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Heterogeneity, social activity types, and loneliness among older adults during the COVID-19 pandemic in the United States

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GRADUATE SCHOOL OF ARTS AND SCIENCES

Thesis

**HETEROGENEITY, SOCIAL ACTIVITY TYPES, AND
LONELINESS AMONG OLDER ADULTS DURING THE
COVID-19 PANDEMIC IN THE UNITED STATES**

by

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Graduation is not the end. Thanks to Sociology, I can see the meaning of life. I hope I can still walk with you in the future!

**HETEROGENEITY, SOCIAL ACTIVITY TYPES, AND LONELINESS AMONG
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ABSTRACT

Loneliness is a critical factor that can significantly affect an individual's health and well-being, especially for older adults. Since they are more vulnerable to suffering life transitions, older people are more likely to experience loneliness than people of younger ages. The fast break out and spread of COVID-19 exacerbated the difficulty of their social connections and intensified their feelings of loneliness. Consequently, effective interventions for the aged, particularly effective ones suited to special occasions, are of vital relevance. Consequently, effective interventions for the aged, particularly effective ones suited to special occasions, are of vital relevance.

As one of the widely mentioned and applied gerontology theories, the activity theory has been well-studied previously to elucidate the effectiveness of leisure activity participation in reducing lonely feelings. It is worth noting that no one solution works for everyone. This thesis examines the alleviating roles of four types of social activities on loneliness in older Americans considering individual differences, including marital, job, and physical health background. Sample data is from the 2020 Health and Retirement Study (HRS) survey. This thesis collected respondents over 50 years old and included a sample of 4,506. According to previous studies, control variables include age, gender,

race and ethnicity, years of education, and health components (self-rated health and memory, COVID infection, and depressive symptoms).

The thesis divides social activities into highly productive-active, moderately productive-active, moderately productive-sedentary, and consumptive activity. Through three-group regression analysis, this thesis concludes that: (i) highly productive-active activity was the most practical way to reduce loneliness for vulnerable groups; (ii) moderately productive-active activity had the best utility on the elderly who already maintained good social relationships and health status; (iii) moderately productive-sedentary was the only activity type not useful for all groups. (iv) consumptive activity presents a protective tendency towards older people disadvantaged in work but not towards married and partnered people.

Meanwhile, the thesis also proposes other classification methods involving activities' cultural and symbolic meanings. The thesis states that activities with spiritual power could better alleviate the loneliness of vulnerable groups, and the symbolic meaning of daily life activity (routine activity) could protect the elderly from isolated feelings caused by being forced out of society to some extent. The repetitive life patterns keep the elderly from inordinate life and psychological gaps.

The contribution of the thesis consists of two aspects. First, the thesis maps leisure activities into a three-dimensional system, divided by practical activity attributes for loneliness. From the process of grouping and categorizing, it is possible to provide a more practical understanding of the social connection. Second, the thesis demonstrates the necessity to consider the diversity of older people. Activities were associated

differently with loneliness in groups with distinct characteristics. The thesis found that individual discrepancy profoundly affects the effectiveness of interventions.

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INTRODUCTION

Population aging is no longer a particular problem faced by a few regions. Countries worldwide are experiencing demographic trends and must thoroughly prepare for the changes. Due to the low fertility rates and aging baby boomers, the increasing number of the elderly is reflected in size and proportions. According to estimates from the World Health Organization (WHO 2022), the shift to an older population is quickening. By 2030, one in six individuals will be over 60, while the number of persons over 80 is projected to treble between 2020 and 2050. Given the frailty of the elderly, population shifts will have substantial effects on economic, health, and social systems, in addition to demographic structures. Therefore, enabling the elderly to live a happy, satisfying, and active life in their later years is an issue that requires not only the attention of individuals and families but also overall efforts and attention.

Much research on older adults has focused on the association between social connections and aging. People connect socially by nature, so social relationships are essential and indispensable for individuals. It has been well-studied that a lack of social relationships strongly affects all-cause mortality (Berkman and Syme 1979). According to the disengagement theory, however, older adults inevitably experience withdrawal from the social connections to which they belong and the social roles that are central to their adult lives. As the disengagement process deepens with age, older adults will have to deal with social isolation caused by retirement, loss of family and friends, and lack of other social ties (Cumming and Henry 1961). Meanwhile, the costs of social connection for the elderly may also increase rapidly because of unpredictable life transitions and

health deterioration, such as unsafe living conditions, transport difficulties, and poor health status (Klinenberg 2016; Mapoma and Masaiti 2012; Wu and Sheng 2020). Especially in 2020, COVID-19 break out significantly damaged the elderly's social life. While aging does not independently lead to social disconnectedness, older adults are more vulnerable to experiencing the risk factors that may cause or increase social isolation and the feeling of loneliness.

According to the National Health and Aging Trends Study (NHATS), 24 percent of community-dwelling adults over 65 considered themselves socially isolated in 2011 (Cudjoe et al. 2020). And a 2018 survey of 3,020 U.S. adults aged over 45 by the AARP Foundation shows that 35 percent of middle-aged and older adults in the sample reported feeling lonely, and 41 percent of those indicating being lonely had lasted for six years or more (Anderson and Thayer 2018). Consequently, the prevalence of being and feeling isolated has recently been an important issue in society, especially for older adults.

Furthermore, the current research shows that social disconnection in older adults can be highly related to physical health and psychological well-being. Failure to connect well with society can be a significant distributor of human suffering, including cognitive decline, depression, chronic disease, obesity, and several poor physical health outcomes. Undoubtedly, the lack of social integration of the elderly has become a problem that cannot be ignored (Calati et al. 2019; Chappell and Badger 1989; Ekwall, Sivberg, and Hallberg 2005; Ekwall et al. 2005; Perissinotto, Cenzer, and Covinsky 2012; Shankar et al. 2011).

Many of the risk factors mentioned above that can lead to social disconnection are beyond the control of individuals. Therefore, older adults must be intervened by conducting adequate social support to help them re-connected with society and avoid much more suffering (Findlay 2003). As one of the effective ways to improve social integration, activity participation in daily life has shown its utility in promoting the physical and mental health of older adults by providing social contacts and fulfilling a sense of psychological belonging (Chao 2016; Gardiner et al. 2018; Khan et al. 2022; Kim and Lim 2022).

Activity theory, in contrast to the disengagement hypothesis, maintains that involvement in activities, particularly leisure activities, can facilitate pleasant social connections and effective aging in older persons. The activity theory is anchored on the Symbolic Interactionist Theory and its application, Role Theory (Lemon et al. 1972), which imply that a person's identity is partially defined by interactions with people and the physical environment or sociocultural events. Retiring, getting married, or losing the capacity to participate in past activities reduces the likelihood that the elderly will maintain their formal involvement and social duties. Consequently, individuals may suffer identity loss, low self-esteem, or loneliness. Intimacy and easily available leisure or informal activities become rewarding and accessible alternatives for the elderly to remain active and sociable. When assessing the well-being of the elderly, it is crucial to quantify leisure activities.

Existing research has focused on logically categorizing activities according to function, content, or requirements and on whether each type can contribute to the

integration process of older people, including improving their cognition, intimacy, and physical health. Although existing research has summarized divergent kinds of activities and corresponding impacts, the activity map still needs to be more consistent. It leads to confusion, such as entirely different interpretations of productive activity raised by Putnam (2000) and Klumb and Baltes (1999); other conclusions about whether the Internet can enhance social connections. One of the main reasons for the problem is that the mechanism of social integration for the elderly involves multiple factors and mutual influence pathways (see Figure 1) (Berkman 2000; Cohen 2004; Cornwell and Waite 2009; Harasemiw et al. 2018; Lu et al. 2020). It is crucial, otherwise will be confusing, to specify the purpose and conditions when referring to the intervention.

Meanwhile, current activity studies also ignore the heterogeneity of older populations. One size does not fit all. Demographic, socioeconomic, and health characteristics are often used as control variables than stratification benchmarks, so whether activities would better protect a particularly vulnerable group still needs to be answered.

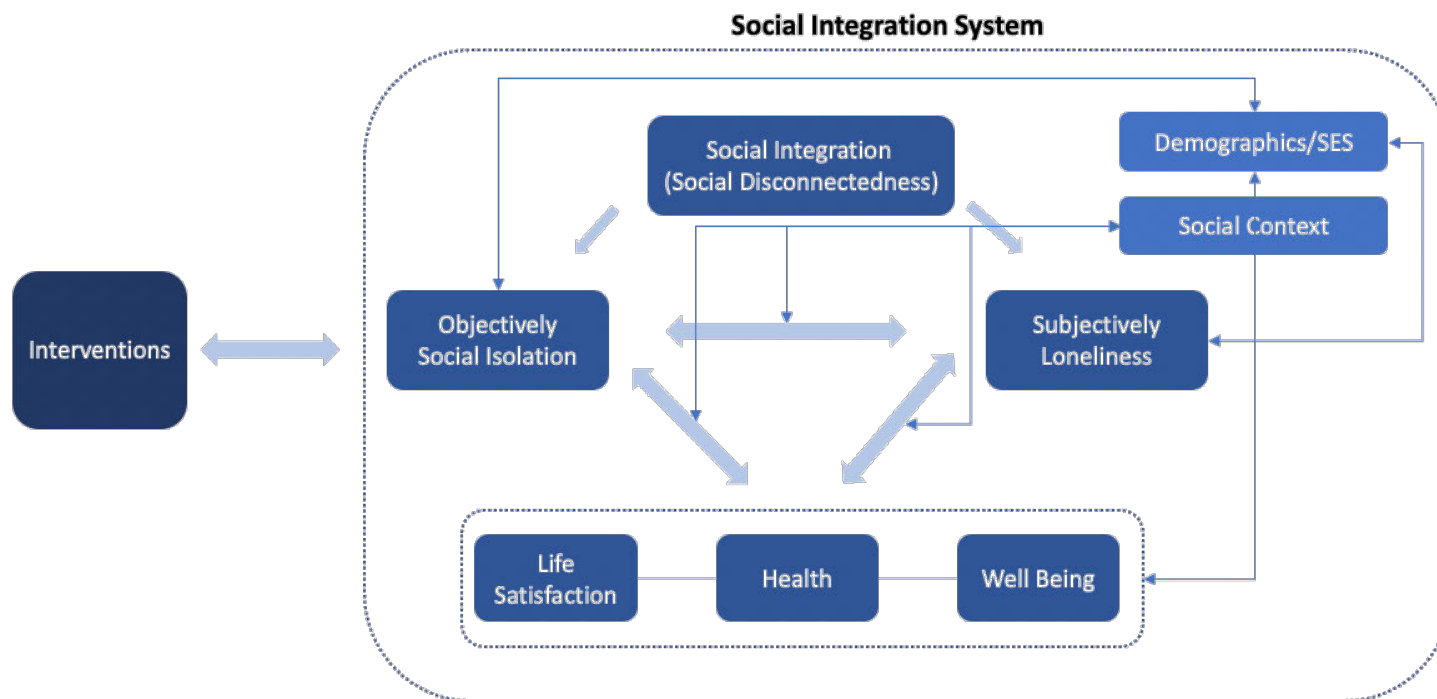


Figure 1. The inter-influence mechanism of social integration system

As two important ways of assessing and presenting the degree of social connectedness, loneliness and social isolation indicate the extent to which people lack social integration (Crowe et al. 2021). Social isolation identifies objective separation, while loneliness reflects subjective feelings of lack of intimacy. Compared to the fact that activity participation is an intuitive way to reduce social isolation, the relationship between activity and loneliness still has an explanation gap.

Therefore, this study aims to investigate the association between engagement in different types of activities and loneliness in subgroups, using data from the 2020 Health and Retirement Study (HRS, 2020). Given the specific impact of COVID, the research question is whether certain activities had stronger protective connections with susceptible groups.

To this end, the thesis will first distinguish between loneliness and social isolation to avoid ambiguous meanings. And then, the principal risk factors and determinants of loneliness will be identified and considered as control variables and stratification basis to illustrate subgroup categories. Next, the thesis will attempt to elucidate an activity classification by considering loneliness features to populate research activities into a map better to understand the association between activity types and target groups.

RISK FACTORS OF LONELINESS

Loneliness and Social Isolation: Subgroup Variations

Loneliness and social isolation are distinct but related concepts. Although people who lack social contact may feel lonely, social isolation and loneliness are not always highly correlated. In other words, social isolation does not always lead to loneliness, and loneliness is also not always accompanied by social isolation. While social isolation can be voluntary or involuntary, loneliness is consistently involuntary (Grenade and Boldy 2008).

For example, while objective isolation may be one of the reasons why older adults feel lonely, some objectively isolated people may also never feel lonely but enjoy that situation. Conversely, other individuals may still feel isolated even in an extensive social network, which is highly related to the quality and type of relationships they embedded. Therefore, when it comes to activity participation, it cannot be assumed that people will not feel lonely because social connections surround them. Social isolation should still be taken into account as a factor.

There are many ways to measure social isolation, of which marriage is essential. As people age, marriage becomes more important in their lives. With adult children leaving or fewer friendships, marriage is the primary place that provides them with a great deal of daily interaction and intimate support. People who lack family and marriage support are more likely to experience higher rates of loneliness (Margolis and Verdery 2017; Warner and Kelley-Moore 2012). Studies have shown that older adults living alone

are likelier to feel lonely than those living with family or partners (Klinenberg 2016; Perissinotto and Covinsky 2014).

Meanwhile, it cannot be assumed that the lack of family or marital companionship can be compensated by activity participation. In other words, some older adults who feel lonely may not be supported by participating in an activity, given that they may value support from their families more, and their feelings are not fulfilled (Hawkey et al. 2008; Saito et al. 2019; Teerawichitchainan et al. 2015; Victor and Bowling 2012).

On the other hand, working condition is another essential factor that affects the social relationship of the elderly. As life expectancy increases, older adults have many career choices in later life. According to the U.S. Bureau of Labor Statistics (BLS), 25 percent of people age 55 and older will still be working by 2024 (Toossi and Mitra 2015). In addition to economic considerations, social needs and the realization of self-worth are also the reasons encouraging some older adults to continue to work. Studies have shown that job security improves the mental health of older adults. The social interaction and satisfaction brought by work will reduce the possibility of the elderly feeling lonely (Kalil et al. 2010). Therefore, marital and job status are moderators to examine whether older people with less social capital would be more sensitive to the mitigating associations of activity participation on loneliness.

Demographic Factors

It has been well-proved that demographic factors can be examined as indicators to help determine whether some individuals may be more affected by loneliness, including age, gender, race and ethnicity, and socioeconomic status (SES). First, although age is not a significant factor in loneliness, it can be a potential cause along with other factors for older adults. As mentioned earlier, older adults are more likely to experience a greater frequency of disruptive events or life-altering conditions that lead to loneliness. Therefore, age is theoretically possible to affect loneliness for the elderly. Second, there is a controversy over gender differences. While a piece of evidence showed that gender differences had nearly a zero effect on loneliness across the life span, a study also concluded that females have more extensive social networks than males, which is one of the factors that can affect an individual's loneliness (Antonucci and Akiyama 1987; Matud 2004).

Besides, ethnicity and SES have shown their effects directly on loneliness in the elderly. One study noted that among the poorest group, older adults were less likely to feel lonely than younger generations, but there was no age difference among the wealthiest people. Another study suggested that greater educational attainment was indirectly associated with loneliness through the mediation of other factors, such as neuroticism and stress. This association appeared to be more prominent in certain group (Bishop and Martin 2007; Jarosław 2020; Zhang et al. 2015). Meanwhile, some studies have demonstrated that the prevalence of loneliness may vary by ethnicity. For example,

Hispanics reported greater loneliness than Caucasians, although they were less likely to live alone .

Moreover, this thesis also uses household expenditure changes during the COVID-19 pandemic to test the respondents' related financial status. The model initially used the income change variable, but it was no relationship with loneliness. So, the thesis was changed to include the household consumption variable to indirectly represent the economic pressure that respondents may face during the epidemic.

At the same time, demographic factors also impact the effectiveness of interventions on loneliness. Gender differences and ethnic differences are two crucial factors. Findlay (2003) demonstrated that activities might have different intervention effects for men or women and a person with social skills. Women are more sensitive to the effects of support group interventions than men. Tomaka et al. (2006) pointed out racial disparities in loneliness, social isolation, and social support. Hispanics and Caucasians relied on different types of social support. Hispanics placed more emphasis on family support, whereas Caucasians depended more on sources outside the family. Therefore, the thesis will consider age, gender, race and ethnicity, years of education, and household spending changes as control variables to more accurately examine group activities' effectiveness.

Health Conditions

Health conditions are one of the most discussed topics in loneliness research. Health conditions can also act as a risk factor or consequence for loneliness in older adults. Previous studies have demonstrated that older adults' poor mental health and disease symptoms were associated with vulnerability to loneliness and social isolation (Goll et al. 2015; Holley 2007; Merz and Gierveld 2016). For example, loneliness can trigger various illnesses in older adults, including Cardiovascular disease, stroke, dementia, depression, etc. (Manemann et al. 2018; Saito et al. 2019). At the same time, diseases may also make it impossible for the elderly to participate in social activities or even to carry out daily life autonomously and thus cause loneliness. Therefore, health factors are closely related to the loneliness of the elderly. At the same time, health conditions may also be deeply rooted in other relationships related to loneliness.

There is a multi-directional association between activity participation, health, and loneliness. Studies have demonstrated that one of the mechanisms between health conditions and loneliness is influencing health-related behaviors. For example, poor health leads to physical inactivity, decreased social interaction, and loneliness. By the effect of health conditions on the inability of the elderly to participate in activities and the impact of health conditions on loneliness through different pathways, it is reasonable to think that health conditions also played certain vital roles in the relationship between activity participation and loneliness (Choi and Bum 2019; Segrin and Domschke 2011). There is robust evidence showing that both physical health conditions as well as mental and memory conditions can have an impact on the elderly's mobility and loneliness.

Moreover, COVID-19 is the most famous black swan event in 2020 and has profoundly impacted the world (Haucke et al. 2022; Kasar and Karaman 2021; Peng and Roth 2022). The lockdown policy in the early stages of the pandemic will undoubtedly hinder people's social activities, thereby increasing the possibility of feeling lonely. Therefore, COVID-19-related variables should be included as control variables. This thesis examines two aspects of COVID-19's impact on the lives of older adults; one is whether respondents have ever delayed their healthcare needs because of the pandemic. Other is whether respondents have been diagnosed with COVID-19 or someone close to them (such as household members, friends, or acquaintances) has been. Because the damage of COVID-19 would be more serious for older adults with lower immunity, exposure to the confirmed cases would affect the willingness of the elderly to participate in activities.

Therefore, this thesis will consider self-rated health, self-rated memory, healthcare delay, COVID exposure, and depressive symptoms as five control variables and physical health conditions (including eight chronic disease symptoms) as another moderator variable.

PRINCIPLES OF INTERVENTION ON LONELINESS

Over the past few decades, research has steadily altered our understanding of loneliness. Early research centered on the characterization and assessment of loneliness, the modeling of possible health-related impacts, and the summary of therapeutic techniques (Chen et al. 2019; Quan et al. 2020). As previously stated, the components involved in the system of social integration are bi- and inter-influence, resulting in ambiguous routes when discussing intervention issues. Nonetheless, the essential premise of loneliness intervention may be deduced from previous research.

For example, group activities may impact mental health by increasing social interaction (reducing isolation), or relaxing the mind and reducing stress (lowering loneliness), or acting directly on the mental state through biological effects. These ambiguities also obscure the classification of interventions and activities that address social integration issues. This thesis will combine previous research to propose an intervention and activity classification for resolving loneliness.

Masi et al. (2011) and Gardiner (2018) contributed two systematic reviews of intervention for loneliness, proposing the taxonomy from a strategic and a functional perspective, respectively. They all provided a complete summary of previous intervention studies. Masi et al. (2011) concluded four primary intervention strategies by qualitative reviews: (i) correcting social skills; (ii) providing social support; (iii) creating opportunities for social contact; (iv) addressing maladaptive social cognition (Masi et al. 2011).

Compared with the generalized theoretical framework of Masi et al., Gardiner sorted out six aspects based on the content of the interventions: (i) social facilitation intervention; (ii) psychological therapies; (iii) health and social care provision; (iv) animal intervention; (v) befriending intervention; (vi) leisure/skill development (Gardiner et al. 2018). Although these two classification methods seem pretty different, both aim to group practices with the same intervention goals starting from the core question of “why people feel lonely” (Table 1). While the impacts of intervention cases summarized in the two articles were mixed and inconsistent, most effective programs achieved their goals through activity participation.

Table1. Strategic and practical approaches grouped by intervention goals

Intervention Strategy	Intervention Practice	Intervention Goal
Correct social skills	<ul style="list-style-type: none"> • Skill development 	<ul style="list-style-type: none"> • Reduce anxiety and shyness • Reduce social isolation
Provide social support	<ul style="list-style-type: none"> • Health and social care provision • Animal intervention 	<ul style="list-style-type: none"> • Meet physical/emotional needs
Create social contact opportunities	<ul style="list-style-type: none"> • Social facilitation intervention • Befriending intervention • Leisure activity 	<ul style="list-style-type: none"> • Improve the quality of life • Find others with common goals
Address impairments in social cognition	<ul style="list-style-type: none"> • Psychological therapies 	<ul style="list-style-type: none"> • Change negative/depressive thinking patterns

Even though there is no consensus on the effectiveness of specific interventions¹, categorization research concluded that classification is an essential prerequisite for determining which elements primarily affect the influence mechanisms, especially facing a wide range of interventions (Gardiner et al. 2018; Quan et al. 2020). Through the

¹ It is not yet possible to define which type of practice is more protective against loneliness

existing categories, it can be seen that the core principles of intervention in loneliness reduction are to:

- Improve the degree of social connection
- Fulfill physical or emotional needs by building skills or breaking the perpetuated circle of negative interactions.

Based on the logic of intervention on loneliness, the thesis will introduce the activity theory further to analyze the category and effectiveness of activity participation.

THE ACTIVITY THEORY AND ACTIVITY CATEGORIZATION

The Activity Theory

Initially proposed by Robert J. Havighurst in 1965, the activity theory suggested that older adults can maintain happiness when they engage in activities and acquire social interactions or alternate roles which may have been lost before due to aging. As one of the social support strategies, the activity theory is regarded as a preventative way to help people avoid being or feeling isolated. Activities do not have to be social and can involve no interaction, but they still have role meanings, such as housework or cognitive games. Outcomes measured by activity focused on health, life satisfaction, survival, well-being, and depression among older adults in previous studies. Loneliness is mainly included as part of outcome measures but rarely examined as an independent variable. Given the complex influence of late-life factors, it is challenging to have a consistent operating method to refine and measure a broad goal, so it is necessary to understand the mechanism by focusing on one of the steps.

Further development of the activity theory distinguished three types of activity, informal, formal, and solitary². It concluded that informal activity has a consistently positive association with well-being in older adults (Adams et al. 2011; Lemon et al.1972a). These three types of activity are a broad classification, emphasizing the importance of leisure/informal activities in later life, and subsequent research has divided leisure/informal activities into more dimensions.

² Formal activity refers to participation with familiar people; informal refers to engagement in formal groups or organizations.

The fundamental dimension depends on whether the activity is social or solitary. The latter refers to activities with no or limited interaction, such as watching TV, gardening, and test tubes. Every activity can be classified according to this domain. Although the social connection is essential for alleviating loneliness, it does not have to be. The performance of solitary activities has been proven its practical functions in maintaining happiness because participants would be less negatively affected by limited social contact (Li and Tang 2022; Sun and Liu 2006). On the other hand, while studies have shown that group-level activities are more likely to provide beneficial outcomes than individual-level, their effectiveness still needs further research, especially during the pandemic period (Dickens et al. 2011; Haucke et al. 2022; Nicholson 2012).

Besides, activities can also be classified by other dimensions, such as *intellectual and physical, consumptive and productive, in-home and out-of-home, regenerative and discretionary, leisure and working, spiritual, cultural and serving, and so on.* (Chen et al. 2019; Ingen and Eijck 2009; Kim and Kim 2022; Lemon et al. 1972b; Li and Tang 2022; Maier and Klumb 2005; Santino et al. 2020; Teh and Tey 2019; Toepoel 2013; Zhang et al. 2015). In addition to the solitary-social dimension, other dimensions widely used to analyze the function of buffering loneliness are the intellectual-physical and consumptive-productive dimensions. The former examines the role of energy expenditure, and the latter mainly discusses from the function perspective. While many studies have used the latter dimension to classify activities, the principles of interpretation vary such that activities may be subsumed into different sides.

Putnam (2000) was the first to indicate that leisure activities can also have a beneficial effect on social capital, despite the fact that leisure activities normally fall outside the purview of social capital formation owing to informal social relationships. Putnam noted that people could form social networks through leisure activities, such as creating opportunities to meet like-minded people or broadening personal contacts by sharing enjoyable times with families, friends, or acquaintances; meanwhile, many job opportunities may be obtained by chance through informal social situations. These occasions are essential for increasing social capital. In addition, some leisure activities can contribute to developing skills useful for people's life or work, which are defined as serious activities. Those leisure activities that can help people acquire social networks and social or job skills are defined as productive activities, otherwise are consumptive activities (Putnam 2000).

Toepoel (2013) further explained the definitions of these two types more straightforwardly. Productive activity refers to *creating* or *doing* activities, and consumptive activity refers to passive *experiencing* activities. Serious activity is the ultimate form of productive activity (Toepoel 2013). For example, volunteering is a productive activity, and so is writing. Although writing does not produce social relationships instantly, it allows for much thought and skill development. Watching TV and shopping are consumptive activities, given that they are less likely to generate lasting returns. Gardiner (2018) stated that productive activity is perceived as more meaningful activities, one of the factors contributing to the success of the intervention.

On the other hand, Klumb and Baltes (1999) defined productive and consumptive activity differently. They excluded daily activities from this dimension and only considered discretionary activities, which means people can do them by choice. They proposed that a third party can conduct productive activities without losing benefits (e.g., housework, gardening, helping others, etc.), but consumptive activities cannot (e.g., social/leisure activity, reading, health-related activity, etc.). They divided activities according to the purpose of the action. An activity is productive if performed to produce outcomes that can act on others but consumptive if it is for the participant's own sake (Klumb and Baltes 1999; Maier and Klumb 2005).

Since loneliness interventions do not necessarily require giving meaning, personal satisfaction and social connection can reduce loneliness. Putnam's definition is more relevant and will use in the thesis.

Activity Categorization

According to the core principles of intervention on loneliness suggesting connection and physical or emotional fulfillment are essential, the thesis categorizes leisure activities along three mutually exclusive dimensions:

- Social and solitary dimension, reflecting the degree of connection.
- Consumptive and productive dimension, reflecting the meaning of function.
- Sedentary and active dimension, reflecting the energy pattern.

Undeniably, the three dimensions can only partially reflect some activity attributes, especially the background information of participation, such as the frequency of engagement and with whom.³

I populated the map (Figure 2) with the 21 activities examined in HRS to cluster a wide range of activities to visualize each activity's three-dimensional properties. The social attribute tends to be positively related to the productive feature because social activities typically have more opportunities to provide social connection and social capital. Armed with a sliding scale, activities can be analyzed along a spectrum. Rather than giving a clear dividing line between each attribute, activities on the map are placed relative to each other. In addition, this thesis does not aim to analyze the relationships between all activity types and loneliness but mainly focuses on social activities. Therefore, the area marked by the circle includes all the primary focus variables.

Comparing Internet use to other social activities, its social attribute has been challenged. Several previous studies have empirically proved the significance of the Internet in combating loneliness but within vastly distinct theoretical frameworks. Some studies regarded the Internet as one of solitary activities. They argued that the Internet could provide the elderly more opportunities to enjoy their private life and desired hobbies even in conditions of social isolation (Larson et al. 1985; Long and Averill 2003), while others continued to treat the Internet as a social tool. They argued that online connection could mitigate loneliness by providing virtual socialization, especially

³ The code for each activity will include the frequency of participation, and possible accompanying participants can be analyzed from the question text.

during a pandemic when physical contact is hampered. (Mohan and Lyons 2022; Morahan-Martin and Schumacher 2003; Pauly et al. 2019).

On the other hand, the association between Internet use and loneliness is still unclear, that is, whether Internet use is a result or a cause of loneliness. Some studies asserted that virtual communication further contributed to rather than interfered with loneliness. Internet as a widespread way of living in contemporary society has raised a controversial debate about its attributes and effectiveness on the elderly's loneliness. In the thesis, I will regard Internet use as a social activity to examine its efficacy for vulnerable groups because the question specifically mentioned e-mail use, which implies the meaning of virtual communication.

From the view of three dimensions, social activities can be further divided into highly productive-active activity, moderately productive-active activity, and consumptive-active/sedentary activity (simplified to consumptive activity). I define productive activity as the degree of personal contributions (*creating*) and the degree of social/emotional gain.

In conjunction with HRS activities, each category will include the following activities (Table 2):

- Highly productive-active activity includes three spiritual activities (volunteering, charity, and religious services);
- Moderately productive activity includes four interest activities (two are active activity and two are sedentary activity);

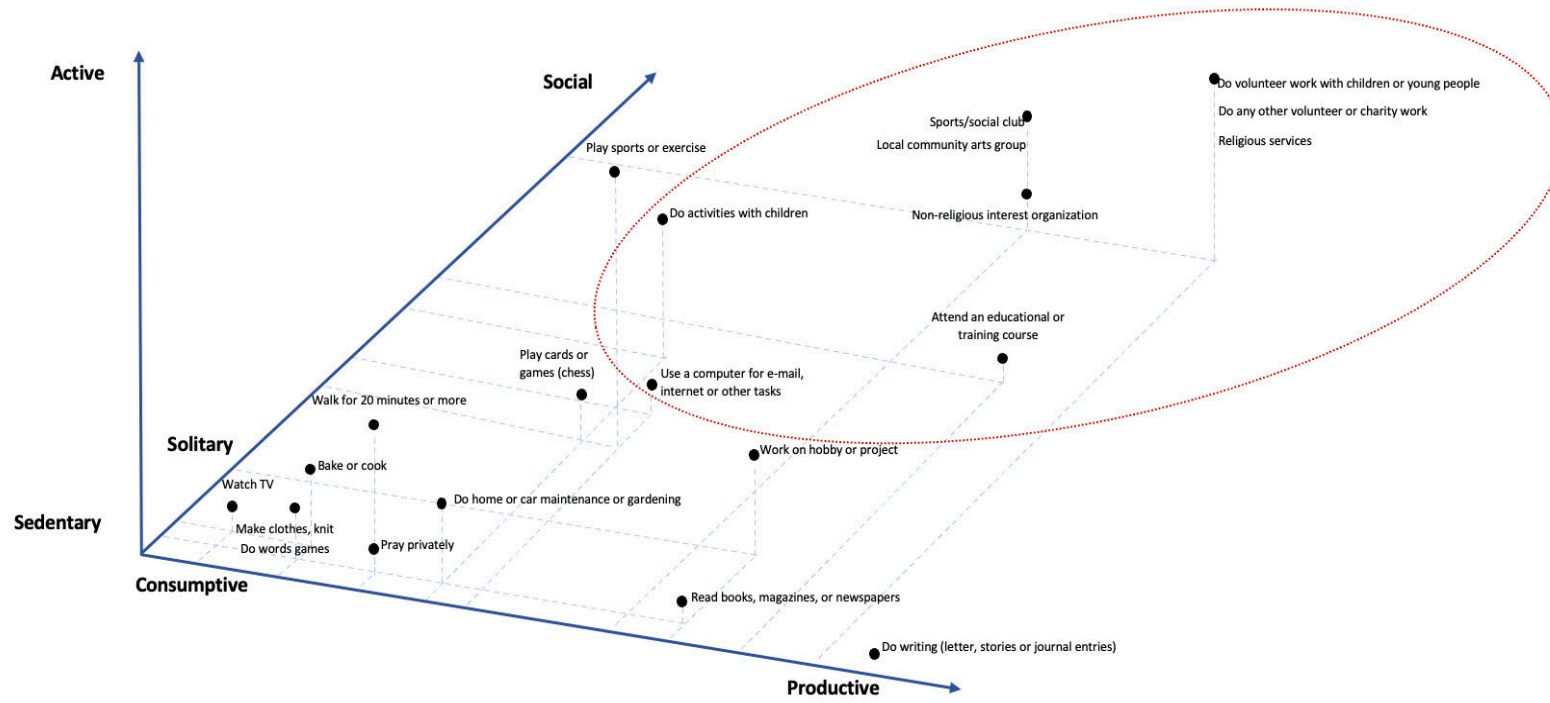
- Consumptive activity includes two activities of daily living with relatively low intensity of social interaction (one with family and one with online communication).

Table 2. The categories of social activity examined in the HRS

Highly productive-active activities	Moderately productive activities	Consumptive activities
<ul style="list-style-type: none"> • Volunteer work with children • Do other charity work • Religious services 	<ul style="list-style-type: none"> • Active: <ul style="list-style-type: none"> - Sports/social club - Community arts group • Sedentary: <ul style="list-style-type: none"> - Non-religious organizations - An educational course 	<ul style="list-style-type: none"> • Do activities with children • Internet use

Meanwhile, Gardiner (2018) concluded three factors that affect successful interventions, and “*adaptability*” is one of them. It refers to the degree to which interventions meet the individual needs of older people driven by demographic differences. While previous studies have explained activity patterns from different perspectives, they have often ignored the moderating role of certain social status and health status (i.e., marriage, job, and physical health status). Therefore, in addition to dividing social activity into three dimensions to illustrate, the thesis attempts to figure out the adaptability of social activities by examining how these three subgroups affect the association between the activity buffering effect and loneliness.

Figure 2. A three-dimensional activity map filled in with HRS⁴ activities



⁴ HRS refers to the Health and Retirement Study database.

HYPOTHESIS

Lack of social integration in older adults will be more likely to increase loneliness, so social connection, emotional enrichment, and physical health will be potential avenues to alleviate loneliness. For older adults with limited access to social capital and social support, leisure activities are an excellent opportunity to bridge the gap between them and society. Based on the mechanisms and characteristics of loneliness, I argue that the sample in the thesis will be consistent with the demographic portrayals of previous studies. People who were unmarried, unemployed, and had more physical symptoms scored higher on loneliness. People who are older, female, mentally ill, or in deteriorating health will face deeper lonely feelings.

According to the core principles of intervention and social activity map on loneliness, I will have mainly three hypotheses in the thesis:

- Highly productive-active activities will be the most successful approach to buffer loneliness for older adults.
- Given that married and working people already have specific social capital and companionship⁵, the utility of activities, especially the highly and moderately protective-active activities, will be more inclined to protect vulnerable groups, such as widows and retirees.

⁵ The activity theory suggests that widowed and retired people are more likely to be socially active because they have already lost their family and social roles.

- Since people with better physical health are more likely to be socially engaged, they would benefit more from activity participation than those who are less regularly involved.

DATA AND METHODS

Data used in this thesis were derived from the 2020 Health and Retirement Study (HRS), a biennial longitudinal study of older Americans over 50. I analyzed the data from the 2020 HRS core file and cross-wave tracker file. The assessments of social activity participation and loneliness indicators were conducted in the Leave-Behind Questionnaire (LBQ), which collected additional information about psychosocial issues, general life, and social relationships. LBQ was initiated in 2006 to randomly select half of the respondents for face-to-face interviews (HRS 2020). For the analysis of the association between social activities and loneliness as the outcome, the final analytical sample contained 4,506 variables after excluding 10,860 cases in which all the indicators of measuring loneliness are missing and 44 cases in which more than half of the loneliness indicators and activity data are missing⁶. After that, all the variables used in the thesis remained missing values; therefore, I used Multiple Imputation by Chained Equations (MICE) to impute missing values by 20 times. The whole data processing was conducted in Stata17.

⁶ Of the 44 cases, three were missing six to nine out of ten loneliness indicators (0.06%), and 41 were missing five to eight out of the nine activities (0.86%).

Measure

Loneliness

The degree of loneliness in the 2020 HRS was measured by an 11-item Revised UCLA scale (Lee and Cagle 2017). This method of assessing loneliness has been used in many previous studies and has proven its effectiveness in the measurement .

In the questionnaire, respondents were asked to rate the frequency they felt: (i) lack of companionship, (ii) being left out, (iii) isolated from others, (iv) being in tune with the people around them, (v) alone, (vi) there are people they can talk to, (vii) there are people they can turn to, (viii) there are people who really understand them, (ix) there are people they feel close to, (x) part of a group of friends, (xi) have a lot in common with the people around them. Each item was coded from 1 ("often") to 3 ("hardly ever or never"). Four items (lack companionship, left out, isolated from others, and alone) were re-coded in reverse, and then a score for each person was created by adding the 11 items. The final score as a continuous variable ranged from 11 to 33 (Cronbach's alpha = 0.88)⁷. Higher scores indicate the severe degrees of loneliness experienced by respondents.

⁷ In order to remove the heteroskedasticity of residual, I logged the loneliness scores in the regression model. A 3-item scale (only including lack of companionship, being left out, and being isolated from others) and a dummy scale of loneliness are also conducted in the sensitivity analysis. The two present strong heteroskedasticity and large BIC values.

Social Activity Participation

2020 HRS measured 20 social activities in the LBQ section. I chose eight activities out of them and one another from the Demographics sections as nine focus variables in the thesis. Since I was interested in the moderating effects of certain social and health statuses on the association between the types of social participation and the subjective loneliness experience, the criterion for selecting the activity was based on whether other people could socially and collectively participate at the same time. The nine focus variables include “do activities with grandchildren, nieces/nephews,” “do volunteer work with children or young people,” “do any other volunteer or charity work,” “attend an educational or training course,” “go to a sport, social, or other clubs,” “attend meetings of non-religious organizations, such as political, community, or other interest groups,” “use the computer for e-mail, internet or other tasks,” “participate in a local community arts group such as a choir, dance, photography, theatre, or music group,” and “attend religious services.”⁸ Each activity was coded as a continuous variable to present the participation frequency⁹. Except for religious services (range: 0-4), the other eight activities range from 0-6, representing whether respondents attend daily, weekly, or

⁸ I will shorten the name of each activity in the following thesis. “Activities with children” refers to “do activities with grandchildren, nieces/nephews”; “Volunteer with the youth” refers to “do volunteer work with children or young people”; “Other charity work” refers to “do any other volunteer or charity work”; “Educational courses” refers to “attend an educational or training course”; “Sports/social club” refers to “go to a sport, social, or other clubs”; “Non-religious organization” refers to “attend meetings of non-religious organizations”; “Internet activities” refers to “”; “Community arts group” refers to “participate in a local community arts group”; “Religious services” refers to “attend religious services”.

⁹ Code meanings for the eight activities examined in the LBQ section: 0=never/not relevant; 1=not in the last month; 2=at least once a month; 3=several times a month; 4=once a week; 5=several times; 6=daily.

Code meanings for the religious services: 0=not at all; 1=one or more times a year; 2=two or three times a month; 3=once a week; 4=more than once a week.

monthly. A higher number indicates that the respondent participated in the activity more frequently.

Covariates

Demographic and socioeconomic controls in the thesis include age (under 65, 65-74, and 75+), gender (0=male, 1=female), race/ethnicity (1=non-Hispanics; 2=non-Hispanic black; 3=Hispanic of any race; 4=non-Hispanic other race), years of education (range:0-17)¹⁰, and household spending change after pandemic¹¹ (1=spending went up, 2=spending went down, 3=around the same).

In previous studies, the minimum age for older adults ranging from 50 to 65. Meanwhile, as mentioned earlier, serious health problems would affect older adults in many ways, especially their ability to participate in physical group activities. People of higher age will raise the likelihood of reduced mobility, thus influencing the impacts. Since this thesis aims to investigate whether certain types of social activities were more protective against loneliness in vulnerable older adults, I selected people over 50 as the sample to partly reduce the negative health impact by lowering the minimum age.

Health covariates included self-rated health (1-5; 1=poor, 5=excellent), self-rated memory (1-5; 1=poor, 5=excellent), depressive symptoms (0=no depressive symptom,

¹⁰ Considering the meaning of the variable and the slight variation in skewness under different transformations, I still use the original format for years of education. There are only minor differences in sensitivity analysis performance between the different formats.

¹¹ I first used income changes due to COVID as a control variable to account for COVID-affected finances, but it was not related to loneliness. Then, I found that changes in spending were significantly associated with loneliness, but the pathways were not examined in the thesis.

1=have depressive symptom), the number of healthcare needs delayed because of the COVID (range:1-6), and whether respondents or someone around has ever been diagnosed COVID-19 (0=never, 1=have had).

The respondents self-evaluate their health and memory rates. The assessment of depressive symptoms used validated Composite International Diagnostic Interview – Short Form (CIDI-SF), including eight symptoms. Respondents were asked: whether they had experienced the following symptoms for two weeks or more in a row during the last 12 months: (i) felt sad, blue, or depressed, (ii) lost more interest in things than usual, (iii) feel more tired out or low in energy than is usual, (iv) change in appetite (lose or increase appetite), (v) have more trouble falling asleep than usually do, (vi) have a lot more trouble concentrating than usual, (vii) sometimes feel down on yourselves and no good or worthless, and (viii) think a lot about death. If they have experienced the symptoms, they were coded as 1; otherwise, they were coded as 0. Finally, I added the eight items to get a range score. Given that most respondents reported that they did not experience depressive feeling and other symptoms, I transformed the scores into two categories to fit in normality, so depressive symptom is measured by “no symptom (0)” and “have symptoms (1)” (Alsubheen et al. 2021; Pena-Gralle et al. 2021; Penning, Liu, and Chou 2014). The delayed healthcare needs include six aspects: medical or dental care, surgery, seeing the doctor, filling a prescription, and other types of care. Each deferred check was registered as 1, otherwise 0. Finally, I added up all the items as measurements. A higher score indicates that the respondent's health is more negatively affected by COVID-19.

Moderators

Previous studies have discussed the detrimental effects of loneliness on the elderly's health and lifespan and focused more on the potentially valuable interventions related to the problems. Individual differences, although always present in the research process, are mostly treated as control variables to adjust models. When we emphasize the well-being of older people, we are paying attention to the views of the disadvantaged group. However, heterogeneity is still sometimes overlooked in the discussion of the elderly. There are also different vulnerable groups among the elderly with the intersection of other demographic, social, and health characteristics. According to the previous research, this thesis selected three highly correlated variables to divide the elderly into several groups: marital status, job status, and physical health conditions. By analyzing the association of social activity and loneliness within different groups, this thesis aims to understand whether and how vulnerable groups respond differently to the same association.

Marital status includes married/partnered, single¹², and widowed. Job status includes working, unemployment/other¹³, and retired. Physical health conditions are firstly measured by the number of chronic disease symptoms, including high blood pressure, diabetes, cancer, lung problems, heart problems, stroke, psychiatric problems, and arthritis. Then, I re-coded the summed score (range:0-8) into three categories: no

¹² Single includes people in separated/divorced status or never married.

¹³ Working status includes people who were working or a homemaker. Unemployment/other includes people who were unemployed and looking for work, temporarily laid off, disabled, on sick or other leave, and others.

symptom, one/two symptoms, and more than two. I used one-way ANOVA tests to compare loneliness in the three mediation groups, and the results are all significant (Choi, Carr, and Namkung 2022; Cornwell and Waite 2009; Penning et al. 2014; Shankar et al. 2011; Thompson and Heller 1990).

Analysis Plan

To investigate whether marital status, work status, and physical health conditions have moderating associations on the relationship between social activities and perceived loneliness of the elderly, I first compared the categories of each status on loneliness using a one-way analysis of variance. Next, I conducted the robust Multiple Regression Model to predict loneliness without adjusting group differences. The baseline model presents unadjusted associations of social activities on loneliness; Model 2 includes demographic and socioeconomic factors, and Model 3 adjusts for health components. The previous study examined all covariates variables and demonstrated a significant association with loneliness. Finally, I conducted Group Regression Model to test whether three statuses modify the associations of social activity. At the same time, I performed the chow test to do the post-hoc examination¹⁴. The test results are statistically significant in three statuses, which means regression coefficients differ between groups.

¹⁴ For marital status: Chow Test = 113.01, $p < 0.001$; For job status: Chow Test = 120.41, $p < 0.001$; For physical health conditions: Chow Test = 139.93, $P < 0.001$

The Multiple Regression Model is presented in the following equation:

$$\begin{aligned} \ln Y &= \beta_0 \\ &+ \beta_1 \text{Activities with children} + \beta_2 \text{Volunteer with the youth} + \beta_3 \text{Other charity work} \\ &+ \beta_4 \text{Educational courses} + \beta_5 \text{Sport and social club} \\ &+ \beta_6 \text{Nonreligious organizations} \\ &+ \beta_7 \text{Internet activities} + \beta_8 \text{Religious services} + \beta_{9-12} \text{Demographics}_{9-13} \\ &+ \beta_{13-15} \text{Health conditions}_{14-18} \end{aligned}$$

RESULTS

Bivariate Analysis

Descriptive statistics between the study variables are presented in Table 3.

ANOVA tests for loneliness in different groups of status and health conditions are shown in the notes. The respondents, overall, had a lower average loneliness score, meaning the majority of older adults in the sample were not emotionally isolated. Of the nine social activities, they preferred using the Internet, doing activities with children, and joining in religious services mainly, followed by going to sports or social clubs and doing charity work. Volunteering with youth and community arts groups were the least engaged activities, with participation rate below 30%. But generally, the proportions of respondents who have participated in various social activities are relatively high, indicating that their social participation is diversified. Respondents were to be middle-old overall, predominantly female and non-Hispanic white, with relatively good levels of education, better self-perceived health and memory, and less depression condition. The household spending of respondents was not negatively impacted by COVID-19. Almost half experienced their family members, friends, or themselves being diagnosed, and an average of nearly three medical needs were postponed due to the pandemic.

For each status, the results present a gradient in the groups' loneliness score and activity participation. Among marital status, married or partnered people had the lowest loneliness score, and then widowed people. Singles in the sample reported the highest loneliness scores. People who are married or have a partner participated in more social activities than single and widowed elderly. The latter two only had a slight difference in

participation rates of most activities. Internet use and religious services had the most pronounced changes in the latter two groups compared to the overall. 67.3% of widowed people have used the Internet compared with 80.8% overall. The reduced engagement may relate to the oldest group's lack of Internet usage habits (77.37 ± 9.45), while the same observations were made among the retired and people in the poorest health. The average ages of the three groups were over 70. And the 59% participation at religious services for singles was also well below the average.

Regarding the demographic characteristics, the male-to-female ratios in single and widowed groups were significantly large, including more females. Widowed people had more non-Hispanic white and poor memory conditions than the other two. Married and partnered elderly had the best control over their spending post-pandemic, while more single and widowed people faced increased household spending. So, it can be roughly inferred that the pandemic has affected single and widowed people more. Meanwhile, single and widowed older adults reported more depressive symptoms than those in couples, and fewer people around them were diagnosed, possibly because they had narrower social networks.

Unemployment and others reported the highest loneliness scores, while the other two did not significantly differ. Working people did present more social attributes (much more engagement in each activity than the other two groups), especially in activities with generally low participation rates, such as two volunteer/charity works and educational activities. The proportion of retired people participating in activities was higher than that of unemployed, possibly because retirees had less pressure and more time to enjoy social

activities. Regarding getting along with their families and religious activities, retirees had a higher participation proportion than the other two groups. For the demographic and health characteristics, retirees were older and had more non-Hispanic whites but did not have lower social participation, nor did they show worse health, memory, and depression. Still, the unemployed had worse health performance, which is different from the hypothesis in the thesis. Rather than the retired elderly, the unemployed were the most vulnerable group among the three job statuses.

Meanwhile, the unemployed people faced more burdensome household spending. Considering they still prepare to find a job suggests they were likely to face significant economic pressure during the pandemic. At the same time, they also had the highest number of unmet healthcare needs. Therefore, on the whole, the pandemic had the most significant impact on the unemployed than the other two, which may be one of the reasons for deepening their loneliness.

From the perspective of physical health conditions, the rise in symptoms accompanied by increases in loneliness scores and age is in line with the argument that poorer physical health harms loneliness. Age would be an effective mediator in this association. Hispanics of any race reported fewer symptoms than other racial and ethnic groups. The health conditions got worse as the number of symptoms increased. People with two or more symptoms reported decreased satisfaction with their health and memory and a higher proportion of being depressed. At the same time, respondents with poorer physical health had more unsatisfied healthcare needs and higher household spending due to the epidemic. However, fewer people had been in contact with or became confirmed

cases of the Coronavirus, which remains the same pattern as the first two statuses; that is, the proportion of exposure to confirmed cases was lower in groups with less social interaction.

Overall, aging was accompanied by decreased social connections (fewer living partners and fewer work obligations), increased chronic disease symptoms, and lower rates of health and memory, which were in close agreement with previous research. However, the association between age and loneliness varied across groups and required further analysis. Table 4 below shows the association between loneliness and three combined statuses. As seen from the table, people who are single and unemployed with two/more symptoms had the highest loneliness score. In addition, from the perspective of activity participation, it shows that the more engagement respondents had, the lower score of loneliness. But it still needs to be discovered how other factors and group variables would affect this association. Therefore, this thesis aims to reveal the moderating roles of three statuses with marriage, work, and health status on the association between diverse social activities and loneliness by conducting multiple regression analyses.

Table 3. Sample descriptive statistics for all variables used in the analysis by marital status, job status and physical health conditions ($N=4,506$)

Variables	Mean±SD or %									
	Total sample ($n=4,506$)	Marital Status			Job Status			Physical Health Conditions		
		Married/ Partnered ^a ($n=2,513$, 55.8%)	Single ^b ($n=1,142$, 25.3%)	Widowed ^c ($n=827$, 18.4%)	Working ^d ($n=1,459$, 32.4%)	Unemployment/ Other ^e ($n=709$, 15.7%)	Retired ^f ($n=2,323$, 51.6%)	None symptom ^g ($n=455$, 10.1%)	One/Two symptoms ^h ($n=2,098$, 46.6%)	More than two symptoms ⁱ ($n=1,927$, 42.8%)
Loneliness (11-33)	16.92±4.81	16.21±4.57	18.02±5.10	17.53±4.74	16.55±4.75	18.65±5.26	16.62±4.58	15.71±4.27	16.46±4.59	17.73±5.04
<i>Participation in social activity</i>										
Activities with children	70.4	74.7	64.5	65.6	70.7	66.2	71.5	71.2	71.8	68.7
Volunteer with youth	29.4	32.1	27.5	23.6	35.4	25.2	26.8	38.9	32.2	23.9
Other charity work	42.9	47.1	37.7	36.9	48.8	31.0	42.7	52.4	46.3	36.7
Educational courses	35.9	38.9	34.7	28.2	49.4	27.3	29.6	49.5	38.5	29.4
Sports/social club	47.9	50.4	45.7	43.4	54.6	35.5	47.3	59.9	51.1	41.1
Non-religious org	38.3	40.3	36.9	34.0	42.2	28.2	38.9	45.3	39.8	34.7
Internet activities	80.8	85.5	80.2	67.3	89.7	73.4	77.5	92.5	84.2	74.4
Community arts group	24.2	23.9	24.7	24.8	25.1	20.6	24.7	27.6	24.5	22.8
Religious services	66.2	69.2	59.4	67.2	65.8	59.5	68.5	67.2	67.1	65.1
<i>Demographic and socioeconomic characteristics</i>										
Age (50-101)	69.32±10.12	68.16±9.39	66.03±9.08	77.37±9.45	63.00±8.12	63.78±8.20	74.96±8.36	62.66±8.21	68.31±9.90	71.94±9.85
< 65 years old	38.0	39.5	52.6	12.2	67.4	65.0	10.6	67.9	41.9	26.4
65-74 years old	33.6	36.9	30.0	28.0	23.4	25.9	42.5	22.9	33.8	35.9
≥ 75 years old	28.4	23.5	17.3	59.8	9.1	9.2	46.9	9.2	24.3	37.7
Gender										
Male	39.8	49.1	34.0	18.8	37.5	38.2	41.8	39.9	40.1	39.6
Female	60.2	50.9	66.0	81.2	62.5	61.8	58.2	60.1	59.9	60.4
Race and ethnicity										
Non-Hispanic White	64.3	67.9	52.2	70.6	60.9	44.9	72.7	64.9	63.6	64.8
Non-Hispanic Black	18.5	12.8	30.8	18.3	17.0	32.6	14.9	12.3	17.7	20.9
Hispanic of any race	4.2	4.4	5.4	2.3	5.9	5.9	2.6	92.0	4.4	28.7
Non-Hispanic other race	13.0	14.9	11.7	8.8	16.1	16.7	9.8	13.7	14.3	11.4
Years of education (0-17)	13.31±2.96	13.50±3.05	13.43±2.74	12.58±2.84	13.64±2.91	12.55±2.99	13.34±2.93	13.98±2.92	13.45±2.94	13.01±2.92
<i>Spending change after COVID</i>										
Spending went up	18.2	15.1	22.9	20.7	16.3	25.7	17.0	14.1	16.3	21.3
Spending went down	22.0	25.4	19.9	15.1	26.1	21.0	19.9	26.8	25.1	17.5
About the same	59.4	59.2	56.8	63.5	57.5	53.0	62.7	58.7	58.3	60.7
<i>Health characteristics</i>										
Self-rated health (1-5)	3.16±0.99	3.26±0.97	3.04±1.01	3.03±1.01	3.39±0.92	2.62±1.05	3.18±0.96	3.96±0.82	3.38±0.90	2.74±0.94
Self-rated memory (1-5)	3.00±0.91	3.03±0.90	3.02±0.94	2.89±0.88	3.21±0.89	2.83±0.98	2.93±0.87	3.36±0.84	3.09±0.87	2.83±0.92
Healthcare delayed (1-6)	2.70±0.85	2.67±0.82	2.76±0.86	2.70±0.90	2.72±0.76	2.84±0.96	2.63±0.85	2.61±0.68	2.68±0.86	2.73±0.86
Have depressive	15.2	12.1	20.1	17.5	11.3	28.5	13.7	7.1	11.1	21.6
COVID diagnosed	49.6	51.1	48.9	38.7	58.6	46.1	44.1	55.0	50.7	46.8

Notes: the $F(df_b, df_w)$ or $\chi^2(df)$ For marital status is 63.47(2) ***, for job status is 49.30(2) ***, for physical health conditions is 49.16(2) ***, and the significant subgroup for loneliness is ab,ac,de,ef,gh,gi,hi

Table 4. Mean scores of loneliness for different group combinations (*N*=4,506)

Rank	Marital Status	Job Status	Physical Health Conditions	Loneliness Mean Score	Percentage (%)
1	Single	Unemployment/ Other	Two/More symptoms	20.50±5.09	3.1%
2	Single	Unemployment/ Other	None/One symptom	19.73±4.99	2.9%
3	Widowed	Unemployment/ Other	Two/More symptoms	19.24±5.58	1.3%
4	Single	Working	Two/More symptoms	18.46±5.49	2.6%
5	Married/Partnered	Unemployment/ Other	Two/More symptoms	17.84±5.43	3.2%
6	Widowed	Working	Two/More symptoms	17.84±5.30	1.2%
7	Single	Retired	Two/More symptoms	17.73±4.84	4.7%
8	Widowed	Retired	None/One symptom	17.45±4.45	5.5%
9	Widowed	Retired	Two/More symptoms	17.41±4.70	6.8%
10	Widowed	Unemployment/ Other	None/One symptom	17.22±4.33	0.8%
11	Single	Working	None/One symptom	17.16±4.85	6.0%
12	Widowed	Working	None/One symptom	17.15±4.63	1.4%
13	Married/Partnered	Unemployment/ Other	None/One symptom	16.80±4.84	3.2%
14	Married/Partnered	Working	Two/More symptoms	16.81±4.47	6.0%
15	Single	Retired	None/One symptom	16.52±4.72	4.6%
16	Married/Partnered	Retired	Two/More symptoms	16.58±4.58	13.4%
17	Married/Partnered	Working	None/One symptom	15.69±4.44	13.9%
18	Married/Partnered	Retired	None/One symptom	15.63±4.27	13.7%
At least one item missing				--	5.8%

Multivariate Analysis

Non-grouped Regression

This section will include four parts of the analysis. The first is a regression analysis of the loneliness among respondents with different types of social participation without considering group differences. And the other three are the group regressions conducted by marital status, job status, and physical health conditions. Each regression will use three models to determine whether social activities are more protective for specific isolated people, such as widowed, retired, or people with severe health conditions.

The relationships between the different types of social activities and loneliness are presented in Table 5. As can be seen, the association of each activity varied slightly after controlling for demographic and health characteristics. Five activities remain highly significant ($p < 0.001$) after adjusting all the covariate variables: activities with children, charity work, sports/social clubs, Internet activities, and religious services. Religious services had the most excellent association with alleviating loneliness but were not significantly different from the other four activities. With the increase in the frequency of religious activities, the elderly who participate every day can reduce loneliness by 9.6% ($=0.016 \times 6$) compared with those who had never attended. Participation in activities with children, other charity work, and sports/social clubs had the same utility size on reducing loneliness (1.5% less loneliness per unit increase in participation frequency). Internet activities have a weaker association (0.8% less per frequency level). The role of volunteering activities with young people on loneliness was counterintuitive. As the

participation frequency increased, the loneliness score also increased, but it is only significant at the $p < .10$ level.

In addition to the number of delayed healthcare needs, changes in household spending, other demographic and socioeconomic characteristics, and health factors were all significantly associated with loneliness. Age was not negatively associated with loneliness in the non-grouped model. The loneliness scores of older adults in the sample decreased with increasing age, which is different from previous studies. Females' loneliness scores were 2% lower than males. Only Hispanics had a slightly significant association with loneliness compared with non-Hispanic whites, with a 3.9 percent lower loneliness score. For COVID-affected household consumption, increased spending was related to higher loneliness scores than the unchanged situation. It shows that the emotional feelings of the elderly can be linked to financial stress, especially in a turbulent and uncertain social environment.

From the perspective of health components, the elderly with higher health and memory satisfaction had lower lonely feelings. Depression had a negative impact, which is consistent with the previous conclusions. But counterintuitively, those who had or knew a confirmed case had even lower loneliness scores than those around them or those who had not been diagnosed. One possible reason is that they may have companions locked together or have more topics to discuss. The grouped regression below allows for a closer look at how the relative associations change.

Table 5. Regression predicts the loneliness scores for respondents engaging in various social activities ($N=4,506$)

	Loneliness scores (95%CI)		
	Model 1	Model 2	Model 3
<i>Social activities</i>			
Activities with children	-0.015*** (-0.02, -0.01)	-0.016*** (-0.02, -0.01)	-0.015*** (-0.02, -0.01)
Volunteer with the youth	0.012** (0.00, 0.02)	0.009* (0.00, 0.02)	0.008† (-0.00, 0.02)
Other charity work	-0.020*** (-0.03, -0.01)	-0.018*** (-0.02, -0.01)	-0.015*** (-0.02, -0.01)
Educational courses	-0.005 (-0.01, 0.00)	-0.006 (-0.01, 0.00)	-0.003 (-0.01, 0.01)
Sports/social club	-0.021*** (-0.03, -0.01)	-0.020*** (-0.03, -0.01)	-0.015*** (-0.02, -0.01)
Non-religious organizations	0.001 (-0.01, 0.01)	0.002 (-0.01, 0.01)	0.001 (-0.01, 0.01)
Internet activities	-0.013*** (-0.02, -0.01)	-0.012*** (-0.02, -0.01)	-0.008*** (-0.01, -0.00)
Community arts group	0.003 (-0.01, 0.01)	0.003 (-0.01, 0.01)	0.004 (-0.01, 0.01)
Religious services	-0.024*** (-0.03, -0.02)	-0.023*** (-0.03, -0.02)	-0.016*** (-0.02, -0.01)
<i>Demographic and socioeconomic characteristics</i>			
Age			
< 65 years old (ref.)			
65-74 years old		-0.025* (-0.04, -0.01)	-0.028** (-0.05, -0.01)
≥ 75 years old		-0.039*** (-0.06, -0.02)	-0.042*** (-0.06, -0.02)
Sex			
Male (ref.)			
Female		-0.013† (-0.03, 0.00)	-0.020* (-0.04, -0.00)
Race and ethnicity			
Non-Hispanic White (ref.)			
Non-Hispanic Black		0.013 (-0.01, 0.03)	0.003 (-0.02, 0.02)
Hispanic of any race		0.043* (0.00, 0.08)	0.039* (0.00, 0.08)
Non-Hispanic other race		-0.013† (-0.04, 0.01)	-0.019 (-0.04, 0.01)
Spending change after COVID			
About the same (ref.)			
Spending went up		0.061*** (0.04, 0.08)	0.050*** (0.03, 0.07)
Spending went down		-0.014 (-0.03, 0.01)	-0.007 (-0.03, 0.01)
Years of education		-0.003† (-0.01, 0.00)	-0.000 (-0.00, 0.00)
<i>Health components</i>			
Self-rated health (1-5)			-0.038*** (-0.05, -0.03)
Self-rated memory (1-5)			-0.018*** (-0.03, -0.01)
Healthcare needs delay (1-6)			0.009 (-0.01, 0.02)
CIDI-SF (depressive)			
No symptoms (ref.)			
Have symptoms			0.158*** (0.12, 0.19)
COVID diagnosed			
No one was diagnosed (ref.)			
Someone diagnosed			-0.041*** (-0.06, -0.02)
Intercept	2.944***	2.996***	3.092***
R²(mean)	0.080	0.095	0.156
Adjusted R²(mean)	0.078	0.092	0.152

Notes. ref = reference group *** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$

Group Regression by Marital Status

After grouping by marital status, a clear gradient association of each activity can be seen in Table 6. Full models are presented in Appendix Table 1-3. Married and partnered people had the highest number of activities that can significantly help reduce loneliness compared to the other two groups. After adjusting for the covariates, activity with children, participation in sports or social clubs, and Internet activities were the three most significant activities for married and partnered individuals. Compared with married/partnered with zero participation, daily participation in these three activities can reduce loneliness by 9.6%, 10.8%, and 5.4%¹⁵, respectively. Other charity work and religious services were also statistically significant towards married and partnered people at the $p < .01$ level, reducing 7.8% and 7.2% loneliness scores for those who insisted on daily participation compared with no engagement. The association of community arts groups with loneliness among married and partnered elderly was negative but only significant at the $p < .1$ level. However, it can help widowed elderly feel less lonely and give them a more excellent utility.

More activities had a protective association with widowed elderly than singles. While charity work and arts groups had the best utility on the widowed group compared to others, the activity of religious services was the best way for single older adults to reduce their loneliness scores. Overall, the association of social activities with loneliness was not particularly predisposed to the vulnerable groups (i.e., single or widowed individuals). On the contrary, more activities did have a more significant association with

¹⁵ Since I logged the loneliness score, the interpretation of the coefficients should be the percentage.

reducing married/partnered people's loneliness, but certain activities did have better utility for groups with no marital companionship. And the utility of activities for specific populations was enhanced compared to the non-group model. The coefficients of sports and social clubs, activities with children, and Internet use were all boosted in the married and partnered groups. At the same time, religious services were higher in singles, and arts groups were higher in widowed. Meanwhile, volunteering with youth still tended to increase loneliness but only for widowed older adults.

Regarding demographic factors, loneliness among married/partnered and single people decreased with aging. Females had less lonely feelings than males for married/partnered and single people. For married/partnered people, non-Hispanics of other races may have the lowest lonely feelings compared with non-Hispanic whites. Years of education did not make a significant association for each marital status. Increased household spending resulted in higher emotional damage for married/partnered and single people, and the latter increased more than married/partnered people. Overall, demographic factors had little association with loneliness among the widowed person.

In terms of health components, better health conditions significantly reduced lonely feelings for the three groups. Similar to the non-grouped model, married and partnered as well as single people showed that people getting contact with COVID diagnosis reported fewer lonely feelings than those who had not.

Table 6. Regression predicts the loneliness scores in different marital statuses for respondents engaging in various social activities ($N=4,506$; only present the main regression)

	Loneliness by Marital Status (95%CI)					
	Model 1			Model 3		
	Married/ Partnered	Single	Widowed	Married/ Partnered	Single	Widowed
<i>Social activities</i>						
Activities with children	-0.016*** (-0.02, -0.01)	-0.013** (-0.02, -0.00)	-0.009† (-0.02, 0.00)	-0.016*** (-0.02, -0.01)	-0.014** (-0.02, -0.01)	-0.008 (-0.02, 0.00)
Volunteer with the youth	0.004 (-0.01, 0.02)	0.015† (-0.00, 0.03)	0.027* (0.00, 0.05)	0.001 (-0.01, 0.01)	0.011 (-0.00, 0.03)	0.022† (-0.00, 0.04)
Other charity work	-0.016*** (-0.02, -0.01)	-0.017* (-0.03, -0.00)	-0.026* (-0.04, -0.01)	-0.013** (-0.02, -0.01)	-0.010 (-0.03, 0.01)	-0.021* (-0.04, -0.00)
Educational courses	-0.004 (-0.02, 0.01)	-0.012 (-0.03, 0.01)	-0.007 (-0.03, 0.02)	-0.001 (-0.01, 0.01)	-0.006 (-0.02, 0.01)	-0.009 (-0.03, 0.01)
Sports/social club	-0.023*** (-0.03, -0.01)	-0.015* (-0.03, -0.00)	-0.019* (-0.04, -0.00)	-0.018*** (-0.03, -0.01)	-0.007 (-0.02, 0.01)	-0.015† (-0.03, 0.00)
Non-religious organizations	0.001 (-0.01, 0.01)	0.004 (-0.01, 0.02)	-0.006 (-0.03, 0.02)	0.001 (-0.01, 0.01)	0.003 (-0.01, 0.02)	-0.006 (-0.03, 0.02)
Internet activities	-0.012*** (-0.02, -0.01)	-0.012*** (-0.02, -0.00)	-0.007† (-0.01, 0.00)	-0.009*** (-0.01, -0.00)	-0.004 (-0.01, 0.00)	-0.007† (-0.01, 0.00)
Community arts group	0.013* (0.00, 0.03)	-0.005 (-0.02, 0.01)	-0.023* (-0.04, -0.00)	0.012† (-0.00, 0.02)	0.003 (-0.01, 0.02)	-0.021* (-0.04, -0.00)
Religious services	-0.019*** (-0.03, -0.01)	-0.024*** (-0.04, -0.01)	-0.023*** (-0.04, -0.01)	-0.012** (-0.02, -0.00)	-0.017** (-0.03, -0.01)	-0.016* (-0.03, -0.00)
<i>Intercept</i>	2.907***	2.981***	2.944***	3.063***	3.201***	3.075***
<i>R²(mean)</i>	0.075	0.058	0.092	0.140	0.183	0.153
<i>Adjusted R²(mean)</i>	0.071	0.050	0.082	0.132	0.167	0.129

Notes. *** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$

Group Regression by Job Status

As with the analysis of loneliness by marital status, three models were also conducted to examine the moderating associations of job groups (Table 7). Each activity's association with loneliness was slightly influenced by controlling the demographic, socioeconomic, and health variables. In the work situation, the roles of activities showed a slightly higher level of protective utility for vulnerable groups, especially retired people, than for groups that already have specific social capital, which is different from the situation in marital status.

Charity work ($\beta=-0.027$) and Internet activity ($\beta=-0.013$) helped the unemployed far more than the other two groups and were all statistically significant for the three groups at different p-value levels. Volunteering with youth increased the loneliness of the unemployed after participation. However, it was only marginally associated ($p<.1$). Some activities could make a difference in loneliness for retirees, and playing with children was the most helpful activity ($\beta=-0.018$). Other functional activities for retirees were charity work, sports and social clubs, Internet activities, and religious services. Retirees benefited the most from the activity participation compared to the other two groups. Working people could also benefit from activities, especially participating in sports/social clubs and religious services. Only non-religious organizations' activity had no significant associations with loneliness among all the job groups.

With the adjustment of other control variables, the association of activity participation on loneliness was not attenuated by aging and disadvantaged job status – working and unemployed middle-old adults did not show a higher level of loneliness than

the youngest-old. The gender difference was significant among working and retired people, suggesting that women in both groups had lower loneliness than men. Non-Hispanics of other races were only meaningful in the unemployed group, with less lonely scores than non-Hispanic whites. Self-rated health and depressive symptoms were significant in all three groups. Higher personal satisfaction was related to lower loneliness scores, especially for the working person. Depressive symptoms increased the respondents' loneliness, especially when intertwined with working and unemployment status, showing a higher negative relationship.

Pandemic-induced spending changes were significantly associated with loneliness among working people and retirees, even though both groups were supposed to be in better and more stable financial positions than unemployed people. The influence channels are unclear, but increased time spent at home could be considered a potential variable. Because of the pandemic, older people who had to stay home increased their household spending, which also means less physical social connection, leading to increased feelings of loneliness. The unemployed, as mentioned above, was the least socially engaged group and may thus be less affected by the epidemic isolation. In addition, the positive association between being or knowing someone with a confirmed case of COVID-19 and loneliness was also found across groups with different work statuses.

Compared with the non-grouped regression, religious services and sports/social clubs had larger utility sizes for working people, charity work for the unemployed, and Internet use and with-children activity for retirees. It can be seen that retirees were more

likely to be healed through family interaction, and the other two groups preferred activities that included social interaction.

Table 7. Regression predicts the loneliness scores in different job statuses for respondents engaging in various social activities ($N=4,506$; only present the main regression)

	Loneliness by Job Status (95%CI)					
	Model 1			Model 3		
	Working	Unemployment/ other	Retired	Working	Unemployment/ other	Retired
Social activities						
Activities with children	-0.016*** (-0.02, -0.01)	-0.007 (-0.02,0.00)	-0.018*** (-0.02, -0.01)	-0.015*** (-0.02, -0.01)	-0.008 (-0.02,0.00)	-0.018*** (-0.02, -0.01)
Volunteer with the youth	0.005 (-0.01,0.02)	0.020† (-0.00,0.04)	0.011† (-0.00,0.02)	0.000 (-0.01,0.01)	0.020† (-0.00,0.04)	0.008 (-0.00,0.02)
Other charity work	-0.018** (-0.03, -0.00)	-0.026* (-0.05, -0.00)	-0.017*** (-0.03, -0.01)	-0.013* (-0.03, -0.00)	-0.027* (-0.05, -0.00)	-0.013** (-0.02, -0.00)
Educational courses	-0.013† (-0.03,0.00)	-0.003 (-0.03,0.02)	0.003 (-0.01,0.02)	-0.010 (-0.02,0.00)	0.002 (-0.02,0.03)	0.005 (-0.01,0.02)
Sports/social club	-0.022*** (-0.03, -0.01)	-0.014 (-0.03,0.01)	-0.021*** (-0.03, -0.01)	-0.018** (-0.03, -0.01)	-0.009 (-0.03,0.01)	-0.015*** (-0.02, -0.01)
Non-religious organizations	0.006 (-0.01,0.02)	0.013 (-0.01,0.04)	-0.005 (-0.02,0.01)	0.006 (-0.01,0.02)	0.012 (-0.01,0.03)	-0.005 (-0.02,0.01)
Internet activities	-0.012*** (-0.02, -0.01)	-0.015*** (-0.02, -0.01)	-0.010*** (-0.01, -0.01)	-0.008† (-0.02,0.00)	-0.013** (-0.02, -0.00)	-0.007** (-0.01, -0.00)
Community arts group	0.011 (-0.01,0.03)	0.011 (-0.01,0.03)	-0.008 (-0.02,0.00)	0.015† (-0.00,0.03)	0.010 (-0.01,0.03)	-0.006 (-0.02,0.01)
Religious services	-0.027*** (-0.04, -0.02)	-0.028*** (-0.04, -0.01)	-0.017*** (-0.02, -0.01)	-0.020*** (-0.03, -0.01)	-0.016* (-0.03, -0.00)	-0.014*** (-0.02, -0.01)
<i>Intercept</i>	2.943***	2.998***	2.915***	3.148***	3.099***	3.008***
<i>R²(mean)</i>	0.087	0.057	0.077	0.157	0.180	0.134
<i>Adjusted R²(mean)</i>	0.081	0.045	0.073	0.143	0.153	0.126

Notes. *** $p < 0.01$, ** $p < 0.01$, * $p < 0.05$, † $p < 0.10$

Group Regression by Physical Health Conditions

The association between activity participation and loneliness moderated by physical health conditions is presented in Table 8. It shows that participation in activities had a better protective association with personal loneliness in vulnerable health groups.

In the fully adjusted model, with-children activity, club activity, and Internet activity were all significant across the three groups of different health statuses. The family activity was more protective for older adults with two or more physical symptoms. Club activity was more beneficial for people with moderate health status. Compared with the other two, Internet activity was the most helpful for the asymptomatic population to reduce loneliness. Besides, charity work had a more significant impact on people with poorer health (more than two symptoms), with each unit increase in the frequency of participation associated with a 2.1% reduction in loneliness. The activity of religious services was greatly associated with loneliness for people with moderate health status.

However, engaging in volunteer activities with youth and community arts groups showed counterintuitive associations with loneliness across groups of different health statuses. Participation in volunteer activity increased loneliness for people with poorer health status, and arts group activity increased loneliness in the other two groups with relatively better health status. Volunteering with young people appeared to increase loneliness in all settings.

Compared to the non-grouped model, the utility size of sports/social clubs was more prominent for the two healthy groups, Internet use was more beneficial for the disease-free group, the activity of religious services was for the moderately healthy

group, and charity work and family activity were more helpful to those afflicted by illness. People with more chronic diseases seemed more likely to relieve loneliness through activities with high spiritual comfort because of physical restraint and emotional emptiness. In contrast, the healthier group was more likely to reduce their lonely feelings through activities with sufficient social density.

A similar pattern was observed for marital and work status: there was no trend toward an increase in loneliness with age. Increased household spending due to COVID-19 could increase loneliness in people with poorer health. Those with the worst health could not even reduce lonely emotions by spending less. Being or knowing a confirmed case around them is also associated with lower loneliness in the two poorer health groups. Meanwhile, the associations between health components and loneliness showed consistent results with previous models: while better health and memory evaluations showed lower loneliness, depression led to higher loneliness.

Table 8. Regression predicts the loneliness scores in different physical health conditions for respondents engaging in various social activities ($N=4,506$; only present the main regression)

	Loneliness by Physical Health Conditions (95%CI)					
	Model 1			Model 3		
	None symptom	One/Two symptoms	More than two symptoms	None symptom	One/Two symptoms	More than two symptoms
<i>Social activities</i>						
Activities with children	-0.017** (-0.03, -0.00)	-0.010** (-0.02, -0.00)	-0.020*** (-0.03, -0.01)	-0.015* (-0.03, -0.00)	-0.010** (-0.02, -0.00)	-0.020*** (-0.03, -0.01)
Volunteer with the youth	0.001 (-0.02,0.03)	0.003 (-0.01,0.01)	0.028*** (0.01,0.04)	-0.000 (-0.03,0.02)	-0.003 (-0.01,0.01)	0.023*** (0.01,0.04)
Other charity work	-0.013 (-0.03,0.01)	-0.014** (-0.02, -0.00)	-0.027*** (-0.04, -0.02)	-0.010 (-0.03,0.01)	-0.009† (-0.02,0.00)	-0.021*** (-0.03, -0.01)
Educational courses	-0.010 (-0.03,0.01)	-0.004 (-0.02,0.01)	-0.001 (-0.02,0.01)	-0.009 (-0.03,0.02)	-0.003 (-0.02,0.01)	-0.002 (-0.02,0.01)
Sports/social club	-0.016† (-0.03,0.00)	-0.022*** (-0.03, -0.01)	-0.018** (-0.03, -0.01)	-0.017† (-0.04,0.00)	-0.018*** (-0.03, -0.01)	-0.011* (-0.02, -0.00)
Non-religious organizations	0.019 (-0.01,0.04)	-0.009 (-0.02,0.00)	0.006 (-0.01,0.02)	0.021 (-0.00,0.05)	-0.008 (-0.02,0.00)	0.005 (-0.01,0.02)
Internet activities	-0.026*** (-0.04, -0.01)	-0.010*** (-0.01, -0.00)	-0.009*** (-0.01, -0.00)	-0.023** (-0.04, -0.01)	-0.007* (-0.01, -0.00)	-0.007** (-0.01, -0.00)
Community arts group	0.022 (-0.01,0.05)	0.010 (-0.00,0.02)	-0.011 (-0.03,0.00)	0.025† (-0.00,0.05)	0.011† (-0.00,0.02)	-0.009 (-0.02,0.01)
Religious services	-0.016† (-0.03,0.00)	-0.024*** (-0.03, -0.02)	-0.024*** (-0.03, -0.02)	-0.015 (-0.03,0.00)	-0.018*** (-0.03, -0.01)	-0.014** (-0.02, -0.00)
<i>Intercept</i>	2.929***	2.903***	2.971***	3.010***	3.048***	3.135***
<i>R²(mean)</i>	0.095	0.073	0.077	0.131	0.133	0.173
<i>Adjusted R²(mean)</i>	0.077	0.069	0.073	0.085	0.124	0.164

Notes. *** $p < 001$, ** $p < 01$, * $p < 05$, † $p < 10$

DISCUSSION AND LIMITATION

The activity theory has been well-studied in the existing research showing the benefits of activity participation for successful aging in life (Adams et al. 2011; Burnett-Wolle and Godbey 2007; DeLiema 2018; Haucke et al. 2022; Lai and Qin 2018; Lemon et al. 1972b; Santino et al. 2020; Sia et al. 2022; Smith and Pollak 2022). Loneliness, as one of the main problems that negatively affect the health and vitality of older adults, can also be well mitigated by participation in social activity. However, the critics of activity theory state that it overlooks diversity among the elderly. Inequalities in health and sociodemographic environment would hinder the ability of older people to participate in certain activities. Therefore, given the unequal background of the elderly, it is essential to understand which activities work best for certain groups to gain a complete picture of what factors encourage and attract older adults to such actions.

Some previous studies have contributed to the activity theory by classification based on the attributes (Kim and Kim 2022; Li and Tang 2022; Teh and Tey 2019). Compared with focusing only on specific activities, category events can provide a broader and more flexible range of options (e.g., how older adults participate in social events and which activities they may choose to attend). Therefore, this thesis classified the nine activities into four categories.

Figure 2 graphically shows the significant regression results of the four models discussed above¹⁶. Through the coefficient position, it can be seen which

¹⁶ The table version is listed in the Appendix 4.

activities have more excellent utility for a particular group than the overall, and thus to find patterns for different portfolio preferences (group + activity).

Based on the activity map organized in the thesis, I grouped volunteering with the youth, other charitable work, and religious services as highly productive-active activity (Type I). This type of activity can simultaneously engage older adults in social connection, a sense of accomplishment and satisfaction, and good exercise opportunities. It can be seen from Figure 2 that compared with the other two, highly productive-active activity is the most helpful type for the elderly in the sample, and is more beneficial to those disadvantaged groups who were not accompanied by marriage, have less professional capital, and have poorer health. Combined with the intervention logic mentioned above, this type of activity undoubtedly meets all the requirements to reduce loneliness. At the same time, all three activities have their cultural and social significance. The essence of these activities is to take altruism as the core principle and help participants gain cohesion through spiritual strength. Filling up a person's feeling of being needed was more protective towards vulnerable persons.

The second category is a moderately productive activity, which includes sports and social clubs, educational programs, non-religious organizations, and community arts groups. This type of activity is characterized by a social and interest focus. What has been gained through participation in these activities far outweighs what participants need to contribute. This type of activity will help participants gain instant gratification and happiness, as they can participate

entirely voluntarily based on their interests (educational projects, which seem to be serious activities, are essentially a choice of interests for the elderly because of non-mandatory characteristics). People can also acquire social capital and social relationships through these interest activities. According to the active-sedentary dimension, there are two types in the second category. One is moderately productive-active activity, including sports and social clubs and community arts groups (Type II), while the other is moderately productive-sedentary activity, including educational programs and non-religious organizations meetings (Type III). Compared to the first type, Type II was more useful to older adults with better social relationships and relatively good health conditions. Still, it was the least correlated with respondents' loneliness compared to the other types. Type III was the only type that had no association with the loneliness of any group. However, the significance of sedentary behaviors still has to be investigated using more databases.

The last type of activity (Type IV) is consumptive activity. Participants have less opportunity to develop more potential social capital and social connections but can still socialize with others by participating in this type of activity. The characteristics of this type are more contact with familiar members, such as family, friends, acquaintances, etc., and remote communication. Despite the ambiguous meaning of Internet use in the HRS questionnaire, it showed a beneficial relationship in alleviating loneliness among older adults in the sample with little protective tendencies towards a particular group. Overall, consumptive

activity did not provide more security opportunities for the loneliness of vulnerable people with few marital relationships and poorer health but was better for disadvantaged groups in job status.

Furthermore, there is another way to categorize these two consumptive activities -- "*routine activity*". Previous studies have highlighted the critical role of "*everyday life activities*" for older adults based on continuity theory. Because of the stable "biological, social, and regulatory rhythms" that exist in older adults' lives before they leave society, the impact of such daily/weekly fixed-patterned activities on the well-being of older adults is particularly essential. The intervention mechanism of these activities on reducing the negative emotions of the elderly is not only through the activities attributes (such as social or emotional enjoyment, etc.) but through the implicit meaning of doing activities, such as an inertia of taking social responsibility, a "busy ethic," and a disguised sense of social participation (Lassen et al. 2020). Similar to the inductive logic of activities with spiritual power mentioned above, activities classified according to the rules of "daily activities" are more based on their cultural connotations, which are more specific and life-oriented symbols. Activities with any attribute can be included, providing a new research direction for activity classification analysis.

Overall, other charity works, religious services, activities with children, and Internet use were the four activities that played essential roles on the lonely feelings of the older adults in the sample. From the perspective of the activity category, highly productive-active activity with spiritual strength was the most

protective way to reduce loneliness in vulnerable groups. Interest activity can only be icing on the cake, not helping when the people need it most. Consumptive activity dependent on familiar and online connections benefited the loneliness of work-disadvantaged groups more, but did not appear discrepancy within different physical health groups and showed more protection to the married/partnered people. From the perspective of group statuses, married and partnered people would be intervened by social activities better than the other two groups; Retirees benefited the most from social participation, but working people could also get a good utility on alleviating loneliness through activity, while unemployed had the weakest associations between various activities and loneliness; the poorest healthy group had more potential to alleviate loneliness through participation in activities, primarily through helping others. Therefore, those already well-connected were more likely to benefit from social involvement, which is partially contrary to the hypothesis made above in this thesis. Married/partnered and working people could still benefit more from activity participation to reduce loneliness. In contrast, healthy people do not benefit more than the less healthy groups. The social capital of this sample shows its cumulative capacity for more connections and relationships.

In addition, another unreasonable place in the analysis needs to be emphasized: the negative relationships between certain activities and loneliness. Volunteering with youth was negatively associated with loneliness among widowed, unemployed, or those with the worst health status. In contrast,

community arts groups were negatively associated with loneliness among those who were married, working, or in better health conditions. This sample showed that the former was not beneficial to disadvantaged groups, and the latter was not helpful to advantaged groups. Although these unusual relationships were prone to association patterns, more empirical evidence is still needed to draw theoretical conclusions, given the possibility of sample bias¹⁷. At the same time, it is also necessary to mention three outliers in the database to be paid attention to. First, most of the respondents in the 2020 HRS database had higher levels of loneliness; age was not associated with greater loneliness; and being or knowing a confirmed case of COVID was associated with higher loneliness scores, which cannot be explained in this thesis.

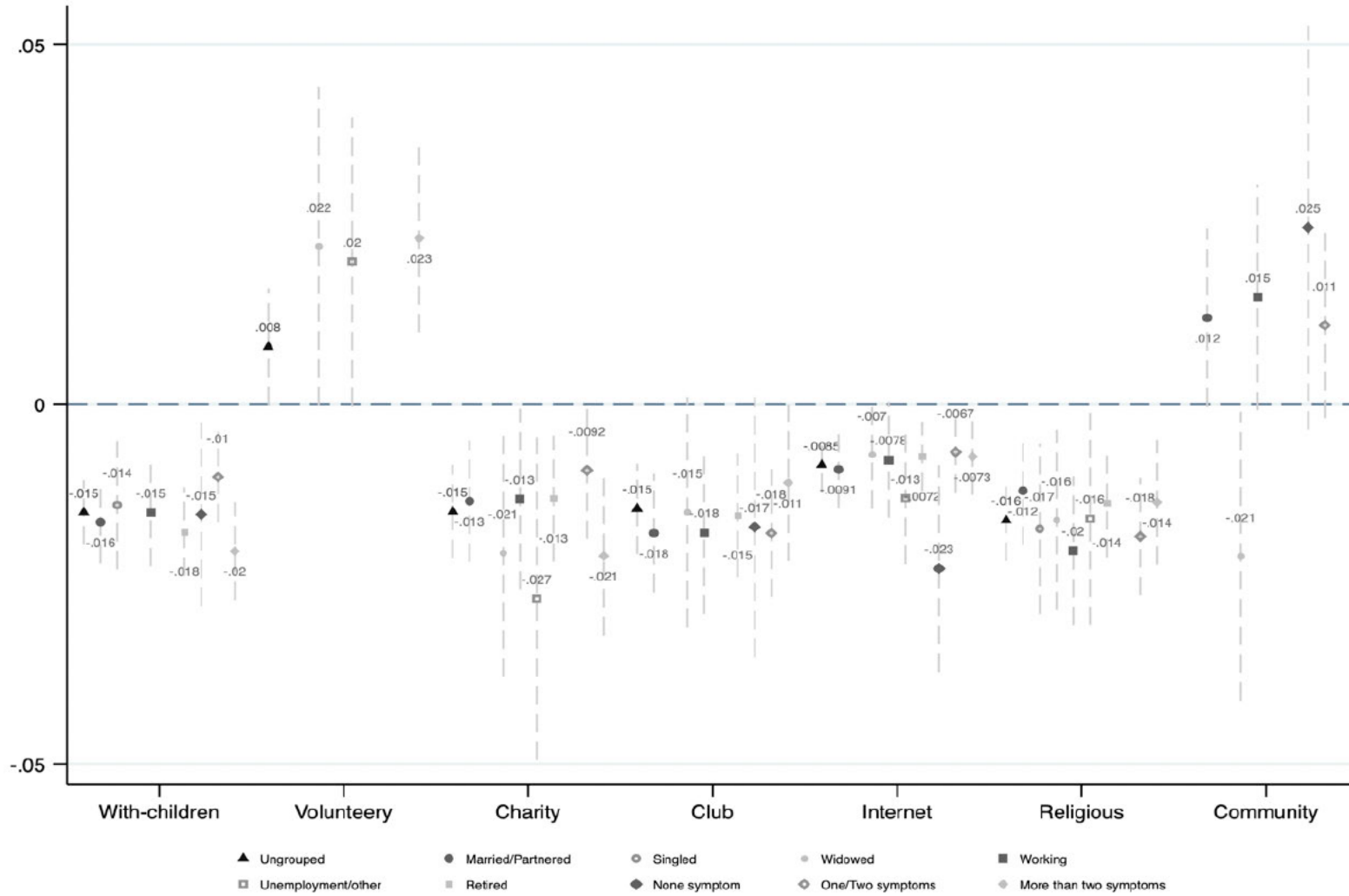
Therefore, it can be seen that the limitations of this thesis are apparent. Firstly, as mentioned above, the thesis fails to explain some anomalous results. A possible reason is that some latent factors still need to be identified, so the explanation of the activity mechanism is not sufficient. Secondly, since this thesis did not use longitudinal data, it is impossible to clarify the causal effect of activity types on loneliness; at the same time, it is also impossible to theoretically summarize the impact of social context changes on activity intervention effects from a life-course perspective.

¹⁷ These two activities had the lowest participation in the sample (around 20%). This may be one of the reasons for the negative relationship with loneliness. Fewer cases weaken explanatory power.

In addition, the impact of the epidemic on the loneliness of the elderly cannot be fully clarified in the thesis. As mentioned earlier, the Coronavirus is a crucial factor that should be considered because of the unusually large-scale life changes, the severe death threats for the elderly, and the long-term isolation living. However, the 2020 HRS data are insufficient to analyze infection's danger or consequences in older adults¹⁸. It requires a re-examination of the impact of COVID-19 on loneliness among older adults. Finally, the activity map compiled in this thesis needs to add more activities to test its effectiveness, such as solitary activities.

¹⁸ The 2020HRS data suggest a low proportion of infections, but this is questionable given data from other sources

Figure 3. Graphical representation of the significant regression results of the four models



CONCLUSION

The thesis summarizes how diverse types of activities are associated with loneliness among older adults and how this association varies across groups according to marital status, employment status, and physical health conditions. The four regression models showed group differences in the association between activity types and reduction in loneliness.

I first defined three dimensions for classifying leisure activity based on the previous studies: sedentary-active, solitary-social, and productive-consumptive. The sedentary and active dimension is based on the degree of physical exertion of the activity, the sedentary and social dimension is based on the number of participants in the activity, and the productive and consumptive dimension is based on how likely the activity is to generate social capital or skill learning opportunities. Then, I categorized the social activities examined in the HRS into four types: highly productive-active activity, including volunteer, charity, and religious activities; moderately productive-active activity and moderately productive-sedentary activity, including four social activities based on personal interests; and consumptive activities, including internet and with-children activities with low-intensity social interaction.

I conclude that highly productive-active activities had the best utility in alleviating loneliness for vulnerable populations. The consumptive activity could help people with employment disadvantaged. Active hobbies were more beneficial for those with good social relationships. And sedentary interests might give almost little assistance to any group.

In the thesis, activity participation has no apparent protective tendency to alleviate the loneliness of vulnerable groups. Social capital in the sample reflects its accumulation ability. Therefore, follow-up research should pay more attention to the life course theory to explore how the previous life shapes social capital and the health conditions of the elderly in their later life.

Furthermore, inspired by the analysis of the pandemic, understanding the pathways through which macro-social factors affect the lives of older adults is important for identifying effective interventions to complete the integration process of older adults (Perrig-Chiello et al. 2016). Besides, this thesis only selects one node (loneliness) in the whole system for analysis to avoid confused and unclear relationships. However, the integration of the elderly is multifaceted and complex, and it is necessary to clarify how to define the position of loneliness in the entire system. At the same time, it is also vital to explain how to measure aggregated indicators that include many factors, such as integration system, life satisfaction, and well-being, in a comprehensive and operable manner.

In addition to the classification of social activities, another contribution point of the thesis is to consider the heterogeneity of the elderly, which is crucial for policymakers and government personnel to implement and formulate a suitable way to achieve a prosperous old age. However, the grouping of the elderly in this thesis still follows the static and traditional principles while ignoring the dynamic characteristics of today's aging society. For example, the trend of today's older adults to live more independent lives; the impact of ethnic diversity on older adults' lives brought about by the wave of

world migration last century, family changes (more older adults without families), and the intersectional effects of these factors on the living conditions of the elderly (Carr and Utz 2020). These are critical to the inclusion and quality of life of older adults but have yet to be further elucidated. Therefore, more relevant factors related to the heterogeneity of the elderly should be considered in future research.

APPENDIX

Appendix Table 1. Full model: Regression predicts the loneliness scores in different marital statuses for respondents engaging in various social activities ($N=4,506$)

	Loneliness by Marital Status (95%CI)								
	Model 1			Model2			Model 3		
	Married/ Partnered	Single	Widowed	Married/ Partnered	Single	Widowed	Married/ Partnered	Single	Widowed
<i>Social activities</i>									
Activities with children	-0.016*** (-0.02, -0.01)	-0.013** (-0.02, -0.00)	-0.009† (-0.02, 0.00)	-0.017*** (-0.02, -0.01)	-0.016*** (-0.02, -0.01)	-0.009† (-0.02, 0.00)	-0.016*** (-0.02, -0.01)	-0.014** (-0.02, -0.01)	-0.008 (-0.02, 0.00)
Volunteer with youth	0.004 (-0.01, 0.02)	0.015† (-0.00, 0.03)	0.027* (0.00, 0.05)	0.002 (-0.01, 0.01)	0.011 (-0.00, 0.03)	0.026* (0.00, 0.05)	0.001 (-0.01, 0.01)	0.011 (-0.00, 0.03)	0.022† (-0.00, 0.04)
Other charity work	-0.016*** (-0.02, -0.01)	-0.017* (-0.03, -0.00)	-0.026* (-0.04, -0.01)	-0.015*** (-0.02, -0.01)	-0.014† (-0.03, 0.00)	-0.026** (-0.04, -0.01)	-0.013** (-0.02, -0.01)	-0.010 (-0.03, 0.01)	-0.021* (-0.04, -0.00)
Educational courses	-0.004 (-0.02, 0.01)	-0.012 (-0.03, 0.01)	-0.007 (-0.03, 0.02)	-0.005 (-0.02, 0.01)	-0.01 (-0.03, 0.01)	-0.008 (-0.03, 0.01)	-0.001 (-0.01, 0.01)	-0.006 (-0.02, 0.01)	-0.009 (-0.03, 0.01)
Sports/social club	-0.023*** (-0.03, -0.01)	-0.015* (-0.03, -0.00)	-0.019* (-0.04, -0.00)	-0.023*** (-0.03, -0.01)	-0.014† (-0.03, 0.00)	-0.020* (-0.04, -0.00)	-0.018*** (-0.03, -0.01)	-0.007 (-0.02, 0.01)	-0.015† (-0.03, 0.00)
Non-religious organizations	0.001 (-0.01, 0.01)	0.004 (-0.01, 0.02)	-0.006 (-0.03, 0.02)	0.002 (-0.01, 0.01)	0.005 (-0.01, 0.02)	-0.005 (-0.03, 0.02)	0.001 (-0.01, 0.01)	0.003 (-0.01, 0.02)	-0.006 (-0.03, 0.02)
Internet activities	-0.012*** (-0.02, -0.01)	-0.012*** (-0.02, -0.00)	-0.007† (-0.01, 0.00)	-0.012*** (-0.02, -0.01)	-0.010** (-0.02, -0.00)	-0.009* (-0.02, -0.00)	-0.009*** (-0.01, -0.00)	-0.004 (-0.01, 0.00)	-0.007† (-0.01, 0.00)
Community arts group	0.013* (0.00, 0.03)	-0.005 (-0.02, 0.01)	-0.023* (-0.04, -0.00)	0.014* (0.00, 0.03)	-0.004 (-0.02, 0.01)	-0.023* (-0.04, -0.00)	0.012† (-0.00, 0.02)	0.003 (-0.01, 0.02)	-0.021* (-0.04, -0.00)
Religious services	-0.019*** (-0.03, -0.01)	-0.024*** (-0.04, -0.01)	-0.023*** (-0.04, -0.01)	-0.017*** (-0.02, -0.01)	-0.025*** (-0.04, -0.01)	-0.022*** (-0.03, -0.01)	-0.012** (-0.02, -0.00)	-0.017** (-0.03, -0.01)	-0.016* (-0.03, -0.00)
<i>Demographic and socioeconomic characteristics</i>									
Age									
< 65 years old (ref)									
65-74 years old				-0.023† (-0.05, 0.00)	-0.023 (-0.06, 0.01)	-0.03 (-0.09, 0.03)	-0.028* (-0.05, -0.00)	-0.023 (-0.06, 0.01)	-0.029 (-0.09, 0.03)
≥ 75 years old				-0.048** (-0.08, -0.02)	-0.058* (-0.10, -0.01)	-0.041 (-0.10, 0.02)	-0.055*** (-0.08, -0.03)	-0.057* (-0.10, -0.01)	-0.038 (-0.10, 0.02)
Sex									
Male (ref)									
Female				-0.036*** (-0.06, -0.02)	-0.025 (-0.06, 0.01)	-0.001 (-0.05, 0.04)	-0.038*** (-0.06, -0.02)	-0.040* (-0.07, -0.01)	-0.003 (-0.05, 0.04)
Race and ethnicity									
Non-Hispanic White (ref)									
Non-Hispanic Black				-0.008 (-0.04, 0.02)	0.02 (-0.02, 0.06)	-0.015 (-0.06, 0.03)	-0.017 (-0.05, 0.01)	0.016 (-0.02, 0.05)	-0.026 (-0.07, 0.02)
Hispanic of any race				0.031 (-0.02, 0.08)	0.067† (-0.01, 0.14)	-0.002 (-0.12, 0.11)	0.040 (-0.01, 0.09)	0.043 (-0.03, 0.11)	-0.017 (-0.13, 0.10)
Non-Hispanic other race				-0.020 (-0.05, 0.01)	0.037 (-0.02, 0.09)	-0.050 (-0.12, 0.02)	-0.031† (-0.06, 0.00)	0.038 (-0.01, 0.09)	-0.047 (-0.11, 0.02)

Spending change after COVID										
About the same (ref)										
Spending went up	0 062***	0 076***	0 013	0 049***	0 068***	0 007				
	(0 03,0 09)	(0 04,0 12)	(-0 03,0 06)	(0 02,0 08)	(0 03,0 11)	(-0 04,0 05)				
Spending went down	-0 010	-0 028	0 026	-0 008	-0 008	0 030				
	(-0 04,0 01)	(-0 07,0 01)	(-0 03,0 08)	(-0 03,0 02)	(-0 05,0 03)	(-0 02,0 08)				
Years of education	-0 004†	-0 003	-0 003	-0 002	-0 000	0 003				
	(-0 01,0 00)	(-0 01,0 00)	(-0 01,0 00)	(-0 01,0 00)	(-0 01,0 01)	(-0 00,0 01)				
Health components										
Self-rated health (1-5)				-0 028***	-0 054***	-0 036***				
				(-0 04, -0 02)	(-0 07, -0 04)	(-0 06, -0 02)				
Self-rated memory (1-5)				-0 020**	-0 019*	-0 019†				
				(-0 03, -0 01)	(-0 04, -0 00)	(-0 04,0 00)				
Healthcare delayed (1-6)				0 013	-0 004	0 005				
				(-0 01,0 03)	(-0 03,0 02)	(-0 03,0 04)				
CIDI-SF (depressive)										
No symptoms (ref)										
Have symptoms				0 177***	0 126***	0 139***				
				(0 13,0 23)	(0 07,0 18)	(0 06,0 21)				
COVID diagnosed										
No one diagnosed (ref)										
Someone diagnosed				-0 027*	-0 073***	-0 033				
				(-0 05, -0 01)	(-0 11, -0 03)	(-0 08,0 02)				
<i>Intercept</i>	2 907***	2 981***	2 944***	2 987***	3 020***	2 997***	3 063***	3 201***	3 075***	
<i>R²(mean)</i>	0 075	0 058	0 092	0 093	0 091	0 097	0 140	0 183	0 153	
<i>Adjusted R²(mean)</i>	0 071	0 050	0 082	0 086	0 077	0 077	0 132	0 167	0 129	

Notes. ref. = reference group. *** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$.

Appendix Table 2. Full model: Regression predicts the loneliness scores in different job statuses for respondents engaging in various social activities ($N=4,506$)

	Loneliness by Job Status (95%CI)								
	Model 1			Model2			Model 3		
	Working	Unemployment/ Other	Retired	Working	Unemployment /Other	Retired	Working	Unemployment /Other	Retired
Social activities									
Activities with children	-0.016*** (-0.02, -0.01)	-0.007 (-0.02, 0.00)	-0.018*** (-0.02, -0.01)	-0.016*** (-0.02, -0.01)	-0.008 (-0.02, 0.00)	-0.019*** (-0.02, -0.01)	-0.015*** (-0.02, -0.01)	-0.008 (-0.02, 0.00)	-0.018*** (-0.02, -0.01)
Volunteer with youth	0.005 (-0.01, 0.02)	0.020† (-0.00, 0.04)	0.011† (-0.00, 0.02)	0.003 (-0.01, 0.02)	0.019† (-0.00, 0.04)	0.008 (-0.00, 0.02)	0.000 (-0.01, 0.01)	0.020† (-0.00, 0.04)	0.008 (-0.00, 0.02)
Other charity work	-0.018** (-0.03, -0.00)	-0.026* (-0.05, -0.00)	-0.017*** (-0.03, -0.01)	-0.016* (-0.03, -0.00)	-0.029* (-0.05, -0.01)	-0.016*** (-0.02, -0.01)	-0.013* (-0.03, -0.00)	-0.027* (-0.05, -0.00)	-0.013** (-0.02, -0.00)
Educational courses	-0.013† (-0.03, 0.00)	-0.003 (-0.03, 0.02)	0.003 (-0.01, 0.02)	-0.014† (-0.03, 0.00)	-0.001 (-0.03, 0.02)	0.005 (-0.01, 0.02)	-0.010 (-0.02, 0.00)	0.002 (-0.02, 0.03)	0.005 (-0.01, 0.02)
Sports/social club	-0.022*** (-0.03, -0.01)	-0.014 (-0.03, 0.01)	-0.021*** (-0.03, -0.01)	-0.022*** (-0.03, -0.01)	-0.017† (-0.04, 0.00)	-0.020*** (-0.03, -0.01)	-0.018** (-0.03, -0.01)	-0.009 (-0.03, 0.01)	-0.015*** (-0.02, -0.01)
Non-religious organizations	0.006 (-0.01, 0.02)	0.013 (-0.01, 0.04)	-0.005 (-0.02, 0.01)	0.007 (-0.01, 0.02)	0.014 (-0.01, 0.04)	-0.005 (-0.02, 0.01)	0.006 (-0.01, 0.02)	0.012 (-0.01, 0.03)	-0.005 (-0.02, 0.01)
Internet activities	-0.012*** (-0.02, -0.01)	-0.015*** (-0.02, -0.01)	-0.010*** (-0.01, -0.01)	-0.011** (-0.02, -0.00)	-0.019*** (-0.03, -0.01)	-0.009*** (-0.01, -0.00)	-0.008† (-0.02, 0.00)	-0.013** (-0.02, -0.00)	-0.007** (-0.01, -0.00)
Community arts group	0.011 (-0.01, 0.03)	0.011 (-0.01, 0.03)	-0.008 (-0.02, 0.00)	0.012 (-0.00, 0.03)	0.012 (-0.01, 0.04)	-0.007 (-0.02, 0.01)	0.015† (-0.00, 0.03)	0.010 (-0.01, 0.03)	-0.006 (-0.02, 0.01)
Religious services	-0.027*** (-0.04, -0.02)	-0.028*** (-0.04, -0.01)	-0.017*** (-0.02, -0.01)	-0.028*** (-0.04, -0.02)	-0.027*** (-0.04, -0.01)	-0.017*** (-0.02, -0.01)	-0.020*** (-0.03, -0.01)	-0.016* (-0.03, -0.00)	-0.014*** (-0.02, -0.01)
Demographic and socioeconomic characteristics									
Age									
< 65 years old (ref)									
65-74 years old				-0.029† (-0.06, 0.00)	-0.058* (-0.11, -0.01)	0.023 (-0.01, 0.06)	-0.034* (-0.07, -0.00)	-0.052* (-0.10, -0.01)	0.011 (-0.03, 0.05)
≥ 75 years old				-0.034 (-0.09, 0.02)	-0.066† (-0.14, 0.01)	0.007 (-0.03, 0.04)	-0.042 (-0.09, 0.01)	-0.057 (-0.13, 0.01)	-0.008 (-0.05, 0.03)
Sex									
Male (ref)									
Female				-0.017 (-0.05, 0.01)	0.048* (0.01, 0.09)	-0.027* (-0.05, -0.01)	-0.027† (-0.05, 0.00)	0.030 (-0.01, 0.07)	-0.030** (-0.05, -0.01)
Race and ethnicity									
Non-Hispanic White (ref)									
Non-Hispanic Black				0.019 (-0.02, 0.06)	-0.040 (-0.09, 0.01)	0.012 (-0.02, 0.04)	0.010 (-0.03, 0.05)	-0.027 (-0.08, 0.02)	0.002 (-0.03, 0.03)
Hispanic of any race				0.046 (-0.01, 0.10)	0.005 (-0.09, 0.10)	0.044 (-0.02, 0.11)	0.045 (-0.01, 0.10)	0.010 (-0.08, 0.10)	0.037 (-0.03, 0.10)
Non-Hispanic other race				0.001 (-0.04, 0.04)	-0.086** (-0.15, -0.02)	0.007 (-0.03, 0.05)	-0.012 (-0.05, 0.03)	-0.067* (-0.13, -0.01)	-0.003 (-0.04, 0.04)
Spending change after COVID									
About the same (ref)									
Spending went up				0.062**	0.045†	0.059***	0.053**	0.040	0.050***

			(0 02,0 10)	(-0 00,0 09)	(0 03,0 09)	(0 02,0 09)	(-0 01,0 09)	(0 02,0 08)
Spending went down			-0 020	0 023	-0 024†	-0 012	0 044	-0 020
Years of education			(-0 05,0 01)	(-0 03,0 08)	(-0 05,0 00)	(-0 04,0 02)	(-0 01,0 10)	(-0 05,0 01)
			-0 003	-0 005	-0 001	-0 001	-0 002	0 002
			(-0 01,0 00)	(-0 01,0 00)	(-0 01,0 00)	(-0 01,0 00)	(-0 01,0 01)	(-0 00,0 01)
Health components								
Self-rated health (1-5)						-0 044***	-0 036**	-0 032***
						(-0 06, -0 03)	(-0 06, -0 01)	(-0 04, -0 02)
Self-rated memory (1-5)						-0 014†	-0 016	-0 019**
						(-0 03,0 00)	(-0 04,0 01)	(-0 03, -0 01)
Healthcare needs delay (1-6)						-0 004	0 014	0 014
						(-0 03,0 02)	(-0 02,0 04)	(-0 01,0 03)
CIDI-SF (depressive)								
No symptoms (ref)								
Have symptoms						0 161***	0 166***	0 135***
						(0 10,0 22)	(0 11,0 22)	(0 08,0 19)
COVID diagnosed								
No one was diagnosed (ref)								
Someone diagnosed						-0 034*	-0 054*	-0 039**
						(-0 06, -0 00)	(-0 10, -0 00)	(-0 06, -0 01)
<i>Intercept</i>	2 943***	2 998***	2 915***	2 982***	3 072***	2 918***	3 148***	3 099***
<i>R²(mean)</i>	0 087	0 057	0 077	0 105	0 087	0 091	0 157	0 180
<i>Adjusted R²(mean)</i>	0 081	0 045	0 073	0 093	0 063	0 084	0 143	0 153

Notes. ref. = reference group. *** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$

Appendix Table 3. Full model: Regression predicts the loneliness scores in different physical health conditions for respondents engaging in various social activities ($N=4,506$)

	Loneliness by Physical Health Conditions (95%CI)								
	Model 1			Model2			Model 3		
	No symptom	One/Two symptoms	More than two symptoms	No symptom	One/Two symptoms	More than two symptoms	No symptom	One/Two symptoms	More than two symptoms
Social activities									
Activities with children	-0.017** (-0.03, -0.00)	-0.010** (-0.02, -0.00)	-0.020*** (-0.03, -0.01)	-0.016* (-0.03, -0.00)	-0.010** (-0.02, -0.00)	-0.023*** (-0.03, -0.02)	-0.015* (-0.03, -0.00)	-0.010** (-0.02, -0.00)	-0.020*** (-0.03, -0.01)
Volunteer with youth	0.001 (-0.02, 0.03)	0.003 (-0.01, 0.01)	0.028*** (0.01, 0.04)	-0.001 (-0.03, 0.02)	-0.002 (-0.01, 0.01)	0.023*** (0.01, 0.04)	-0.000 (-0.03, 0.02)	-0.003 (-0.01, 0.01)	0.023*** (0.01, 0.04)
Other charity work	-0.013 (-0.03, 0.01)	-0.014** (-0.02, -0.00)	-0.027*** (-0.04, -0.02)	-0.011 (-0.03, 0.01)	-0.011* (-0.02, -0.00)	-0.025*** (-0.04, -0.01)	-0.010 (-0.03, 0.01)	-0.009† (-0.02, 0.00)	-0.021*** (-0.03, -0.01)
Educational courses	-0.010 (-0.03, 0.01)	-0.004 (-0.02, 0.01)	-0.001 (-0.02, 0.01)	-0.012 (-0.04, 0.01)	-0.005 (-0.02, 0.01)	-0.004 (-0.02, 0.01)	-0.009 (-0.03, 0.02)	-0.003 (-0.02, 0.01)	-0.002 (-0.02, 0.01)
Sports/social club	-0.016† (-0.03, 0.00)	-0.022*** (-0.03, -0.01)	-0.018** (-0.03, -0.01)	-0.017† (-0.03, 0.00)	-0.022*** (-0.03, -0.01)	-0.015** (-0.03, -0.00)	-0.017† (-0.04, 0.00)	-0.018*** (-0.03, -0.01)	-0.011* (-0.02, -0.00)
Non-religious org	0.019 (-0.01, 0.04)	-0.009 (-0.02, 0.00)	0.006 (-0.01, 0.02)	0.019 (-0.01, 0.04)	-0.008 (-0.02, 0.00)	0.008 (-0.01, 0.02)	0.021 (-0.00, 0.05)	-0.008 (-0.02, 0.00)	0.005 (-0.01, 0.02)
Internet activities	-0.026*** (-0.04, -0.01)	-0.010*** (-0.01, -0.00)	-0.009*** (-0.01, -0.00)	-0.026*** (-0.04, -0.01)	-0.009** (-0.01, -0.00)	-0.010*** (-0.02, -0.01)	-0.023** (-0.04, -0.01)	-0.007* (-0.01, -0.00)	-0.007** (-0.01, -0.00)
Community arts group	0.022 (-0.01, 0.05)	0.010 (-0.00, 0.02)	-0.011 (-0.03, 0.00)	0.022 (-0.01, 0.05)	0.012† (-0.00, 0.02)	-0.012 (-0.03, 0.00)	0.025† (-0.00, 0.05)	0.011† (-0.00, 0.02)	-0.009 (-0.02, 0.01)
Religious services	-0.016† (-0.03, 0.00)	-0.024*** (-0.03, -0.02)	-0.024*** (-0.03, -0.02)	-0.017† (-0.03, 0.00)	-0.023*** (-0.03, -0.01)	-0.021*** (-0.03, -0.01)	-0.015 (-0.03, 0.00)	-0.018*** (-0.03, -0.01)	-0.014** (-0.02, -0.00)
Demographic and socioeconomic characteristics									
Age									
< 65 years old (ref)									
65-74 years old				-0.015 (-0.07, 0.04)	-0.021 (-0.05, 0.01)	-0.080*** (-0.11, -0.05)	-0.016 (-0.07, 0.04)	-0.021 (-0.05, 0.00)	-0.067*** (-0.10, -0.04)
≥ 75 years old				-0.010 (-0.10, 0.08)	-0.035* (-0.07, -0.00)	-0.101*** (-0.13, -0.07)	-0.024 (-0.11, 0.06)	-0.035* (-0.07, -0.00)	-0.081*** (-0.11, -0.05)
Sex									
Male (ref)									
Female				-0.033 (-0.08, 0.01)	-0.025* (-0.05, -0.00)	-0.002 (-0.03, 0.02)	-0.033 (-0.08, 0.01)	-0.031** (-0.05, -0.01)	-0.009 (-0.03, 0.02)
Race and ethnicity									
Non-Hispanic White (ref)									
Non-Hispanic Black				0.044 (-0.03, 0.12)	0.010 (-0.02, 0.04)	-0.002 (-0.03, 0.03)	0.039 (-0.04, 0.11)	0.006 (-0.03, 0.04)	-0.007 (-0.04, 0.02)
Hispanic of any race				0.029 (-0.06, 0.11)	0.085** (0.03, 0.14)	0.018 (-0.05, 0.09)	0.029 (-0.06, 0.11)	0.071* (0.02, 0.13)	0.016 (-0.05, 0.09)
Non-Hispanic other race				0.003 (-0.07, 0.08)	-0.013 (-0.05, 0.02)	-0.007 (-0.05, 0.03)	-0.005 (-0.08, 0.07)	-0.020 (-0.05, 0.02)	-0.012 (-0.05, 0.03)
Spending change after COVID									
About the same (ref)									

Spending went up	-0.008 (-0.08, 0.06)	0.055*** (0.02, 0.09)	0.069*** (0.04, 0.10)	-0.017 (-0.09, 0.05)	0.050** (0.02, 0.08)	0.062*** (0.03, 0.09)
Spending went down	-0.021 (-0.08, 0.03)	-0.035* (-0.06, -0.01)	0.028 (-0.01, 0.06)	-0.021 (-0.08, 0.04)	-0.033* (-0.06, -0.01)	0.039* (0.01, 0.07)
Years of education	0.003 (-0.01, 0.01)	-0.002 (-0.01, 0.00)	-0.004 (-0.01, 0.00)	0.004 (-0.01, 0.01)	-0.001 (-0.01, 0.00)	-0.000 (-0.00, 0.00)
Health components						
Self-rated health (1-5)				-0.025 (-0.06, 0.01)	-0.023*** (-0.04, -0.01)	-0.041*** (-0.05, -0.03)
Self-rated memory (1-5)				-0.013 (-0.04, 0.02)	-0.017* (-0.03, -0.00)	-0.019** (-0.03, -0.01)
Healthcare needs delay (1-6)				0.013 (-0.03, 0.05)	0.004 (-0.02, 0.02)	0.011 (-0.01, 0.03)
CIDI-SF (depressive)						
No symptoms (ref.)						
Have symptoms				0.115 (-0.05, 0.28)	0.180*** (0.12, 0.24)	0.131*** (0.09, 0.17)
COVID diagnosed						
No one diagnosed (ref.)						
Someone diagnosed				-0.041 (-0.09, 0.01)	-0.027* (-0.05, -0.00)	-0.054*** (-0.08, -0.03)
<i>Intercept</i>	2.929***	2.903***	2.971***	2.909***	2.956***	3.072***
<i>R²(mean)</i>	0.095	0.073	0.077	0.106	0.096	0.110
<i>Adjusted R²(mean)</i>	0.077	0.069	0.073	0.069	0.088	0.101
					0.131	0.133
					0.085	0.124
						0.173
						0.164

Notes. ref. = reference group. *** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$.

Appendix Table 4. Summary of significant regression results of the four models

	Totally	Married	Singled	Widowed	Working	Unemployment	Retired	None symptom	One/Two symptoms	More than two symptoms
Highly productive-active activities										
Volunteer work with the youth	0.008†			0.022†		0.020†				0.023***
Do other charity work	-0.015***	-0.013**		-0.021*	-0.013*	-0.027*	-0.013**		-0.009†	-0.021***
Religious services	-0.016***	-0.012**	-0.017**	-0.016*	-0.020***	-0.016*	-0.014***		-0.018***	-0.014**
Moderately productive-active activities										
Sports/social club	-0.015***	-0.018***		-0.015†	-0.018**		-0.015***	-0.017†	-0.018***	-0.011*
Community arts group		0.012†		-0.021*	0.015†			0.025†	0.011†	
Moderately productive-sedentary activities										
Educational course										
Non-religious organization										
Consumptive activities										
Do activities with children	-0.015***	-0.016***	-0.014**		-0.015***		-0.018***	-0.015*	-0.010**	-0.020***
Internet use	-0.008***	-0.009***		-0.007†	-0.008†	-0.013**	-0.007**	-0.023**	-0.007*	-0.007**

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CURRICULUM VITAE

