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Digital gaming and subsequent health and well-being among older adults: A longitudinal outcome-wide analysis

Atsushi Nakagomi, Kazushige Ide, Katsunori Kondo, Koichiro Shiba

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Abstract

Background: Digital gaming has become increasingly popular among older adults, potentially offering cognitive, social, and physical benefits. However, its broader impact on health and well-being, particularly in real-world settings, remains unclear.

Objective: This study aimed to evaluate the multidimensional effects of digital gaming on health and well-being among older adults, using data from the Japan Gerontological Evaluation Study (JAGES) conducted in Matsudo City, Chiba, Japan.

Methods: Data were drawn from three survey waves (2020 pre-baseline, 2021 baseline, 2022 follow-up) of the JAGES, which targets functionally independent older adults. The exposure variable, digital gaming, was defined as regular video game play and was assessed in 2021. Eighteen outcomes across six domains were evaluated in 2022: Domain 1—Happiness and life satisfaction, Domain 2—Physical and mental health, Domain 3—Meaning and purpose, Domain 4—Character and virtue, Domain 5—Close social relationships, and Domain 6—Health behavior. Ten items from the Human Flourishing Index were included in Domains 1 to 5, with two items for each domain. The overall Flourishing was defined as the average of the means across these five domains. Additionally, seven items related to Domain 2, Domain 5, and Domain 6 were assessed. The final sample consisted of 2,504 participants aged 65 or older, with questionnaires containing the Human Flourishing Index randomly distributed to approximately half of the respondents (Sub-module: n = 1,243). Consequently, we utilized two datasets for analysis. We applied targeted maximum likelihood estimation (TMLE) to estimate the population average treatment effects (ATEs), with Bonferroni correction used to adjust for multiple testing.

Results: Digital gaming was not significantly associated with overall Flourishing or with any of the five domains from the Human Flourishing Index. While initial analyses indicated associations between digital gaming and participation in hobby groups (mean difference = 0.124, p = 0.005) as well as meeting with friends (mean difference = 0.076, p = 0.024), these associations did not remain significant after applying the Bonferroni correction for multiple testing. Additionally, digital gaming was not associated with increased sedentary behavior or reduced outdoor activities.

Conclusions: This study provides valuable insights into the impact of digital gaming on the health and well-being of older adults in a real-world context. While digital gaming did not show a significant association with improvements in flourishing or in the individual items across the five domains, it was also not associated with increased sedentary behavior or reduced outdoor activities. These findings suggest that digital gaming can be part of a balanced lifestyle for older adults, offering opportunities for social engagement, particularly through hobby groups. Considering the solitary nature of gaming, promoting social gaming opportunities may be a promising approach to enhance the positive effects of digital gaming on well-being.

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Digital gaming and subsequent health and well-being among older adults: A longitudinal outcome-wide analysis

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Keywords:
Digital gaming; older adults; flourishing; well-being; physical activity; social engagement

Introduction

Digital Gaming for Health

Digital gaming has become increasingly common among older adults. In 2021, 10.7% of people aged 65 or older in Japan played digital games for hobbies and entertainment [1]. This trend illustrates the growing appeal of digital gaming among older adults, which holds potential for promoting both physical and cognitive health [2, 3]. A systematic review, for example, has demonstrated that video game-based interventions, such as exergames, can support physical health in older adults by improving balance, mobility, strength, physical fitness, and walking performance [3]. Such evidence suggests that digital gaming could serve as a valuable tool for supporting active aging, helping older adults maintain physical and cognitive vitality while providing an enjoyable and engaging activity.

Limitations of current evidence

While existing research has provided valuable insights into the health impacts of digital gaming, several limitations remain. First, although digital games can enhance the lives of older adults in various ways [4], current evidence is largely focused on physical and cognitive health outcomes [3] [5, 6]. The World Health Organization defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" [7]. This definition highlights the complexity and breadth of health beyond the absence of illness. In recent years, there has been growing recognition of the multidimensional nature of health, leading to increased attention on the concept of human flourishing. Human flourishing refers to "a state in which all aspects of a person's life are good" and include five core domains: (1) happiness and life satisfaction, (2) physical and mental health, (3) meaning and purpose, (4) character and virtue, and (5) close social relationship [8]. While games can facilitate engaging conversations and serve as a shared activity that helps reduce social isolation and increase satisfaction [9], the broader social and psychological impacts of digital gaming among older adults remain underexplored [10] [11, 12].

Second, much of the existing evidence comes from studies that examine a single or limited number of outcomes, making it difficult to fully understand the range of digital gaming's effects. The impact of gaming on older adults is inherently multidimensional—potentially beneficial for some outcomes but less so for others. For example, while certain games may encourage physical activity, gaming could also contribute to a more sedentary lifestyle if it predominantly occurs indoors. To gain a holistic understanding of digital gaming's effects, comprehensive, large-scale studies that assess a wide range of health and well-being outcomes simultaneously are needed.

Third, many previous studies have been conducted in controlled settings, such as short-term exergame interventions lasting three months. While these studies provide valuable evidence about the effects of specific gaming interventions, they do not capture the long-term impact of daily gaming activities on health and well-being. To address this gap, studies using well-powered real-world data from community-dwelling older adults are necessary. Such research can offer deeper insights into how regular, everyday digital gaming interacts with the long-term health trajectories of older adults.

The aim of this study

This study aimed to expand the current body of evidence on the multidimensional impact of digital gaming on the health and well-being of older adults. We used an outcome-wide analytic approach to simultaneously examine the longitudinal associations between digital gaming and 18 subsequent health and well-being outcomes among Japanese older adults. We examined outcomes across domains of happiness and life satisfaction, physical and mental health, meaning and purpose,

character and virtue, social well-being, and health behaviors [13].

Methods

2.1.Data sources

We used data from the 2020 (pre-baseline), 2021 (baseline), and 2022 (follow-up) waves of the Japan Gerontological Evaluation Study (JAGES), a nationwide survey of adults aged 65 years or older who were not receiving public long-term care insurance benefits in Japan [14]. Our analysis focused on data from participants in one of the JAGES study sites—Matsudo City, , as the questionnaire on digital gaming was included only there. Matsudo City is located in Chiba Prefecture, Japan, just northeast of Tokyo. It serves as a suburban area within the Greater Tokyo Area, with a population of around 500,000. Self-administered questionnaires were distributed in 15 districts through random sampling. The study included respondents aged 65 or older in 2020, who completed the 2020 survey (n = 5,347; response rate: 82.6%). Respondents with inconsistently reported age or gender, as well as those with implausible height (<100 cm or >200 cm) or weight (<30 kg or >100 kg) values, were excluded. Of the 2020 respondents, 73.7% responded to the 2021 survey (n = 3,941). Of these 2021 respondents, 63.8% responded to the 2022 survey (n = 2,515). After excluding 11 participants with inconsistently reported ages, the analytic sample consisted of 2,504 participants. For the assessment of human flourishing, the questionnaire version that included the Human Flourishing index was distributed only to randomly-selected half of the respondents (Sub-module: n = 1,243). Thus, we used two analytic samples: the sub-module respondents for flourishing assessments (n=1,243), and the full analytic sample for all other outcomes (n=2,504). Figure 1 and Supplementary Figure 1 provide a detailed flowchart of the data linkage and sample selection process. The participants of the JAGES were informed that their participation was voluntary, and returning the questionnaire implied their consent to participate in the study. Ethical approval for the study was obtained from the Ethics Committee at Chiba University (Approval number: M10460).

2.2. Measures

We measured the covariates, exposures, and outcomes in a temporal sequence using the three-wave panel structure of the data (2020, 2021, and 2022). This structure allowed us to account for pre-exposure covariates, including prior values of the outcomes before exposure to digital gaming, which helps mitigate the risks of confounding and reverse causality without the need to adjust for potential mediators [13].

2.2.1. Exposure variable

The exposure variable, digital gaming, was obtained from the 2021 survey. Participants were asked, “Have you played video games with a PC, cell phones, smartphones, tablets, or consoles in the last five years?” The response options included: “Playing regularly,” “Have played,” “Know video games, but have not played,” and “Do not know video games.” For analysis, we created a binary variable, where participants who answered “Playing regularly” were coded as 1, indicating regular digital gaming, while all other responses were coded as 0.

2.2.2. Outcome variables

We examined 18 outcomes in 2022 across six domains of health and well-being, following VanderWeele’s human flourishing framework and a previous outcome-wide study using the JAGES

data [8, 15]. We first assessed human flourishing based on the Human Flourishing Index. This index consists of 10 self-reported items measuring human well-being outcomes across the following five domains (i.e., two items per domain): **Domain 1**: Happiness and life satisfaction, **Domain 2**: Physical and mental health, **Domain 3**: Meaning and purpose, **Domain 4**: Character and virtue, **Domain 5**: Close relationships. For each domain, we calculated the mean of the responses to two domain-specific items, and the overall Flourishing was defined as the average of these means across the five domains.

In addition to these outcomes, we also examined other outcomes based on items available in the JAGES survey. For Domain 2, we assessed instrumental activities of daily living (IADL), forgetfulness, and depressive symptoms using the Geriatric Depression Scale (GDS). For Domain 3, we assessed ikigai, broadly defined as "what makes life worth living," a well-accepted psychological concept in Japanese culture[16]. For Domain 5, we assessed participation in hobby groups, participation in sports groups, meeting with friends, and the number of friends. We also examined several health behaviors as outcomes (**Domain 6**: Health behavior), including sedentary lifestyle, smoking, drinking, and frequency of going out. The detailed information on the definitions and measures of these outcomes are shown in Supplementary Table 1.

2.2.3. Covariates

All covariates were obtained from the 2020 survey, conducted a year before the wave in which the exposure levels were assessed.

As confounders in this study, we included several socio-demographic factors: age, gender (men or women), years of education (6–9 years versus 10 or more years), self-rated deprivation, marital status (married or not), living arrangement (living alone or not), and employment status (employed or not).

To minimize the potential for reverse causation, we adjusted for prior values of outcome variables wherever available. These included pre-exposure levels of happiness, life satisfaction (as a binary variable), self-rated health, IADL, forgetfulness, GDS, participation in hobby groups, participation in sports groups, meeting with friends, number of friends, sedentary behavior, smoking, alcohol consumption, and frequency of going out.

2.2.4. Statistical analysis

This study adopted an outcome-wide analytic approach, which explores the associations between a single exposure and multiple outcomes simultaneously [13, 17]. This method allows for a comprehensive assessment of the impact of an exposure across a wide range of outcomes. Additionally, this approach offers methodological advantages, such as being less susceptible to p-hacking and publication bias.

We estimated the population average treatment effects (ATEs) of video gaming on each of the 18 outcomes across the six domains, using the doubly robust targeted maximum likelihood estimation (TMLE). This approach fits both exposure and the outcome models while adjusting for the pre-baseline covariates and provide consistent estimates for the ATEs if at least one of the models is correctly specified and the causal identification assumptions hold. To further mitigate the potential bias due to model misspecification, both the exposure and outcome models were fitted data-adaptively using the SuperLearner, an ensemble method that combines weighted estimates from multiple candidate algorithms, including generalized linear models, gradient-boosting machines, and neural networks [18]. The targeted maximum likelihood estimation and Super Learning procedures were performed using the ltmle and SuperLearner packages in R (R Foundation for Statistical Computing, Vienna, Austria). For continuous variables, we estimated the difference in the mean levels of the outcomes. All continuous outcomes were standardized (mean = 0, standard deviation (SD) = 1) to ensure that the effect estimates could be interpreted as SD changes in the mean

outcomes. For binary outcomes, we estimated risk ratios. To address the issue of multiple testing, we applied the Bonferroni correction used a highly conservative p-value threshold for statistical significance of p = 0.00278 (0.05/18).

As a sensitivity analysis, we calculated the E-values for each exposure-outcome association to assess the robustness of the estimated associations against unmeasured confounding [19]. E-values quantify the minimum strength of association, on the risk ratio scale, that an unmeasured confounder would need to have with both the exposure and outcome, conditional on the adjusted covariates, for the confounding bias to account for the observed associations.

To address potential bias due to missing data, we used random forest imputation via the R package "missRanger" to impute missing values. All analyses were performed using R, version 4.3.1.

Results

Table 1 shows the pre-baseline characteristics of the sub-module sample by the baseline digital gaming. Among the 1,243 respondents, 192 (15.45%) and 380 (15.18%) played digital games, respectively. Individuals who played digital games tended to be younger and men, have higher educational attainment, experience less deprivation, be married, live with others, and be employed. These trends were consistent between the sub-module sample and the full analytic sample (Supplementary Table 2; n=2,504).

Table 1: Baseline Characteristics of Participants Who Responded to the Sub-Module Questionnaires

Pre-baseline characteristics	Total	Digital gaming	
		No	Yes
	(N=1243)	(N=1051)	(N=192)
Age (years)			
Mean (standard deviation)	75.7 (5.65)	76.0 (5.68)	74.3 (5.27)
Gender			
Men	617 (49.6%)	509 (48.4%)	108 (56.3%)
Women	626 (50.4%)	542 (51.6%)	84 (43.8%)
Education			
High education	1035 (83.3%)	865 (82.3%)	170 (88.5%)
Low education	208 (16.7%)	186 (17.7%)	22 (11.5%)
Deprivation			
No deprivation	1068 (85.9%)	892 (84.9%)	176 (91.7%)
Deprivation	175 (14.1%)	159 (15.1%)	16 (8.3%)
Marital status			
Married	913 (73.5%)	754 (71.7%)	159 (82.8%)
Not married	330 (26.5%)	297 (28.3%)	33 (17.2%)
Living alone			
Living with someone	1026 (82.5%)	853 (81.2%)	173 (90.1%)
Living alone	217 (17.5%)	198 (18.8%)	19 (9.9%)

Employment status			
Employed	309 (24.9%)	255 (24.3%)	54 (28.1%)
Not employed	934 (75.1%)	796 (75.7%)	138 (71.9%)
Happiness			
Mean (standard deviation)	7.57 (1.75)	7.56 (1.80)	7.62 (1.49)
Life satisfaction			
No	199 (16.0%)	172 (16.4%)	27 (14.1%)
Yes	1044 (84.0%)	879 (83.6%)	165 (85.9%)
Self-rated health			
Poor	126 (10.1%)	110 (10.5%)	16 (8.3%)
Good	1117 (89.9%)	941 (89.5%)	176 (91.7%)
Instrumental activities of daily living			
Mean (standard deviation)	4.94 (0.355)	4.93 (0.379)	4.97 (0.174)
Forgetfulness			
No	1143 (92.0%)	966 (91.9%)	177 (92.2%)
Yes	100 (8.0%)	85 (8.1%)	15 (7.8%)
Depressive symptoms			
Mean (standard deviation)	2.76 (2.80)	2.82 (2.84)	2.42 (2.55)
Participation in hobby groups			
Mean (standard deviation)	1.93 (1.39)	1.92 (1.38)	1.98 (1.45)
Participation in sports groups			
Mean (standard deviation)	2.16 (1.77)	2.11 (1.74)	2.44 (1.91)
Meeting friends			
Mean (standard deviation)	3.20 (1.65)	3.17 (1.64)	3.37 (1.71)
Number of friends			
Mean (standard deviation)	2.85 (1.42)	2.81 (1.41)	3.05 (1.45)
Sedentary lifestyle			
No	1171 (94.2%)	991 (94.3%)	180 (93.8%)
Yes	72 (5.8%)	60 (5.7%)	12 (6.3%)
Smoking			
No	1143 (92.0%)	972 (92.5%)	171 (89.1%)
Yes	100 (8.0%)	79 (7.5%)	21 (10.9%)
Alcohol consumption			
No	672 (54.1%)	577 (54.9%)	95 (49.5%)
Yes	571 (45.9%)	474 (45.1%)	97 (50.5%)
Going out			
Mean (standard deviation)	6.12 (1.09)	6.08	6.31

	(1.11)	(0.969)

Table 2 shows the estimated effects of digital gaming on the overall flourishing and each of its five domains based on the Human Flourishing Index. We found no evidence of the association between digital gaming these outcomes.

Table 2: Digital Gaming and Subsequent Flourishing

Outcomes	Estimate	Lower CI	Upper CI	P value
Flourish (Mean across the domains 1 - 5)	-0.001	-0.107	0.105	0.984
Domain 1 Happiness and Life satisfaction	-0.082	-0.183	0.020	0.116
Domain 2 Mental and Physical health	0.000	-0.136	0.136	0.996
Domain 3 Meaning and Purpose	-0.001	-0.119	0.117	0.986
Domain 4 Character and Virtue	0.033	-0.117	0.184	0.665
Domain 5 Close social relationship	0.037	-0.092	0.165	0.577

CI: confidence interval

All variables are continuous.

Table 3 shows the estimated effects of digital gaming on other outcomes related to human flourishing and health behaviors. Digital gaming was associated with more frequent participation in hobby groups (mean difference = 0.124, p = 0.005) and meeting friends (mean difference = 0.076, p = 0.024). However, these associations were above the alpha=0.05 cut-off after applying the Bonferroni correction for multiple testing.

Table 3 Digital gaming and subsequent health and well-being

		Risk ratio or mean difference			
Outcomes	Reference (Variable type)	Estimate	Lower CI	Upper CI	P value
Domain 2 Mental and Physical health					
Instrumental activities of daily living	0.00 (continuous)	0.067	-0.020	0.153	0.129
Forgetfulness	1.00 (binary)	1.175	0.898	1.539	0.240
Depressive symptoms	0.00 (continuous)	0.027	-0.039	0.093	0.419
Domain 3 Meaning and Purpose					
Ikigai	0.00 (continuous)	-0.092	-0.199	0.016	0.094
Domain 5 Close social relationship					
Participation in hobby groups	0.00 (continuous)	0.124	0.037	0.210	0.005**
Participation in sports groups	0.00 (continuous)	0.011	-0.053	0.075	0.743
Meeting with friends	0.00 (continuous)	0.076	0.010	0.142	0.024*
Number of friends	0.00 (continuous)	0.015	-0.061	0.091	0.695
Domain 6 Health behavior					
Sedentary lifestyle	1.00 (binary)	1.055	0.788	1.411	0.720
Smoking	1.00 (binary)	0.991	0.888	1.105	0.865
Drinking	1.00 (binary)	1.047	0.989	1.109	0.115
Going out	0.00 (continuous)	0.026	-0.081	0.133	0.635

CI: confidence interval

*p < 0.05 before Bonferroni correction.

**p < 0.01 before Bonferroni correction.

***p < 0.05 after Bonferroni correction (the p-value cutoff for Bonferroni correction is p = 0.05/18 outcomes = p < 0.00278.

Supplementary Tables 3 and 4 present E-values, which indicate the robustness of the observed associations between digital gaming and subsequent health and well-being outcomes against potential unmeasured confounders. For example, in the association between digital gaming and participation in hobby groups, an unmeasured confounder would need to have a risk ratio of at least 1.48 with both the exposure and the outcome, conditional on the measured covariates, to fully account for the observed association. Additionally, a risk ratio of 1.22 would be required to shift the confidence interval to include the null value.

Discussion

The main findings of this study were threefold. First, video gaming was associated with more frequent participation in hobby groups and meeting with friends, although these results should be interpreted with caution as they may be false positive findings due to multiple testing. Second, video gaming was not associated with lower levels of physical activity, as indicated by measures of sedentary lifestyle and frequency of going out. Third, video gaming did not appear to be associated with the flourishing outcomes across the five domains, including psychological well-being.

Our findings suggest the potential of digital gaming to positively impact the social well-being of older adults. Previous studies have shown that older adults who play digital games experience social benefits [11] and improved social functioning [20]. However, these studies were based on qualitative research or quantitative data with fewer than 500 participants. In contrast, our study provides evidence from a larger sample size, further supporting the social benefits of digital gaming. Digital gaming may foster social interactions through participation in hobby groups, where gaming may serve as a topic of conversation and social engagement.

Digital gaming, especially non-physical types, has the potential to reduce physical activity levels among older adults by encouraging sedentary behavior, as players may remain seated for extended periods. This sedentary time can replace activities like walking or socializing outdoors, potentially reducing overall physical activity levels. While exergames—digital games that require physical movement—have been shown to promote physical activity [2], the unintended reduction in physical activity of digital gaming can be difficult to capture in experimental settings. However, our study found that, in a real-world context, digital gaming was not associated with increased sedentary behavior or decreased outdoor activities among older adults in Japan. This suggests that, for many older adults, digital gaming may integrate into a balanced lifestyle without significantly impacting their physical activity levels.

Digital gaming may also enhance psychological well-being among older adults by providing relaxation and social interaction [20, 21], although we did not find evidence of such improvements in our study. Research indicates that the social aspects of gaming—such as playing together or discussing games with family and friends—are crucial for translating digital gaming experiences into positive well-being outcomes [11, 22]. However, many older adults tend to play digital games alone, which can limit the potential social benefits that gaming might otherwise offer. This highlights the need for targeted initiatives to promote and encourage more social forms of digital gaming among older. Facilitating environments where digital games are played together, such as community centers or online platforms designed for older users, could help harness the social benefits of gaming and, in turn, improve their overall well-being.

This study has several limitations. First, we did not capture detailed aspects of digital gaming, such as the frequency of play, duration (hours per day), the types of games played, and whether participants played alone or with others. These factors could influence the effects of digital gaming. Second, the generalizability of our findings is limited, as our data were derived from a single city in Japan. Results may differ in other regions or countries with different cultural contexts and gaming habits. Third, due to the observational nature of this study, the possibility of unmeasured

confounding and reverse causation cannot be completely ruled out. However, to mitigate this issue, we adjusted for numerous covariates, including confounders and pre-baseline outcome variables, as recommended in outcome-wide approach [13, 17]. Fourth, while our study is larger than previous studies, it is still likely underpowered (e.g., n = 1,243 with an exposure prevalence of approximately 15%). Future studies with larger sample sizes are warranted to provide more robust conclusions.

Conclusion

While digital gaming did not show a significant association with improvements in flourishing or its sub-domains, our results indicate that digital gaming could lead to greater social engagement without increasing sedentary behavior and reducing outdoor activities. These findings suggest that digital gaming can be part of a balanced lifestyle for older adults.

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Abbreviations

JAGES: Japan Gerontological Evaluation Study
IADL: instrumental activities of daily living
GDS: Geriatric Depression Scale
ATE: average treatment effects
TMLE: targeted maximum likelihood estimation
SD: standard deviation

Data Availability

Data are from the JAGES study. All enquiries are to be addressed at the data management committee via e-mail: dataadmin.ml@jages.net. All JAGES datasets have ethical or legal restrictions for public deposition due to inclusion of sensitive information from the human participants.

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Figures

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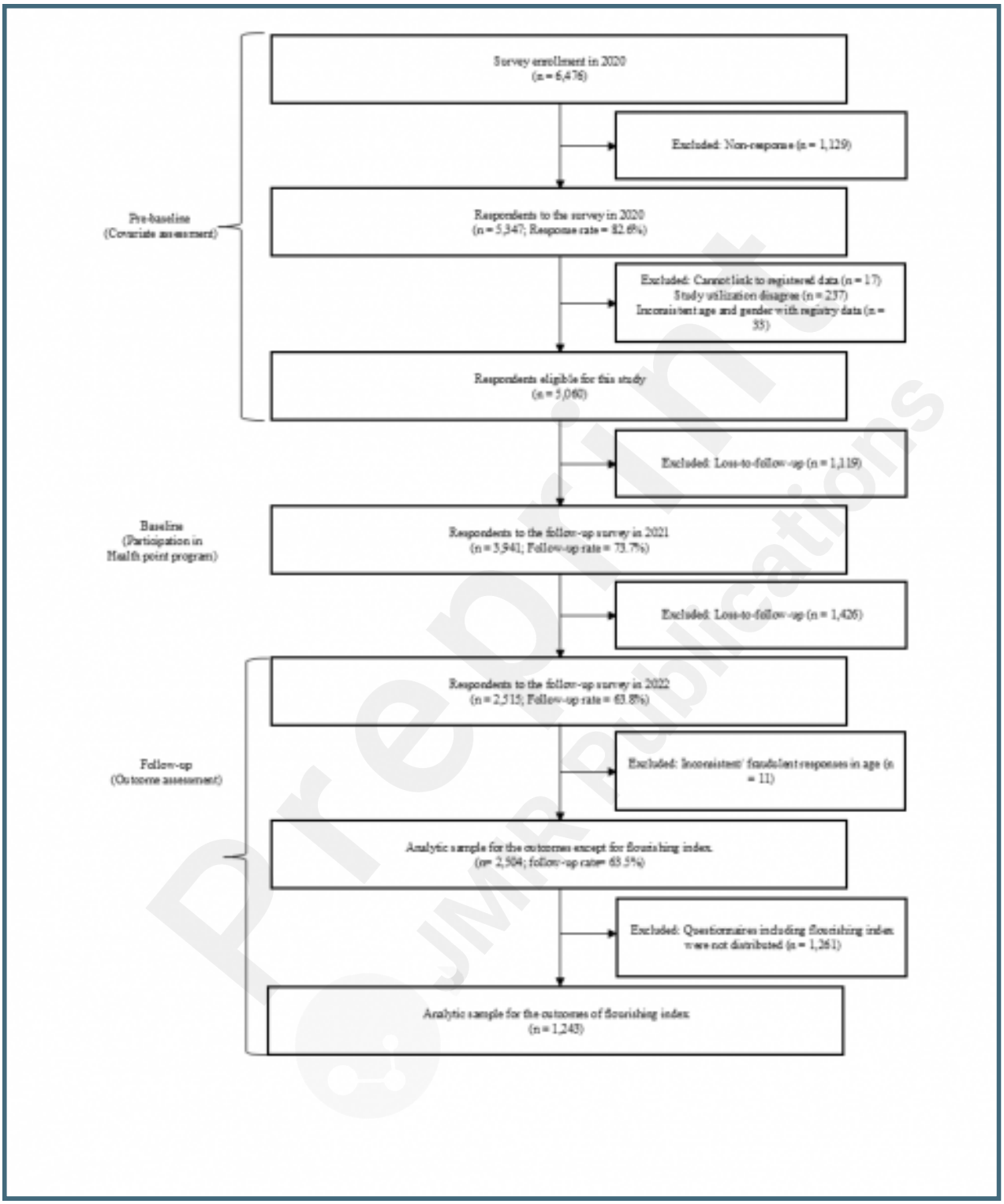
Flow chat of study participants.



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