




Original Research

A two-stage analysis of social media use patterns, psychosocial well-being, and frailty in an aging Japan

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ABSTRACT

Background: In Japan's super-aged society, frailty prevention is a critical public health issue. While social media use is increasing among older adults, its impact on well-being is complex and not fully understood beyond a simple active-passive dichotomy. This study aims to explore the relationship between specific social media usage patterns, users' psychosocial backgrounds, and frailty risk.

Methods: We conducted a cross-sectional online survey of 950 community-dwelling older adults in Japan. Frailty was assessed using the Kihon Checklist. A two-stage analysis was performed: 1) K-means cluster analysis was used to classify participants based on eight SOCIAL MEDIA use behavior variables, followed by a Kruskal-Wallis test to compare psychosocial characteristics across clusters; 2) Ordinal logistic regression analysis was used to identify specific behaviors associated with frailty after adjusting for covariates.

Results: Three distinct user clusters were identified: "Balanced, reality-oriented communicators" ($n = 333$), "Low-engagement, passive users" ($n = 419$), and "Active, multi-purpose users" ($n = 198$). The "Low-engagement" group reported the highest levels of loneliness and unhappiness, despite high real-world social participation. Regression analysis revealed that the specific behavior of "using social media to keep a record of my own activities" (self-documentation) was independently associated with an increased risk of frailty ($\beta = 0.105, p < .05$). Conversely, high exercise self-efficacy ($p < .001$), sleep satisfaction ($p < .01$), and satisfaction with face-to-face communication ($p < .001$) were protective factors.

Conclusion: Social media usage patterns reflect underlying psychosocial states, but are not direct predictors of frailty. The motivation-driven behavior of self-documentation, rather than general activity, is a risk factor. These findings suggest that interventions should focus on the quality and function of social media use, promoting digital literacy that enhances well-being in older adults.

1. Introduction

Due to declining mortality rates and advances in medical technology, Japan has transitioned into a super-aged society at a rate unparalleled in the world. As of 2022, the aging rate reached 29.1 %, and this trend is expected to continue, with a projected increase to 35.3 % by 2040 [1]. This rapid demographic shift is having a serious impact on the social security system, particularly on the caregiving infrastructure. The number of individuals certified as needing long-term care (or support) under the Long-Term Care Insurance System is steadily increasing, and while caregiving costs are rising, a simultaneous decline in the working-age population is creating a structural problem of caregiver shortages [2]. Against this backdrop, "preventive care," which aims to

prevent or delay the transition to a state requiring long-term care, has become an urgent issue for maintaining a sustainable society.

A central concept in the context of preventive care is frailty. Frailty is defined as a state of increased vulnerability to various stressors due to a combined decline in physical, psychological, and social functions [3]. What is important is that frailty is a reversible stage positioned between a state of requiring long-term care and a state of health. In other words, appropriate intervention can lead to recovery to a healthy state, making its early detection and preventive management extremely important. The concept of frailty was initially focused on physical aspects such as weight loss and muscle weakness [4], but it is now mainstream to view it as a comprehensive framework that includes psychological aspects such as cognitive decline and depression, as well as social aspects such as

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social isolation. In Japan, the Kihon Checklist is widely used as a tool to assess this comprehensive frailty [5].

A particularly important aspect of this comprehensive view is “social frailty.” This is closely related to social isolation and has a major impact on the quality of life and healthy life expectancy of older adults. In Japan, the number of older adults living alone is increasing, and their isolation from the local community is a serious problem. According to research, the frequency of social participation and the lack of connections with people other than family members have a major impact on the progression of frailty [6]. However, there are many older adults for whom participation in conventional community activities is difficult due to physical limitations or psychological barriers. In this situation, social media is expected to be a means of creating and maintaining new social connections.

Indeed, the use of social media among older persons is rapidly increasing [7], with studies showing that communication on these platforms contributes to greater overall communication satisfaction [8] and is positively associated with a reduction in loneliness [9].

However, the impact of social media on the well-being of older adults is not uniform. While there are positive reports of strengthening existing relationships and increasing the sense of social support [8,9], negative impacts have also been pointed out, such as the mental burden of comparing oneself with others and the deepening of loneliness due to the proliferation of superficial connections [10].

Furthermore, a study that analyzed social media use by dividing it into active and passive categories showed that Facebook activity and symptoms of depression, anxiety, and stress were more strongly associated with active use than with passive use. In contrast, social comparison orientation, flow experience on social media, social media addiction, fear of missing out (FOMO), and the intensity of social media use were more closely related to passive use than to active use [11]. Additionally, previous research has shown that being able to express oneself satisfactorily on social media is associated with an increased risk of frailty, while understanding others on social media is associated with a reduced risk of frailty [12].

These findings highlight that the impact of social media is not uniform and depends on the specific nature of the engagement. A simple active/passive dichotomy is insufficient to explain these complex effects, necessitating a more nuanced investigation into the functions and motivations behind different usage behaviors.

Therefore, in this study, we will conduct a two-stage analysis to unravel this complex relationship. The first objective is to classify the diverse social media use of older adults into several clusters based on their behavior patterns and to clarify the psychosocial background associated with each pattern. This will allow us to explore what constitutes a healthier usage style. The second objective is to identify which individual usage behaviors are directly related to the risk of frailty.

2. Methods

2.1. Survey design and measurement items

This study used data from a cross-sectional online survey conducted in January 2025. The subjects were 950 community-dwelling older adults in Japan. The sample was allocated to reflect the national demographics for gender and age, with the latter divided into two bands: 65–74 years (“young-old”) and 75 years and older (“old-old”). This distinction, originally proposed by Neugarten, is a standard approach in gerontology as these groups often differ in health status, social activity, and technology adoption [13]. The survey was conducted through an online research company with a panel of registered monitors. This research plan was approved by the Research Ethics Committee for Life Sciences and Medical Research at the Tokyo University of Science (Approval No. #23,077 on December 2024), and all participants provided informed consent online after being informed of the purpose, content, and privacy protection of the survey.

The questionnaire consisted of multiple sections including frailty, social media use behavior, psychosocial factors, lifestyle habits, and demographic variables. The full list of survey items is available as Supplementary Material (Table S1).

Assessment of Frailty. Frailty was assessed using the validated Kihon Checklist (25 items), which is widely used in Japan’s preventive care projects [5]. This checklist comprehensively covers domains such as IADL, motor function, nutrition/oral function, social withdrawal, cognitive function, and depressive tendencies. Based on the total score, subjects were classified into three groups: “robust” (0–3 points), “pre-frail” (4–7 points), and “frail” (8 points or more).

Measurement of Social Media Use Behavior. Based on the Uses and Gratifications Theory (UGT), we identified four primary dimensions of social media use.

- (1). Self-expression and presentation (Q23, Q24, Q25) to communicate one’s own experiences and opinions. This dimension reflects the motivation to construct and manage one’s identity online, a concept extensively discussed in research on self-presentation and narcissistic behaviors on social media [14]. It aligns with gratifications such as “self-status seeking” and “image-based use” identified in recent multidimensional scales [15].
- (2). Interpersonal communication (Q29, Q30) to maintain and build relationships with others. This is a core tenet of UGT, often categorized as “social interaction” or “maintaining relationships” [16,17].
- (3). Information consumption (Q27, Q28) to obtain information. This corresponds to the “information seeking” gratification, a foundational motive in UGT for all forms of media, including social media [16,18].
- (4). Social interaction (Q26) to react to others’ posts. This dimension captures the more lightweight, responsive forms of engagement (e.g., ‘liking’, brief comments) that are characteristic of social media platforms. This type of interaction is often subsumed under broader “active social use” categories in measurement scales but represents a distinct and frequent mode of engagement [15].

Psychosocial Factors. As a relationship between frailty and subjective well-being has been demonstrated, the latter was included as a covariate [19]. To measure subjective well-being, we asked about general feelings of happiness (Q2) and unhappiness (Q3). From a social perspective, given that depression influences frailty [20], we evaluated the presence of loneliness (Q10) and the feeling of being truly understood by others (perceived social support, Q11). Additionally, as items related to self-perception, we measured the need for approval from others (Q12) and the sense of feeling favorably about oneself (self-esteem, Q13).

Health-Related Lifestyle Habits. For health-related habits, drawing from previous research [21,22], we first assessed dietary patterns, including the regularity of eating three meals a day (Q5) and nutritional balance (consumption of a staple food, main dish, and side dishes) (Q4). For physical activity, we inquired about the presence of daily exercise habits (Q6), participation in specific activities like gymnastics or sports (Q14), and self-efficacy regarding the ability to continue exercising in the future (Q7) [23]. Regarding sleep, we evaluated its quantitative aspect by asking if participants secured 6–8 h of sleep (Q8), and its qualitative aspect through their satisfaction with their own sleep (Q9) [24].

Social Participation and Communication. Previous research has indicated the necessity of communication with a wide range of people [6], having a sense of purpose [8], and engagement in leisure activities [25] for reducing frailty risk. Therefore, to evaluate real-world social relationships, we asked about engagement in interactive activities with friends and acquaintances (e.g., tea parties, chatting) (Q15). Furthermore, we investigated roles and involvement in the community by asking about participation in learning activities, such as courses at community centers (Q16), and engagement in fulfilling social

contribution activities, such as volunteering (Q17). To understand interpersonal communication in detail, we measured the presence of face-to-face conversations with cohabitants (Q21) and satisfaction with them (Q22), as well as the presence of face-to-face conversations with non-cohabitants (Q19) and satisfaction with them (Q20).

Satisfaction in Specific Life Domains. As measures of satisfaction in specific life domains, we evaluated satisfaction with the current financial situation (Q1) [26] and satisfaction with one’s job (Q18) [27].

2.2. Classification and comparison of social media use patterns

As the first stage of this study, to get an overall picture of the subjects’ social media use, we conducted a cluster analysis using the K-means method, a non-hierarchical clustering technique, based on the eight social media use behavior variables. This method classifies each subject into the cluster with the most similar characteristics of their use pattern. Prior to the analysis, each variable was standardized. The optimal number of clusters was determined comprehensively by referring to the elbow method and the average silhouette width, which evaluate the cohesion within clusters and the separation between clusters.

After the clusters were formed, the characteristics of each cluster were interpreted. Next, to clarify how these social media use patterns are related to the users’ psychosocial background, we used the Kruskal-Wallis test to verify whether there were statistically significant differences in the mean values of various psychosocial factors (loneliness, unhappiness, self-esteem, etc.) between the clusters.

2.3. Analysis of the relationship with frailty

As the second stage of this study, to identify which individual use behaviors are directly related to frailty, we conducted an ordinal logistic regression analysis. This analysis method is suitable when the dependent variable is an ordinal scale such as “robust,” “pre-frail,” and “frail.”

In the analysis, the three categories of frailty were used as the dependent variable, and the eight social media use behavior variables, the psychosocial factors suggested to be important in the first stage of the analysis, and other covariates were used as explanatory variables. We confirmed that there was no problem of multicollinearity using the variance inflation factor (VIF). In constructing the final model, we performed variable selection using the stepwise method based on the Akaike information criterion (AIC) in order to balance the simplicity and explanatory power of the model. This allowed us to identify the social media use behaviors that are independently related to the risk of frailty after adjusting for the effects of many other factors.

3. Results

3.1. Subject characteristics

The average age was 73.2 years (standard deviation 4.9 years), and

Table 1
Participant Demographics (N = 950).

| Category | N |
|----------------|-----|
| All | 950 |
| gender | |
| Male | 443 |
| Female | 507 |
| Age | |
| 65~75 years | 659 |
| 75years~ | 291 |
| Frailty Status | |
| Frail | 263 |
| Pre-frail | 273 |
| Robust | 414 |

507 (53.3 %) were female (Table 1). Fig. 1 shows the distribution of frailty status. There were 414 subjects (43.6 %) in the robust group, 273 (28.7 %) in the pre-frail group, and 263 (27.7 %) in the frail group.

3.2. Social media use patterns and psychosocial background

As a result of the cluster analysis, participants were classified into three distinct groups based on their social media use patterns: “Balanced, reality-oriented communicators” (n = 333), “Low-engagement, passive users” (n = 419), and “Active, multi-purpose users” (n = 198). Table 2 presents the mean scores of the eight social media use items for each cluster.

Cluster 1. “Balanced, reality-oriented communicators” was characterized by a primary focus on using social media to maintain existing relationships. This group showed the highest mean score for “Communicating with existing family/friends” (Mean = 4.47, SD = 1.72). In contrast, they scored low on items related to online self-presentation and seeking validation, such as “Seeking reactions (likes/shares)” (Mean = 1.79, SD = 0.86).

Cluster 2. “Low-engagement, passive users” consistently reported the lowest mean scores across all eight use items. Their engagement was minimal, indicating a general passivity or low interest in using social media for any of the measured purposes.

Cluster 3. “Active, multi-purpose users” demonstrated intensive and varied use of social media, with the highest mean scores on most items. This group was highly active in both broadcasting content, such as “Posting about work/hobbies” (Mean = 4.96, SD = 1.38), and engaging in interpersonal communication with both existing friends (Mean = 4.92, SD = 1.27) and friends met online (Mean = 4.26, SD = 1.45). They also scored high on self-documentation and information gathering, reflecting a broad and active engagement with the platforms.

The results of the Kruskal-Wallis test comparing psychosocial and lifestyle factors across these three clusters are presented in Table 3. Significant differences were observed for numerous variables. For instance, Cluster 2 (“Low-engagement”) reported significantly higher levels of general unhappiness (Q3, $\chi^2=10.00, p=.007$) and loneliness (Q10, $\chi^2=13.42, p=.001$) compared to the other groups. This group also showed the highest need for approval (Q12, $\chi^2=24.21, p<.001$). Paradoxically, this same group (Cluster 2) also reported the highest levels of real-world social engagement, including activities with friends (Q14, $\chi^2=19.52, p<.001$), participation in hobbies (Q15, $\chi^2=38.30, p<.001$), learning (Q16, $\chi^2=81.52, p<.001$), and volunteering (Q17, $\chi^2=64.76, p<.001$). In contrast, Cluster 1 (“Balanced”) reported the lowest need for approval and the highest self-esteem (Q13, $\chi^2=14.93, p<.001$).

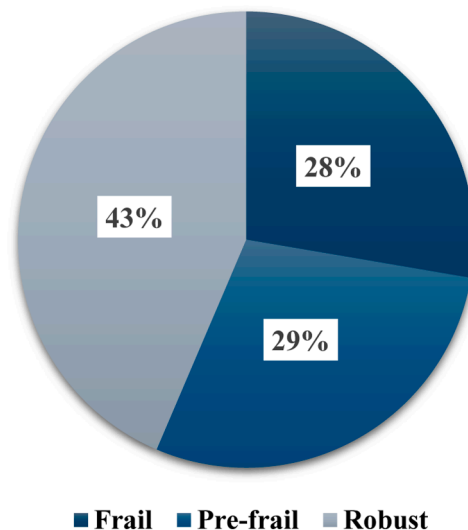


Fig. 1. Distribution of Frailty Status in the Study Population (N = 950).

Table 2
Mean Scores of Social Media Use Items for Each Cluster.

| Social Media Use Item | Cluster 1 (N = 333) | Cluster 2 (N = 419) | Cluster 3 (N = 198) |
|--|---------------------|---------------------|---------------------|
| Q23.posting about work/hobbies | 2.80 ± 1.59 | 1.41 ± 1.02 | 4.96 ± 1.38 |
| Q24.Self-documentation | 2.29 ± 1.23 | 1.19 ± 0.47 | 4.47 ± 1.32 |
| Q25.Seeking reactions (likes/shares) | 1.79 ± 0.86 | 1.13 ± 0.38 | 3.99 ± 1.39 |
| Q26.Reacting to others' posts | 2.19 ± 1.21 | 1.18 ± 0.58 | 4.38 ± 1.32 |
| Q27.Purposeful information gathering | 3.77 ± 1.69 | 1.37 ± 0.93 | 4.85 ± 1.28 |
| Q28.Passive, aimless browsing | 2.99 ± 1.41 | 1.27 ± 0.67 | 3.82 ± 1.45 |
| Q29.Communicating with existing family/friends | 4.47 ± 1.72 | 2.02 ± 1.76 | 4.92 ± 1.27 |
| Q30.Communicating with friends met online | 2.09 ± 1.16 | 1.16 ± 0.57 | 4.26 ± 1.45 |

Table 3
Comparison of psychosocial and lifestyle factors across social media use clusters.

| Variable | Cluster1 | Cluster2 | Cluster3 | Test Statistic | p-value | Sig. |
|----------|--------------|--------------|--------------|---------------------|---------|------|
| AGE | 70.29 ± 2.84 | 70.22 ± 2.68 | 70.06 ± 2.86 | $\chi^2(2) = 0.58$ | 0.75 | |
| Q1 | 3.99 ± 1.59 | 4.00 ± 1.34 | 4.04 ± 1.6 | $\chi^2(2) = 0.2$ | 0.905 | |
| Q2 | 4.00 ± 1.40 | 4.37 ± 1.18 | 4.28 ± 1.34 | $\chi^2(2) = 6.72$ | 0.035 | * |
| Q3 | 2.76 ± 1.34 | 2.93 ± 1.21 | 2.55 ± 1.35 | $\chi^2(2) = 10$ | 0.007 | ** |
| Q4 | 5.46 ± 1.26 | 5.27 ± 1.32 | 5.51 ± 1.33 | $\chi^2(2) = 4.65$ | 0.098 | |
| Q5 | 5.33 ± 1.87 | 5.47 ± 1.39 | 5.49 ± 1.83 | $\chi^2(2) = 2.68$ | 0.262 | |
| Q6 | 4.07 ± 1.96 | 4.69 ± 1.62 | 4.38 ± 1.8 | $\chi^2(2) = 8.09$ | 0.017 | * |
| Q7 | 4.17 ± 1.88 | 4.76 ± 1.48 | 4.64 ± 1.7 | $\chi^2(2) = 9.3$ | 0.01 | ** |
| Q8 | 4.98 ± 1.74 | 4.97 ± 1.43 | 5.07 ± 1.51 | $\chi^2(2) = 1.18$ | 0.553 | |
| Q9 | 4.38 ± 1.78 | 4.44 ± 1.45 | 4.48 ± 1.59 | $\chi^2(2) = 0.14$ | 0.932 | |
| Q10 | 3.01 ± 1.73 | 3.26 ± 1.43 | 2.69 ± 1.49 | $\chi^2(2) = 13.42$ | 0.001 | ** |
| Q11 | 4.23 ± 1.69 | 4.71 ± 1.21 | 4.74 ± 1.38 | $\chi^2(2) = 9.54$ | 0.008 | ** |
| Q12 | 3.57 ± 1.43 | 4.30 ± 1.20 | 3.94 ± 1.41 | $\chi^2(2) = 24.21$ | <0.001 | *** |
| Q13 | 4.16 ± 1.42 | 4.7 ± 1.06 | 4.53 ± 1.18 | $\chi^2(2) = 14.93$ | <0.001 | *** |
| Q14 | 3.31 ± 1.97 | 4.18 ± 1.70 | 3.71 ± 1.8 | $\chi^2(2) = 19.52$ | <0.001 | *** |
| Q15 | 3.17 ± 1.85 | 4.28 ± 1.48 | 3.95 ± 1.6 | $\chi^2(2) = 38.3$ | <0.001 | *** |
| Q16 | 1.90 ± 1.26 | 3.41 ± 1.68 | 2.47 ± 1.59 | $\chi^2(2) = 81.52$ | <0.001 | *** |
| Q17 | 2.15 ± 1.49 | 3.41 ± 1.54 | 2.57 ± 1.55 | $\chi^2(2) = 64.76$ | <0.001 | *** |
| Q18 | 3.67 ± 1.69 | 4.38 ± 1.17 | 4.01 ± 1.39 | $\chi^2(2) = 17.4$ | <0.001 | *** |
| Q19 | 4.00 ± 1.92 | 4.78 ± 1.26 | 4.66 ± 1.51 | $\chi^2(2) = 15.73$ | <0.001 | *** |
| Q20 | 4.04 ± 1.82 | 4.68 ± 1.24 | 4.54 ± 1.41 | $\chi^2(2) = 9.96$ | 0.007 | ** |
| Q21 | 4.36 ± 2.12 | 4.81 ± 1.48 | 5.12 ± 1.69 | $\chi^2(2) = 14$ | <0.001 | *** |
| Q22 | 4.33 ± 1.94 | 4.76 ± 1.37 | 4.77 ± 1.61 | $\chi^2(2) = 4.83$ | 0.09 | |

sig:*** p < .001, ** p < .01, * p < .05, . p < .1.

3.3. Factors related to frailty

Among the social media use behaviors, “using social media to keep a record of my own activities” (Q24) was shown to significantly increase

the risk of frailty ($\beta = 0.105, p < .05$). Other significant factors that increased the risk of frailty were gender (male), older age, high subjective unhappiness (Q3), and strong loneliness (Q10). Conversely, high exercise self-efficacy (Q7), high sleep satisfaction (Q9), and high satisfaction with face-to-face communication (Q20) were factors that reduced the risk of frailty. [Table 4](#)

4. Discussion

This study explored the complex relationship between social media use and frailty among older adults in Japan through a two-stage approach: identifying usage patterns and analyzing individual behaviors. The findings revealed that the “quality” and “motivation” behind social media use are more critical for understanding user well-being and frailty risk than superficial aspects such as the volume or pattern of use.

4.1. Psychosocial backgrounds reflected in social media use patterns

The cluster analysis in the first stage suggested that each usage pattern strongly reflects a unique psychosocial profile.

First, the “Low-engagement, passive users” (Cluster 2), who forgo online communication, appeared to face the most severe psychological challenges. Despite being the most active group in real-world social activities—such as interacting with friends, pursuing hobbies, and volunteering—they reported the highest levels of loneliness, unhappiness, and need for approval. This seemingly contradictory result indicates that the quantity of social participation, whether online or offline, does not necessarily correlate with psychological fulfillment. Their vigorous off-line activities are likely a form of “compensatory behavior” to make up for unmet social needs and loneliness [28], suggesting a state where they remain unfulfilled despite participating in numerous activities.

Moving to a different profile, the “Balanced, reality-oriented communicators” (Cluster 1) reported the lowest need for approval and high self-esteem. However, it is important to distinguish their psychological state from that of Cluster 2; while Cluster 2 reported the highest presence of unhappiness (negative effect), Cluster 1 reported the lowest presence of happiness (positive effect). This distinction aligns with two-factor models of subjective well-being, which posit that positive and negative effect are independent dimensions rather than opposite ends of a single spectrum [29]. This suggests their lack of need for approval may be intertwined with low intrinsic happiness, and their restrained social media use might reflect a cautious approach or a low motivation for deep engagement with others.

Finally, the “Active, multi-purpose users” (Cluster 3) were the group with the highest subjective well-being, reporting the lowest loneliness and unhappiness. This positive state was associated with versatile use of social media and active engagement both online and offline. However, this high subjective well-being is strongly supported by self-presentational activities, such as “self-documentation” and seeking reactions from others. This reliance presents a potential vulnerability, as

Table 4
Results of ordinal logistic regression analysis for frailty.

| Variable | Estimate | Std. Error | z value | p value | |
|----------|----------|------------|---------|---------|-----|
| SEX | 0.269 | 0.129 | 2.078 | 0.038 | * |
| AGE | 0.054 | 0.013 | 4.108 | < 0.001 | *** |
| Q2 | -0.086 | 0.054 | -1.601 | 0.109 | |
| Q3 | 0.275 | 0.054 | 5.108 | < 0.001 | *** |
| Q7 | -0.191 | 0.041 | -4.616 | < 0.001 | *** |
| Q8 | 0.096 | 0.063 | 1.516 | 0.129 | |
| Q9 | -0.174 | 0.063 | -2.763 | 0.006 | ** |
| Q10 | 0.096 | 0.046 | 2.094 | 0.036 | * |
| Q20 | -0.183 | 0.049 | -3.754 | < 0.001 | *** |
| Q24 | 0.105 | 0.049 | 2.137 | 0.033 | * |
| Q27 | -0.074 | 0.040 | -1.827 | 0.068 | . |

sig: *** p < .001, ** p < .01, * p < .05, . p < .1.

the very behavior linked to their happiness is also associated with an increased risk of frailty.

4.2. The mechanism of social media use's impact on frailty

Building on these insights, the second-stage regression analysis revealed a core paradox: the individual behavior of “using social media for self-documentation” (Q24), most prominent in the subjectively happiest group (Cluster 3), independently and significantly increased the risk of frailty.

This contradiction can be unraveled by questioning the “quality of happiness.” The happiness derived from self-documentation is likely a form of momentary, Hedonic Well-being, which depends on external validation such as likes [30].

This introduces the contrasting concept of Eudaimonic well-being, providing a stronger theoretical anchor for your argument. This happiness-seeking strategy, by potentially entrusting one's self-worth to unstable external evaluations, may undermine “autonomy”—a cornerstone of psychological resilience and a key component of psychological frailty [31]. This state of dependency on others' evaluations could be considered a mechanism of “psychological frailty,” or vulnerability to stressors. Therefore, while a person may feel “happy,” the foundation of this happiness could be fragile and come at the cost of an increased future health risk. This interpretation requires confirmation through longitudinal research.

Thus, our two-stage analysis first identified user profiles reflecting distinct psychological backgrounds and then specified how a particular social media behavior impacts frailty risk, highlighting the importance of looking beyond mere correlation to the underlying psychological drivers.

4.3. General implications and limitations

The foregoing discussion challenges the simplistic dichotomy of whether more digital connection is good or bad. Frailty is more closely related to how social media is used than how much. This study demonstrated that behavior in the social domain of social media is deeply intertwined with the psychological domains of loneliness and the need for approval, and ultimately affects the comprehensive state of frailty, which spans physical, psychological, and social domains.

These findings provide important suggestions for social media-based interventions for frailty and long-term care prevention. In programs using social media to alleviate social isolation among older adults, merely providing access to technology or operational training is insufficient. Without addressing the qualitative aspects of online engagement, such approaches could unintentionally promote the negative aspects of social media and encourage unhealthy behavior. Therefore, interventions should incorporate the perspective of fostering “psycho-social digital literacy” [32]. The ultimate goal is to empower older adults to master technology as a tool to enrich, rather than replace, the quality of their real-world social lives, thereby serving as a countermeasure against all aspects of frailty.

This study has several limitations. First, its cross-sectional design makes it impossible to identify the direction of causality. Second, as an online survey, it excludes more vulnerable older adults who do not use the internet. We also did not include a measure of self-rated health, which is a significant limitation as it is a robust predictor of frailty and mortality in older adults [33]. Furthermore, this study does not distinguish between the effects of different social media platforms. The social media landscape in Japan, where platforms like LINE are widely used for maintaining close-knit networks [34], may influence usage patterns, limiting generalizability to other cultures.

Finally, while the K-means clustering method is effective, it has limitations, such as the need to pre-specify the number of clusters. We mitigated this by using both the elbow method and average silhouette width—standard techniques for this purpose [35]—to determine the

optimal cluster number.

5. Conclusion

This study revealed that while overall social media use patterns were not direct predictors of frailty, they served as a strong reflection of users' underlying psychosocial states. Furthermore, it identified the specific behavior of using social media for “self-documentation” as being independently associated with an increased risk of frailty. This uncovered a significant paradox wherein the most socially active older adults, both online and offline, exhibited adverse psychosocial characteristics, suggesting that their intensive activity may be a symptom of, rather than a solution for, unmet social needs.

Consequently, for frailty and long-term care prevention, it is necessary to move beyond merely promoting digital technology use and to implement social media interventions accompanied by solid literacy. Future research should employ longitudinal designs to confirm the causal pathways identified in this study. Moreover, interventions aimed at promoting suitable social media use for the older population should be proposed.

Declarations

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CRediT authorship contribution statement

Yuki Nakada: Writing – original draft, Visualization, Methodology, Investigation, Data curation. **Yuna Seo:** Writing – review & editing, Validation, Resources, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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