Original Article

DOI: 10.5582/ddt.2026.01019

Seasonality of psychiatric symptoms in older adults in long-term psychiatric care

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SUMMARY: The annual periodicity of psychiatric symptoms in older adults within long-term care remains under-explored. This exploratory, single-center, retrospective pilot study investigated seasonality in agitation/aggression, depressive symptoms, and hallucinations/delusions among 28 older Japanese inpatients (*mean* age 74.1 ± 9.1 years) over a one-year period to inform the chronobiological optimization of pharmacotherapy. Generalized Linear Mixed-effects Models (GLMMs) with trigonometric terms were used to assess periodicity based on daily clinical records. A possible seasonal pattern, with the model-estimated peak in March and nadir in September, was observed for agitation/aggression (Incidence Rate Ratio [IRR] = 1.50, $p = 0.037$) and depressive symptoms (IRR = 1.08, $p = 0.041$). Hallucinations/delusions showed no significant periodicity. These findings suggest that older adults in long-term care retain sensitivity to seasonal environmental changes, with spring representing a potential period of circadian vulnerability. These findings may help identify periods requiring closer clinical monitoring and medication review, although prospective studies are needed before seasonally guided dosage adjustments can be recommended.

Keywords: Seasonal pattern, institutionalization, GLMM

1. Introduction

In Japan's psychiatric healthcare system, the average length of hospitalization exceeds 200 days (*1*). With an aging inpatient population, prolonged hospitalization of older adult patients in psychiatric wards poses a significant challenge. This extended period of care often leads to deconditioning and a decline in physical function, which can reduce patients' quality of life (QOL) and increase their risk of mortality. Beyond physical decline, temporal fluctuations in psychiatric symptoms present another critical challenge. Extensive research has shown significant annual seasonality in cognitive function among older adults and patients with dementia, an effect comparable to several years of age-related cognitive change (*2*). Seasonality can exacerbate schizophrenia symptoms (*3,4*), mood episodes in bipolar disorder (*5*), and depression (*6*). Strelnik *et al*. (*7*) suggested the need for more complex temporal factors and individualized predictive models beyond simple seasonality. Existing reports have limitations, including inconsistent definitions of seasons. Particularly, the detailed annual periodicity patterns exhibited by specific symptoms, such as agitation/aggression and hallucinations/delusions, in chronic-phase patients in long-term psychiatric care wards, which is the focus of the present study, have yet to be thoroughly clarified.

In Japanese psychiatric long-term care wards, patients often reside for extended periods with standardized schedules for meals, sleep, and activities. This unique controlled setting minimizes lifestyle-related confounders, allowing for a clearer observation of biological seasonal rhythms driven by environmental cues such as photoperiod. Elucidating these patterns in a controlled long-term care setting provides an objective basis for chronobiological optimization of pharmacotherapy. Understanding these seasonal "windows of vulnerability" is valuable for clinicians to identify periods requiring closer clinical monitoring and timely medication review. Anticipating potential symptomatic peaks, such as the observed spring fluctuation, may help healthcare providers optimize patient care and carefully evaluate need for psychotropic interventions. However, prospective studies are warranted before these seasonal patterns can be used to guide proactive dosage adjustments or prevent polypharmacy in this frail older population.

Beyond pharmacotherapy, non-pharmacological approaches also play a vital role; for instance, increasing

physical activity has been shown to potentially reduce the requirement for psychotropic medications (*8*). However, identifying periods of symptomatic stability is essential for the safe and effective implementation of active interventions. Therefore, this exploratory pilot study aimed to quantitatively investigate the presence and detailed patterns of annual periodicity in specific major psychiatric symptoms, namely agitation/aggression, depressive symptoms, and hallucinations/delusions, among older adult inpatients in long-term psychiatric care wards, using daily clinical records. As a single-center, retrospective study, it was specifically designed to generate hypotheses for future large-scale studies. By elucidating these patterns, we aim to provide a foundation for seasonally tailored pharmacological and non-pharmacological care strategies, including proactive psychiatric rehabilitation and active exercise interventions during stable periods (*9-11*). These findings can be useful for patients, healthcare staff, and family members involved in their care.

2. Materials and Methods

2.1. Study design

An analytical time-series design was used in this exploratory, single-center, retrospective observational pilot study. The study population included patients who were hospitalized in the long-term psychiatric care wards of a psychiatric hospital in Japan between January 1, 2023, and March 31, 2025, for whom 12 consecutive months of observational data were available.

2.2. Ethical considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki (as revised in 2013) and approved by the Institutional Review Board (IRB) of a psychiatric hospital in Japan (approval number: 20250302). Informed consent was obtained *via* an opt-out method approved by the IRB. Details of the study were published on the hospital's official website to ensure that participants had the opportunity to decline participation at any time. Additionally, a notice was posted within the hospital informing potential participants of their right to opt out.

2.3. Participants

The participants in this study were older adult inpatients in the long-term psychiatric care ward of a psychiatric hospital in Japan. Initially, a pool of potential participants (n = 50) was identified from those who were hospitalized during the data collection period (January 1, 2023, to March 31, 2025) and met the basic eligibility criteria (length of stay of six months or longer, ability to move independently within the ward with or without a wheelchair, and receiving rehabilitation therapy). From this initial pool (n = 50), participants were selected for the present analysis (n = 28) if they met the following inclusion criteria: (1) availability of medical records for the number of days of symptom occurrence in each month over 12 consecutive months corresponding to a calendar year (January to December). This 1-year observation period was necessary for the statistical analysis of the annual periodicity; and (2) a total length of hospitalization of one year or longer, including a 12-month observation period. This 1-year observation period was selected from the overall data collection period (January 1, 2023, to March 31, 2025).

This criterion was highlighted to exclude the influence of the highly variable acute phase of illness and specifically assess the underlying symptom patterns in patients during a chronic, more stable phase. Furthermore, this population represents a significant challenge in Japanese psychiatric long-term care, making the elucidation of their symptom patterns clinically important. The hospital ward consisted entirely of private (single-occupancy) rooms, and all participants resided in these rooms during the observation period. Participants who did not meet the two key inclusion criteria were excluded. For instance, if their 1-year data were not fully available because the observation period commenced mid-year or ward transfer during the observation period. The detailed participant selection process, including the number of individuals excluded at each stage, specific reasons for exclusion, and distribution of observation years, is illustrated in the Strengthening the Reporting of Observational studies in Epidemiology (STROBE)-style flow diagram (Figure 1). Owing to this rigorous selection procedure, the dataset used in this analysis contained no missing data.

2.4. Measurements

2.4.1. Baseline characteristics

Baseline patient characteristics were extracted from medical records. These included age, sex, height, body weight, Body Mass Index (BMI), number of antipsychotic drugs administered, total number of prescribed medications, Mini-Mental State Examination (MMSE) score, history of falls, Functional Independence Measure (FIM) scores, duration of hospitalization, and Charlson Comorbidity Index (CCI) score.

2.4.2. Outcomes

The occurrence of key psychiatric symptoms (agitation/aggression, depressive symptoms, and hallucinations/delusions), defined as the number of days per month in which each symptom was present, was recorded for 1-year period. This information was obtained through a systematic chart review of daily nursing and

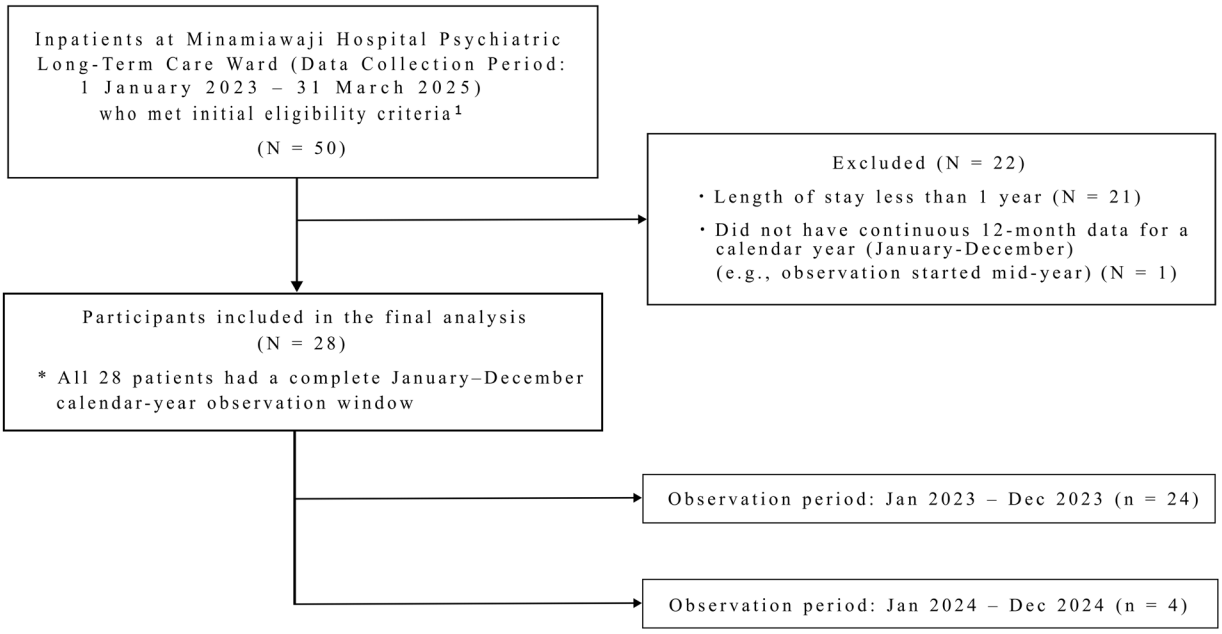

Figure 1. STROBE-style flow diagram of the participant selection process.

rehabilitation progress notes by a physical therapist assigned to the ward who possessed longitudinal familiarity with the patients.

2.5. Definition of variables

2.5.1. Agitation/aggression

Agitation/aggression was assessed as a chart-derived indicator based on the Overt Aggression Scale (OAS) concepts (*12*). Specifically, agitation/aggression was considered present if medical records documented behaviors corresponding to the OAS "Verbal Aggression" items (*e.g.*, shouting, loud voice, abusive language, reviling) or "Physical Aggression" items (*e.g.*, hitting, kicking, and throwing objects). The number of days on which symptoms were observed was recorded monthly.

2.5.2. Depressive symptoms

To capture the behavioral manifestations of depression in this long-term care setting, symptoms were operationalized as chart-derived indicators based on the Patient Health Questionnaire-2 (PHQ-2) concepts (*13*). Depressive symptoms were considered present if the medical records indicated observations corresponding to either "little interest or pleasure in doing things" (anhedonia) or "feeling down, depressed, or hopeless" (depressed mood). The number of days on which these behavioral indicators were observed was recorded monthly.

2.5.3. Hallucinations/delusions

The presence of hallucinations or delusions was determined by reviewing medical chart entries for explicit mentions of "hallucinations" or "delusions" or descriptions suggestive of such symptoms (*e.g.*, talking to someone who was not there, seeing, or hearing things that were not actually present). The number of days on which symptoms were observed was recorded monthly.

2.6. Statistical analysis

2.6.1. Descriptive statistics and trend visualization

First, descriptive statistics, including means, standard deviations (*SD*), medians, and ranges, were calculated for patient characteristics (age, sex, and duration of hospitalization) and each outcome variable (monthly number of days of agitation/aggression, hallucinations/delusions, and depressive symptoms). Subsequently, monthly trends for each symptom were plotted at the individual and group average levels to visually examine data patterns.

2.6.2. Temporal dependence analysis

To evaluate the temporal dependence patterns, autocorrelation functions (ACFs) and partial autocorrelation functions (PACFs) were generated for agitation/aggression, depressive symptoms, and hallucinations/delusions. Additionally, the Ljung-Box test was used to assess the presence of overall autocorrelation in each time series.

2.6.3. Assessment of annual periodicity

Annual periodicity was assessed using a trigonometric function model to evaluate seasonality as a continuous

fluctuation pattern with a 1-year cycle rather than defining categorical seasons (*e.g.*, "spring" or "autumn"). The monthly number of days of agitation/aggression, depressive symptoms, and hallucinations/delusions were the dependent variables. Given that these outcome variables represent over-dispersed count data, Generalized Linear Mixed Models (GLMMs) were fitted assuming a negative binomial distribution using the glmmTMB package (version 1.1.7) in R software. The model included fixed effects for the intercept, month (coded 1–12, treated as a continuous variable to control for linear trends), and trigonometric terms (sine and cosine) to capture seasonal patterns. A random intercept for the participant ID was included to account for baseline inter-patient variability. The presence of a seasonal pattern was primarily determined based on the *p*-values from Wald tests for the coefficients of the trigonometric terms (β_{sin} for the sine term and β_{cos} for the cosine term). If either β_{sin} or β_{cos} was statistically significant ($p < 0.05$), a seasonal pattern was considered present at the group level. Model fit was assessed using information criteria, including the Akaike information criterion (*AIC*) and Bayesian information criterion (*BIC*), and a simulated residual analysis appropriate for GLMMs. All data were analyzed using R statistical software (version 4.4.2; R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at a two-sided *p*-value of < 0.05.

2.6.4. Power analysis

To address the limitations of the sample size ($n = 28$), a simulation-based power analysis was performed. Informed by effect sizes reported in previous research on seasonal cognitive fluctuations in older adults (*2*) and preliminary trends observed in our dataset (target effect sizes: sine coefficient = 0.6, cosine coefficient = 0.3), we performed a custom simulation using a negative binomial GLMM with a likelihood ratio test (1,000 iterations). The estimated power to detect the specified effect sizes was 100% (95% CI: 0.955–1.000). These results confirmed that the longitudinal design ($T = 12$ observations per participant), despite the modest sample size, provided adequate statistical power to detect the target seasonal patterns.

To address the potential for type I errors and evaluate the robustness of the observed findings, we performed a 2-degree-of-freedom joint likelihood ratio test (LRT) comparing the full model, which included sine and cosine terms, with a nested null model without seasonality terms. Furthermore, because multiple symptom outcomes were analyzed, the *p*-values obtained from the joint tests were adjusted using the Benjamini–Hochberg False Discovery Rate (FDR) method. Finally, sensitivity analyses were conducted by incorporating baseline age and sex as fixed effect covariates within the GLMM framework.

3. Results

3.1. Participant characteristics

The final sample for the periodicity analysis consisted of 28 participants (Table 1). The mean age of the participants was 74.1 years (*SD* = 9.1); 11 (39%) were male, and 17 (61%) were female (Table 1). During the observation period, the average number of days per month with agitation/aggression symptoms was 0.6 (*SD* = 1.7), with depressive symptoms was 7.2 (*SD* = 11.6), and with hallucination/delusion symptoms was 0.5 (*SD* = 1.7) (Table 2).

Regarding the baseline medication profile, the mean total number of prescribed medications was 5.3 (*SD* = 2.2). Psychotropic medications included antipsychotics in 17 participants (61%), antidepressants in four participants (14%), and antiepileptics in four participants (14%). As documented in Supplementary Figure S1 (*https://www.ddtjournal.com/supplementaldata/308*), the psychotropic medication burden remained highly stable throughout the 1-year observation window, with more than 85% of the participants maintaining an unchanged regimen across all months. Medication changes observed during spring symptom peaks were predominantly reactive adjustments (dose enhancements) rather than preemptive dose reductions.

3.2. Descriptive statistics and monthly symptom trends

The descriptive statistics for the mean monthly number of days for each major psychiatric symptom are presented in Table 2. The group-average monthly trends for days with agitation/aggression and depressive symptoms visually suggested a pattern of increase in spring and decrease in autumn (Figures 2 and 3). However, considerable variability was observed in the individual trajectories. Figure 4 shows the monthly progression of hallucinations and delusions. For these symptoms, a clear annual pattern at the group-average level was less evident.

3.3. Exploratory analysis of temporal structure

Exploratory analyses, including the ACF, partial autocorrelation function (PACF), and Ljung-Box tests, were performed on group-average monthly data for each symptom. At the group-average level, these analyses did not reveal a clear significant autocorrelation within a 6-month lag (agitation/aggression: Ljung-Box $Q(6) = 6.30$, $p = 0.391$; depressive symptoms: Ljung-Box $Q(6) = 5.22$, $p = 0.516$; hallucinations/delusions: Ljung-Box $Q(6) = 7.63$, $p = 0.266$). However, considering that this finding might have been influenced by the averaging of individual data, a more detailed periodicity analysis was conducted using GLMMs that can analyze individual-level data.

Table 1. Baseline characteristics of subjects (*n* = 28)

Characteristic	*N* = 28
Age (y)	74.1 (9.1) [72.5 (68.0–80.5)]
Sex	
female	17 (61%)
male	11 (39%)
Height (m)	1.5 (0.1) [1.6 (1.5–1.6)]
Weight (kg)	50.3 (11.2) [50.5 (40.9–55.1)]
BMI (kg/m²)	21.0 (3.7) [21.0 (18.0–24.9)]
Length of stay (d)	1158.0 (1476.2) [867.0 (192.8–1638.5)]
MMSE	17.1 (7.9) [18.5 (14.2–22.2)]
Stroke	8 (29%)
Hypertension	7 (25%)
Diabetes mellitus	9 (32%)
Dyslipidemia	4 (14%)
Cancer	6 (21%)
Pulmonary disease / Respiratory disease	5 (18%)
Cardiac disease / Heart disease	7 (25%)
Osteoarthritis	3 (11%)
CI score (Charlson Comorbidity Index score)	6.4 (2.5) [6.0 (5.0–7.5)]
GAF score (Global Assessment of Functioning score)	31.0 (7.1) [30.0 (27.5–35.0)]
Mobility status (Ambulatory, Wheelchair-bound)	
Independent ambulation	5 (18%)
Wheelchair	18 (64%)
Rollator	3 (11%)
cane	2 (7.1%)
Mental illness diagnosis	
Depressive disorder	2 (7.1%)
Schizophrenia	9 (32.1%)
Organic mental disorder	3 (10.7%)
Alcohol dependence	3 (10.7%)
Late-life psychosis	4 (14.3%)
Others[a]	7 (25.0%)
Total number of prescribed medications	5.3 (2.2) [5.0 (4.0–7.0)]
Patients using antipsychotics	17 (61%)
Patients using antidepressants	4 (14%)
Patients using antiepileptics	4 (14%)
Falls in the past year	15 (53%)
Baseline FIM-Motor score (Functional Independence Measure - Motor)	63.9 (23.3) [69.0 (48.0–84.0)]
Baseline FIM-Cognitive score (Functional Independence Measure - Cognitive)	23.5 (6.5) [24.5 (19.0–27.5)]
Baseline FIM-Total score (Functional Independence Measure - Total)	87.4 (28.5) [96.5 (67.0–110.0)]

ND: Mean (*SD*) [Median (Q1-Q3)]; *n* (%). [a]The 'Others' category includes one patient each with the following: delusional disorder, somatic symptom disorder, symptomatic psychosis, emotionally unstable personality disorder, delirium, late-life psychosis, and Korsakoff's syndrome.

Table 2. Descriptive statistics for monthly symptom days

Characteristic	*n* = 336
Agitation/Aggression Symptoms	0.6 (1.7) [0.0 (0.0, 0.0)] (0–17)
Depressive Symptoms	7.2 (11.6) [0.0 (0.0, 9.0)] (0–31)
Hallucination/Delusion Symptoms	0.5 (1.7) [0.0 (0.0, 0.0)] (0–9)

ND: Mean (*SD*) [Median (Q1, Q3)] (Min - Max).

When the overall seasonal effect was evaluated using the 2-degree-of-freedom joint LRT, the periodic trends for agitation or aggression (joint χ^2= 3.74, *df* = 2, raw *p* = 0.154) and depressive symptoms (joint χ^2 = 4.80, *df* = 2, raw *p* = 0.091) did not reach statistical significance. After the FDR multiple-comparison correction was applied, the adjusted *p*-values were 0.231 for both the symptoms. Sensitivity analyses adjusting for age and sex yielded consistent directional patterns, although statistical significance was similarly attenuated, except for the individual cosine term in the depressive symptom model, which remained significant (β = 0.077, *p* = 0.043). Although statistical significance was not maintained after these rigorous adjustments, the individual trigonometric terms initially demonstrated an exploratory signal (Table 3), suggesting a potentially clinically meaningful seasonal trend characterized by a spring peak in this exploratory pilot study.

3.4. GLMM analysis of seasonal pattern

To evaluate the seasonal pattern of each psychiatric symptom (agitation/aggression, hallucinations/delusions, and depression), negative binomial GLMMs were fitted using 1 year of monthly symptom-day data from 28 patients admitted to a psychiatric long-term care ward. These models included participant ID as a random

intercept and trigonometric terms (sine and cosine) representing seasonal patterns as a fixed effect. The key results for the fixed effects of these models, which summarize the findings for the three symptoms, are shown in Table 3.

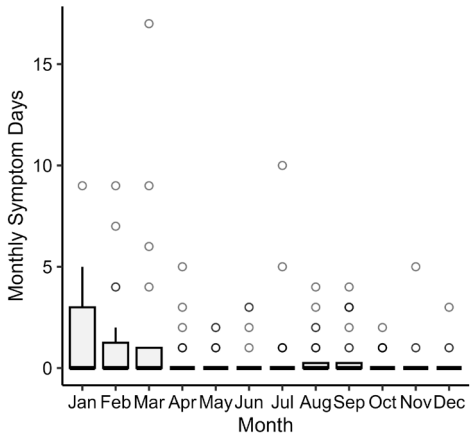

Figure 2. Monthly box plots of agitation/aggression symptom days. The box represents the interquartile range (IQR, 25th–75th percentiles) and the line within the box indicates the median. Whiskers extended to the minimum and maximum values within 1.5 × IQR from the box edges. Outliers are denoted by filled circles.

3.5. Agitation/aggression symptoms

A possible seasonal trend was observed in the number of days with agitation/aggression symptoms (Table 3). Specifically, the sine term was significant (Incidence Rate Ratio [IRR] = 1.50, 95% confidence interval [CI] 1.02–2.20, $p = 0.037$), whereas the cosine term was not (IRR = 1.18, 95% CI 0.79–1.77, $p = 0.414$). This IRR of 1.50 indicates that the rate of agitation/aggression symptom days increased by 50% at the peak of the cycle compared to the baseline. While a visual inspection of the monthly box plots (Figure 2) might suggest that symptoms are most prominent in January, the GLMM, which accounts for inter-individual variability and intra-individual correlations, identified an underlying periodic pattern in the data. The model estimated that this pattern peaked in spring (March) and reached its nadir in autumn (September) (Figure 5). The amplitude of this seasonal variation (on a log-incidence rate scale) was estimated to be approximately 0.439. Considerable inter-patient variability in baseline symptom levels was observed (variance in random intercept for ID = 5.023). The

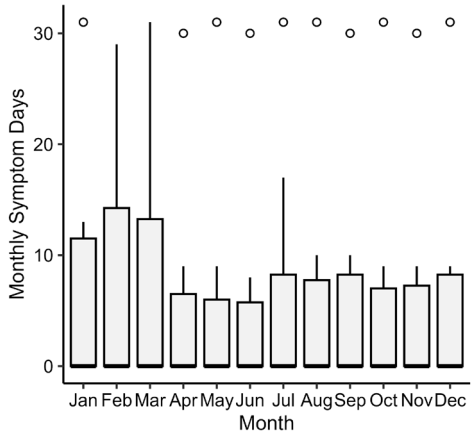

Figure 3. Monthly box plots of depressive symptom days. The box represents the interquartile range (IQR, 25th–75th percentiles) and the line within the box indicates the median. Whiskers extended to the minimum and maximum values within 1.5 × IQR from the box edges. Outliers are denoted by filled circles.

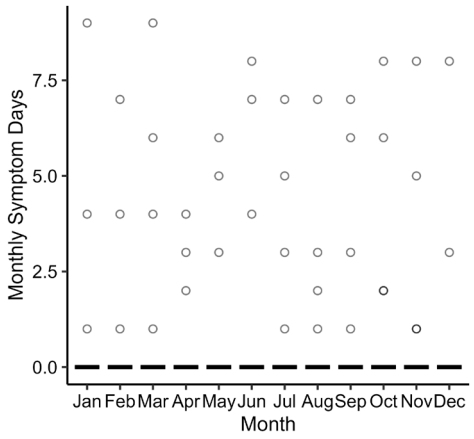

Figure 4. Monthly box plots of hallucination/delusion symptom days. The box represents the interquartile range (IQR, 25th–75th percentiles) and the line within the box indicates the median. Whiskers extended to the minimum and maximum values within 1.5 × IQR from the box edges. Outliers are denoted by filled circles.

Table 3. Generalized Linear Mixed Model (GLMM) analysis of seasonal patterns for psychiatric symptoms ($n = 28$)

Symptom	Predictor Variable	IRR	95% CI	*p*-value
Agitation/Aggression Symptoms	sine	1.50	1.02–2.20	0.037
	cosine	1.18	0.79–1.77	0.414
Depressive Symptoms	sine	1.08	1.00–1.15	0.041
	cosine	1.05	0.98–1.12	0.177
Hallucination/Delusion Symptoms	sine	1.11	0.67–1.81	0.692
	cosine	1.02	0.63–1.65	0.939

ND: CI = Confidence Interval; IRR = incidence rate ratio. The *p*-values presented here are unadjusted values for the individual trigonometric terms reflecting initial exploratory signals. For the results of the 2-degree-of-freedom joint LRTs, multiple-comparison corrections using the FDR method (adjusted $p = 0.231$ for both agitation/aggression and depressive symptoms), and sensitivity analyses, please refer to the Results section.

model accounted for overdispersion in the data (negative binomial dispersion parameter θ = 0.530). The goodness-of-fit statistics for the model were *AIC* = 548.85 and *BIC* = 571.75.

3.6. Depressive symptoms

A possible seasonal trend was also identified in the number of days with depressive symptoms (Table 3). The sine term was significant (IRR = 1.08, 95% CI 1.00–1.15, p = 0.041), whereas the cosine term was not (IRR = 1.05, 95% CI 0.98–1.12, p = 0.177). This corresponds to an estimated 8% increase in the rate of depressive symptom days during the peak period. As with agitation/aggression, although the monthly box plots (Figure 3) show a median value peaking in February, the GLMM, which models the entire continuous annual cycle, revealed a statistically significant periodicity. The estimated periodic pattern showed a slight increase in spring (March) and a slight decrease in autumn (September) (Figure 6). The estimated fixed effect for the sine term, which represents the magnitude of this periodic variation (on a log-incidence rate scale), was 0.072. This magnitude was smaller than that observed for agitation and aggression symptoms (Figure 6). An exceptionally large inter-patient variability in baseline symptom levels was evident (variance of the random intercept for the ID = 91.857). The model accounted for overdispersion in the data (negative binomial dispersion parameter θ = 75.480). The model fit was confirmed with an *AIC* of 1001.35 and a *BIC* of 1024.25.

3.7. Hallucination/delusion symptoms

In contrast, no statistically significant seasonal pattern was detected in the number of days with hallucination or delusion symptoms (Table 3, Figure 7). Neither the sine (p = 0.692) nor cosine (p = 0.939) terms were statistically significant. An exceptionally large inter-patient variability in baseline symptom levels was evident (variance in the random intercept for ID = 78.370). The model accounted for overdispersion in the data (negative binomial dispersion parameter θ = 0.796). The goodness-of-fit statistics were *AIC* = 328.06 and *BIC* = 350.97.

4. Discussion

In this study, we assessed the seasonal pattern of key psychiatric symptoms using 1-year data on the monthly symptomatic days of 28 patients in a long-term psychiatric care setting in Japan. Although rigorous

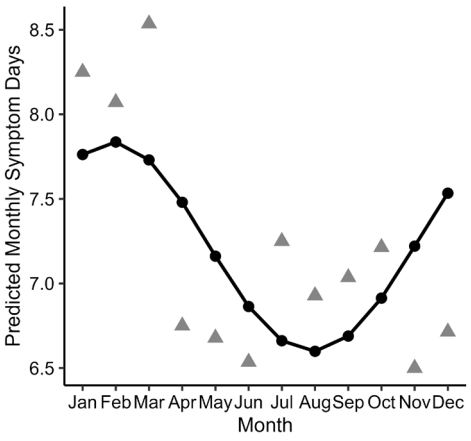

Figure 6. Predicted annual periodic pattern for depressive symptoms (from GLMM). The lines and black dots represent the model-predicted monthly expected number of symptom days (group average) from GLMM. The grey triangles indicate the observed mean monthly number of days with symptoms (for reference).

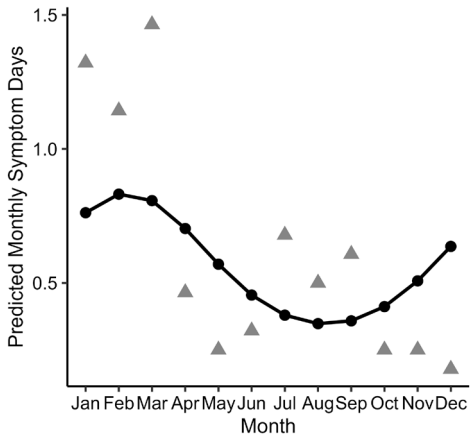

Figure 5. Predicted annual periodic pattern for Agitation/Aggression symptoms (from GLMM). The lines and black dots represent the model-predicted monthly expected number of symptom days (group average) from GLMM. The grey triangles indicate the observed mean monthly number of days with symptoms (for reference).

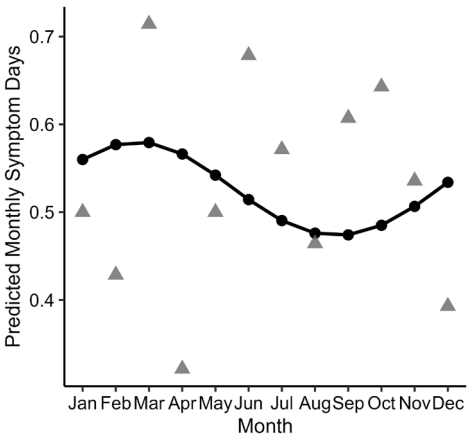

Figure 7. Predicted annual periodic pattern for hallucination/delusion symptoms (from GLMM). The lines and black dots represent the model-predicted monthly expected number of symptom days (group average) from GLMM. The grey triangles indicate the observed mean monthly number of days with symptoms (for reference).

joint testing and multiple-comparison corrections reduced statistical significance, exploratory analyses using GLMMs suggested a possible seasonal trend in agitation/aggression and depressive symptoms. These two symptoms shared an annual pattern, with the number of symptomatic days increasing in spring (March–April) and decreasing in autumn (October–November). While these results have highlighted the seasonality of depressive symptoms in individuals with chronic mental illness, they also indicate periodicity in agitation/aggression symptoms, which have previously received limited attention regarding their seasonal patterns.

Although prolonged psychiatric hospitalization in Japan is a unique systemic characteristic, it provides a highly controlled longitudinal environment that is ideal for chronobiological research. Unlike community-dwelling outpatients, the participants in this study followed standardized schedules for light exposure, meals, and sleep, effectively minimizing lifestyle-related confounders. Consequently, while our findings offer preliminary insights into the possible seasonal patterns of older adults in a highly controlled environment because this was an exploratory, single-center, retrospective study, the findings should be interpreted cautiously, and overgeneralization to all long-term care facilities should be avoided. Further multi-center studies are required to determine whether these patterns apply to other facilities with varying environmental structures.

Previous research on seasonal depression has shown mixed patterns. While winter depression in older adults has been attributed to insufficient light exposure, our finding of spring-symptom peaks suggests a different mechanism. This finding aligns with the observations of Sato *et al*. (*14*), who reported that spring can trigger depressive mixed states distinct from classic winter depression. A key factor is the phase advance in the circadian rhythm of older adults (*15,16*). In spring, the timing of dawn advances rapidly. For individuals with an internal clock that is already running early, this accelerated advance of morning light can act as a powerful yet disruptive stimulus, potentially leading to instability in emotional regulation. Furthermore, this vulnerability may be amplified by the diminished amplitude of the circadian signal common in aging (*15,16*). While Lim *et al*. (*2*) found that cognitive function in older adults peaked in late summer and early autumn, our findings suggest that psychiatric symptoms follow a different trajectory, peaking in spring. The interaction between a phase-advanced, low-amplitude circadian system and the dynamic light environment in spring provides a plausible neurobiological mechanism for the observed peaks. This hypothesis is supported by recent sensor-based research demonstrating that environmental triggers directly precede agitation episodes (*17*).

Beyond biological mechanisms, we must consider psychosocial factors specific to long-term care environments. As is common in Japanese healthcare institutions, personnel rotation typically occurs in April. It could be argued that this social stressor solely explains spring exacerbation. However, our analysis suggests a more complex mechanism. While staff rotations occurred, the scale was minimal, and the symptom upward trend began as early as February–March. We propose that the spring peak likely results from a "synergistic interaction" between biological vulnerability (circadian mismatch) (*18,19*) and psychosocial stressors. This "double hit" of biological and social cues renders spring a period of heightened vulnerability.

Regarding agitation/aggression symptoms, for which periodicity was observed in this study, direct reports on their seasonality are limited. Although the involvement of serotonin has been suggested (*20*), this relationship remains unclear (*21*). In contrast, this study did not find any significant seasonal patterns in hallucinations or delusions. Given that the mean monthly occurrence of hallucinations/delusions was nearly identical to that of agitation/aggression, this null finding is highly informative. This highlights the specificity of seasonal effects, suggesting that psychotic symptoms are more strongly influenced by individual pathology or internal neurobiological factors rather than environmental cues such as seasons.

The clinical significance of the observed seasonal fluctuations warrants careful consideration. Although the identified 8% increase in the number of days with depressive symptoms (IRR = 1.08) might appear numerically modest, its impact on a frail population is substantial. Given that depressive symptoms are highlighted as predictors of falls (*22*), this fluctuation translates to an extended "window of vulnerability" during spring (March–April). Furthermore, the 50% increase in agitation/aggression days (IRR = 1.50) represented a more overt and immediate risk to patient safety. For older adults living on the threshold of physical frailty (*23-25*), even a marginal elevation in the symptom baseline can act as a "tipping point," pushing them from a state of precarious balance to functional decline or behavioral incidents. Therefore, the spring peak should not be dismissed as statistical noise but recognized as a critical period where the safety margin is significantly eroded. To address this, care strategies must be proactively adjusted, for instance, by increasing the frequency of behavioral monitoring from standard routines to more intensive checks during March and April. Such targeted, seasonally tailored interventions not only enhance patient safety but also offer a cost-effective approach by preventing severe incidents that necessitate resource-intensive medical care. Furthermore, clinicians must remain vigilant, as these spring behavioral exacerbations often align with other seasonal health risks common in older adults, such as cardiovascular events, potentially compounding the overall clinical management challenges.

Several limitations warrant consideration. First, because this was an exploratory, single-center, retrospective pilot study, the sample size (n = 28) was modest, thereby limiting the generalizability of the findings to other long-term care settings. However, our simulation-based power analysis (estimated at 100%) confirmed that the dense repeated-measures design (12 observations per participant) provided adequate statistical power to detect the target seasonal pattern. Second, the 1-year observation period limits our ability to confirm the multi-year reproducibility of these cycles; further longitudinal studies are required to establish the stability of seasonal patterns. Third, the reliance on daily nursing and rehabilitation records, while offering high ecological validity, lacks the precision of prospective structured diagnostic interviews, and inter-rater reliability was not formally assessed. Furthermore, we could not determine whether the documented symptoms represented new onset, exacerbation of existing symptoms, or improved detection, as nursing documentation practices may have varied during the observation period. Finally, while we accounted for major confounders such as medication adjustments and infectious outbreaks, other unmeasured environmental or psychosocial factors inherent to long-term care may have influenced our findings. Despite these constraints, this study provides critical preliminary evidence for the chronobiological management of psychiatric symptoms in older adults in Japan.

These findings offer an objective rationale for tailoring interventions based on seasonal risks. The risk of worsening spring symptoms could prompt healthcare teams to adjust their staffing or pre-emptively review care strategies. Specifically, agitation and aggression increase the risk of hazardous actions (*26*), whereas significant depressive symptoms increase fall likelihood (*22*). Therefore, we recommend tailoring interventions based on symptomatic states: facilitating de-escalation through non-activating engagement during periods of high excitability (spring), and fostering activity-enhancing interactions when negative symptoms are prominent. Moreover, these findings provide vital preliminary information for planning home discharge and community re-entry, as families can be educated about seasonal periods of instability. Clinically, these patterns suggest the need for proactive measures; for instance, increasing the frequency of monitoring or preventive rehabilitation during the high-risk months of March and April could help mitigate these risks. Future research should aim to elucidate how these seasonal variations correlate with physical functioning (activities of daily living, ADL) and QOL to further refine these interventions.

Although preliminary, our findings suggest that in older adult patients with chronic conditions residing in long-term psychiatric care facilities, the symptoms of agitation/aggression and depression tended to peak in spring and were least prevalent in autumn. These findings underscore the importance of considering seasonal factors in the development of preventive approaches and individualized care plans for these symptoms.

Acknowledgements

We would like to express our sincere gratitude to all the staff members of the psychiatric long-term care wards at Minamiawaji Hospital, which served as the site for this research. We would like to thank Editage (*www.editage.com*) for English language editing.

During the revision process of this manuscript, the author(s) used Gemini (Google) for assistance in editing and refining the language for clarity and readability. The author(s) reviewed and edited all content and take full responsibility for the final version of the publication.

Funding: None.

Conflict of Interest: The authors have no conflicts of interest to disclose.

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Received April 2, 2026; Revised June 5, 2026; Accepted June 15, 2026.

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Released online in J-STAGE as advance publication June 21, 2026.