.3)	85(51.5)	80(48.5)	
Oral care management during hospitalization	380(37.6)	53(13.9)	327(86.1)	

(%)

*chi-square test

**Student's-t-test

Demographic, clinical, and hospital dental treatment characteristics of 1,011 patients in a hospital dental clinic, comparing those with multimorbidity (defined as ≥ 2 chronic conditions) to those with 0–1 chronic conditions. Statistical significance of differences was evaluated using the chi-square test and Student's t-tests

Determination of the multimorbidity patterns in hospital dental patients 65 years and older

Factor analysis identified and extracted five multimorbidity patterns among patients aged 65 years and older (631 patients), each with cumulative contribution rates greater than 35%. Using these factors, cluster analysis was performed to classify the patients into five patterns, with each cluster containing more than 15% of the patients. Table 2 (right) highlights the central disease (colored cells) and the degree of association of each chronic disease within each cluster (0.3 or higher in bold). Clusters 1, 2, and 3 displayed a multimorbidity pattern centered on stroke, cardiac disease, and gastrointestinal disease (≥ 0.9), while cluster 5 featured a multiple disease pattern centered on dyslipidemia and hypertension. Cluster 4 was a multiple disease pattern that was difficult to characterize because only lumbar spine disease exceeded 0.3, while the other chronic diseases did not exceed 0.3. Hypertension was highly associated with all patterns, while digestive diseases were also highly associated with all clusters, except for cluster 4. Lumbar disease scored 0.25 or higher across all clusters, indicating its relevance among many dental patients.

Table 3 illustrates the relationships between each cluster and the patient information. Clusters 1, 2, and 5 included more patients aged > 80 year. Cluster 1 included the highest percentage of patients living outside their homes and of hospitalized patients. Cluster 5 recorded the highest average number of chronic conditions and percentage of patients sharing information, whereas Cluster 2 included the highest average number of medications and percentage of patients using > 10 medications. Cluster 4 included the lowest average number of conditions, medications, and information-sharing. Regarding the relationship between multimorbidity patterns and hospital dental treatment, more than 35% of

Table 2 Chronic diseases prevalence and cluster patterns in patients aged 65 years and older

	Number of each chronic disease		Cluster				
	Overall	≧65 years	1	2	3	4	5
n(%)	1011(100)	631(100)	95(15.1)	98(15.5)	127(20.1)	192(30.4)	119(18.9)
Hypertension	356(35.2)	321(50.9)	**0.40**	**0.74**	**0.38**	0.29	**0.90**
Diabetes	140(13.8)	126(20.0)	0.27	**0.35**	0.13	0.09	0.27
Dyslipidemia	190(18.8)	166(26.3)	0.17	0.00	0.10	0.09	**1.00**
Stroke	153(15.1)	143(22.7)	**1.00**	0.20	0.00	0.00	0.24
Cardiac Disease	205(20.3)	194(30.7)	0.15	**1.00**	0.02	0.10	**0.50**
Respiratory Disease	118(11.7)	95(15.1)	0.17	0.19	0.21	0.07	0.16
Digestive Disease	307(30.4)	276(43.7)	**0.52**	**0.55**	**1.00**	0.00	**0.39**
Kidney Disease	103(10.2)	96(15.2)	0.18	**0.36**	0.06	0.10	0.15
Urological Disease	65(6.4)	62(9.8)	0.14	0.06	0.13	0.08	0.09
Arthritis and Rheumatism	58(5.7)	50(7.9)	0.09	0.04	0.09	0.10	0.06
Lumbar Disease	207(20.5)	189(30.0)	0.29	0.29	0.26	**0.36**	0.26
Neurological Disorders	130(12.9)	121(19.2)	**0.33**	0.20	0.18	0.15	0.16
Mental Disease	71(7.0)	50(7.9)	0.05	0.05	0.11	0.09	0.08
Endocrine Disorders	79(7.8)	58(9.2)	0.09	0.11	0.06	0.09	0.11
Malignancy	174(17.2)	147(23.3)	0.12	0.14	**0.36**	0.22	0.29
Vision Abnormalities	87(8.6)	79(12.5)	0.12	0.09	0.09	0.15	0.16
Skin Disease	72(7.1)	48(7.6)	0.06	0.07	0.10	0.06	0.08

highlighted central disease

bold ≧0.3

Column 2 presents the prevalence of various chronic diseases among all 1,011 patients and Column 3 the respective prevalence in 631 patients aged 65 years and older in a hospital dental clinic. Data are presented as the number of patients (n) and percentages (%) per disease category

Columns 4–8 present the cluster analysis results for the 631 patients, aged 65 years and older, with five distinct clusters identified based on the presence of chronic diseases. These columns illustrate the strength of the association between diseases within each cluster, with the most prominent diseases highlighted in bold and those with a prevalence of 0.3 or higher

patients in Clusters 2, 4, and 5 received dental and oral surgical treatment, whereas more than 60% of patients in Clusters 1 and 3 received oral care management during hospitalization.

Prevalence and patterns of multimorbidity among patients aged 65 and older hospitalized in other department and receiving treatment at the hospital dental clinic

Among the 334 hospitalized patients aged 65 and older, 311 (93.1%) had multimorbidity. The primary diseases at admission most commonly fell into the gastrointestinal, musculoskeletal, neurological, and cardiovascular categories, forming the common clusters. Respiratory diseases, including recurrent aspiration pneumonia, were the most common in Cluster 1, suggesting a link with chronic neurological diseases such as stroke. Cluster 5 had the highest average disease count, while Cluster 4 had the lowest. Patients in Clusters 3, 4, and 5 exhibited a higher degree of independence than those in Clusters 1 and 2. The mean score of nursing care intensity for Clusters 1 and

Table 3 Characteristics of patients aged 65 years and older by cluster

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5
Overall	95(15.1)	98(15.5)	127(20.1)	192(30.4)	119(18.8)
Sex					
Male	56(58.9)	58(59.2)	61(48.0)	70(36.5)	46(38.7)
Female	39(41.1)	40(40.8)	66(52.0)	122(63.5)	73(61.3)
Age					
Average (year)	80.4	81.9	78.6	78.3	80.3
65–79	39(41.1)	40(40.8)	73(57.5)	109(56.8)	56(47.1)
80≦	56(58.9)	58(59.2)	54(42.5)	83(43.2)	63(52.9)
Living environment					
Home	31(32.6)	46(46.9)	56(44.1)	113(58.9)	60(50.4)
Hospital, nursing home	64(67.4)	52(53.1)	71(55.9)	79(41.1)	59(49.6)
Patient status					
Inpatient	65(68.4)	51(52.0)	81(63.8)	78(40.6)	59(50.6)
Outpatient	30(31.6)	47(48.0)	46(36.2)	114(59.4)	60(50.4)
Average disease	4.15	4.46	3.29	2.03	4.89
Number of concurrent medications					
Average	6.81	7.53	5.19	3.75	7.03
0	2(2.1)	1(1.0)	10(7.9)	36(18.8)	2(1.7)
1-4	21(22.1)	27(27.6)	53(41.7)	92(47.9)	29(24.4)
5-9	53(55.8)	43(43.9)	45(35.4)	49(25.5)	61(51.3)
≧10	19(20.0)	27(27.6)	19(15.0)	15(7.8)	27(22.7)
Collaboration with any additional institution					
No	79(83.2)	80(81.6)	111(87.4)	173(90.1)	96(80.7)
Yes	16(16.8)	18(18.4)	16(12.6)	19(9.9)	23(19.3)
Hospital dental treatment category					
Dental and oral surgical treatment	27(28.4)	40(40.9)	29(22.8)	69(35.9)	44(37.0)
Non-invasive treatment	11(11.6)	10(10.2)	19(15.0)	42(21.9)	14(11.8)
Oral care management during hospitalization	57(60.0)	48(49.0)	79(62.2)	81(42.2)	61(51.3)

( ) the percentage within the cluster

Characteristics, clinical features, and hospital dental treatment details of 631 patients aged 65 years and older, categorized into five distinct clusters based on multimorbidity patterns

2 was higher than the overall mean for all clusters (6.73). Cluster 1 exhibited particularly elevated mean scores for in-bed positioning, eating, directing, and managing risky behaviors.

Summary of Multimorbidity patterns in hospital dental patients

Each cluster is summarized below (refer to Tables 2, 3 and 4).

Cluster 1: Stroke, digestive diseases, hypertension, and neurological disease (patients living outside the home).

Cluster 2: Cardiovascular disease, hypertension, digestive disease, and metabolic disease (low independence).

Cluster 3: Digestive disease, hypertension, and malignancy.

Cluster 4: Nonspecific patterns with mild lumbar disease.

Cluster 5: Dyslipidemia, hypertension, cardiovascular disease, and digestive disease (high independence).

Discussion

We believe that this study reflects the current situation and challenges related to multimorbidity among dental patients. A systematic review by Nguyen et al. showed that the multimorbidity prevalence is notably high among people aged 65 years and older [14], and Japan with a rapidly aging population, has one of the highest global proportions of people aged 65 years and older (24.2% in 2022) [24]. This report is pioneering in addressing multimorbidity in dentistry, which is especially relevant in Europe, the United States, and Asia where aging populations are expected to increase in the near future. The prevalence of multimorbidity in this study (86.2%) exceeds that in Japan's general population (62.8% per Aoki et al. [16] and 52.0% per Kato et al. [25], underscoring the complexity of hospital dental clinic.

Kuthy reports that older people who are in poorer general health and have more medical visits are less likely to use dental services [26]. It would be expected that patients attending dental clinics would have a lower proportion of older people with multimorbidity and would

Table 4 Clinical and care characteristics of hospitalized patients aged 65 years and older by cluster

		Cluster1	Cluster2	Cluster3	Cluster4	Cluster5
Over all	334	65(19.5)	51(15.3)	81(24.3)	78(23.4)	59(17.7)
Main disease for admission						
Gastrointestinal diseases	77	8	10	42	8	9
Musculoskeletal disorders	72	9	11	11	29	12
Neurological disorders	53	24	5	5	6	13
Respiratory diseases	47	14	8	10	8	7
Hematologic diseases	25	0	0	5	13	7
Renal and male genitourinary diseases	21	7	5	2	3	4
Cardiovascular diseases	15	1	10	0	1	3
Other diseases	24	2	2	6	10	4
Average diseases	3.85	4.29	4.78	3.33	2.46	5.08
Degree of independence living						
High independence	189	22	18	60	47	42
Low independence	145	43	33	21	31	17
Average score of nursing care intensity	6.73	8.00	7.65	5.58	6.73	6.10
Repositioning	1.46	1.71	1.63	1.33	1.42	1.24
Transfer	1.54	1.72	1.73	1.41	1.51	1.42
Oral hygiene	0.86	0.91	0.94	0.81	0.86	0.81
Eating	1.01	1.34	1.16	0.70	0.92	1.03
Dressing and undressing	1.53	1.74	1.76	1.37	1.45	1.42
Instruction	0.46	0.71	0.57	0.31	0.41	0.37
Risk behavior	0.64	0.98	0.90	0.42	0.54	0.47

Clinical and care characteristics of 334 hospitalized patients aged 65 years and older, categorized into five distinct clusters based on multimorbidity patterns

be more likely to receive preventive dental services. In contrast, hospital dental clinic tends to cater to older and medically complex patients. This is because they receive many referrals for treatment of patients with systemic disease from surrounding dental clinics and referrals of patients with dental diseases and oral care requests from other departments in the hospital. Therefore, hospital dental patients should be considered when analyzing disease patterns in patients with multimorbidity requiring dental care. However, age demographics, and dental services vary across countries and hospitals. For example, in a survey of 233 dental surgery patients at an Australian university hospital, the prevalence of multimorbidity was 33.0%, but only 17.6% of these patients were over 65 years old [27]. This suggests that the multimorbidity prevalence and patterns may differ because of Australia's lower aging rate (14.8% in 2022) [24] than that of Japan's as well as differences in patient types and dental practices.

However, even within Japan, there are differences in age and disease distribution among hospitals and regions, which may alter the results. Data collection and analysis were conducted by one person collating medical history data from shared hospital medical records. However, the medical history data records were collected by several health care professionals with different clinical experiences, which may have resulted in unknown misclassifications of medical conditions and medications. There may also have been patient recall bias in the self-administered questionnaires.

A review by The Kudesia et al. recommended using a variety of methods to analyze the prevalence and patterns of multimorbidity, emphasizing that a transparent and consistent study design is important for accurate cross-study comparisons [28]. This study used unsupervised cluster analysis (the k-means method), which has been applied in several reports [29, 30, 31]. Clustering can be either hierarchical or non-hierarchical. Compared to hierarchies, non-hierarchies (k-means) are less susceptible to outliers, distance measures and irrelevant variables, and do not require a distance matrix, making them suitable for analyzing large data sets [32, 33, 34]. The method also identifies subgroups of patients with multimorbidity and reveals their respective disease patterns, contributing to the understanding of biological heterogeneity and the development of more effective patient management [35]. In unsupervised learning, there are no data for correct answers and correct answers are inferred from input data, allowing the results to be interpreted in the context of each country's or institution's patient groups. We believe that this method could be valuable in managing multimorbidity.

Notably, few studies have included dental disease as a part of chronic multimorbidity (Ghosh et al.) [36]. This may stem from oral hygiene often being of low priority for multimorbid patients [37]. Including issues with oral health as a chronic disease in multimorbidity (Mirza et al.) [12] would assist non-dental professionals, such as

medical doctors, develop appropriate care plans and avoid fragmented dental treatment and care.

In this study, multimorbidity was defined as the presence of two or more chronic conditions aside from dental diseases. Among the patients aged 65 years and older, 546 (86.5%) belonged to this category. Including 68 patients with a single chronic condition brought the total to 614, representing 97.3% of the study population. This highlights that most hospital dental patients aged 65 years and older require care planning that addresses more than just dental conditions, underscoring the need for a stratified and efficient approach to health resource allocation to enhance dental care safety.

Patients with multimorbidity face challenges such as lack of decision-making support, ineffective communication, and fragmented health services [38] potentially resulting in "fragmented, incomplete, inefficient, and ineffective" care. Addressing these issues requires micro- and meso-level strategies that prioritize healthcare resource allocation and effective communication tailored to the specific characteristics of each multimorbidity pattern [5, 10, 11]. A similar approach is needed for dental patients, aligning with the cluster-specific attributes of each cluster identified in this study:

Cluster 1, including stroke, digestive diseases, hypertension, and neurological disease (patients living outside the home), is marked by a high proportion of hospitalized, low independence patients who often move between hospitals and nursing homes, complicating continuity of care because they have difficulty making their own decisions. This can result in fragmented dental information and reduced efficiency. Dental professionals can aid in preventing aspiration pneumonia by collaborating with other hospital staff members [39]. Integrating dental information into shared networks enables smooth information exchange between primary care physicians and dentists. Effective management of this complex cluster depends on close collaboration among caregivers.

Cluster 2, incorporating cardiovascular disease, hypertension, digestive disease, and metabolic disease (low independence), includes patients requiring multiple medications, complicating the management of highly invasive oral procedures. To enhance safety, physicians and caregivers need to improve coordination between themselves. Hospitalized patients, like those in Cluster 1, often have lower levels of independence. Additionally, conditions such as diabetes, kidney disease, dialysis, and cardiovascular disease impact dental disease, requiring careful timing and medication for dental treatments and oral surgeries. Hospital dentists play a central role in oral care and collaborative care efforts. A system or device enabling real-time patient status updates for both physicians and hospital dentists would be highly beneficial.

Cluster 5 shares focus on cardiovascular disease with Cluster 2 but involves more independent patients. Providing information on multimorbidity, medication status, frailty, and self-management guidance as well as improving oral health literacy, can prevent cardiovascular disease and decline in ADL due to chronic conditions. Collaboration between hospitals and clinics is required to support dentists involved primary care in providing care focused on patients' daily lives.

Cluster 4 involves a younger, less medicated, and more independent patients, primarily with a mild relation of lumbar disease pattern. The decline in physical function may continue in the future, underscoring the need for all dental professionals to enhance health literacy of patients to help prevent disease progression and increased medication use. In this study, lumbar disease was not the central condition in any cluster but appeared as a mild relation across all clusters. Given the high prevalence of osteoporosis among lumbar diseases in this study, hospital dental clinics may frequently encounter many patients with this condition, regardless of other chronic diseases. Dentists can contribute not only to the prevention of medication-related osteonecrosis of the jaw [40] but also to supporting osteoporosis treatment adherence by collaborating with physicians and pharmacists to ensure patients continue their osteoporosis medication. Hospital dental professionals are increasingly involved in multidisciplinary teams, such as osteoporosis liaison services in Japan.

Patients in Cluster 3 had a higher rate of oral care management during hospitalization than those in the other clusters. In Japan, the "perioperative oral management fee" has been listed since 2012, and is now being performed by universal health insurance system, mainly by hospital dentists. This is aimed at preventing postoperative pneumonia from general anesthesia surgery, preventing dental damage from intubation, and preventing infections and mucositis originating from oral contamination during chemotherapy. Cluster 3 is the multimorbidity pattern, centered gastrointestinal diseases and malignant tumors, and many of them were hospitalized for the purpose of surgery and chemotherapy of other department in the hospital and as a result, we consider that they had more oral care management during hospitalization.

A hygienist-centered triage system has proven effective for preventing postoperative pneumonia [41]. Similarly in this study, dental hygienists take the lead in assessing oral infection status and risk of tooth loss and conducting oral screenings, based on the dentist's guidelines and instructions. To serve a large number of eligible patients with limited human resources, a system is in place to stratify the intensity of oral care by patient. Integrating dental and oral care plans with overall medical treatment

requires collaboration among dentists, dental hygienists, physicians, and nurses.

In an aging society like Japan, where medical resources are relatively decreasing, incentives are crucial to ensure that healthcare providers and institutions can continue to offer adequate care for patients with high complexity. One possible form is an increase in reimbursement for dental treatment of complex patients under the public insurance system, functioning as a macro-level support mechanism for multimorbidity.

This study was limited to chronic disease patterns, but factors like independence and nursing care intensity—which add to patient complexity—were identified as potentially relevant. Thus, further research is required to develop suitable indicators for efficient triage of dental service targets.

A bottom-up care model is essential for supporting a patient-centered approach to multimorbidity [42]. Support systems for multimorbidity patients to self-manage, communication between patients and health care providers, and communication between health care providers have been proposed, and the five patterns divided in this study also refer to the bottom-up type. To address the diverse needs of patients, a system centered on generalists, who can integrate a broad range of knowledge into personalized care, is required. Moreover, enhancing communication and collaboration across medical systems is also critical for patient safety [43]. Dental professionals play a key role as managers of oral health care who can promote integration of oral health care and primary care. In particular, dental hygienists can address both oral health care and patient primary care issues through comprehensive patient-centered care and collaboration and appropriate referrals.

Conclusion

This study identified the prevalence and disease combination patterns of multimorbidity among older patients of a hospital dental clinic in Japan, providing valuable insights to help dental professionals enhance care and manage complex multimorbidity cases.

Abbreviations

ADL	Activities of Daily Living
JCHO	Japan Communication Healthcare Organization
k-means	K-means Clustering Method

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Author contributions

K.M. and T.T. designed the study; K.M. collected the data; M.S., R.H., and T.O. helped interpret the results from their respective health professions and drafted the manuscript; T.T. and M.A. supervised the project; K.M. wrote the manuscript with the help of T.T.; K.M. and T.T. wrote the manuscript. All authors discussed the results and commented on the manuscript.

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Data availability

The authors have researched and maintain their own database of information on the institutions studied. The data cannot be shared openly, for example to protect the privacy of study participants, but is available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Japan Community Health Care Organization Kobe Central Hospital, approval number [330] and the University of Hyogo, approval number [2023-0008]. The need for individual informed consent was waived by the IRB due to the retrospective nature of the study and the use of anonymized data, in accordance with [relevant national regulation or guideline, e.g., the Japanese Ethical Guidelines for Medical and Health Research Involving Human Subjects]. Patient consent was obtained through the facility's opt-out process.

Consent for publication

Not application.

Competing interests

The authors declare no competing interests.

Clinical trial number

Not applicable.

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References

1. Tugwell P, Knottnerus JA. Multimorbidity and comorbidity are now separate MESH headings. J Clin Epidemiol. 2019;105:vi–viii.
2. Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of Multimorbidity and implications for health care, research, and medical education: a cross-sectional study. Lancet. 2012;380:37–43.
3. Skou ST, Mair FS, Fortin M, Guthrie B, Nunes BP, Miranda JJ, et al. Multimorbidity Nat Rev Dis Primers. 2022;8:48.
4. Vollset SE, Goren E, Yuan CW, Cao J, Smith AE, Hsiao T, et al. Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the global burden of disease study. Lancet. 2020;396:1285–306.
5. Multimorbidity. Technical series on safer primary care. World Health Organization; 2016.
6. Wolff JL, Starfield B, Anderson G. Prevalence, expenditures, and complications of multiple chronic conditions in the elderly. Arch Intern Med. 2002;162:2269–76.
7. Multimorbidity. A priority for global health research. The Academy of Medical Sciences; 2018.
8. Peres MA, Macpherson LMD, Weyant RJ, Daly B, Venturelli R, Mathur MR, et al. Oral diseases: a global public health challenge. Lancet. 2019;394:249–60.
9. Patel J, Wallace J, Doshi M, Gadanya M, Ben Yahya I, Roseman J, et al. Oral health for healthy ageing. Lancet Healthy Longev. 2021;2:e521–7.
10. Watt RG, Serban S. Multimorbidity: a challenge and opportunity for the dental profession. Br Dent J. 2020;229:282–6.
11. Gill B, Harris A, Tredwin C, Gill P. Multimorbidity and oral health: need for new models of care. Fam Med Community Health. 2020;8:e000387.
12. Mirza A, Watt RG, Heilmann A, Stennett M, Singh A. Social disadvantage and Multimorbidity including oral conditions in the united States. J Dent Res. 2024;103:477–83.
13. Larvin H, Kang J, Aggarwal VR, Pavitt S, Wu J. Systemic Multimorbidity clusters in people with periodontitis. J Dent Res. 2022;101:1335–42.

14. Nguyen H, Manolova G, Daskalopoulou C, Vitoratou S, Prince M, Prina AM. Prevalence of Multimorbidity in community settings: a systematic review and meta-analysis of observational studies. J Comorb. 2019;9:2235042X19870934.
15. Cheng C, Christensen M. Interventions addressing symptoms in older adults with Multimorbidity: an umbrella review. J Multidiscip Healthc. 2024;17:3181–92.
16. Aoki T, Yamamoto Y, Ikenoue T, Onishi Y, Fukuhara S. Multimorbidity patterns in relation to polypharmacy and dosage frequency: a nationwide, cross-sectional study in a Japanese population. Sci Rep. 2018;8:3806.
17. Marques LP, de Aguiar OB, Paula DP, Oliveira FEG, Chor D, Benseñor I, et al. Multimorbidity prevalence and patterns at the baseline of the Brazilian longitudinal study of adult health (ELSA-Brasil). J Multimorb Comorb. 2023;13:26335565231173845.
18. Mitsutake S, Ishizaki T, Teramoto C, Shimizu S, Ito H. Patterns of co-occurrence of chronic disease among older adults in Tokyo, Japan. Prev Chronic Dis. 2019;16:E11.
19. Lenzi J, Avaldi VM, Rucci P, Pieri G, Fantini MP. Burden of Multimorbidity in relation to age, gender and immigrant status: a cross-sectional study based on administrative data. BMJ Open. 2016;6:e012812.
20. Kshatri JS, Palo SK, Bhoi T, Barik SR, Pati S. Prevalence and patterns of Multimorbidity among rural elderly: findings of the AHSETS study. Front Public Health. 2020;8:582663.
21. Ministry of Health. Labour and Welfare https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000158505_00002.html. Accessed 19 February 2023.
22. The Ministry of Health Labour and Welfare. Japan. The standards for the degree of independent living for elderly and disabled people. www.mhlw.go.jp › 06-Seisakujouhou-12300000-Roukenkyoku. pdf. Accessed 8 August 2023.
23. Tsutsui T, Otaga M, Higashino S. Role of standardized nursing records in the evaluation of nursing care intensity. Rev Manage Inform. 2012;24:25–37.
24. World Health Organization data. https://data.who.int/countries/392. Accessed 11 August 2024.
25. Kato D, Kawachi I, Saito J, Kondo N. Complex Multimorbidity and mortality in Japan: a prospective propensity-matched cohort study. BMJ Open. 2021;11:e046749.
26. Kuthy RA, Strayer MS, Caswell RJ. Determinants of dental user groups among an elderly, low-income population. Health Serv Res. 1996;30:809–25.
27. Ngu ACS, Arora S, Reher P. Medical profile of patients referred to an Australian postgraduate oral surgery clinic. Clin Exp Dent Res. 2023;9:899–905.
28. Kudesia P, Salimarouny B, Stanley M, Fortin M, Stewart M, Terry A, et al. The incidence of Multimorbidity and patterns in accumulation of chronic conditions: a systematic review. J Multimorb Comorb. 2021;11:26335565211032880.
29. Violán C, Roso-Llorach A, Foguet-Boreu Q, Guisado-Clavero M, Pons-Vigués M, Pujol-Ribera E, et al. Multimorbidity patterns with K-means nonhierarchical cluster analysis. BMC Fam Pract. 2018;19:108.
30. Launders N, Hayes JF, Price G, Osborn DP. Clustering of physical health Multimorbidity in people with severe mental illness: an accumulated prevalence analysis of united Kingdom primary care data. PLoS Med. 2022;19:e1003976.
31. Guisado-Clavero M, Roso-Llorach A, López-Jimenez T, Pons-Vigués M, Foguet-Boreu Q, Muñoz MA, et al. Multimorbidity patterns in the elderly: a prospective cohort study with cluster analysis. BMC Geriatr. 2018;18:16.
32. Everitt BS, Landau S, Leese M, Stahl D. Cluster analysis. 5th ed. Chichester: John Wiley & Sons,Ltd; 2011.
33. Liao M, Li Y, Kianifard F, Obi E, Arcona S. Cluster analysis and its application to healthcare claims data: a study of end-stage renal disease patients who initiated Hemodialysis. BMC Nephrol. 2016;17:25.
34. Ilmarinen P, Tuomisto LE, Niemelä O, Tommola M, Haanpää J, Kankaanranta H. Cluster analysis on longitudinal data of patients with adult-onset asthma. J Allergy Clin Immunol Pract. 2017;S2213–2198(17):30048-X.
35. Fabbri E, Zoli M, Gonzalez-Freire M, Salive ME, Studenski SA, Ferrucci L. Aging and Multimorbidity: new tasks, priorities, and frontiers for integrated gerontological and clinical research. J Am Med Dir Assoc. 2015;16(8):640–7.
36. Ghosh A, Mukhopadhyay S, Mukhopadhyay B. An investigation on the prevalence and patterns of multi-morbidity among a group of slum-dwelling older women of Kolkata, India. BMC Geriatr. 2024;24:624.
37. Serban S, Dietrich T, Lopez-Oliva I, de Pablo P, Raza K, Filer A, et al. Attitudes towards oral health in patients with rheumatoid arthritis: a qualitative study nested within a randomized controlled trial. JDR Clin Trans Res. 2019;4:360–70.
38. Gill A, Kuluski K, Jaakkimainen L, Naganathan G, Upshur R, Wodchis WP. Where do we go from here? Health system frustrations expressed by patients with Multimorbidity, their caregivers and family physicians. Healthc Policy. 2014;9:73–89.
39. Ozaki K, Tohara H, Baba M, Teranaka S, Kawai Y, Komatsumoto S. A Dentist-led oral care system can prevent stroke-associated pneumonia: the effects of early intervention by dental team. J Multidiscip Healthc. 2023;16:2937–45.
40. Ruggiero SL, Dodson TB, Aghaloo T, Carlson ER, Ward BB, Kademani D. American association of oral and maxillofacial surgeons' position paper on Medication-Related osteonecrosis of the Jaws-2022 update. J Oral Maxillofac Surg. 2022;80(5):920–43.
41. Sekiya H, Kurasawa Y, Kaneko K, Takahashi KI, Maruoka Y, Michiwaki Y, et al. Preventive effects of sustainable and developmental perioperative oral management using the oral triage system on postoperative pneumonia after cancer surgery. Int J Environ Res Public Health. 2021;18:6296.
42. Wilson MG, Lavis JN, Gauvin FP. Designing integrated approaches to support people with Multimorbidity: key messages from systematic reviews, health system leaders and citizens. Healthc Policy. 2016;12:91–104.
43. Theile CW, Strauss SM, Northridge ME, Birenz S. The oral health care manager in a patient-centered health facility. J Evid Based Dent Pract. 2016;16:34–42.

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