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Social participation, loneliness, and physical inactivity over time: evidence from SHARE

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ABSTRACT

Objectives: We aimed to explore the reciprocal effects of social participation, loneliness, and physical inactivity over a period of 6 years in a representative sample of European adults over 50 years old.

Design: A longitudinal study with a six-year follow-up period was conducted.

Setting: Four waves of the Survey of Health, Ageing and Retirement in Europe project were used.

Participants: This study includes 64,887 participants from Europe and Israel, who were aged 50 or older at the first time.

Measurements: The relationship between participation in social activities, loneliness and physical inactivity was analyzed, controlling for age, gender, and disability. A series of cross-lagged panel models (CLPMs) were applied to analyze the relationships among these variables.

Results: A CLPM with equal autoregressive cross-lagged effects across waves was the best fit to the data ($\chi^2 = 7137.8$, CFI = .972, RMSEA = .049, SRMR = .036). The autoregressive effects for the three variables showed high stability across waves, and all the cross-lagged effects in the model were statistically significant. Social activity and physical inactivity maintained a strong negative cross-lagged effect, while their cross-lagged effects on loneliness were comparatively smaller. Social activity had a positive cross-lagged effect on loneliness, while physical inactivity had a negative cross-lagged effect on loneliness.

Conclusions: These findings highlight the importance of promoting physical activity and social participation and addressing loneliness through targeted interventions in older adults.

Key words: social participation, loneliness, physical activity, older adults, longitudinal design, SHARE

Introduction

Aging is a complex process influenced by a wide range of factors, with physical activity identified as a key element for the well-being of middle-aged and older adults (Lin *et al.*, 2020). Regular physical activity contributes to the prevention of premature death and several health conditions and is associated with improved mental health (WHO, 2018). However, more than 30% of adults remain insufficiently active (WHO, 2014) and the Global Action Plan on Physical Activity 2018–2030 recommends finding evidence-based policies to increase physical activity levels in this population (WHO, 2018). Participation in physical activity is influenced by a range of factors, encompassing individual traits as well as social, cultural, environmental, and economic aspects (WHO, 2018). To effectively increase opportunities for physical activity, a comprehensive approach is needed, demanding a deeper understanding of these dynamics. In recent years, there has been a growing focus on the association between physical inactivity and conditions such as social participation or loneliness. Studies have suggested that engaging in social activities promotes physical exercise and overall physical health (Ashida *et al.*, 2016). This connection may be explained by the fact that social interactions often involve physical activity, such as leaving the house and participating in activities with others. Conversely, reduced social contact and isolation are linked to lower physical activity levels (De Koning *et al.*, 2021).

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In the context of old age, both loneliness and physical inactivity are prevalent (Netz *et al.*, 2013) and seem to be related. Theory suggests that physical activity can facilitate social engagement, the development of social support networks, and therefore reduce loneliness (Pels and Kleinert, 2016). For its part, loneliness can lead to lower self-regulation levels, which could result in health risk behaviors, including physical inactivity (Hawkley *et al.*, 2009; Peltzer and Pengpid, 2019). Despite the apparent clarity of the relationship between loneliness and physical inactivity, the bidirectional associations between loneliness and physical inactivity remain unclear. Some studies show that physical inactivity is associated with feelings of loneliness (Beutel *et al.*, 2017; Giné-Garriga *et al.*, 2021), and other studies indicate no association (Schrempft *et al.*, 2019; Smith *et al.*, 2017). Therefore, additional longitudinal research is required.

Given the COVID-19 pandemic, attention has also been paid to social participation and loneliness in recent years, which has emerged as a challenge among older populations (Hwang *et al.*, 2020; Watson-Borg *et al.*, 2023). The implementation of social distancing measures has led to reduced social participation and physical activity among older adults (Salman *et al.*, 2021), as well as higher levels of loneliness (Freedman and Nicolle, 2020). Although there is evidence of a possible relationship between these variables, to our knowledge, there are few studies examining their reciprocal relations in adulthood. Some studies demonstrate that engagement in social participation and regular physical activity were independently associated with decreased loneliness (Gyasi *et al.*, 2021). However, longitudinal studies with bidirectional analysis are needed to test how these variables feedback on each other.

Previous research highlights the complexity of the relationship between these conditions (De Koning *et al.*, 2021), but understanding how these variables interplay over the lifespan is highly relevant because all three are related to mental and physical health in old age, and can potentially be modified (Creese *et al.*, 2021). A body of cross-sectional studies shows potential bivariate relationships between social isolation, loneliness, or healthy lifestyles such as physical activity among older adults. However, prospective longitudinal research assessing these reciprocal effects in complex models in older adults has been scarce. To address the existing gap in the literature, the aim of this research is to examine reciprocal relations of physical activity, loneliness, and social participation across six years of follow-up in a representative sample of European adults over 50 years old using a Cross-Lagged Panel Model (CLPM).

Materials and methods

Sample and procedure

Data from the Survey of Health, Ageing and Retirement in Europe (SHARE) (Börsch-Supan *et al.*, 2013) was employed in this study. SHARE is a harmonized panel study from European and Israeli citizens aged 50 years old or older. The sampling protocol follows a probabilistic sampling strategy that can vary across countries (Bethmann *et al.*, 2019). Starting in 2004, SHARE counts with 8 waves of publicly available panel data. In this study, data from waves 5 (Börsch-Supan, 2022a), 6 (Börsch-Supan, 2022b), 7 (Börsch-Supan, 2022c), and 8 (Börsch-Supan, 2022d) were used. All waves were reviewed and approved by the Ethics Council of the Max Planck Society (see: https://share-eric.eu/fileadmin/user_upload/Ethics_Documentation/SHARE_ethics_approvals.pdf).

The sample was formed by all respondents who participated in wave 5 and were aged 50 years or older at that moment. This resulted in 64,887 individuals, of which 55.4% were female and 44.6% were male. Their mean age at the beginning of the study was 66.68 years old (SD = 10.03). A total of 15 countries were represented in the study: Austria (6.5%), Germany (8.6%), Sweden (7.0%), Netherlands (6.3%), Spain (10.1%), Italy (7.2%), France (6.8%), Denmark (6.3%), Switzerland (4.6%), Belgium (8.5%), Israel (3.9%), Czech Republic (8.5%), Luxembourg (2.4%), Slovenia (4.5%), and Estonia (8.8%).

Instruments

Social participation included individuals' participation in four different activities during the previous year. The activities considered were: doing voluntary or charity work, attending educational or training courses, going to sport/social/other clubs, and taking part in political or community-related organizations coded as 1 (yes) or 0 (no). The social participation index was computed as the sum of the activities, responses ranged between 0 (did not participate in any of the activities) and 4 (participated in all considered activities).

Loneliness was assessed using the Three-Item Loneliness Scale (Hughes *et al.*, 2004). This scale considers feelings of lack of companionship, isolation, and exclusion as indicators of loneliness. Each indicator is answered using a three-point Likert scale: 1 = Hardly ever or never, 2 = Some of the time, and 3 = Often. The total loneliness score is computed as the sum of the three items and hence ranged from 3 (least lonely) to 9 (loneliest).

Physical inactivity was measured as a binary indicator merging two variables asking about participation in moderate and vigorous physical activities. For each variable, the individual was asked

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to report their frequency of enrolling in that kind of activity, using a four-point Likert scale (1 = More than once a week, 2 = Once a week, 3 = One to three times a month, and 4 = Hardly ever or never). Individuals who reported hardly ever or never engaging in either moderate or vigorous activities were considered physically inactive (1), and the rest were not (0). This operationalization has been previously reported in other studies using SHARE data (Matos *et al.*, 2021).

In addition to the three measures employed over time, age, gender, and disability were also considered as time-invariant control variables. Disability was measured as a binary marker of whether the individual was limited in activities because of health (1) or not (0), based on the Global Activity Limitation Index (Van Oyen *et al.*, 2006).

Statistical analyses

The statistical analyses include the calculation of descriptive statistics and correlations in SPSS 28) and structural models in Mplus 8.9 (Muthén and Muthén, 2011). The specific structural equation model employed was the CLPM, a model widely used to analyze the relationships between two or more variables longitudinal measured for two or more occasions. In this model, the variables are measured at each time point and the model examines the relationships between the variables across time. The "cross-lagged" aspect of the model refers to the fact that the model examines the lagged effects of one variable on another and the lagged effects of the other variable on the first. It allows examining the directionality and longitudinal relationships between the variables. The panel model refers to the fact that the same individuals are measured at multiple time points, making it possible to examine the autoregressive paths, the stability in the variables over time, and to control for individual differences. Model fit of the structural models was assessed with the most prevalent statistics and indices: a) the chi-square test; the Comparative Fit Index (CFI); the Root Mean Squared Error of Approximation (RMSEA); and the Standardized Root Mean Squared residual (SRMR) (Kline, 2023), a CFI of .95 or higher, an RMSEA less than .06, and an SRMR less than .08 together can be considered an excellent fit (Hu and Bentler, 1999).

Results

Descriptive statistics and correlations among variables

Descriptive statistics of all variables in the study and for all waves are presented in Table 1. Additionally, correlations among the measures of social participation, loneliness, and physical inactivity are presented in Table 2.

Table 1. Means, percentages, standard deviations minimum, and maximum of the variables in the study

VARIABLE	MEAN OR %	SD	MIN.	MAX.
Age	66.68	10.034	50	103
Gender			0	1
Male	44.6%			
Female	55.4%			
Activity limitations				
Not	54.4%			
Yes	45.6%			
SP1	.668	.896	.00	4.00
SP2	.675	.904	.00	4.00
SP3	.653	.885	.00	4.00
SP4	.743	.920	.00	4.00
LO1	3.79	1.325	3	9
LO2	3.86	1.335	3	9
LO3	3.84	1.341	3	9
LO4	3.84	1.314	3	9
PI1			0	1
No	83.2%			
Yes	16.8%			
PI2			0	1
No	83.4%			
Yes	16.6%			
PI3			0	1
No	81.1%			
Yes	18.9%			
PI3			0	1
No	82.5%			
Yes	17.5%			

SD, Standard deviation; Min., Minimum; Max., Maximum; SP1 to SP4: Social Participation waves 5 to 8 SHARE; LO1 To LO4: Loneliness waves 5 to 8 SHARE; PI1 to PI4: Physical inactivity waves 5 to 8 SHARE.

Cross-lagged panel models

CLPMs for examining reciprocal effects of social participation, loneliness, and physical inactivity using four waves of the SHARE. We followed this modeling strategy: Firstly, we estimated the CLPM freely estimating within-wave associations and autoregressive and cross-lagged effects between adjacent waves. Secondly, we are constrained to equality of the autoregressive paths. If this model does not deteriorate model fit compared to the first model, it means that the stability (or lack of) across waves is the same. Thirdly, we further restricted cross-lagged effects to equality across waves. Again, if this model fit remains the same as the first model, it means that the effects among the variables of interest are constant across waves. All constraints were tested in the unstandardized coefficients. These three models controlled for age, gender, and disability.

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Table 2. Correlations among social participation, loneliness, and physical inactivity across all waves of the study

	SP1	SP2	SP3	SP4	LO1	LO2	LO3	LO4	PI1	PI2	PI3
SP1	1										
SP2	.649**	1									
SP3	.602**	.667**	1								
SP4	.576**	.611**	.651**	1							
LO1	−.128**	−.122**	−.119**	−.124**	1						
LO2	−.132**	−.138**	−.128**	−.138**	.502**	1					
LO3	−.145**	−.154**	−.152**	−.161**	.479**	.547**	1				
LO4	−.142**	−.139**	−.144**	−.156**	.414**	.484**	.573**	1			
PI1	−.206**	−.163**	−.161**	−.150**	.189**	.161**	.159**	.141**	1		
PI2	−.181**	−.189**	−.178**	−.152**	.162**	.191**	.182**	.139**	.389**	1	
PI3	−.205**	−.215**	−.244**	−.201**	.169**	.164**	.218**	.227**	.385**	.441**	1
PI4	−.184**	−.196**	−.205**	−.227**	.134**	.156**	.214**	.199**	.282**	.341**	.438**

**= $p < .001$; SP1 to SP4: Social Participation waves 5 to 8 SHARE; LO1 To LO4: Loneliness waves 5 to 8 SHARE; PI1 to PI4: Physical inactivity waves 5 to 8 SHARE.

Table 3 offers model fit indexes for this sequence of models. The model with autoregressive effects constrained to equality did not deteriorate model fit compared to the freely estimated model. For example, the differences in CFI's were low (.007), and therefore, this means that stability of the autoregressive models is maintained across waves of data. In the same vein, when all cross-lagged effects were constrained to equality across waves, the fit not only not deteriorated but improved. Both the SRMR and the RMSEA improved, while the decrease in the CFI was negligible (.005). Overall, the best CLPM is the one with equal stability and cross-lagged effects across waves, which means that the effects among the three variables of interest remain constant across them.

As already said, age, gender, and disability were control variables in the CLPM. Table 4 shows all these standardized effects. In general, age had positive effects on social participation and positive ones on loneliness and physical inactivity. Women participated less than men in social activities, were less active, and had more feelings of loneliness. Finally, old adults limited were less socially participative and less active, while having more feelings of loneliness. All these effects decreased when social participation, loneliness, and physical inactivity were also predictors. That is, in waves 6, 7, and 8.

Regarding the within-waves associations, in almost all cases were statistically significant ($p < .05$), but of small magnitude. Within wave 5, social participation correlated −.134 with loneliness and −.34 with physical inactivity, and physical inactivity correlated .151 with loneliness. The same correlations in waves 6, 7, and 8 were: .005 ($p > .05$), .084, and .061 for wave 6; .074, .121, and .062 for wave 7; and .006 ($p > .05$), −.021 ($p > .05$), and .015 ($p > .05$).

The autoregressive and cross-lagged standardized effects are presented in Figure 1. These estimates are the main ones for the aim of this research, and it is important to bear in mind that all effects are equal across waves. The autoregressive effects for the three variables show great stability across waves. Regarding the cross-lagged effects, all of them are statistically significant. However, the magnitude of the relationships shows a pretty clear pattern. On one hand, psychical inactivity and social participation had medium to large effects on each other (Orth *et al.*, 2022). Indeed, the effect of social participation on physical inactivity was −.144 (95% CI: −.134, −.153), while the effect of physical inactivity on social participation was −.156 (95% CI: −.143, −.169). On the other hand, the impact of loneliness on social participation and physical as well as the impact of these two variables on loneliness were much smaller. In these cases, the effects were small to medium in size. Specifically, the effect of loneliness on social participation was −.038 (95% CI: −.032, −.045) and the effect on physical inactivity was .051 (95% CI: .041, .061), while the effect of social participation on loneliness was −.045 (95% CI: −.037, −.052), and finally, the effect of physical inactivity on loneliness was .046 (95% CI: .036, .055).

Discussion

As far as we know, this is the first study to examine the longitudinal relationship between social participation, physical activity, and loneliness. Our model confirmed previous research findings that all these variables were interrelated at each time point, but with a clear pattern across waves, social participation, and physical activity feedback each other, both

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Table 3. Model fit indexes

MODELS	X^2	DF	*P*	RMSEA [CI 90%]	SRMR	CFI	ΔCFI
CLPM free estimates	6008.8	27	<.001	.059 [.057, .060]	.041	.977	–
CLPM equal Autoregressive effects	7655.9	33	<.001	.060 [.059, .061]	.048	.970	.007
CLPM equal Autoregressive and cross-lagged effects	7137.8	45	<.001	.049 [.045, .050]	.036	.972	.005

ΔCFI, differences between CFIs always against the freely estimated model; CLPM, Cross-lagged panel model.

Table 4. Standardized effects of the control variables (age, gender, and activity limitations) on social participation, loneliness and physical inactivity across waves

	OUTCOMES		
PREDICTORS	SP1	LO1	PI1
Age	−.195	−.077	.276
Gender	−.028	.077	.037
Limitations	.145	.206	.308
	SP2	LO2	PI2
Age	−.017	.034	.117
Gender	.000ns	.027	.007ns
Limitations	−.005ns	.016	.065
	SP3	LO3	P3
Age	−.030	.085	.167
Gender	.010	.039	.049
Limitations	.006ns	.040	.069
	SP4	LO4	PI4
Age	−.018	−.018ns	.049
Gender	.006ns	.003ns	−.024
Limitations	.013	.029	.018ns

Note: all estimates are statistically significant ($p < .05$) unless ns (not significant) is marked.
SP1 to SP4: Social participation waves 5 to 8 SHARE; LO1 To LO4:Loneliness waves 5 to 8 SHARE; PI1 to PI4: Physical inactivity waves 5 to 8 SHARE.

are related bidirectionally. However, loneliness has less predictive capacity in the model and is less related to the other variables.

Our findings showed that effects were consistent across waves, indicating that the impact of loneliness, physical activity, and social participation tends to remain stable over time. In this sense, the effects of being physically inactive, having feelings of loneliness, or lacking social engagement at younger ages do not usually change over the years. Therefore, encouraging physical activity or social participation at an early stage is not only beneficial at that moment but can also establish positive changes with long-term benefits for healthy aging trajectories. Although motivating older people to start and maintain regular physical activity can be challenging, there are some programs as the neighborhood-based walking programs that proved to be effective (Iolascon *et al.*, 2020) and were easy to implement.

Being physically active is especially important at old age for maintaining the independence (Hirsch *et al.*, 2010), mental health, and well-being (Du *et al.*, 2015). Given the importance of promoting physical activity, various studies have analyzed the impact of different strategies on sedentary lifestyle, including social participation. The evidence suggests that social interaction is the most relevant interpersonal motivator, including communication with friends or others, peer support, and exercising with friends, among others (Yarmohammadi *et al.*, 2019). There is also evidence that social isolation is associated with reduced levels of physical activity (De Koning *et al.*, 2021) and that, in early life, it predicts future physical inactivity (Caspi *et al.*, 2006). On the other hand, it is stated that physical activity can facilitate social engagement and the development of social support networks (Pels and Kleinert, 2016). It is also interesting to note that much of the physical activity in older adults is accumulated through short trips outside of the home such as visiting relatives and friends, exercise classes, attending cultural events, or walking (Schrempft *et al.*, 2019). All in all, this research supports the hypothesis suggested by a cross-sectional study (Salman *et al.*, 2021), confirming the bidirectional relationships between social participation and levels of physical activity.

A body of cross-sectional studies demonstrates relationships between social isolation, loneliness, and healthy lifestyles such as physical activity among older adults (Kobayashi and Steptoe, 2018; Salman *et al.*, 2021), although prospective longitudinal research assessing these reciprocal effects in later life has been scarce. Social isolation and loneliness were associated cross-sectionally with low levels of physical activity (Shankar *et al.*, 2011). The interaction effects between social isolation and loneliness were attenuated by 50% after adjustment for health behaviors including physical activity (Hakulinen *et al.*, 2018). Previous studies showed that social isolation, but not loneliness, was

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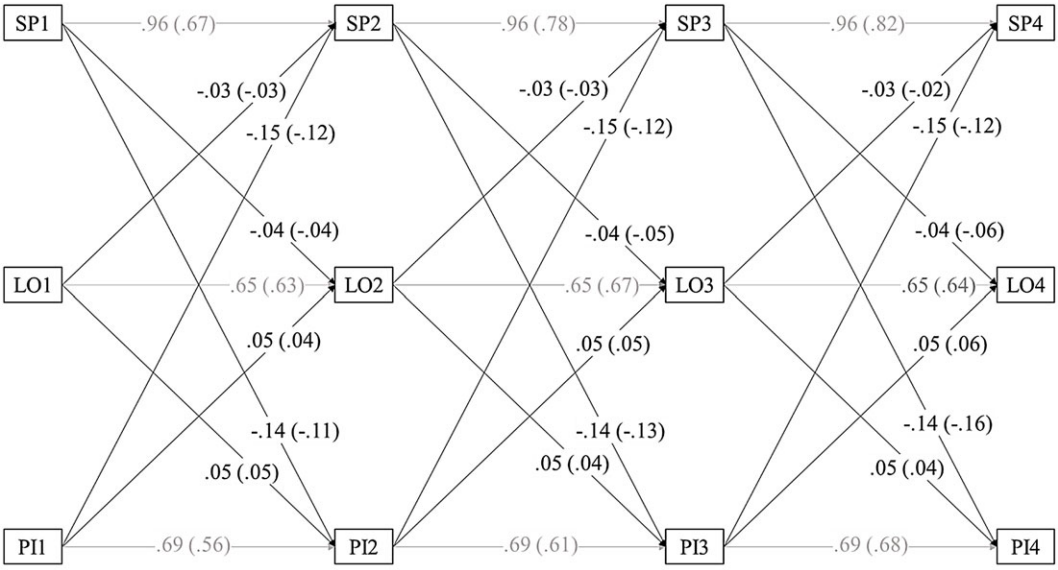

Figure 1. Standardized estimates of the autoregressive and cross-lagged effects of the best fitting cross-lagged panel model. Autoregressive effects are in gray and cross-lagged effects in black, within waves associations and effects of the control variables not shown for the shake of clarity; all estimates are statistically significant ($p < .05$). SP1 to SP4: Social Participation waves 5 to 8 SHARE; LO1 to LO4: Loneliness waves 5 to 8 SHARE; PI1 to PI4: Physical inactivity waves 5 to 8 SHARE. Standardized coefficients between parentheses. It must be borne in mind that equality of parameters is stablished with non-standardized parameters.

associated with sedentary behaviors (Schrempft *et al.*, 2019; Tully *et al.*, 2019). In addition, a longitudinal study of older English adults over 10 years showed that social isolation, but not loneliness, had an impact on health-related behaviors as being physically active (Kobayashi and Steptoe, 2018). These findings are in line with the notion that social isolation has stronger links with physical inactivity than loneliness does, supporting the results of the present study.

Our results also showed that lower levels of social participation and higher levels of physical inactivity predicted loneliness, as in previous research (Zhao and Wu, 2022). These results have practical implications, as physical activity and social participation are recommended as possible multidisciplinary strategies to reduce loneliness in older people (Gyasi *et al.*, 2021; Vancampfort *et al.*, 2019). However, the impact of social and physical activity on loneliness, as well as the impact of loneliness on these two variables, was small compared to the impact found between the other two variables. These findings indicated a weak relationship between loneliness and social isolation (Shankar *et al.*, 2011). One possible explanation for these results is that not everyone benefits from these activities to alleviate feelings of loneliness; some studies have considered individual factors and found that for those who are extraverted, high social involvement reduces loneliness, whereas less social participation is better for those who are introverted, have social anxiety, or enjoy being alone (Schutter *et al.*, 2020).

This study has several strengths, including the use of a large and representative sample of older adults, which provided greater statistical power. Another strength is the long six-year follow-up of participants, as well as the control for confounding factors such as age, gender, and disability. However, there are several potential limitations that need to be acknowledged. Firstly, our data is based on self-reported questionnaires, which may introduce reporting bias. Secondly, while our research attempted to control for the most relevant confounding variables, future studies should consider other variables such as participants' levels of depression, which have been associated with loneliness and low social and physical activity (Wang *et al.*, 2019). In our study, social participation was measured as a sum of attendance to certain social activities, but other aspects such as the frequency of participation that have also been linked to better mental health (Tomioka *et al.*, 2017) could be considered in future studies.

Conclusions

This study found a significant bidirectional relationship between social participation, physical inactivity, and loneliness in older adults with an especially large effect between physical inactivity and social participation. Furthermore, these effects remained stable across aging trajectories. Thus, strategies aimed at promoting social participation

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and physical activity in earlier stages of age should be considered mutual goals to promote quality aging. Additionally, older adults who experience loneliness, although this condition requires a person-centered intervention, could benefit from attending social participation activities or engaging in physical activity.

Conflicts of interest

None.

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Description of authors' roles

ZT, JMT, and TSM designed the study. JMT and IF analyzed the data. JMT and IF wrote the results section. ZT, TSM, and NPS wrote the paper. All authors provided critical input on the written manuscript and data interpretation.

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