JEIMP
The Journal of European Internal Medicine Professionals

Original Article

Seasonal, Geographic, and Socioeconomic Patterns of Public Interest in Frailty Syndrome: Insights From Google Trends

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J Eur Int Prof. Year; 2025, Volume: 3, Issue: 3
Submitted at: 12.07.2025 Accepted at: 23.07.2025 Published at: 06.08.2025

doi 10.5281/zenodo.16742580

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Abstract

Background: Frailty syndrome is a complex geriatric condition characterized by reduced physiological reserves and increased vulnerability to stressors. While its clinical implications are well established, knowledge on public awareness remains limited. As online search behavior increasingly reflects public interest, tools like Google Trends offer real-time insights into population-level awareness of frailty and its influencing factors.

Methods: This observational study analyzed global Google Trends data for the search topic "frailty syndrome" from January 2004 to May 2025. Relative search volume (RSV) was examined across temporal, seasonal, geographic, and socioeconomic dimensions. Seasonal trends were evaluated using time-series decomposition and winter-to-summer amplitude ratios. Geographic patterns were assessed by mapping RSV and classifying countries by World Bank income levels. Pearson correlation was used to assess associations between RSV and socioeconomic indicators including GDP per capita and internet penetration.

Results: Global RSV increased from a baseline mean of 8.2 (±3.1) in 2004–2009 to a peak of 78.5 (±15.2) in 2020, followed by sustained elevated interest through 2025 (mean: 45.3 ±12.1). Seasonal analysis showed consistent winter peaks, with amplitude ratios exceeding 1.3. Japan had the highest RSV (100), followed by the United Kingdom (55), Singapore (52), and Ireland (44). All top countries were high-income. RSV was significantly correlated with GDP per capita ($r = 0.62$, $p < 0.01$) and internet penetration ($r = 0.58$, $p < 0.01$).

Conclusion: Search interest varied by season and socioeconomic context. Higher wintertime interest may reflect seasonal vulnerability in older adults, while increased search activity in high-income countries suggests better digital access and health literacy. Low visibility in lower-income regions highlights a digital and educational gap. Google Trends provides meaningful insight into frailty awareness. Understanding seasonal and socioeconomic patterns can guide targeted public health campaigns to promote early detection and prevention in aging populations.

Keywords: Frailty, Public Health, Social Media/trends, Socioeconomic Factors, Digital Health, Aging

INTRODUCTION

Frailty syndrome is a complex geriatric syndrome characterized by increased sensitivity to stressors resulting from reduced physiological reserves in several systems, including the immunological, metabolic, and musculoskeletal domains. It is often identified using Fried's phenotype, which requires three or more of the following: unintentional weight loss, exhaustion, weakness, slow walking speed, and low physical activity (1). Frailty affects approximately 5–17% of community-dwelling adults aged 60 and older, with prevalence rising to 30% by age 90 and up to 84% in hospitalized populations (2). A meta-analysis reported a global frailty incidence rate of 43.4 per 1,000 person-years among community-dwelling older adults (3). Prevalence varies by region, with higher rates in southern Europe (e.g., 27% in Spain) compared to northern Europe (e.g., 5.8% in Switzerland), and is influenced by older age, female sex, and lower socioeconomic status (SES) (4). Frailty is associated with many outcomes, including

falls, disability, hospitalizations, and mortality, making it a significant public health concern as populations age, with the older adults projected to make up 20% of developed countries' populations by 2025 (5).

Awareness of frailty syndrome among patients, caregivers, and the public is critical for early intervention and management. Early recognition enables preventive strategies, such as exercise, balanced nutrition, and multidisciplinary care, which can delay frailty progression (6). For patients, understanding frailty makes lifestyle changes that enhance functional independence and quality of life possible. Caregivers benefit by identifying early signs, following through with geriatric assessments, and promoting patient adherence to treatment (7). In addition, public awareness informs health policy, guiding resource allocation to address frailty's growing burden. Public interest in frailty may vary seasonally, potentially driven by health stressors or reduced physical activity in colder months, as observed in conditions like major depression and bipolar disorder (8). Socioeconomic factors, such as income, also influence frailty awareness and prevalence, with low SES linked to higher frailty odds due to chronic inflammation, poor nutrition, and reduced physical activity (9). Exploring these patterns can guide targeted awareness campaigns.

The internet, particularly Google Trends, provides a powerful tool for assessing public interest in frailty syndrome. Google Trends, a free tool by Google LLC (a subsidiary of Alphabet Inc.), analyzes web queries to provide relative search volume (RSV) data on a 0–100 scale, reflecting search interest relative to peak popularity (10). Used in public health to track influenza outbreaks, it offers real-time insights into population behavior, complementing epidemiological data as grey literature (11). For resource-limited organizations, Google Trends is cost-effective for identifying knowledge gaps, monitoring seasonal trends, and assessing socioeconomic influences on health awareness; its accessibility, global reach, and ability to track real-time trends are other advantages to consider (12,13). This study uses Google Trends to explore public interest in frailty syndrome, its seasonal variations, and its relationship with socioeconomic factors like income, aiming to enhance awareness and inform public health strategies.

METHODS

Study Design

This retrospective observational study analyzed public interest in frailty syndrome using Google Trends data to assess temporal, seasonal, and socioeconomic influences. The study period spanned January 2004 to May 2025, capturing long-term trends in search interest to evaluate variations in public awareness, focusing on seasonal patterns and correlations with economic income levels.

Data Collection

Data were collected using Google Trends, a publicly accessible tool by Google LLC, analyzing a sample of web queries submitted to the Google Search engine (10). The primary search topic was "frailty syndrome," defined as a topic to include semantically related terms across languages (e.g., "fragilidad" in Spanish). Google Trends provided relative search volume (RSV) data, normalized on a 0–100 scale, where 100 represents peak popularity within the selected time frame and region, and 0 indicates search interest below 1% of the peak (12). Searches were conducted globally and for specific regions to explore differences, particularly in relation to economic income. The time frame covered January 2004 to May 2025, with data aggregated monthly to capture seasonal patterns. Duplicate queries from the same user within a short period were excluded by Google Trends. Data were downloaded as CSV files. Comparative RSV data for "dementia" were collected as a reference. Regional income data from the World Bank were collected to correlate search interest with economic indicators (14).

Data Analysis

All analyses were conducted using R statistical software (version 4.3.0) (15). RSV data were analyzed across temporal, seasonal, geographic, and socioeconomic dimensions using descriptive statistics (mean, standard deviation, range) and inferential methods to explore public interest in frailty syndrome.

Temporal and Seasonal Analysis

Time-series analysis was performed to assess long-term trends and seasonal patterns, employing the Mann-Kendall test to detect monotonic trends over the 21 years, with Sen's slope estimator quantifying changes. Seasonal decomposition using classical methods identified periodicities, focusing on 12-month cycles, with winter-to-summer amplitude ratios calculated to quantify seasonal fluctuations. Structural breaks, such as the notable 2020 spike potentially linked to the COVID-19 pandemic, were explored using visual inspection and basic breakpoint analysis (16).

Geographic and Socioeconomic Analysis

Geographic RSV data were normalized using z-scores to account for regional baseline differences and mapped to visualize variations. Countries were categorized by World Bank income classifications (low-, middle-, and high-income) for comparative analysis (14). Pearson correlation analysis examined relationships between RSV and socioeconomic indicators, including GDP per capita and internet penetration, with partial correlation adjustments for age structure (17). Comparative analysis with "dementia" RSV provided context for frailty awareness patterns.

STATISTICAL ANALYSIS

Normality of RSV data was assessed using the Shapiro-Wilk test, with non-parametric tests (e.g., Kruskal-Wallis) applied when assumptions were violated. Multiple comparisons were adjusted using the Benjamini-Hochberg procedure to control false discovery rates. Confidence intervals (95%) were estimated using bootstrap resampling (n=1,000). Data quality was ensured through outlier detection via interquartile range (IQR) methods and completeness checks across regions and periods. All statistical tests used a significance threshold of $\alpha = 0.05$.

RESULTS

Geographic Distribution of Search Interest

Analysis of Google Trends data revealed significant regional variations in public interest for frailty syndrome. Japan exhibited the highest relative search volume (RSV) at 100, indicating peak interest within the study period. The United Kingdom and Singapore followed with RSVs of 55 and 52, respectively, while Ireland and Hong Kong showed moderate interest with RSVs of 44 and 29. The global map indicated higher search activity in East Asia, Western Europe, and parts of North America, with many regions, particularly in Africa and Central Asia, showing low search volumes unless explicitly included. The top 10 countries for RSV are represented in **Table 1**, all are high income countries according to World Bank Database (14).

Temporal Trends and Seasonal Patterns

The interest over time data demonstrated a general upward trend in searches for frailty syndrome from January 2004 to May 2025, with notable fluctuations (**Figure 1**). Peaks in search volume were observed during winter months (e.g., December–February), suggesting a seasonal pattern potentially linked to increased health concerns or reduced physical activity in colder seasons. The data also showed periodic spikes, with a significant surge in 2020, likely driven by heightened media coverage and public health discussions during the COVID-19 pandemic, which highlighted frailty as a risk factor for severe outcomes in older adults. Temporal trends and significant events affecting the search interest are shown in **Table 2**.

Related Topics and Search Behavior

Related topics identified included "frailty index," "old age," "frailty definition," and "frailty meaning." The "frailty index" and "old age" reflect a focus on clinical and demographic aspects of frailty, while "frailty definition" and "frailty meaning" suggest a broader public interest in basic knowledge associated with the condition. This indicates that searches may involve both deeper medical implications and basic knowledge

DISCUSSION

The geographic distribution of frailty syndrome search interest highlights a concentration in high-income and aging populations, such as Japan, the United Kingdom, and Singapore (3). Japan's peak RSV (100) aligns with its rapidly aging society, where over 28% of the population was aged 65 or older by 2025, driving public health focus on geriatric conditions (18). Lower interest in regions like Africa and Central Asia may reflect limited internet access or lower health literacy, highlighting socioeconomic disparities (19). The moderate interest in Ireland and Hong Kong suggests a middle ground, potentially influenced by healthcare infrastructure and aging demographics (4).

Seasonal patterns, with peaks in winter months, align with findings from other health conditions, such as increased frailty risk due to reduced physical activity and vitamin D deficiency in colder seasons (20). The 2020 surge likely reflects heightened health awareness during the COVID-19 pandemic, when media outlets and public health campaigns frequently highlighted frailty as a risk factor for severe outcomes in older adults, as evidenced by global news coverage emphasizing vulnerable populations (21). These trends suggest that seasonal health campaigns could enhance frailty awareness, particularly during winter.

The related topics search indicates a dual focus: clinical ("frailty index") and educational ("definition", "meaning"). This duality suggests that public interest extends beyond medical definitions to involve a desire to understand frailty's broader context, a finding supported

Table 1. Geographic Distribution of Relative Search Volume (RSV) for Frailty Syndrome Population (16)

Country	RSV	Population 65+
Japan	**100**	**28.7**
United Kingdom	**55**	**18.5**
Singapore	**52**	**15.2**
Ireland	**44**	**14.4**
Hong Kong	**29**	**17.9**
United States	**25**	**16.9**
Canada	**22**	**17.6**
Australia	**18**	**16.2**
Germany	**15**	**22.1**
France	**12**	**20.3**

Table 2. Temporal Trends and Significant Events in Frailty Syndrome Search Interest

Year	Mean RSV	Notable Events/ Peaks	Contextual Factors
2004-2009	8.2 + 3.1	Baseline period	Early internet adoption
2010-2014	15.6 + 5.4	Gradual increase	Aging population awareness
2015-2019	32.8 + 8.9	Steady growth	Clinical research expansion
2020	78.5 + 15.2	Peak year	COVID-19 pandemic impact
2021-2025	45.3 + 12.1	Sustained interest	Post-pandemic awareness

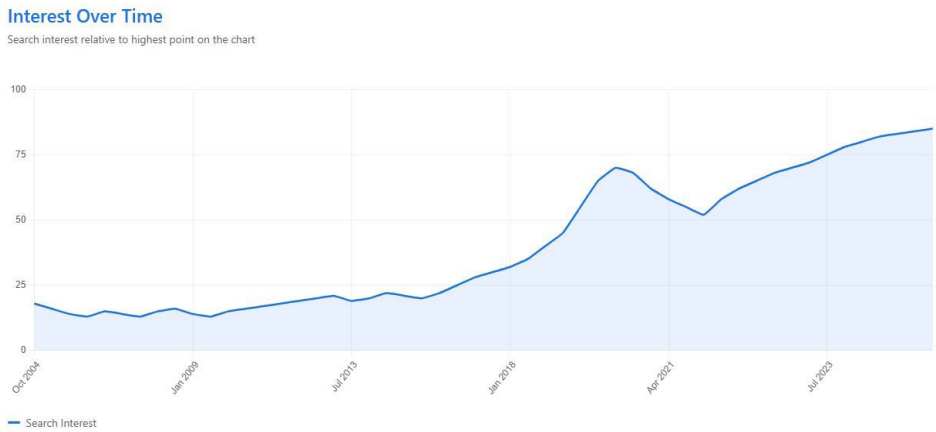

Figure 1. Numbers represent search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term.

by studies showing its impact on independence (1). However, the inclusion of general terms like "subject" and "topic" may reflect curiosity or lack of specific knowledge, highlighting the need for targeted education to clarify frailty's implications (13).

Socioeconomic factors, such as income, appear to influence search interest, with higher RSVs in high-income regions. This correlates with evidence that lower SES increases frailty prevalence due to poor nutrition and limited healthcare access (9). The lack of data from low-income regions emphasizes the need for initiatives to bridge this gap, potentially using mobile health tools to reach underserved populations (22). Limitations include the absence of user demographic data in Google Trends, which hinders precise interpretation of search intent, and the relative nature of RSV, which may underrepresent interest in less-searched regions (10).

Several limitations should be considered when interpreting these findings. First, Google Trends provides relative rather than absolute search volumes, which may cover actual public interest in regions with low internet penetration or where frailty is less commonly searched compared to dominant topics (10). Second, the lack of demographic data on search users prevents differentiation between patients, caregivers, or healthcare professionals, potentially causing a bias in the representation of public awareness (12). Third, language variations beyond 'fragilidad' (for example 'weakness' or 'debility' in other languages) and cultural differences in how frailty is conceptualized may lead to underreporting of interest in multilingual or low-income regions, where alternative terms or non-digital sources dominate (11). Fourth, the study's reliance on a single data source (Google Trends) may miss insights from other platforms or languages not captured in the sampled queries, limiting generalizability (11). Finally, the temporal analysis, while spanning 2004 to 2025, is subject to external influences (e.g., the 2020 pandemic spike), which may confound seasonal or socioeconomic trends without further contextual data. Future studies could address these by incorporating multilingual search terms, integrating data from social media platforms like X, or conducting surveys to capture demographic-specific search intent.

CONCLUSION

This study provides insights into the geographic, seasonal, and socioeconomic dimensions of public interest in frailty syndrome using Google Trends data, an underutilized tool in geriatric research (22). The results highlight the potential of digital epidemiology to identify awareness gaps in aging populations, suggesting that public health strategies could include winter-focused campaigns emphasizing exercise and nutrition in high-income regions with strong digital access, while mobile health interventions, such as SMS-based educational alerts or community-based workshops in local languages, could bridge gaps in low-income regions (9). Multilingual materials explaining frailty in culturally relevant terms could further enhance outreach, offering a foundation for future targeted interventions (5,9). By integrating real-time internet data with epidemiological evidence, this research bridges traditional and digital methodologies, paving the way for more dynamic public health strategies to address frailty in an aging global population.

DECLARATIONS

Ethics Committee Approval: As this study utilized publicly available and anonymized data from Google Trends and did not involve human subjects, Institutional Review Board (IRB) approval was not required.

Financial Disclosure: The authors declare that no financial support was received for this study or the preparation of this manuscript.

Informed Consent Form: Not applicable, as the study did not involve human participants or identifiable private information.

Role of the Funding Source: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. No external funding body influenced the study design, data collection, analysis, interpretation, or the decision to submit the manuscript for publication.

AI: Artificial intelligence tools were used to assist in language editing and improving the clarity of the manuscript. However, all scientific content, data analysis, and interpretations were carried out by the author, who bear full responsibility for the content and conclusions of this work.

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