The Impact of Digital Isolation on Dementia Risk Among Older Adults: Findings from a Longitudinal Cohort Study

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Table of Contents

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Abstract

Background: Dementia poses a significant global health challenge, characterized by progressive cognitive decline and functional impairment. With the aging global population, dementia prevalence is projected to surge, reaching an estimated 153 million cases by 2050. While the impact of traditional social isolation on dementia risk has been extensively studied, the influence of digital isolation—a phenomenon unique to the digital age—remains underexplored.

Objective: This study investigates the association between digital isolation and dementia risk among older adults, hypothesizing that higher levels of digital isolation significantly increase the risk of developing dementia.

Methods: We conducted a longitudinal cohort study using data from the National Health and Aging Trends Study (NHATS), analyzing 8,189 participants aged 65 and older from the third (2013) to the twelfth wave (2022). Digital isolation was quantified using a composite Digital Isolation Index, derived from participants' usage of digital devices, electronic communication, internet access, and engagement in online activities. Participants were stratified into low isolation and moderate to high isolation groups. Dementia incidence was assessed using cognitive tests and proxy reports. Cox proportional hazards models were employed to estimate the association between digital isolation and dementia risk, adjusting for potential confounders including sociodemographic factors, baseline health conditions, and lifestyle variables.

Results: The moderate to high isolation group demonstrated a significantly elevated risk of dementia compared to the low isolation group. In the discovery cohort, the adjusted hazard ratio (HR) was 1.25 (95% CI: 1.03-1.52, P=0.023), while the validation cohort showed an HR of 1.68 (95% CI: 1.30-2.16, P<0.001). The pooled analysis across both cohorts revealed an adjusted HR of 1.40 (95% CI: 1.20-1.64, P<0.001). Kaplan-Meier curves corroborated a higher incidence of dementia in the moderate to high isolation group.

Conclusions: Our findings indicate that digital isolation is a significant risk factor for dementia among older adults. This study underscores the importance of digital engagement in mitigating dementia risk and suggests that promoting digital literacy and access to digital resources should be integral components of public health strategies aimed at dementia prevention.

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Results:

The moderate to high isolation group demonstrated a significantly elevated risk of dementia compared to the low isolation group. In the discovery cohort, the adjusted hazard ratio (HR) was 1.25 (95% CI: 1.03-1.52, P=0.023), while the validation cohort showed an HR of 1.68 (95% CI: 1.30-2.16, P<0.001). The pooled analysis across both cohorts revealed an adjusted HR of 1.40 (95% CI: 1.20-1.64, P<0.001). Kaplan-Meier curves corroborated a higher incidence of dementia in the moderate to high isolation group.

Conclusions:

Our findings indicate that digital isolation is a significant risk factor for dementia among older adults. This study underscores the importance of digital engagement in mitigating dementia risk and suggests that promoting digital literacy and access to digital resources should be integral components of public health strategies aimed at dementia prevention.

Keywords: Dementia; Digital Isolation; Cognitive Decline; Older Adults; Cohort Study

Introduction

Dementia, characterized by progressive cognitive decline and functional impairment, represents a formidable global health challenge[1, 2]. As the world's population ages rapidly, the prevalence of dementia is projected to surge, with an estimated 153 million individuals affected by 2050[3]. In the absence of curative treatments, the imperative for effective prevention strategies has never been more pressing. The etiology of dementia is multifactorial, encompassing both non-modifiable factors such as age and genetic predisposition, and modifiable risk factors including cardiovascular health, lifestyle choices, and social engagement[4-6].

In the context of an increasingly digitalized society, interaction with technology has become integral to modern life. However, the digital revolution has not benefited all segments of the population equally. A significant proportion of older adults find themselves in a state of "digital isolation," either due to limited access or inadequate digital literacy[7-9]. This digital divide may not only restrict access to information and social resources but also potentially diminish cognitive stimulation and social interaction, factors crucial for maintaining cognitive health[10-12]. The concept of digital isolation offers a novel lens through which to examine dementia risk, yet its impact remains insufficiently explored.

While the association between traditional social isolation and dementia risk has been extensively studied, the impact of digital isolation—a phenomenon unique to our technologically driven era—has received comparatively little attention[13-15]. Preliminary investigations suggest a

potential link between digital isolation and accelerated cognitive decline, as well as increased dementia risk. However, these studies are often constrained by limited sample sizes and cross-sectional designs, precluding the establishment of causal relationships. Moreover, many existing studies fail to adequately control for potential confounding factors such as depression, anxiety, chronic comorbidities, and lifestyle variables, potentially biasing their results[10, 16].

The present study aims to elucidate the relationship between digital isolation and dementia risk through a large-scale, longitudinal cohort study. Employing a multi-stage Cox proportional hazards model analysis on both discovery and validation cohorts, we will rigorously control for an extensive array of potential confounding factors. Our objective is to provide robust evidence supporting the hypothesis that higher levels of digital isolation significantly elevate the risk of dementia. This investigation not only seeks to delineate the potential mechanisms underlying this emerging risk factor but also aims to inform novel intervention strategies for dementia prevention.

Methods

Study Population

This investigation leveraged data from the National Health and Aging Trends Study (NHATS), a longitudinal survey of Medicare beneficiaries aged 65 and older in the United States. Our analysis utilized data spanning from the third wave (2013), when digital product usage assessment was initiated, to the twelfth wave (2022). The study cohort was stratified into discovery and validation samples.

In the third wave (2013), 5,799 participants remained in the study. We excluded individuals lacking baseline digital isolation data or with pre-existing dementia diagnoses. We rigorously controlled for potential confounders influencing the digital isolation-dementia risk relationship, including age, gender, race/ethnicity, baseline diseases, depression, anxiety, smoking status, and sleep difficulties. Participants were followed from the fourth wave (2014) through the twelfth wave (2022). During follow-up, some individuals were excluded due to attrition or death prior to dementia diagnosis. The final analytical sample comprised 4,455 individuals.

To validate our findings, we utilized an independent cohort of 4,182 individuals newly recruited in the fifth wave (2015). After applying the same exclusion criteria as the discovery cohort and accounting for attrition and mortality during follow-up, 3,734 individuals were included in the validation sample. This cohort was followed from the fifth wave (2015) through the twelfth wave (2022).

The research protocol was approved by the Institutional Review Board at Union Hospital,

Tongji Medical College, Huazhong University of Science and Technology in Wuhan, China.

Digital Isolation

Digital isolation was assessed using a composite Digital Isolation Index, which was constructed based on individuals' usage of various digital devices and the internet. The design of this index was informed by relevant literature in the fields of social isolation and digital health. For instance, Cornwell and Waite (2009) quantified social isolation by evaluating the extent of individuals' social contact and participation, and proposed a method for constructing a social isolation index using self-reported data[17]. Similarly, digital isolation, as a modern form of isolation, is primarily reflected in the insufficient engagement with and use of digital technologies.

In this study, we operationalized digital isolation through a composite Digital Isolation Index comprising seven parameters: (1) mobile phone utilization, (2) computer usage, (3) tablet employment, (4) frequency of electronic communication (email or text messaging), (5) internet access, (6) engagement in online activities, and (7) participation in health-related digital platforms. The selection and quantification of these indicators were informed by extant literature on digital technology adoption, such as Kraut et al. (1998), who investigated the impact of internet use on social involvement. Each parameter was dichotomized (0 = non-use, 1 = use), and the sum of these binary scores constituted the aggregate Digital Isolation Index[18]. For stratification purposes, we adopted methodologies analogous to those employed in social frailty research by Makizako et al. (2015) and Wei et al. (2018)[19, 20]. Subjects were categorized into two cohorts based on their Digital Isolation Index: those scoring 2 or less were classified as "low isolation," while those scoring 3 or above were designated as "moderate to high isolation." This bifurcation strategy was designed to elucidate the potential differential impacts of varying degrees of digital isolation on health outcomes.

Dementia

In the NHATS database, dementia ascertainment is primarily predicated on cognitive function assessments and self-reports or proxy reports. NHATS employs a multifaceted approach to dementia evaluation, encompassing cognitive testing, proxy reports, and clinical records. Specifically, NHATS utilizes a battery of cognitive tests to assess participants' memory, attention, and executive function, with these metrics serving as indicators of cognitive status. Concurrently, NHATS collects proxy reports, typically from family members or caregivers, regarding the participants' cognitive condition. These reports may encompass physician-diagnosed dementia and observed cognitive deficits in activities of daily living. Investigators typically synthesize these data with additional clinical

information to determine dementia status and monitor its progression longitudinally. Upon confirmation or report of dementia in any follow-up wave, subsequent inquiries regarding dementia status are discontinued for that participant.

Covariates

This study incorporated a comprehensive set of covariates to ensure a precise estimation of the association between digital isolation and dementia risk. These covariates encompass sociodemographic characteristics, clinical parameters, and health-related behaviors.

Sociodemographic variables include age, gender, and race/ethnicity. Age was stratified into six cohorts: 65–69, 70–74, 75–79, 80–84, 85–89, and ≥90 years. Gender was dichotomized as male or female. Race/ethnicity was categorized as non-Hispanic White, non-Hispanic Black, Hispanic, and Other. These variables are routinely employed as baseline covariates to adjust for sociodemographic heterogeneity in health outcomes[21-23].

Clinical parameters comprise the number of baseline diseases, depressive symptomatology, and anxiety manifestations. The number of baseline diseases was trichotomized based on self-reported chronic conditions (including arthritis, cardiovascular disease, hypertension, diabetes, pulmonary disease, cerebrovascular accident, osteoporosis, and malignancy): no diseases, 1-2 diseases, and ≥3 diseases. Depressive and anxiety symptoms were assessed via validated self-report instruments and operationalized as binary variables in the analyses[24, 25].

Health-related behaviors include smoking status and sleep difficulties. Smoking status was dichotomized as current smokers and non-current smokers to account for potential cognitive effects of tobacco use[26]. Sleep difficulties were stratified based on the frequency of difficulty falling asleep within 30 minutes: high sleep difficulty (every night or most nights), moderate sleep difficulty (some nights), and low or no sleep difficulty (rarely or never)[27]. Prior research has demonstrated associations between poor sleep quality, cognitive decline, and elevated dementia risk, warranting its inclusion as a key covariate.

Statistical Analysis

Baseline characteristics of the study population were summarized using descriptive statistics, with categorical variables presented as frequencies and percentages. To assess the probability of dementia-free survival across different digital isolation groups (low isolation vs. moderate to high isolation), we employed Kaplan-Meier survival analysis. The resultant Kaplan-Meier survival curves are depicted in Figure 1. To quantify the association between digital isolation and dementia risk, we

utilized Cox proportional hazards regression models, calculating hazard ratios (HRs) with corresponding 95% confidence intervals (CIs). Two models were constructed: Model 1 (unadjusted) and Model 2 (adjusted for potential confounders including age, gender, race, number of baseline diseases, depression, anxiety, smoking status, and sleep difficulties).

We further investigated the individual components of digital isolation (e.g., mobile phone use, computer use, tablet use, frequency of email usage, internet usage, online activities, and health-related online activities) and their respective impacts on dementia risk. Each component was analyzed independently using Cox proportional hazards models to estimate HRs and 95% CIs.

To examine the potential heterogeneity in the association between digital isolation and dementia, we conducted stratified analyses across subgroups defined by gender, age, race/ethnicity, and comorbidity status. Effect modification by these factors was assessed through the inclusion of interaction terms in the Cox models. To enhance the robustness of our findings, we combined the results from the discovery and validation samples using meta-analytic techniques. Pooled HRs and CIs were computed using a fixed-effects model, under the assumption of homogeneity across samples. All analyses adhered to the intention-to-treat principle. Statistical analyses were performed using R statistical software (version 4.4.1; R Foundation for Statistical Computing, Vienna, Austria; www.r-project.org). A two-sided p-value < 0.05 was considered statistically significant for all analyses.

Results

Baseline Characteristics of the Study Population

The study cohort comprised 8,189 participants, with 4,455 individuals in the discovery sample and 3,734 in the validation sample. Females constituted a slight majority, accounting for 57.68% of the cohort. The racial/ethnic composition was predominantly non-Hispanic White (68.58%), followed by non-Hispanic Black (20.48%) and Hispanic (5.73%). Age distribution analysis revealed that the 70–74 year age group was most prevalent (23.27%), succeeded by the 75–79 (20.63%) and 80–84 (18.06%) age groups. With respect to baseline diseases, 47.85% of participants reported no chronic conditions, while 31.67% had 1–2 diseases, and 20.49% had 3 or more chronic conditions. The prevalence of depression and anxiety was 26.74% and 34.43%, respectively. The majority of participants (92.58%) were non-smokers. Sleep difficulties were reported as significant by 20.84% of participants, and moderate by 24.29%. In the context of digital isolation, 54.62% of participants were categorized as experiencing moderate to high isolation, while 45.38% were classified as having low isolation. Digital device utilization rates were as follows: mobile phones (80.80%), computers

(59.31%), and tablets (24.98%). Frequent engagement in digital activities was reported for email or text messaging (79.83%), internet access (57.51%), general online activities (88.93%), and health-related online activities (77.13%).

Association Between Digital Isolation and the Risk of Dementia

The association between digital isolation and dementia risk was comprehensively examined, with results presented in Table 2. In the discovery sample, the moderate to high isolation group demonstrated a significantly elevated risk of dementia compared to the low isolation group. The unadjusted Cox proportional hazards model (Model 1) yielded a hazard ratio (HR) of 1.58 (95% CI: 1.31-1.89, P<0.001) for dementia in the moderate to high isolation group. After adjusting for potential confounders (age, gender, race/ethnicity, number of baseline diseases, depression, anxiety, smoking status, and sleep disorders), the HR in Model 2 attenuated to 1.25 (95% CI: 1.03-1.52, P=0.023), yet remained statistically significant. The validation sample corroborated these findings. The unadjusted Model 1 revealed an HR of 2.36 (95% CI: 1.86-3.01, P<0.001) for the moderate to high isolation group, while the adjusted Model 2 showed an HR of 1.68 (95% CI: 1.30-2.16, P<0.001), consistently indicating a significantly higher dementia risk in the moderate to high isolation group. To enhance the robustness of our findings, we conducted a pooled analysis of both samples. The pooled analysis yielded HRs of 1.89 (95% CI: 1.63-2.19, P<0.001) in the unadjusted Model 1 and 1.40 (95% CI: 1.20-1.64, P<0.001) in the adjusted Model 2, further substantiating the significant risk increase.

Kaplan-Meier survival curves were employed to visualize dementia incidence across different digital isolation groups (Figure 1). These curves demonstrated a significantly higher probability of dementia development in the moderate to high isolation group, corroborating the Cox regression analysis results. Figure 2 illustrates the association between digital isolation and dementia risk across various demographic and clinical subgroups. Consistently elevated dementia risk was observed in the moderate to high isolation group across all subgroups, with notable differences in gender, age, and comorbidity status. These findings underscore the pervasive impact of digital isolation on dementia onset, demonstrating a consistent trend of increased risk both in the overall population and within specific subgroups.

Association Between Digital Isolation Components and the Risk of Dementia

We examined the association between individual components of digital isolation and incident dementia risk, with results presented in Table 3. In the discovery sample, the use of mobile phones,

computers, tablets, and the internet were significantly associated with dementia risk. Specifically, the unadjusted Cox proportional hazards model (Model 1) indicated that non-users of mobile phones had a significantly higher risk of developing dementia compared to users (HR = 1.78, 95% CI: 1.41-2.24, P<0.001). After covariate adjustment (Model 2), the hazard ratio attenuated to 1.49 (95% CI: 1.17-1.90, P<0.001). Similar significant associations were observed for non-users of computers, tablets, and the internet. The validation sample corroborated these findings. Non-users of mobile phones, computers, or the internet, and those not participating in online activities, exhibited significantly higher dementia risk. For instance, in the validation sample, the HR for mobile phone non-users was 3.05 (95% CI: 2.28-4.08, P<0.001) in the unadjusted model, and 2.16 (95% CI: 1.58-2.96, P<0.001) in the adjusted model. The pooled analysis further substantiated these associations. Non-users of mobile phones, computers, the internet, or those not engaging in online activities demonstrated significantly higher dementia risk, with adjusted HRs of 1.70 (95% CI: 1.40-2.07, P<0.001), 1.17 (95% CI: 0.99-1.38, P=0.069), 1.46 (95% CI: 1.21-1.76, P<0.001), and 1.35 (95% CI: 1.02-1.78, P=0.036), respectively. These findings underscore that various aspects of digital isolation, particularly the absence of basic digital device and internet usage, are significantly associated with increased dementia risk. This evidence further supports the potential role of digital engagement as a strategy for dementia prevention.

Discussion

Principal Results

This study investigated the association between digital isolation and dementia risk, revealing that higher degrees of digital isolation significantly increase dementia risk. These findings underscore the importance of digital engagement for cognitive health in older adults and offer new perspectives for public health policy development. Our results demonstrate a significant association between digital isolation and dementia risk. In both discovery and validation samples, individuals who did not use basic digital devices (e.g., mobile phones, computers, and tablets) or lacked internet access and online activity participation exhibited a significantly higher risk of dementia compared to their digitally engaged counterparts. The pooled analysis revealed that individuals with a higher Digital Isolation Index had approximately a 1.4-fold increased risk of dementia. This aligns with previous research indicating social isolation and lack of social interaction as independent risk factors for dementia[28, 29].

Furthermore, this study validates digital isolation as a novel form of isolation that may influence cognitive health through multiple mechanisms. Digital technologies can promote social interaction

and participation, crucial for maintaining cognitive function[30-32]. Conversely, a lack of digital engagement may exacerbate social isolation, thereby increasing cognitive decline risk. Additionally, digital technology use can provide cognitive stimulation, potentially helping older adults maintain brain vitality[33, 34]. Thus, digital isolation not only reflects diminished social interaction but may also represent insufficient cognitive stimulation. These findings have significant public health implications. As society undergoes digital transformation, issues related to digital engagement among older adults are becoming increasingly salient. Our study suggests that promoting digital technology use among older adults, particularly within vulnerable populations, could effectively mitigate dementia risk. This implies that enhancing digital literacy and expanding access to digital resources should be integral components of dementia prevention strategies.

Limitations

However, this study has limitations. Despite controlling for multiple covariates, the observational nature of our study design precludes complete elimination of confounding factors. For instance, individuals' health behaviors and cognitive abilities may simultaneously influence their digital technology use and dementia risk, potentially leading to reverse causality[10, 35]. Additionally, our reliance on self-reported data may introduce information bias, particularly in the preclinical stages of dementia when individuals' recollection of their digital usage may not be entirely accurate.

Notwithstanding these limitations, this study provides important empirical support for exploring the relationship between digital isolation and dementia risk. Future research should further investigate factors that promote or hinder digital engagement among older adults to develop more effective interventions. Additionally, longitudinal study designs and randomized controlled trials will be essential for further validating our findings and exploring the causal relationship between digital technology use and cognitive health.

Conclusions

This study, examining the association between digital isolation and dementia risk in older adults, underscores the critical role of digital engagement in maintaining cognitive health. Our findings demonstrate that digital isolation significantly increases dementia risk, particularly among individuals who do not use basic digital devices, lack online communication, and abstain from online activities. These results suggest that promoting digital engagement among the elderly may be an effective strategy for mitigating dementia risk in an increasingly digitalized society.

Our research not only provides new evidence of the detrimental effects of digital isolation but also offers valuable insights for future public health interventions. Enhancing digital literacy and expanding accessibility to digital resources among older adults may effectively reduce digital isolation, potentially lowering dementia incidence. Future research should explore the specific mechanisms through which digital engagement affects cognitive health and further validate the causal relationship between digital isolation and dementia via longitudinal studies and intervention trials.

In conclusion, this study highlights the importance of digital technology in older adults' health and advocates for the integration of digital literacy education and widespread digital resource availability in public health policies. These measures will facilitate older adults' integration into the digital society, thereby potentially improving their cognitive health and overall quality of life.

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Conflicts of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Tables and Figures

TABLE 1. Baseline characteristics of the study population
TABLE 2 Association between digital isolation and the risk of dementia
TABLE 3 Association between digital isolation items and the risk of dementia.

FIGURE 1 Kaplan–Meier curves of the relationship between digital isolation and risk of dementia

FIGURE 2 Association between digital isolation and risk of dementia among subgroups.

TABLE 1. Baseline characteristics of the study population			
Variables	**Discovery Sample (N = 4,455)**	**Validation Sample (N = 3,734)**	**Pooled Sample (N = 8,189)**
Gender, n (%)			
Male	1,843 (41.37)	1,622 (43.44)	3,465 (42.32)
Female	2,612 (58.63)	2,112 (56.56)	4,724 (57.68)
Race/Ethnicity, n (%)			
White, non-Hispanic	3,162 (70.98)	2,453 (65.69)	5,615 (68.58)
Black, non-hispanic	915 (20.54)	762 (20.41)	1,677 (20.48)
Hispanic	230 (5.16)	239 (6.40)	469 (5.73)
Other	148 (3.32)	280 (7.50)	428 (5.22)
Age, n (%)			
65 to 69	459 (10.30)	1,000 (26.78)	1,459 (17.82)
70 to 74	1,076 (24.15)	830 (22.23)	1,906 (23.27)
75 to 79	961 (21.57)	728 (19.50)	1,689 (20.63)
80 to 84	899 (20.18)	580 (15.53)	1,479 (18.06)
85 to 89	647 (14.52)	355 (9.51)	1,002 (12.23)
90+	413 (9.27)	241 (6.45)	654 (7.99)
Baseline Disease, n (%)			
No disease	3,568 (80.09)	350 (9.37)	3,918 (47.85)
1-2 diseases	861 (19.33)	1,732 (46.38)	2,593 (31.67)
3 or more diseases	26 (0.58)	1,652 (44.24)	1,678 (20.49)
Depression, n (%)			

No Depression	3,241 (72.75)	2,759 (73.89)	6,000 (73.26)
Depression	1,214 (27.25)	975 (26.11)	2,189 (26.74)
Anxiety, n (%)			
No Anxiety	2,908 (65.27)	2,462 (65.93)	5,370 (65.57)
Anxiety	1,547 (34.73)	1,272 (34.07)	2,819 (34.43)
Smoking Status, n (%)			
Non-smoker	4,152 (93.20)	3,430 (91.86)	7,582 (92.58)
Smoker	303 (6.80)	304 (8.14)	607 (7.42)
Sleep Difficulty, n (%)			
High Difficulty	848 (19.13)	859 (23.07)	1,707 (20.84)
Medium Difficulty	1,115 (25.15)	874 (23.47)	1,989 (24.29)
Low/No Difficulty	2,470 (55.72)	1,991 (53.46)	4,461 (54.47)
Digital Isolation Group, n (%)			
Low Isolation	1,803 (40.47)	1,913 (51.23)	3,716 (45.38)
Medium/High Isolation	2,652 (59.53)	1,821 (48.77)	4,473 (54.62)
Items of Digital Isolation, n (%)			
Phone Use, n (%)	3,446 (77.35)	3,169 (84.87)	6,615 (80.80)
Computer Use, n (%)	2,531 (56.81)	2,326 (62.29)	4,857 (59.31)
Tablet Use, n (%)	764 (17.15)	1,281 (34.31)	2,045 (24.98)
Email Frequency, n (%)	3,603 (80.88)	2,934 (78.58)	6,537 (79.83)
Internet Use, n (%)	2,498 (56.07)	2,211 (59.21)	4,709 (57.51)
Online Activity, n (%)	3,945 (88.55)	3,337 (89.37)	7,282 (88.93)

Health-Related Online Use, n (%)	3,484 (78.20)	2,831 (75.82)	6,315 (77.13)

Note:
Race/ethnicity was reclassified into four categories: White, non-Hispanic; Black, non-Hispanic; Hispanic; and Other. The depression, anxiety, and smoking status variables were reclassified as binary variables. Responses of "Don't know," "Refused to answer," and similar were treated as missing data. The Digital Isolation Index was used to create a new variable (Digital Isolation Group) dividing participants into low and moderate/high isolation groups. Sleep difficulty was categorized by the frequency of difficulty falling asleep within 30 minutes, with unknown or refused responses treated as missing data.

TABLE 2 Association between digital isolation and the risk of dementia

Sample/Variables	Event/N (%)	Model 1 HR (95% CI)	P-Value	Model 2 HR (95% CI)	P-Value
Discovery Sample					
Low Isolation (Ref)	1,803/4,455 (40.47)	1 (Ref)		1 (Ref)	
Medium/High Isolation	2,652/4,455 (59.53)	1.58 (1.31, 1.89)	<0.001	1.25 (1.03, 1.52)	0.023
Validation Sample					
Low Isolation (Ref)	1,913/3,734 (51.23)	1 (Ref)		1 (Ref)	
Medium/High Isolation	1,821/3,734 (48.77)	2.36 (1.86, 3.01)	<0.001	1.68 (1.30, 2.16)	<0.001
Pooled Sample					
Low Isolation (Ref)	3,716/8,189 (45.38)	1 (Ref)		1 (Ref)	
Medium/High Isolation	4,473/8,189 (54.62)	1.89 (1.63, 2.19)	<0.001	1.40 (1.20, 1.64)	<0.001

Notes:
Model 1: Unadjusted Cox proportional hazards model.
Model 2: Cox proportional hazards model adjusted for age, gender, race, baseline disease, depression, anxiety, smoking status, and sleep difficulty.
Abbreviation: HR, Hazard Ratio; CI, Confidence Interval.

TABLE 3 Association between digital isolation items and the risk of dementia.

Variables	Discovery Sample	Validation Sample	Pooled Sample
	Model 1	Model 2	Model 1
	HR (95% CI) P-Value	HR (95% CI) P-Value	HR (95% CI) P-Value
Phone Use	1.78 1.41, 2.24 <0.001	1.49 1.17, 1.90 <0.001	3.05 2.28, 4.08 <0.001
Computer Use	1.22 1.00, 1.50 0.052	1.09 0.88, 1.34 0.427	1.50 1.15, 1.97 0.003
Tablet Use	1.39 1.02, 1.88 0.035	1.32 0.97, 1.79 0.075	1.19 0.88, 1.60 0.264
Email Frequency	0.74 0.56, 0.99 0.043	0.75 0.56, 0.99 0.045	1.03 0.74, 1.44 0.848
Internet Use	1.42 1.12, 1.79 0.004	1.37 1.08, 1.74 0.010	1.75 1.30, 2.34 <0.001
Online Activity	1.12 0.78, 1.59 0.541	1.11 0.78, 1.58 0.579	1.93 1.24, 3.02 0.004
Health-Related Online Use	1.08 0.78, 1.48 0.656	1.17 0.84, 1.61 0.353	0.92 0.61, 1.40 0.707

Notes: Model 1: unadjusted; Model 2: adjusted for age, gender, race, baseline disease, depression, anxiety, smoking status, and sleep difficulty. All variables compare "Not using" vs "Using."

FIGURE 1 Kaplan–Meier curves of the relationship between digital isolation and dementia

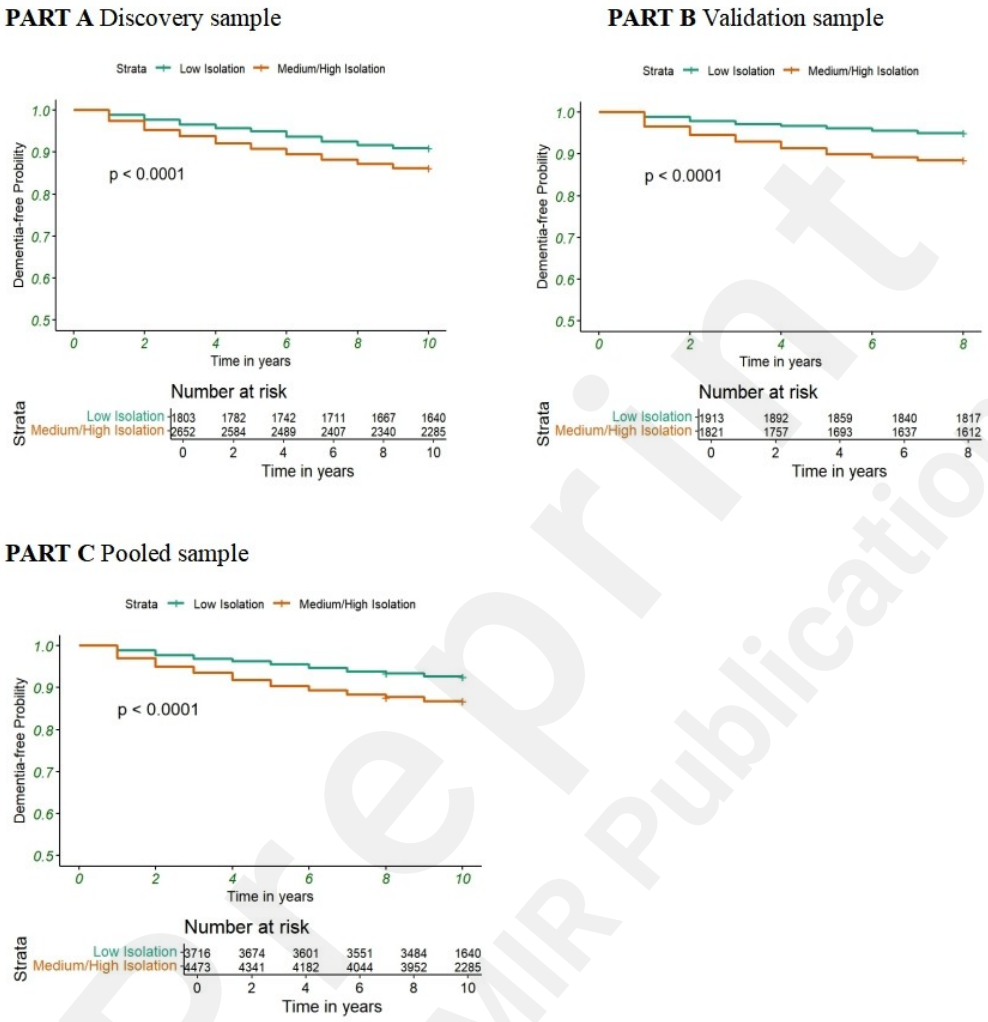
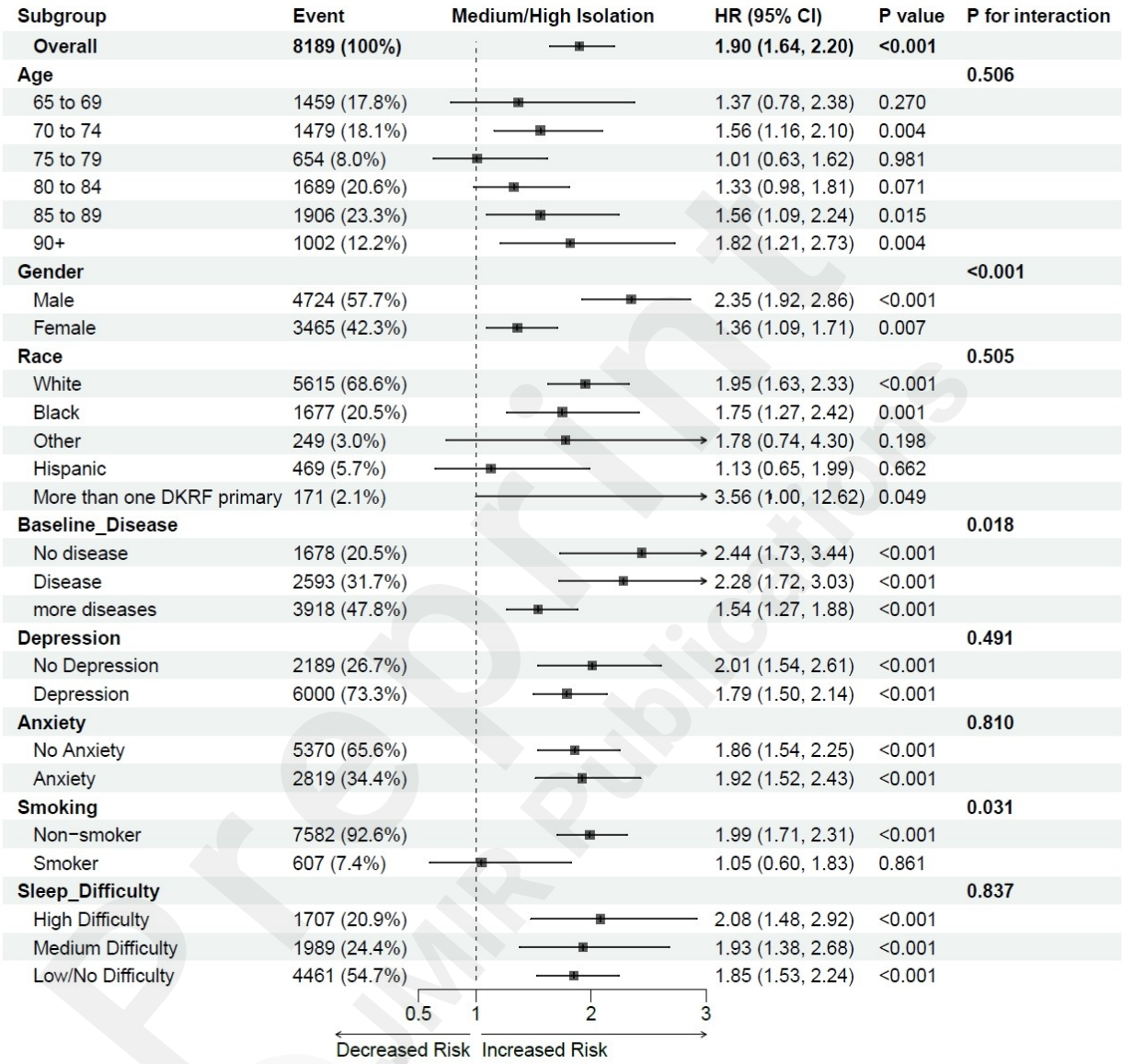


FIGURE 2 Association between digital isolation and dementia among subgroups.

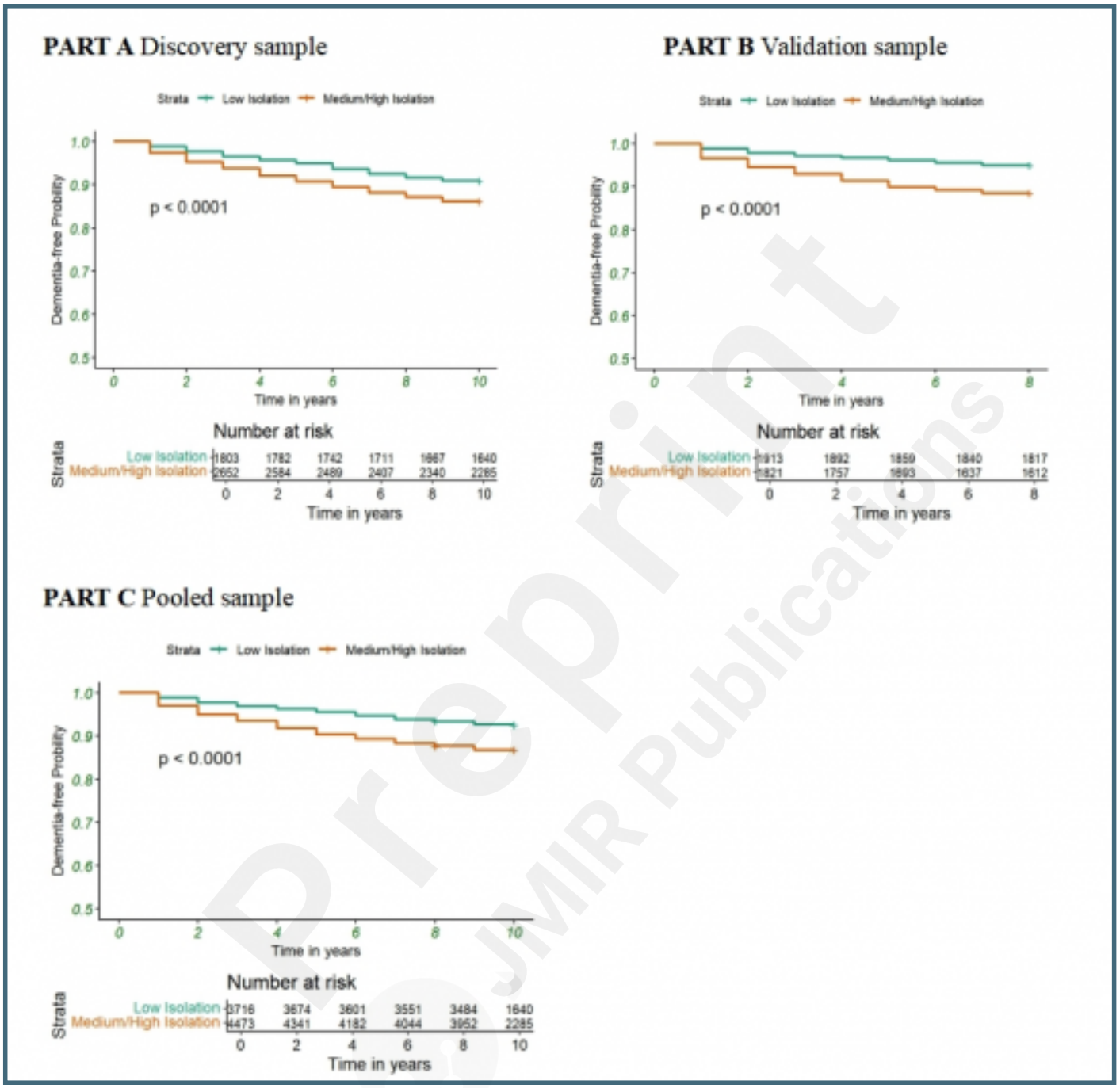


Reference group: Low digital isolation group. All models were adjusted for age, gender, race, baseline disease, depression, anxiety, smoking, sleep difficulty. P-int represents the heterogeneity among subgroups based on the metaregression analysis.

Supplementary Files

Figures

Kaplan?Meier curves of the relationship between digital isolation and dementia.



Association between digital isolation and dementia among subgroups. Reference group: Low digital isolation group. All models were adjusted for age, gender, race, baseline disease, depression, anxiety, smoking, sleep difficulty. P-int represents the heterogeneity among subgroups based on the metaregression analysis.