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The Significance of Social Isolation and Loneliness among U.S. Older Adults During the Covid-19 Pandemic

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Abstract

The Significance of Social Isolation and Loneliness among U.S. Older Adults During the Covid-19 Pandemic

By Audrey Ling

This study examined the relationship between social isolation and loneliness among U.S. older adults during the Covid-19 pandemic with a unique opportunity to conduct a study when social isolation was high among the general population due to covid risk reduction measures. Data from the round 10 iteration and the covid module of the National Health and Aging Trends Survey (NHATS), representative of the age 70+ Medicare beneficiary population of older adults living in the United States, examined the dichotomized loneliness outcome, which identified those who experienced an increase in loneliness during the pandemic versus those who did not, using descriptive analytics and logistic regression. Findings from this analysis supported existing literature suggesting a limited correlation between the two concepts, further demonstrating that they are indeed unique as they share only a minimal correlation even when the larger population is more socially isolated. When comparing severe social isolation to social integration the association crossed the null (OR=1.6, 95% CI: 0.4, 6.9).

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Chapter 1. Introduction

The COVID-19 pandemic and measures to prevent illness resulted in huge changes in the way we connect with others. While there may be an expectation that lockdown measures resulting in an increase in social isolation would simultaneously increase loneliness, early research on the impact of covid restrictions on loneliness show conflicting evidence (Ray & Shebib, 2022). Additionally, earlier studies assert that loneliness and social isolation are distinct concepts and, while they may coexist, each may also occur on its own (Valtorta & Hanratty, 2013).

While the connection between physical illness and morbidity and mortality has long been understood, the growing body of research describing the impact of mental and social health is continuing to demonstrate their relationship to morbidity and mortality. Although current literature lacks reliable and consistent prevalence measures for both loneliness and social isolation among older adults there is ample evidence to suggest that these are common experiences among this age group living in the United States (Anderson, n.d.; Iliffe et al., 2007; Nicholson Jr., 2009; Nicholson, 2012; Taylor et al., 2016; Theeke, 2009).

Both social isolation and loneliness have been demonstrated to be a significant risk factor for negative health outcomes and early mortality (Holt-Lunstad et al., 2015; Leigh-Hunt et al., 2017; Luo et al., 2012; Rico-Uribe et al., 2018). Due to the growing population of older adults in the United States it is imperative to understand and address these concerns.

While loneliness is a subjective measure of how one experiences social isolation, social isolation objectively measures one's network size and strength (Cacioppo et al., 2006; Cornwell & Waite, 2009; Perlman, Daniel & Letitia Anne Peplau, n.d.; N. Valtorta & Hanratty, 2012). As such, they are distinct in the aspect of the experience they measure, yet related in that they are

measuring similar and potentially overlapping experiences. Furthermore, while loneliness and social isolation each have unique risk factors, they also share some overlapping risk factors including gender, marital status, and social network size (Cudjoe et al., 2020; Dahlberg et al., 2022; Holt-Lunstad, 2017; Theeke, 2009).

In considering older adults, who are known to be at a higher risk for serious illness or death due to a covid-19 infection, compared to adults under 65, the pandemic and its safety measures create a unique opportunity to understand how the risk of loneliness and/or social isolation among this population may have been impacted by covid safety measures, such as social distancing, and covid consequences, such as the loss of a partner.

The National Health and Aging Study (NHATS) is a longitudinal study conducted in the United States which is representative of adults over age 65 who are on Medicare and therefore is specific to our population of interest. During the 2020 data collection, NHATS included a COVID-19 supplement that provides information on covid prevention measures, living situations, and social activity along with the well-being section found in the standard survey which scores the frequency of various emotions including loneliness. The data present from the survey will allow us to understand how pre-pandemic risk factors for loneliness among older adults in the U.S. were influenced by the pandemic.

Chapter 2. Literature Review

While the connection between physical illness and morbidity and mortality has long been understood, the growing body of research describing the impact of mental and social health is continuing to demonstrate their relationship to morbidity and mortality. Although current literature lacks reliable and consistent prevalence measures for both loneliness and social

isolation among older adults there is ample evidence to suggest that these are common experiences among this age group living in the United States (Anderson, n.d.; Iliffe et al., 2007; Nicholson Jr., 2009; Nicholson, 2012; Taylor et al., 2016; Theeke, 2009). Moreover, each has been demonstrated to be a significant risk factor for negative health outcomes and early mortality (Holt-Lunstad et al., 2015; Leigh-Hunt et al., 2017; Luo et al., 2012; Rico-Uribe et al., 2018). Due to the growing population of older adults in the United States it is imperative to understand and address these concerns. While loneliness is a subjective measure of how one experiences social isolation, social isolation objectively measures one's network size and strength (Cacioppo et al., 2006; Cornwell & Waite, 2009; Perlman, Daniel & Letitia Anne Peplau, n.d.; N. Valtorta & Hanratty, 2012). As such, they are distinct in the aspect of the experience they measure, yet related in that they are measuring similar and potentially overlapping experiences. Furthermore, while loneliness and social isolation each have unique risk factors, they also share some overlapping risk factors including gender, marital status, and social network size (Cudjoe et al., 2020; Dahlberg et al., 2022; Holt-Lunstad, 2017; Theeke, 2009). In considering older adults who are known to be at a higher risk for serious illness or death due to a Covid-19 infection compared to adults under 65, the pandemic and its safety measures create a unique opportunity to understand how the risk of loneliness and/or social isolation among this population may have been impacted by covid safety measures, such as social distancing, and covid consequences, such as the loss of a partner.

2.1 Loneliness

Loneliness is defined as the subjective shortcoming between the desired and experienced quantity and quality of social relationships of an individual (Cacioppo et al., 2006; Perlman,

Daniel & Letitia Anne Peplau, n.d.). The subjective aspect of this measure allows for an understanding of loneliness in the context of people's varying needs rather than objectively measuring an individual's social interactions to determine whether someone is socially isolated (Cudjoe et al., 2020). Although precise prevalence estimates of loneliness among older adults in the United States are not yet available in peer-reviewed literature, data from an AARP survey demonstrate that approximately one-third of adults aged 45 and older experience loneliness (Anderson, n.d.). This helps quantify the significant burden of disease referenced in the literature throughout the past six decades (Theeke, 2009).

A systematic literature review examined and synthesized risk factors for loneliness among older adults from studies conducted in OECD (Organization for Economic Cooperation and Development) countries, however of the 34 studies included in the review, nine were contributed by the United States and ten by the Netherlands (Dahlberg et al., 2022). Loneliness has been demonstrated to be higher in countries that are more individualistic (Barreto et al., 2021). While the United States has the highest Hofstede individualism score among the countries included in the review, the studies were all from individualistic countries with the exception of one study from Israel and thus can provide information relevant and applicable to this study (*Country Comparison Tool*, n.d.; Dahlberg et al., 2022). While a few studies in the review included people as young as 40, most studies included those 50 or 55 and older, with two studies requiring participants to be at least 70 and a study in Israel requiring participants to be at least 75 years of age (Dahlberg et al., 2022). While 24 of the studies included measured loneliness through a validated scale measure (UCLA Loneliness and Jong-Gierveld scales), the remaining ten used a single item measure (Dahlberg et al., 2022). It is also of note that loneliness is generally underreported in studies which could also impact which risk factors are noted

(Hawkley & Kocherginsky, 2018). The key risk factors synthesized from the systematic review found that being unpartnered, perceiving one's own health as poor, having a small social network, and experiencing depression are all positively associated with experiencing loneliness (Dahlberg et al., 2022).

Loneliness is not only a distressing and common experience, but can result in negative health outcomes and contribute to premature mortality (Holt-Lunstad et al., 2015; Leigh-Hunt et al., 2017; Luo et al., 2012; Rico-Uribe et al., 2018). There are further distinctions within loneliness including temporality (situational vs. chronic) and typology (social, emotional, and existential) (Shiovitz-Ezra & Ayalon, 2010; van Tilburg, 2021, 2022). While those who experience situational and chronic loneliness both had higher mortality risk than those who did not experience either, the mortality risk in those chronically lonely was only somewhat higher than those categorized as situationally lonely (Shiovitz-Ezra & Ayalon, 2010). This suggests, given the context of the COVID-19 pandemic and the rising levels of loneliness described among older adults in the United States, there is not a need to differentiate between situational and chronic loneliness within this analysis (Killgore et al., 2020; Luchetti et al., 2020). However, a study conducted in the United Kingdom during covid lockdowns identifies that sociodemographic groups previously indicated to be at a higher risk for experiencing loneliness remained at higher risk during lockdown (Bu et al., 2020). Risk factors for loneliness defined prior to the covid pandemic including living alone, low household income and unemployment, and living in urban areas remained the same before and during the pandemic (Bu et al., 2020). The only risk factor with a notable change was being a student which changed from a moderate to greater risk factor before and during the pandemic respectively (Bu et al., 2020).

Typologies within loneliness as described in the literature include social, emotional, and existential loneliness (van Tilburg, 2021, 2022). Despite these distinctions within loneliness, when people report feeling loneliness, it is more strongly associated with emotional loneliness, however the body of research which specifically aims to compare all three is small (van Tilburg, 2021). This context is relevant when interpreting results around people's experiences of loneliness. Measures of loneliness in the literature include single and multi-question scale measures (Dahlberg et al., 2022). Scale measures include 3- and 20-item versions of the Revised UCLA Loneliness Scale as well as 6- and 11-item versions of the Jong-Gierveld Scale (Dahlberg et al., 2022).

The covid-19 supplement conducted shortly after round 10 data collection includes questions which specifically ask respondents how their levels of loneliness during the past week compare to their average levels of loneliness prior to the pandemic. This change variable is particularly useful given the context.

2.2 Social Isolation

While closely related to loneliness, social isolation is an objective measure of one's social interactions and participation levels (Cornwell & Waite, 2009). Some studies assert that loneliness and social isolation are distinct concepts and, while they may coexist, each may also occur on its own (Valtorta & Hanratty, 2013). Nicholson suggests a new definition of social isolation as "a state in which the individual lacks a sense of belonging socially, lacks engagement with others, has a minimal number of social contacts and they are deficient in fulfilling and quality relationships" (Nicholson Jr., 2009). The inclusion of objective and subjective measures in this definition seems to oppose the definition offered by Havens which defines social isolation

as an objective measure (Havens et al., 2004). Furthermore, Perlman and Peplau's definition of loneliness as a subjective experience of social isolation is also somewhat contradicted by Nicholson's newer definition (Nicholson Jr., 2009; Perlman, Daniel & Letitia Anne Peplau, n.d.).

Current measures of social isolation are not only inconsistent to each other, but also lack the ability to capture a comprehensive understanding of social connection due to a more narrow focus on the quantity of relationships in one's network (Holt-Lunstad, 2017; Nicholson Jr., 2009). While this is a key aspect to understanding social isolation, emerging definitions and measures assert that quality of those relationships should also be considered (Zavaleta et al., 2017). Guidelines to quantify social isolation which incorporates measures of both quantity and quality of relationships has been developed and suggests future measures include two distinct indicators to understand both external and internal social isolation (Zavaleta et al., 2017). The study proposes the external indicator include questions from each of the following four domains (1) frequency of social contact, (2) social network support, (3) presence of a discussion partner, and (4) reciprocity and volunteering (Zavaleta et al., 2017). Similarly, the guidelines of internal indicator include the five domains of (1) satisfaction with social relations, (2) need for relatedness, (3) feelings of belonging to own neighborhood or community, (4) loneliness, and (5) trust (Zavaleta et al., 2017).

The study population of the National Health and Aging Trends Study (NHATS) is Medicare beneficiaries aged 65 years or older living in the United States. While the social isolation indicator questions in NHATS are not as extensive as the Zavaleta guidelines, there is overlap and respondents receive a value of zero or one for their responses to six questions leading to a composite social isolation score ranging from zero to six with higher scores indicating greater social isolation (Pohl et al., 2017). Respondents receive a one (or an indication

of social isolation) if they respond to a series of questions in the survey intended to measure social isolation which indicate that (1) they are unmarried/unpartnered, (2) family members or (3) friends were not among those with whom they most often discussed important matters in the past year, and in the past month did not (4) visit in-person with family or friends, (5) attend a religious service, or (6) participate clubs, classes, or other organized activities (Pohl et al., 2017). It is important to note that indicators four through six were likely to be heavily impacted by the covid-19 pandemic. Using the composite score of covid precaution measures will act as a proxy to estimate social isolation.

Due to multiple accepted definitions, definitions changing over time, and the lack of a common and effective measurement tool for social isolation, it is difficult to determine the prevalence of social isolation within the United States population of older adults (Cudjoe et al., 2020; Holt-Lunstad, 2017; Nicholson Jr., 2009; Pohl et al., 2017). There is a wide variation among prevalence estimates of social isolation among community-dwelling older adults of all genders living in developed countries which ranges from 10-43% with a possibility for meaningfully different prevalence rates among older adults living in long term care facilities (Iliffe et al., 2007; Nicholson Jr., 2009; Nicholson, 2012; Taylor et al., 2016). A 2020 study found that the prevalence of social isolation in 2011 among community dwelling older adults in the United States was 24%, however there is discrepancy if the tool accurately captures the entire experience of social isolation (Cudjoe et al., 2020). Despite the likely underestimation, there is a clear need to further understand social isolation.

Social isolation is associated with negative outcomes among older adults pertaining to both physical and mental health as well as premature mortality (Cacioppo & Cacioppo, 2014; Flegal et al., 2013; Holt-Lunstad et al., 2010; Shankar et al., 2017). Older adults who are socially

isolated are at a higher risk for dementia, cognitive decline, and depression (Cacioppo & Cacioppo, 2014; *The Global Council on Brain Health (GCBH)*, n.d.). Isolation is also associated with a reduced capacity to perform daily living activities and subsequently functional status in the older adult population (Shankar et al., 2017). The higher risk of mortality associated with limited social connection is similar to well documented risks including air pollution, smoking (up to 15 cigarettes/day), physical inactivity, and obesity (Holt-Lunstad et al., 2010). Conversely, increased social connection is associated with a 50% reduction in risk for early mortality demonstrating the importance to identify those at risk and facilitate intervention (Holt-Lunstad et al., 2010).

To understand who is at a higher risk of experiencing social isolation, it is necessary to determine common risk factors. Despite this need, limited studies have explored the risk factors associated with social isolation (Cudjoe et al., 2020). Known factors already identified include older age, being unmarried, having lower education and income levels as risks for experiencing severe social isolation and social isolation relative to those socially integrated (Cudjoe et al., 2020; Evans et al., 2008; Steptoe et al., 2013). The AARP has suggested that retirement and physical challenges, such as frailty, loss of hearing, and reduced mobility, may also be risk factors for social isolation (*Isolation Among Older Adults – Causes & Responses*, n.d.). The risk of social isolation increases over the life course and as social isolation itself is a dose response risk factor, interventions that are able to reduce one's level of social isolation will likely elicit positive impacts on the health and well-being of older adults (Cudjoe et al., 2020; Holt-Lunstad, 2017).

2.3 Comparing and Contrasting Social Isolation and Loneliness

Despite similarities in risk factors, health implications, and experiences related to connection, social isolation and loneliness do not strongly predict one another (Cornwell & Waite, 2009; Coyle & Dugan, 2012; Steptoe et al., 2013). Some of this may be attributable to the lack of a standard definition and measurement mechanism for social isolation, however, there are likely other factors which contribute to the lack of association. Given the strong similarities between the two concepts, the weakness of their correlation is interesting and has potential to point towards a deeper understanding in how each may impact health and well-being.

2.4 Covid-19

The covid-19 pandemic provided a context in which many people within the United States were practicing social distancing as a risk reduction measure, especially those in higher risk groups which includes all older adults. Evaluating data collected during this period, can provide further insights into the relationship between social isolation and loneliness.

Early studies suggest that those living alone during the COVID-19 pandemic had an increased odds of experiencing loneliness compared to those living with others (Savage et al., 2021). During the height of the COVID-19 pandemic, the United States Centers for Disease Control and Prevention (CDC) recommended social distancing, mask wearing, and quarantine for those infected or exposed. Due to the heightened risk of death or serious illness associated with adults over 65 and age-related risk factors including diabetes, dementia, heart disease, and having a compromised immune system it is imperative to understand how the threat of COVID-19 infection and subsequent risk reduction measures impacted this population in regards to loneliness and social isolation (CDC, 2023). Pandemic realities and guidelines may have directly

impacted known risk factors for loneliness and social isolation among older adults such as loss of a spouse or close friends, limited social activity and connection, and self-perception of one's own health as poor. As a result, this study seeks to understand how the pandemic context of individuals and its influence on social isolation may have impacted their experiences of loneliness.

Compliance with social distancing guidelines during covid was used as a proxy to estimate social isolation experienced by older adults in a cross national study (Kim & Jung, 2021). The findings demonstrated social distancing is a significant predictor of poor mental health (Kim & Jung, 2021). However, in countries with more stringent policies and more trust in government there was a buffer for the negative impact of social distancing on mental distress (Kim & Jung, 2021). Countries with higher death rates had stronger associations between social distancing and mental distress (Kim & Jung, 2021). This is particularly interesting given the wide range of risk reduction compliance and government trust in the U.S. during the pandemic among different regions.

2.5 Significance

Loneliness and social isolation were existing issues among the older adult population prior to covid. During covid, many people experienced an increase in risk factors for experiencing loneliness and/or social isolation including reduced contact with friends and family and potential loss of a friend, partner, or family member (which would reduce the size of their social network) making this issue one that is immediately relevant in caring for this demographic. Additionally, given that the risks of social isolation are cumulative over the life course, the impact of risk factors on younger populations is also pertinent as they will one day

make up the older adult population (Holt-Lunstad, 2017). All populations should be considered to reduce loneliness and social isolation among older adults now and in generations to come.

Chapter 3. Methods

3.1 Data

The National Health and Aging Trends Study (NHATS) collects data on a nationally representative sample of Medicare beneficiaries aged 65 and older. Participants for the original cohort were selected in 2011 and additional participants were added in 2015. This allows the data to be used for both national and individual-level analysis. The data is collected with the intention of amplifying the ability to create effective preventions and treatments of challenges encountered by many older adults: becoming disabled, losing independent functioning capacity, and reduction in quality of life.

As the vast majority, 96-97%, of older adults in the United States are enrolled in Medicare, Medicare enrollment is an effective sampling frame for the population of interest and is used in this study. The initial cohort of NHATS participants was sampled for Round 1 with a three-stage stratified sample design. At this point, 95 primary sampling units (PSUs), individual counties and groups of counties, were selected. Subsequently, zip codes and zip code fragments were used as the secondary sampling units (SSUs), and 655 SSUs were selected from the elected PSUs. Finally, 14,643 beneficiaries who were 65 as of September 30, 2010, were sampled from selected SSUs. Within these beneficiaries, 11,961 were included in the initial release with the remaining 2,682 held in reserve. Ultimately, a total of 12,411 beneficiaries were contacted for participation in the study of which 8,245 (71%) completed the study.

After accounting for nonresponse and differential selection probabilities based on age group and race, 84-90% of living sample persons were retained in Rounds 2-4. Prior to Round 5 data

collection, the sample was restored to its original sizes by age and race groups. The three-stage stratified sample design employed in the initial sample was used again. This time beneficiaries eligible were those who were at least 65 years of age as of September 30, 2014. The adjusted response rate for Round 5 including those newly added was 73%. Rounds 6-10 elicited retention rates of 88-96% among living sample persons.

Data in NHATS is primarily collected through the Sample Person (SP) Interview instrument. Other instruments, the Performance Activities Booklet, the Interviewer Remark Section, and the Facility Questionnaire, are also used to collect information for the study, but the information in these sections is not relevant to this analysis. NHATS traditionally collects data from respondents in person, however, the covid-19 pandemic resulted in round 10 data being collected via telephone. An additional covid-19 supplement was completed after the phone interviews via paper surveys mailed to participants. This supplement contains information used to estimate levels of social isolation and loneliness.

For the purposes of this analysis, the data available through NHATS public use files will be analyzed as I am ineligible to apply for restricted use files. The NHATS sample includes community-dwelling older adults as well as those residing in a nursing home, but the analytic sample will be restricted to those who are community-dwelling as those in nursing homes lack key variables. Sampled participants who are unable to respond by themselves may have a proxy respond for them, however, they will also be excluded since the proxies are unable to answer key questions. While there is no documentation specifically stating if people who are incarcerated are included in the sample, NHATS documentation does state that “individuals are included in NHATS no matter where they reside”. It should also be noted that undocumented immigrants are not eligible for Medicare and documented immigrants are only eligible after residing in the U.S.

for five years regardless of their age. The sample is also limited to those living in the contiguous 48 states of the U.S. due to the prohibitive costs of conducting interviews in Alaska, Hawaii, Puerto Rico, and other U.S. territories. These limitations must be considered when utilizing the results of this analysis to create and design interventions. Sampling procedures oversample Black non-Hispanic individuals and older individuals by 5-year age groups (65-69, 70-74, 75-79, 80-84, 85-89, and 90+) to ensure sufficient data to effectively analyze data and understand trends over time. While these groups have a higher likelihood of being selected, this will be accounted for during analysis and allows for meaningful sub-analyses relating to race and age to be conducted. NHATS also collects information in a variety of other areas including a last month of life interview and dried blood spot biomarkers which will not be used in this analysis.

The sample of the NHATS is replenished periodically after the initial cohort was sampled in 2011. Sample replenishments occurred in 2015 and 2021. As round 10 surveys were conducted in 2020, the 2021 sample replenishment is not relevant to this analysis. Since the sample is only refreshed periodically, the lower bound of age for those in the sample increases each year in which a new cohort of participants is not added to the sample. As such, the participants in round 10 of the survey are aged 70 years and older. It is also of note that there is a lag between the time participants are sampled to when they are interviewed and subsequently represents a population that is slightly older.

Rounds 1 through 9 of the NHATS were conducted via in-person interviews. However, round 10, which will be used for this analysis, was conducted via phone interviews due to the covid-19 pandemic. As a result, some questions and observations were not able to be answered. A new open-ended question was added at the opening of round 10 of the study where participants were asked to describe in their own words how the outbreak had affected their life.

The clock drawing exercise of the survey, intended to assess cognitive function, was adapted by mailing materials to participants and conducted over the phone. The performance assessment portion of the study was not collected as they require in-person administration. The Environmental Checklist, which is observations of the participants' homes, was also unable to be collected. The only two questions retained in the Interviewer Remarks section were the participants' "attitude toward the interview" and "whether the interview was conducted in more than one session and reason".

3.2 Analyses

Primary Outcome

This study examines loneliness as its primary outcome. Loneliness was of increased interest during the COVID-19 pandemic and as such, variables to measure loneliness were added to the NHATS covid module administered through a mailed survey. The two questions ask participants to report how often they felt lonely in a typical week *before* the covid outbreak using a Likert scale. The subsequent question asks participants how this frequently they have felt lonely *during* covid in comparison to before with response options: more often, less often, or about the same. Responses to this question will be both retained (and assessed using ordered logistic regression) and dichotomized (and assessed using standard logistic regression) to indicate which participants experienced loneliness more often as was done in another study examining loneliness using the NHATS COVID-19 module (Hua & Thomas, 2021). As this is the primary outcome, those with missing data for the loneliness comparison variable are excluded from the analytic sample. The frequency of loneliness participants reported feeling prior to the pandemic will be retained and used as a covariate in analysis.

Primary Exposure

The COVID-19 outbreak provided an interesting context to study the exposure of social isolation as many people were practicing social distancing as a risk reduction measure. In this study, the social isolation measure will be included as both a set of four nominal variables and a single composite variable made up of these four nominal variables about activities within the previous month 1) visiting with family or friends 2) attending religious services 3) participating in clubs, classes, or other organized activities and 4) going out for enjoyment. Each of the responses for these dichotomized questions was assigned 0 for "no" and 1 for "yes". Composite social isolation scores range from 0 to 4 with zero indicating severe social isolation and four indicating social integration. As this is the primary exposure, those with missing data for any of the four variables making up the composite score are excluded from the analytic sample.

Covariates

The covariates included in this analysis are age, gender, race, education, employment status, living situation, individual level covid compliance measures, marital status, social network size, perception of community, and overall health status. In the public use files utilized in this analysis, age is reported in age categories by 5-year age groups (65-69, 70-74, 75-79, 80-84, 85-89, and 90+) corresponding with codes 1 through 6. These codes will be retained in these categories for analysis although it is important to note that since the sample has not been replenished in 5 years, there are currently no respondents who fall into the 65-69 age category, as such this category will be dropped. There is a variable for sex with response options of male or female and have been coded as 0 and 1 respectively. Gender was not recorded in the dataset. The race categories reported are non-Hispanic white, non-Hispanic black, non-Hispanic other,

Hispanic, and more than one race. These categories will be retained for analysis and are coded 0 through 4 respectively. Education variables had nine possible options coded 1 through 9 beginning with no schooling followed sequentially by 1st-8th grade, 9th-12th grade (without a diploma), high school graduate, vocational or trade school beyond high school, some college but no degree, associate degree, bachelor's degree, and masters professional or doctoral degree. Education will be recategorized and coded to 0 - less than high school education; 1 - high school graduate or post-high school vocational school; 2 - associate degree, bachelor's degree, or some college; and 3 - master's or doctoral degree. Employment is reported as a dichotomous variable with no/yes coded as 0 and 1 respectively. The living situation variable seeks to understand if the respondent lives alone or with at least one other person. To create this variable the variable for the total number of people in the household will be dichotomized to those with one person, recoded to 0, and those with two or more people, recoded to 1. The individual-level covid compliance measure is derived from a composite score that was created to conduct this specific analysis. Respondents are asked whether they have adapted nine different behaviors during the COVID-19 outbreak to reduce the spread of the virus. These behaviors are a) frequently washing or sanitizing their hands, b) avoiding contact with people they live with, c) avoiding contact with people they do not live with, d) staying at least 6 feet away from people they do not live with, e) limiting group gatherings with family they do not live with, f) avoiding being in restaurants and bars, g) limiting shopping and errands, h) wearing a face mask when going out, and i) avoiding touching their face when they are out. Respondents receive one point for each behavior for which they selected yes, for total scores ranging from zero to nine. They are subsequently categorized into strong risk reduction behavior (6-9 points recoded as 2), moderate risk reduction behavior (3-5 points recoded to 1), and little to no risk reduction behavior (0-2 points recoded as 1). The

marital statuses are retained as recorded with options of married, living with a partner, separated, divorced, bereaved, and never married. Social network size counts those with whom the participant feels they can talk to about important matters up to five people. As the perception of our community became of increased relevance during the pandemic, a composite variable will be constructed based on participants' agreement to statements that: people in their community know each other well, are willing to help each other, and can be trusted. Existing codes in the data; 1 for “agree a lot”, 2 for “agree a little”, and 3 for “do not agree”; will be summed to create the community perception score. For missing data points, no additional points will be added to the existing sum. Scores will be treated as continuous variables with lower scores indicating a more positive perception of community. Overall health condition is reported as a Likert scale with five options (poor, fair, good, very good, and excellent) which are retained. All those with missing values for any variable included in the analysis are excluded.

Impossible values

As all variables in the analysis are categorical, each was examined for nonsensical values by tabulating the frequency with which each category was selected. No impossible values were discovered. Data was presumably cleaned quite thoroughly prior to being distributed.

Analytic sample

The Round 10 iteration of NHATS includes responses from those who were able to engage in the data collection interview without a proxy. Out of the 4,389 non-proxy respondents, all community-dwelling older adults who responded to the COVID-19 module were eligible to be included in the analysis resulting in 2,998 observations. The analytic sample was further

restricted by 726 participants to missing data for any variable included in the analysis resulting in an analytic sample size of 2,272.

Descriptive methods

All variables to be included in the analysis are assessed for unweighted correlations to each other variable (as weighted correlations cannot be calculated in SAS). The frequency of loneliness respondents reported experiencing prior to the COVID-19 pandemic is cross tabulated with the relative change in loneliness people experience during the pandemic to understand the relationship between loneliness before and during the pandemic. The distribution of categorical variables will be examined, while accounting for survey weights, using the survey frequency procedure in SAS. The distribution of continuous variables will be assessed by comparing mean, median, minimum, and maximum values. The demographic characteristics of the analytic sample are displayed in Table 1 with sample totals, weighted population frequency, and the population proportion or mean with 95% confidence intervals. Table 2 shows the demographic characteristics of the analytic sample stratified by those who felt lonelier during the pandemic versus those who did not.

Analytic methods

As the outcome of interest is a three-level ordinal categorical variable, an ordered logistic regression model will be used to estimate the relationship between social isolation and loneliness among the study population. The model will first be run with only the exposure of social isolation and the outcome of loneliness frequency relative to before the pandemic. The demographic variables (age, gender, race, and education) will be added as covariates in the

second model. The third model incorporates the demographic variables as well as social variables (employment status and living situation) as covariates. A fourth model also accounts for complex demographic variables (marital status, social network size, perception of community, and overall health status). Finally, the last model will add a variable measuring the extent of individuals' covid risk reduction measures. Additionally, the fully adjusted model will be stratified by sex.

Chapter 4. Results

Table 1. Weighted population percentages and 95% confidence intervals estimate the general distribution of demographic characteristics within the target population.

Respondent characteristics	*Estimated Population % or Population mean (95% Confidence Interval)*
Overall	100
Sex	
Male	46.3 (43.6, 49.0)
Female	53.7 (51.0, 56.4)
Age (in years)	
70-74	39.3 (36.9, 41.7)
75-79	30.8 (28.5, 33.1)
80-84	18.3 (16.7, 19.8)
85-89	8.2 (7.2, 9.2)
90+	3.4 (2.8, 4.0)
Race/Ethnicity	
Non-Hispanic white	86.5 (84.4, 88.7)
Non-Hispanic black	5.8 (4.8, 6.9)
Other	2.9 (1.8, 4.0)
Hispanic	4.7 (3.2, 6.3)
Education	
Less than high school education	9.5 (7.9, 11.0)
High school graduate or equivalent	30.1 (26.7, 33.5)
Associate’s, Bachelor’s, or some college	41.4 (38.1, 44.7)
Master’s or doctoral degree	19.0 (16.0, 22.0)
Employment	
Retired	87.1 (85.0, 89.2)
Working	12.9 (10.8, 15.0)
Household size	2.0 (1.9, 2.0)
Living situation	
Lives alone	28.0 (26.1, 29.8)
Lives with others	72.0 (70.2, 73.9)
Risk reduction score (out of 9)	7.3 (7.2, 7.4)
Covid risk reduction behaviors	
Frequently washing hands	98.1 (97.4, 98.8)
Avoiding contact with people they live with	13.4 (11.6, 15.1)
Avoiding contact with people they do not live with	84.2 (82.3, 86.2)
Staying at least 6 feet away from people they do not live with	91.2 (89.6, 92.7)

Limiting group gatherings with family they do not live with	86.8 (84.8, 88.8)
Avoiding being in restaurants and bars	86.6 (84.8, 88.5)
Limiting shopping and errands	86.6 (84.7, 88.4)
Wearing a face mask when going out	96.4 (95.4, 97.3)
Avoiding touching their face when they are out	87.6 (85.9, 89.2)
Marital status	
Married	57.0 (54.7, 59.3)
Living with a partner	2.3 (1.5, 3.1)
Separated	0.7 (0.3, 1.1)
Divorced	12.3 (10.7, 13.9)
Widowed	25.1 (23.0, 27.3)
Never married	2.5 (1.7, 3.4)
Social network size	2.6 (2.5, 2.7)
No one in network	2.1 (1.4, 2.7)
One person	24.4 (21.8, 27.0)
Two people	26.5 (24.1, 28.8)
Three people	20.2 (18.2, 22.2)
Four people	13.3 (11.0, 15.5)
Five or more people	13.6 (11.1, 16.0)
Community perception score (out of 9)	4.6 (4.5, 4.7)
Health status	
Poor	2.6 (1.6, 3.5)
Fair	11.7 (9.8, 13.5)
Good	35.5 (33.0, 37.9)
Very good	37.5 (34.9, 40.1)
Excellent	12.8 (10.7, 14.9)
Frequency of feeling lonely before the pandemic	
Never	30.9 (28.8, 33.1)
Rarely	34.4 (32.2, 36.6)
Some days	26.4 (24.3, 28.5)
Most days	6.2 (4.7, 7.7)
Every day	2.1 (1.4, 2.8)
Social isolation score (0 – 4)	1.7 (1.6, 1.7)
Social activities in the previous month (June – October 2020)	
Visiting with family or friends	72.8 (70.3, 75.2)
Attending religious services	36.4 (33.3, 39.6)
Participating in clubs, classes, or other organized activities	20.3 (17.7, 22.9)
Going out for enjoyment	36.2 (33.1, 39.2)
Loneliness comparison during covid	
Less lonely	2.9 (2.0, 3.9)
About the same	74.6 (72.1, 77.1)
Lonelier	22.5 (20.0, 25.0)
Loneliness comparison (dichotomized)	
Less or same level of loneliness	77.5 (75.0, 80.0)
Lonelier	22.5 (20.0, 25.0)

Note: This data is sourced from the Round 10 (2020) iteration and COVID-19 supplementary module of the National Health and Aging Trends Survey (n=2,998) *representative of community-dwelling Medicare beneficiary adults age 70+ residing in the United States. Loneliness was measured by asking participants how frequently they have felt lonely during the pandemic in comparison to before with response options: more often, less often, or about the same. Response options were dichotomized into lonely more often vs. not lonely more often. Social isolation was measured by asking participants if, in the previous month they had visited with family or friends, attended religious services, participated in clubs, classes, or other organized activities, or went out for enjoyment. A composite variable was created by summing the total number of questions to which one responded "no".*

Table 2. Weighted population percentages and 95% confidence intervals of demographic characteristics stratified by those who experienced an increase in loneliness during the pandemic versus those who did not.

Respondent characteristics	*Estimated Population % or Population mean (95% Confidence Interval) for those who did not experience an increase in loneliness during the pandemic.*	*Estimated Population % or Population mean (95% Confidence Interval) for those who experienced an increase in loneliness during the pandemic*
Sex		
Male	50.4 (47.0, 53.7)	32.1 (26.9, 37.2)
Female	49.6 (46.3, 53.0)	67.9 (62.8, 73.1)
Age (in years)		
70-74	37.4 (34.3, 40.5)	45.9 (40.9, 50.9)
75-79	31.9 (28.8, 34.9)	27.0 (22.7, 31.3)
80-84	18.6 (16.6, 20.5)	17.4 (14.5, 20.2)
85-89	8.6 (7.3, 9.9)	6.8 (4.8, 8.9)
90+	3.5 (2.9, 4.2)	2.9 (1.7, 4.1)
Race/Ethnicity		
Non-Hispanic white	85.5 (83.2, 87.8)	90.2 (86.7, 93.7)
Non-Hispanic black	6.5 (5.2, 7.7)	3.7 (2.2, 5.1)
Other	3.2 (1.9, 4.4)	2.0 (0.7, 3.2)
Hispanic	4.9 (3.3, 6.5)	4.2 (1.5, 6.9)
Education		
Less than high school education	10.7 (9.0, 12.5)	5.1 (2.7, 7.6)
High school graduate or equivalent	32.0 (28.5, 35.5)	23.5 (17.6, 29.3)
Associate's, Bachelor's, or some college	40.4 (37.1, 43.6)	45.1 (38.7, 51.6)
Master's or doctoral degree	16.9 (13.7, 20.1)	26.3 (20.8, 31.7)
Employment		
Retired	85.9 (83.7, 88.2)	91.0 (87.3, 94.7)
Working	14.1 (11.8, 16.3)	9.0 (5.3, 12.7)
Household size	2.0 (2.0, 2.1)	1.9 (1.8, 2.0)
Living situation		
Lives alone	74.5 (72.3, 76.6)	63.6 (58.5, 68.8)
Lives with others	25.5 (23.4, 27.7)	36.4 (31.2, 41.5)
Risk reduction score (out of 9)	7.2 (7.1, 7.3)	7.7 (7.6, 7.8)
Covid risk reduction behaviors		
Frequently washing hands		
Yes	97.8 (97.0, 98.6)	99.4 (98.8, 100.0)
No	2.2 (1.4, 3.0)	0.6 (0.0, 1.2)
Avoiding contact with people they live with		
Yes	13.7 (11.8, 15.6)	12.3 (8.5, 16.2)
No	65.1 (62.2, 67.9)	56.1 (49.7, 62.6)
N/A	21.2 (18.9, 23.5)	31.6 (26.4, 36.8)
Avoiding contact with people they do not live with		
Yes	82.0 (79.7, 84.4)	91.7 (88.8, 94.6)
No	16.7 (14.4, 19.0)	7.2 (4.4, 10.1)
N/A	1.2 (0.8, 1.7)	1.1 (0.0, 2.2)
Staying at least 6 feet away from people they do not live with		
Yes	90.1 (88.3, 91.8)	95.1 (92.7, 97.4)
No	8.3 (6.6, 10.0)	3.8 (1.7, 5.9)
N/A	1.6 (1.0, 2.3)	1.1 (0.5, 1.8)

Limiting group gatherings with family they do not live with		
Yes	84.8 (82.3, 87.2)	93.9 (91.0, 96.7)
No	10.1 (8.2, 12.0)	3.2 (0.8, 5.5)
N/A	5.2 (4.0, 6.3)	2.9 (1.3, 4.6)
Avoiding being in restaurants and bars		
Yes	84.9 (82.9, 86.9)	92.6 (89.7, 95.5)
No	12.6 (10.8, 14.5)	7.1 (4.2, 9.9)
N/A	2.5 (1.7, 3.2)	0.3 (0.1, 0.6)
Limiting shopping and errands		
Yes	85.2 (83.2, 87.2)	91.2 (88.1, 94.4)
No	14.2 (12.3, 16.1)	8.2 (5.3, 11.2)
N/A	0.6 (0.3, 0.9)	0.6 (0.0, 1.6)
Wearing a face mask when going out		
Yes	95.6 (94.5, 96.7)	99.0 (97.5, 100.0)
No	4.0 (3.0, 5.1)	0.9 (0.0, 2.5)
N/A	0.3 (0.1, 0.5)	0.0 (0.0, 0.1)
Avoiding touching their face when they are out		
Yes	86.2 (84.3, 88.1)	92.2 (89.2, 95.2)
No	12.6 (10.7, 14.6)	7.6 (4.7, 10.5)
N/A	1.2 (0.6, 1.7)	0.2 (0.0, 0.5)
Marital status		
Married	58.2 (55.3, 61.1)	52.9 (48.0, 57.7)
Living with a partner	2.5 (1.6, 3.4)	1.6 (0.0, 3.3)
Separated	0.7 (0.3, 1.1)	0.6 (0.0, 1.4)
Divorced	10.7 (9.1, 12.3)	17.9 (13.6, 22.1)
Widowed	25.1 (22.4, 27.7)	25.4 (21.7, 29.1)
Never married	2.8 (1.8, 3.8)	1.7 (0.1, 3.3)
Social network size	2.5 (2.4, 2.6)	3.0 (2.7, 3.2)
No one in network	2.4 (1.7, 3.2)	0.9 (0.0, 2.0)
One person	27.2 (24.2, 30.1)	14.8 (10.6, 19.0)
Two people	26.1 (23.6, 28.6)	27.5 (21.6, 33.5)
Three people	19.9 (17.5, 22.3)	21.4 (17.2, 25.6)
Four people	12.5 (10.3, 14.8)	15.8 (11.0, 20.5)
Five or more people	11.8 (9.3, 14.4)	19.6 (14.0, 25.2)
Community perception score (out of 9)	4.6 (4.5, 4.7)	4.5 (4.4, 4.7)
Health status		
Poor	13.4 (11.3, 15.6)	10.7 (7.3, 14.1)
Fair	37.5 (34.4, 40.6)	37.4 (32.9, 42.0)
Good	35.2 (32.5, 38.0)	36.3 (30.7, 41.9)
Very good	11.5 (9.2, 13.8)	12.2 (8.4, 16.1)
Excellent	2.4 (1.3, 3.4)	3.3 (1.5, 5.1)
Frequency of feeling lonely before the pandemic		
Never	0.9 (0.4, 1.4)	6.2 (3.5, 8.8)
Rarely	2.9 (2.0, 3.7)	17.6 (12.1, 23.2)
Some days	15.2 (13.5, 16.9)	64.9 (58.5, 71.3)
Most days	41.1 (38.9, 43.3)	11.3 (6.6, 16.1)
Every day	39.9 (37.2, 42.6)	-
Social isolation score (0 – 4)	1.6 (1.5, 1.7)	1.8 (1.7, 1.9)
Social activities in the previous month		
Visiting with family or friends		
Yes	71.2 (68.5, 73.9)	78.1 (73.6, 82.7)
No	28.8 (26.1, 31.5)	21.9 (17.3, 26.4)

Attending religious services		
Yes	36.3 (32.6, 40.0)	37.0 (31.6, 42.3)
No	63.7 (60.0, 67.4)	63.0 (57.7, 68.4)
Participating in clubs, classes, or other organized activities		
Yes	17.9 (15.2, 20.6)	28.7 (24.0, 33.4)
No	82.1 (79.4, 84.8)	71.3 (66.6, 76.0)
Going out for enjoyment		
Yes	36.4 (32.7, 40.0)	35.4 (30.7, 40.1)
No	63.6 (60.0, 67.3)	64.6 (59.9, 69.3)

Note: This data is sourced from the Round 10 (2020) iteration and COVID-19 supplementary module of the National Health and Aging Trends Survey (n=2,998) representative of community-dwelling Medicare beneficiary adults age 70+ residing in the United States. Loneliness was measured by asking participants how frequently they have felt lonely during the pandemic in comparison to before with response options: more often, less often, or about the same. Response options were dichotomized into lonely more often vs. not lonely more often. Social isolation was measured by asking participants if, in the previous month they had visited with family or friends, attended religious services, participated in clubs, classes, or other organized activities, or went out for enjoyment. A composite variable was created by summing the total number of questions to which one responded "no".

Table 3. Weighted population percentages and their 95% confidence intervals for the cross tabulation of the frequency of loneliness respondents reported before COVID-19 versus the relative change in loneliness during the pandemic.

Frequency of loneliness before COVID-19	Estimated population % (95% confidence interval) of loneliness increase during the pandemic	Estimated population % (95% confidence interval) of loneliness decrease during the pandemic	Estimated population % (95% confidence interval) of no change in loneliness during the pandemic
Every day	1.4 (0.8, 2.0)	0.0 (0.0, 0.1)	0.7 (0.3, 1.1)
Most days	4.0 (2.5, 5.4)	0.4 (0.1, 0.8)	1.8 (1.2, 2.4)
Some days	14.6 (12.5, 16.6)	1.3 (0.7, 1.8)	10.6 (9.2, 11.9)
Rarely	2.6 (1.5, 3.6)	1.1 (0.5, 1.8)	30.7 (28.5, 32.9)
Never	-	0.1 (0.0, 0.1)	30.9 (28.7, 33.0)

Note: This data is sourced from the 2020 COVID-19 supplementary module of the National Health and Aging Trends Survey (n=2,998) *representative of community-dwelling Medicare beneficiary adults age 70+ residing in the United States. Loneliness was measured by asking participants how frequently they felt lonely prior to the pandemic and by then asking participants how frequently they have felt lonely during the pandemic in comparison with response options: more often, less often, or about the same.*

The CORR Procedure

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	Loneliness frequency prior to pandemic	Comparison of loneliness during pandemic to prior	Comparison of loneliness during pandem to prior (dichotoized more lonely vs. not more lonely)	Social isolation score	Age	Sex	Race/Ethnicity	Education	Work/retirement status	Covid risk prevention score	Health condition	Number of people living in the household (including respondent)	Marital status
Loneliness frequency prior to pandemic	1.00000 2272	0.42926 <.0001 2272	0.53160 <.0001 2272	-0.02836 0.1766 2272	0.05050 0.0161 2272	0.21901 <.0001 2272	-0.00897 0.6693 2272	-0.02743 0.1913 2272	-0.08655 <.0001 2272	0.11022 <.0001 2272	-0.22608 <.0001 2272	-0.14068 <.0001 2272	0.18288 <.0001 2272
Comparison of loneliness during pandemic to prior	0.42926 <.0001 2272	1.00000 2272	0.92196 <.0001 2272	0.04840 0.0211 2272	-0.03802 0.0700 2272	0.11892 <.0001 2272	-0.06939 0.0009 2272	0.15481 <.0001 2272	-0.04423 0.0350 2272	0.08678 <.0001 2272	-0.00267 0.8988 2272	-0.06299 0.0027 2272	0.01060 0.6136 2272
Comparison of loneliness during pandem to prior (dichotoized more lonely vs. not more lonely)	0.53160 <.0001 2272	0.92196 <.0001 2272	1.00000 2272	0.05343 0.0109 2272	-0.04840 0.0210 2272	0.13731 <.0001 2272	-0.04067 0.0526 2272	0.13878 <.0001 2272	-0.03905 0.0628 2272	0.10277 <.0001 2272	-0.02054 0.3277 2272	-0.05751 0.0061 2272	0.02545 0.2252 2272
Social isolation score	-0.02836 0.1766 2272	0.04840 0.0211 2272	0.05343 0.0109 2272	1.00000 2272	-0.08508 <.0001 2272	-0.04319 0.0396 2272	-0.14923 <.0001 2272	0.10658 <.0001 2272	0.07481 0.0004 2272	-0.13829 <.0001 2272	0.17540 <.0001 2272	-0.04711 0.0247 2272	-0.07344 0.0005 2272
Age	0.05050 0.0161 2272	-0.03802 0.0700 2272	-0.04840 0.0210 2272	-0.08508 <.0001 2272	1.00000 2272	0.03584 0.0876 2272	-0.01301 0.5354 2272	-0.10712 <.0001 2272	-0.20508 <.0001 2272	-0.05127 0.0145 2272	-0.07739 0.0002 2272	-0.08488 <.0001 2272	0.23587 <.0001 2272
Sex	0.21901 <.0001 2272	0.11892 <.0001 2272	0.13731 <.0001 2272	-0.04319 0.0396 2272	0.03584 0.0876 2272	1.00000 2272	0.02589 0.2174 2272	-0.11557 <.0001 2272	-0.07877 0.0002 2272	0.13951 <.0001 2272	-0.04946 0.0184 2272	-0.07586 0.0003 2272	0.34549 <.0001 2272
Race/Ethnicity	-0.00897 0.6693 2272	-0.06939 0.0009 2272	-0.04067 0.0526 2272	-0.14923 <.0001 2272	-0.01301 0.5354 2272	0.02589 0.2174 2272	1.00000 2272	-0.17164 <.0001 2272	-0.03756 0.0735 2272	0.16863 <.0001 2272	-0.14257 <.0001 2272	0.12248 <.0001 2272	0.10028 <.0001 2272
Education	-0.02743 0.1913 2272	0.15481 <.0001 2272	0.13878 <.0001 2272	0.10658 <.0001 2272	-0.10712 <.0001 2272	-0.11557 <.0001 2272	-0.17164 <.0001 2272	1.00000 2272	0.09638 <.0001 2272	0.01962 0.3498 2272	0.23091 <.0001 2272	-0.03005 0.1522 2272	-0.16107 <.0001 2272
Work/retirement status	-0.08655 <.0001 2272	-0.04423 0.0350 2272	-0.03905 0.0628 2272	0.07481 0.0004 2272	-0.20508 <.0001 2272	-0.07877 0.0002 2272	-0.03756 0.0735 2272	0.09638 <.0001 2272	1.00000 2272	-0.03480 0.0972 2272	0.11428 <.0001 2272	0.02670 0.2033 2272	-0.04943 0.0185 2272
Covid risk prevention score	0.11022 <.0001 2272	0.08678 <.0001 2272	0.10277 <.0001 2272	-0.13829 <.0001 2272	-0.05127 0.0145 2272	0.13951 <.0001 2272	0.16863 <.0001 2272	0.01962 0.3498 2272	-0.03480 0.0972 2272	1.00000 2272	-0.07614 0.0003 2272	0.09548 <.0001 2272	0.02648 0.2071 2272
Health condition	-0.22608 <.0001 2272	-0.00267 0.8988 2272	-0.02054 0.3277 2272	0.17540 <.0001 2272	-0.07739 0.0002 2272	-0.04946 0.0184 2272	-0.14257 <.0001 2272	0.23091 <.0001 2272	0.11428 <.0001 2272	-0.07614 0.0003 2272	1.00000 2272	0.01047 0.6179 2272	-0.10718 <.0001 2272
Number of people living in the household (including respondent)	-0.14068 <.0001 2272	-0.06299 0.0027 2272	-0.05751 0.0061 2272	-0.04711 0.0247 2272	-0.08488 <.0001 2272	-0.07586 0.0003 2272	0.12248 <.0001 2272	-0.03005 0.1522 2272	0.02670 0.2033 2272	0.09548 <.0001 2272	0.01047 0.6179 2272	1.00000 2272	-0.30742 <.0001 2272
Marital status	0.18288 <.0001 2272	0.01060 0.6136 2272	0.02545 0.2252 2272	-0.07344 0.0005 2272	0.23587 <.0001 2272	0.34549 <.0001 2272	0.10028 <.0001 2272	-0.16107 <.0001 2272	-0.04943 0.0185 2272	0.02648 0.2071 2272	-0.10718 <.0001 2272	-0.30742 <.0001 2272	1.00000 2272
Size of social network (up to 5 people)	0.05559 0.0081 2271	0.14009 <.0001 2271	0.13505 <.0001 2271	0.10847 <.0001 2271	-0.04626 0.0275 2271	0.15133 <.0001 2271	-0.07781 0.0002 2271	0.19455 <.0001 2271	-0.00126 0.9522 2271	0.09353 <.0001 2271	0.06859 0.0011 2271	-0.00365 0.8622 2271	0.01649 0.4322 2271
Agreement to statement that people in the respondents local community know each other well.	0.02100 0.3171 2272	0.00194 0.9265 2272	-0.00613 0.7701 2272	-0.10785 <.0001 2272	0.00512 0.8072 2272	-0.00522 0.8037 2272	0.01616 0.4413 2272	0.02735 0.1925 2272	-0.00512 0.8073 2272	-0.03454 0.0998 2272	-0.06920 0.0010 2272	0.03497 0.0956 2272	0.02294 0.2745 2272
Agreement to statement that people in the respondents local community are willing to help eachother.	0.05284 0.0118 2272	-0.02083 0.3209 2272	-0.02302 0.2726 2272	-0.14401 <.0001 2272	0.00585 0.7806 2272	-0.00398 0.8495 2272	0.13069 <.0001 2272	-0.10099 <.0001 2272	0.00827 0.6936 2272	-0.01979 0.3458 2272	-0.12524 <.0001 2272	0.05385 0.0103 2272	0.06145 0.0034 2272
Agreement to statement that people in the respondents local community can be trusted.	0.04354 0.0380 2272	-0.06674 0.0015 2272	-0.04959 0.0181 2272	-0.14047 <.0001 2272	-0.03986 0.0575 2272	0.03792 0.0707 2272	0.17910 <.0001 2272	-0.15930 <.0001 2272	-0.04366 0.0374 2272	0.00828 0.6932 2272	-0.14152 <.0001 2272	0.04753 0.0235 2272	0.08573 <.0001 2272
Covid risk prevention: Wash hands	-0.05137 0.0143 2272	-0.02368 0.2592 2272	-0.03783 0.0714 2272	0.04263 0.0422 2272	0.02528 0.2285 2272	-0.07738 0.0002 2272	-0.03673 0.0800 2272	-0.01416 0.5000 2272	-0.01271 0.5448 2272	-0.34298 <.0001 2272	0.00016 0.9941 2272	0.00292 0.8892 2272	0.00091 0.9655 2272
Covid risk prevention: Avoid others living in the household	0.13154 <.0001 2272	0.06649 0.0015 2272	0.07535 0.0003 2272	0.00108 0.9590 2272	0.05205 0.0131 2272	0.13623 <.0001 2272	-0.13106 <.0001 2272	0.04367 0.0374 2272	-0.02461 0.2409 2272	-0.27633 <.0001 2272	0.01382 0.5104 2272	-0.42731 <.0001 2272	0.31258 <.0001 2272
Covid risk prevention: Avoid others not living in the household	-0.05438 0.0095 2272	-0.07534 0.0003 2272	-0.08496 <.0001 2272	0.08117 0.0001 2272	0.05596 0.0076 2272	-0.07664 0.0003 2272	-0.05611 0.0075 2272	-0.08417 <.0001 2272	0.03126 0.1363 2272	-0.63164 <.0001 2272	0.03656 0.0815 2272	-0.09105 <.0001 2272	0.05415 0.0098 2272
Covid risk prevention: Maintain 6 ft of distance	-0.01266 0.5466 2272	-0.02266 0.2803 2272	-0.02980 0.1557 2272	0.03687 0.0789 2272	0.08909 <.0001 2272	0.00748 0.7217 2272	-0.02391 0.2545 2272	-0.03110 0.1384 2272	0.00557 0.7909 2272	-0.51122 <.0001 2272	0.01707 0.4160 2272	-0.08180 <.0001 2272	0.05372 0.0104 2272
Covid risk prevention: Limit family gatherings	-0.05141 0.0143 2272	-0.09390 <.0001 2272	-0.08688 <.0001 2272	-0.01993 0.3423 2272	0.06889 0.0010 2272	-0.03020 0.1502 2272	-0.05770 0.0059 2272	-0.03670 0.0803 2272	0.02492 0.2350 2272	-0.53323 <.0001 2272	-0.02414 0.2500 2272	-0.06854 0.0011 2272	0.08369 <.0001 2272
Covid risk prevention: Avoid restaurants are bars	-0.08496 <.0001 2272	-0.05480 0.0090 2272	-0.06640 0.0015 2272	0.10173 <.0001 2272	0.04367 0.0374 2272	-0.01939 0.3556 2272	-0.06955 0.0009 2272	-0.04865 0.0204 2272	-0.00896 0.6693 2272	-0.58066 <.0001 2272	0.05282 0.0118 2272	-0.04371 0.0372 2272	0.02589 0.2173 2272
Covid risk prevention: Limint shopping and errands	-0.09604 <.0001 2272	-0.04759 0.0233 2272	-0.05970 0.0044 2272	0.07958 0.0001 2272	0.02472 0.2389 2272	-0.10159 <.0001 2272	-0.04269 0.0419 2272	-0.04291 0.0409 2272	0.01122 0.5931 2272	-0.62642 <.0001 2272	0.05330 0.0111 2272	-0.01118 0.5942 2272	-0.02499 0.2338 2272
Covid risk prevention: Wear a mask	-0.07366 0.0004 2272	-0.05570 0.0079 2272	-0.07355 0.0005 2272	0.03360 0.1094 2272	0.04993 0.0173 2272	-0.06728 0.0013 2272	-0.06999 0.0008 2272	-0.02079 0.3218 2272	0.03272 0.1190 2272	-0.44515 <.0001 2272	0.04840 0.0211 2272	-0.03546 0.0910 2272	-0.00669 0.7500 2272
Covid risk prevention: Avoid touching face	-0.02958 0.1588 2272	-0.05142 0.0142 2272	-0.05772 0.0059 2272	0.02328 0.2673 2272	0.08540 <.0001 2272	-0.14126 <.0001 2272	-0.10972 <.0001 2272	0.00770 0.7139 2272	0.01586 0.4497 2272	-0.55408 <.0001 2272	0.00622 0.7669 2272	-0.01833 0.3824 2272	-0.03873 0.0649 2272

	Size of social network (up to 5 people)	Agreement to statement that people in the respondents local community know each other well.	Agreement to statement that people in the respondents local community are willing to help eachother.	Agreement to statement that people in the respondents local community can be trusted.	Covid risk prevention: Wash hands	Covid risk prevention: Avoid others living in the household	Covid risk prevention: Avoid others not living in the household	Covid risk prevention: Maintain 6 ft of distance	Covid risk prevention: Limit family gatherings	Covid risk prevention: Avoid restaurants are bars	Covid risk prevention: Limint shopping and errands	Covid risk prevention: Wear a mask	Covid risk prevention: Avoid touching face
Loneliness frequency prior to pandemic	0.05559 0.0081 2271	0.02100 0.3171 2272	0.05284 0.0118 2272	0.04354 0.0380 2272	-0.05137 0.0143 2272	0.13154 <.0001 2272	-0.05438 0.0095 2272	-0.01266 0.5466 2272	-0.05141 0.0143 2272	-0.08496 <.0001 2272	-0.09604 <.0001 2272	-0.07366 0.0004 2272	-0.02958 0.1588 2272
Comparison of loneliness during pandemic to prior	0.14009 <.0001 2271	0.00194 0.9265 2272	-0.02083 0.3209 2272	-0.06674 0.0015 2272	-0.02368 0.2592 2272	0.06649 0.0015 2272	-0.07534 0.0003 2272	-0.02266 0.2803 2272	-0.09390 <.0001 2272	-0.05480 0.0090 2272	-0.04759 0.0233 2272	-0.05570 0.0079 2272	-0.05142 0.0142 2272
Comparison of loneliness during pandem to prior (dichotoized more lonely vs. not more lonely)	0.13505 <.0001 2271	-0.00613 0.7701 2272	-0.02302 0.2726 2272	-0.04959 0.0181 2272	-0.03783 0.0714 2272	0.07535 0.0003 2272	-0.08496 <.0001 2272	-0.02980 0.1557 2272	-0.08688 <.0001 2272	-0.06640 0.0015 2272	-0.05970 0.0044 2272	-0.07355 0.0005 2272	-0.05772 0.0059 2272
Social isolation score	0.10847 <.0001 2271	-0.10785 <.0001 2272	-0.14401 <.0001 2272	-0.14047 <.0001 2272	0.04263 0.0422 2272	0.00108 0.9590 2272	0.08117 0.0001 2272	0.03687 0.0789 2272	-0.01993 0.3423 2272	0.10173 <.0001 2272	0.07958 0.0001 2272	0.03360 0.1094 2272	0.02328 0.2673 2272
Age	-0.04626 0.0275 2271	0.00512 0.8072 2272	0.00585 0.7806 2272	-0.03986 0.0575 2272	0.02528 0.2285 2272	0.05205 0.0131 2272	0.05596 0.0076 2272	0.08909 <.0001 2272	0.06889 0.0010 2272	0.04367 0.0374 2272	0.02472 0.2389 2272	0.04993 0.0173 2272	0.08540 <.0001 2272
Sex	0.15133 <.0001 2271	-0.00522 0.8037 2272	-0.00398 0.8495 2272	0.03792 0.0707 2272	-0.07738 0.0002 2272	0.13623 <.0001 2272	-0.07664 0.0003 2272	0.00748 0.7217 2272	-0.03020 0.1502 2272	-0.01939 0.3556 2272	-0.10159 <.0001 2272	-0.06728 0.0013 2272	-0.14126 <.0001 2272
Race/Ethnicity	-0.07781 0.0002 2271	0.01616 0.4413 2272	0.13069 <.0001 2272	0.17910 <.0001 2272	-0.03673 0.0800 2272	-0.13106 <.0001 2272	-0.05611 0.0075 2272	-0.02391 0.2545 2272	-0.05770 0.0059 2272	-0.06955 0.0009 2272	-0.04269 0.0419 2272	-0.06999 0.0008 2272	-0.10972 <.0001 2272
Education	0.19455 <.0001 2271	0.02735 0.1925 2272	-0.10099 <.0001 2272	-0.15930 <.0001 2272	-0.01416 0.5000 2272	0.04367 0.0374 2272	-0.08417 <.0001 2272	-0.03110 0.1384 2272	-0.03670 0.0803 2272	-0.04865 0.0204 2272	-0.04291 0.0409 2272	-0.02079 0.3218 2272	0.00770 0.7139 2272
Work/retirement status	-0.00126 0.9522 2271	-0.00512 0.8073 2272	0.00827 0.6936 2272	-0.04366 0.0374 2272	-0.01271 0.5448 2272	-0.02461 0.2409 2272	0.03126 0.1363 2272	0.00557 0.7909 2272	0.02492 0.2350 2272	-0.00896 0.6693 2272	0.01122 0.5931 2272	0.03272 0.1190 2272	0.01586 0.4497 2272
Covid risk prevention score	0.09353 <.0001 2271	-0.03454 0.0998 2272	-0.01979 0.3458 2272	0.00828 0.6932 2272	-0.34298 <.0001 2272	-0.27633 <.0001 2272	-0.63164 <.0001 2272	-0.51122 <.0001 2272	-0.53323 <.0001 2272	-0.58066 <.0001 2272	-0.62642 <.0001 2272	-0.44515 <.0001 2272	-0.55408 <.0001 2272
Health condition	0.06859 0.0011 2271	-0.06920 0.0010 2272	-0.12524 <.0001 2272	-0.14152 <.0001 2272	0.00016 0.9941 2272	0.01382 0.5104 2272	0.03656 0.0815 2272	0.01707 0.4160 2272	-0.02414 0.2500 2272	0.05282 0.0118 2272	0.05330 0.0111 2272	0.04840 0.0211 2272	0.00622 0.7669 2272
Number of people living in the household (including respondent)	-0.00365 0.8622 2271	0.03497 0.0956 2272	0.05385 0.0103 2272	0.04753 0.0235 2272	0.00292 0.8892 2272	-0.42731 <.0001 2272	-0.09105 <.0001 2272	-0.08180 <.0001 2272	-0.06854 0.0011 2272	-0.04371 0.0372 2272	-0.01118 0.5942 2272	-0.03546 0.0910 2272	-0.01833 0.3824 2272
Marital status	0.01649 0.4322 2271	0.02294 0.2745 2272	0.06145 0.0034 2272	0.08573 <.0001 2272	0.00091 0.9655 2272	0.31258 <.0001 2272	0.05415 0.0098 2272	0.05372 0.0104 2272	0.08369 <.0001 2272	0.02589 0.2173 2272	-0.02499 0.2338 2272	-0.00669 0.7500 2272	-0.03873 0.0649 2272
Size of social network (up to 5 people)	1.00000 2271	-0.04454 0.0338 2271	-0.12615 <.0001 2271	-0.13217 <.0001 2271	-0.04071 0.0524 2271	0.03032 0.1486 2271	-0.07956 0.0001 2271	-0.04116 0.0499 2271	-0.09371 <.0001 2271	-0.06617 0.0016 2271	-0.08362 <.0001 2271	-0.05905 0.0049 2271	-0.03671 0.0803 2271
Agreement to statement that people in the respondents local community know each other well.	-0.04454 0.0338 2271	1.00000 2272	0.55292 <.0001 2272	0.37538 <.0001 2272	0.01644 0.4334 2272	0.04771 0.0229 2272	0.00686 0.7439 2272	0.02071 0.3239 2272	0.05742 0.0062 2272	-0.01510 0.4720 2272	0.01403 0.5038 2272	-0.00311 0.8821 2272	0.06019 0.0041 2272
Agreement to statement that people in the respondents local community are willing to help eachother.	-0.12615 <.0001 2271	0.55292 <.0001 2272	1.00000 2272	0.54503 <.0001 2272	0.01148 0.5846 2272	-0.01189 0.5710 2272	0.01094 0.6023 2272	0.02677 0.2021 2272	0.04812 0.0218 2272	-0.00684 0.7445 2272	0.02743 0.1913 2272	0.03425 0.1027 2272	0.05881 0.0050 2272
Agreement to statement that people in the respondents local community can be trusted.	-0.13217 <.0001 2271	0.37538 <.0001 2272	0.54503 <.0001 2272	1.00000 2272	-0.01578 0.4521 2272	-0.01808 0.3891 2272	0.03383 0.1069 2272	0.01682 0.4229 2272	0.04291 0.0408 2272	-0.01684 0.4224 2272	0.01367 0.5149 2272	-0.01006 0.6317 2272	0.01543 0.4623 2272
Covid risk prevention: Wash hands	-0.04071 0.0524 2271	0.01644 0.4334 2272	0.01148 0.5846 2272	-0.01578 0.4521 2272	1.00000 2272	-0.00811 0.6992 2272	0.10966 <.0001 2272	0.14296 <.0001 2272	0.06746 0.0013 2272	0.16278 <.0001 2272	0.12303 <.0001 2272	0.27814 <.0001 2272	0.24402 <.0001 2272
Covid risk prevention: Avoid others living in the household	0.03032 0.1486 2271	0.04771 0.0229 2272	-0.01189 0.5710 2272	-0.01808 0.3891 2272	-0.00811 0.6992 2272	1.00000 2272	0.16316 <.0001 2272	0.13633 <.0001 2272	0.13231 <.0001 2272	0.05477 0.0090 2272	0.03667 0.0806 2272	0.03586 0.0875 2272	0.03838 0.0674 2272
Covid risk prevention: Avoid others not living in the household	-0.07956 0.0001 2271	0.00686 0.7439 2272	0.01094 0.6023 2272	0.03383 0.1069 2272	0.10966 <.0001 2272	0.16316 <.0001 2272	1.00000 2272	0.33073 <.0001 2272	0.26614 <.0001 2272	0.27274 <.0001 2272	0.33058 <.0001 2272	0.17358 <.0001 2272	0.22255 <.0001 2272
Covid risk prevention: Maintain 6 ft of distance	-0.04116 0.0499 2271	0.02071 0.3239 2272	0.02677 0.2021 2272	0.01682 0.4229 2272	0.14296 <.0001 2272	0.13633 <.0001 2272	0.33073 <.0001 2272	1.00000 2272	0.25267 <.0001 2272	0.20238 <.0001 2272	0.23760 <.0001 2272	0.19243 <.0001 2272	0.21535 <.0001 2272
Covid risk prevention: Limit family gatherings	-0.09371 <.0001 2271	0.05742 0.0062 2272	0.04812 0.0218 2272	0.04291 0.0408 2272	0.06746 0.0013 2272	0.13231 <.0001 2272	0.26614 <.0001 2272	0.25267 <.0001 2272	1.00000 2272	0.37696 <.0001 2272	0.29418 <.0001 2272	0.13380 <.0001 2272	0.19647 <.0001 2272
Covid risk prevention: Avoid restaurants are bars	-0.06617 0.0016 2271	-0.01510 0.4720 2272	-0.00684 0.7445 2272	-0.01684 0.4224 2272	0.16278 <.0001 2272	0.05477 0.0090 2272	0.27274 <.0001 2272	0.20238 <.0001 2272	0.37696 <.0001 2272	1.00000 2272	0.38478 <.0001 2272	0.21369 <.0001 2272	0.20330 <.0001 2272
Covid risk prevention: Limint shopping and errands	-0.08362 <.0001 2271	0.01403 0.5038 2272	0.02743 0.1913 2272	0.01367 0.5149 2272	0.12303 <.0001 2272	0.03667 0.0806 2272	0.33058 <.0001 2272	0.23760 <.0001 2272	0.29418 <.0001 2272	0.38478 <.0001 2272	1.00000 2272	0.20918 <.0001 2272	0.25040 <.0001 2272
Covid risk prevention: Wear a mask	-0.05905 0.0049 2271	-0.00311 0.8821 2272	0.03425 0.1027 2272	-0.01006 0.6317 2272	0.27814 <.0001 2272	0.03586 0.0875 2272	0.17358 <.0001 2272	0.19243 <.0001 2272	0.13380 <.0001 2272	0.21369 <.0001 2272	0.20918 <.0001 2272	1.00000 2272	0.37026 <.0001 2272
Covid risk prevention: Avoid touching face	-0.03671 0.0803 2271	0.06019 0.0041 2272	0.05881 0.0050 2272	0.01543 0.4623 2272	0.24402 <.0001 2272	0.03838 0.0674 2272	0.22255 <.0001 2272	0.21535 <.0001 2272	0.19647 <.0001 2272	0.20330 <.0001 2272	0.25040 <.0001 2272	0.37026 <.0001 2272	1.00000 2272

Note: This data is sourced from the 2020 COVID-19 supplementary module of the National Health and Aging Trends Survey (n=2,998) *representative of community-dwelling Medicare beneficiary adults age 70+ residing in the United States. Loneliness was measured by asking participants how frequently they felt lonely prior to the pandemic and by then asking participants how frequently they have felt lonely during the pandemic in comparison with response options: more often, less often, or about the same.*

Table 5. Weighted odds ratios and 95% confidence intervals, accounting for complex sampling methods, of unadjusted and adjusted association between social isolation and loneliness.

	Unadjusted Associations	*Fully Adjusted Associations* (without loneliness frequency)*	*Fully Adjusted Associations* (with loneliness frequency)*
Social isolation score (refence = 0: social integration)			
1: Social integration	1.6 (1.1, 2.5)	1.3 (0.7, 2.6)	1.0 (0.5, 2.0)
2: Social isolation	1.6 (1.1, 2.5)	1.3 (0.6, 2.8)	1.1 (0.4, 2.7)
3: Severe social isolation	1.8 (1.2, 2.8)	1.3 (0.4, 3.7)	0.8 (0.2, 3.0)
4: Severe social isolation	2.4 (1.2, 4.9)	1.6 (0.4, 6.9)	1.3 (0.2, 7.4)
Frequency of feeling lonely before the pandemic	6.3 (4.6, 8.6)	-	10.4 (7.6, 14.3)
Age (reference=70 – 74)			
75 – 79	0.7 (0.6, 1.0)	0.7 (0.5, 1.0)	0.7 (0.4, 1.1)
80 – 84	0.7 (0.6, 0.9)	0.8 (0.5, 1.1)	0.8 (0.5, 1.2)
85+	0.9 (0.6, 1.2)	0.7 (0.4, 1.1)	0.7 (0.4, 1.2)
Sex (reference=male)	2.2 (1.6, 2.9)	2.0 (1.5, 2.7)	1.3 (0.9, 1.9)
Race/ethnicity (reference=non-Hispanic white)			
Non-Hispanic black	0.6 (0.4, 0.9)	0.5 (0.3, 0.9)	0.7 (0.4, 1.3)
Other	0.6 (0.3, 1.3)	0.7 (0.4, 1.5)	0.5 (0.1, 1.8)
Hispanic	0.9 (0.4, 1.7)	1.0 (0.5, 2.1)	1.1 (0.4, 3.2)
Education (reference=less than a high school education)			
High school or equivalent (includes post-HS vocational school)	1.4 (0.8, 2.6)	1.3 (0.7, 2.3)	1.4 (0.6, 3.4)
Associate or bachelor's degree or some college	2.2 (1.2, 3.8)	2.0 (1.1, 3.6)	2.4 (1.1, 5.6)
Master's or doctoral degree	3.0 (1.8, 5.1)	2.8 (1.6, 5.2)	4.1 (1.7, 10.1)
Employment status (reference=retired)	0.6 (0.4, 0.9)	0.6 (0.4, 0.9)	0.7 (0.4, 1.3)
Marital status (reference=married/living with partner)			
Separated or divorced	1.8 (1.3, 2.6)	1.6 (1.0, 2.4)	1.1 (0.6, 2.0)
Widowed	1.1 (0.9, 1.5)	0.9 (0.7, 1.3)	0.6 (0.4, 0.9)
Never married	0.7 (0.2, 2.0)	0.6 (0.2, 1.8)	0.6 (0.1, 2.5)
Health status (reference=poor or fair health)			
Good	0.9 (0.6, 1.4)	0.8 (0.5, 1.3)	1.8 (0.9, 3.6)
Very good	0.8 (0.5, 1.2)	0.7 (0.4, 1.1)	2.0 (1.1, 3.7)
Excellent	0.6 (0.4, 1.0)	0.4 (0.3, 0.7)	2.0 (1.1, 3.7)
Household size	0.9 (0.7, 1.0)	0.9 (0.8, 1.1)	1.1 (0.9, 1.4)

Social network size (reference=0 people)	1.3 (1.1, 1.4)	1.1 (1.0, 1.3)	1.1 (1.0, 1.3)
Community perception			
Feeling that know people well	1.0 (0.8, 1.2)	1.0 (0.7, 1.3)	0.9 (0.7, 1.3)
Feeling that people are willing to help	1.0 (0.8, 1.2)	1.2 (0.8, 1.6)	0.9 (0.6, 1.3)
Feeling that people can be trusted	0.9 (0.7, 1.1)	0.9 (0.6, 1.2)	0.7 (0.5, 1.1)
Social activities in previous month			
Visiting with friends and family	0.9 (0.6, 1.3)	0.9 (0.5, 1.6)	0.7 (0.4, 1.3)
Attending religious services	1.3 (0.9, 1.8)	1.0 (0.7, 1.6)	0.8 (0.4, 1.5)
Participating in clubs, classes, or other organized activities	0.5 (0.4, 0.8)	0.7 (0.5, 1.1)	0.7 (0.4, 1.3)
Covid risk reduction behaviors			
Frequently washing hands	0.3 (0.1, 0.7)	0.7 (0.2, 2.3)	1.2 (0.3, 5.8)
Avoiding contact with people they live with	1.4 (1.1, 1.7)	1.3 (1.0, 1.7)	1.3 (0.9, 1.8)
Avoiding contact with people they do not live with	0.5 (0.3, 0.7)	0.8 (0.5, 1.2)	0.8 (0.5, 1.4)
Staying at least 6 feet away from people they do not live with	0.6 (0.4, 0.8)	0.8 (0.5, 1.3)	0.8 (0.5, 1.4)
Limiting group gatherings with family they do not live with	0.5 (0.4, 0.8)	0.7 (0.5, 1.1)	0.7 (0.4, 1.1)
Avoiding being in restaurants and bars	0.4 (0.3, 0.6)	0.7 (0.4, 1.0)	0.5 (0.2, 0.9)
Limiting shopping and errands	0.6 (0.4, 0.9)	1.1 (0.7, 1.7)	1.2 (0.7, 2.1)
Wearing a face mask when going out	0.2 (0.1, 1.0)	0.5 (0.1, 2.1)	0.8 (0.2, 3.2)
Avoiding touching their face when they are out	0.5 (0.4, 0.8)	0.9 (0.5, 1.3)	0.6 (0.3, 1.0)

Note: This data is sourced from the Round 10 (2020) iteration and COVID-19 supplementary module of the National Health and Aging Trends Survey (n=2,998) representative of community-dwelling Medicare beneficiary adults age 70+ residing in the United States. Loneliness was measured by asking participants how frequently they have felt lonely during the pandemic in comparison to before with response options: more often, less often, or about the same. Response options were dichotomized into lonely more often vs. not lonely more often. Social isolation was measured by asking participants if, in the previous month they had visited with family or friends, attended religious services, participated in clubs, classes, or other organized activities, or went out for enjoyment. A composite variable was created by summing the total number of questions to which one responded "no".

Table 6. Weighted odds ratios and 95% confidence intervals, accounting for complex sampling methods, of fully adjusted association between social isolation and loneliness stratified by sex.

	Male	Female
Social isolation score (refence = 0: social integration)		
1: Social integration	1.1 (0.4, 3.0)	1.6 (0.7, 3.6)
2: Social isolation	1.5 (0.5, 4.6)	1.2 (0.4, 3.5)
3: Severe social isolation	0.8 (0.2, 3.7)	1.8 (0.5, 7.0)
4: Severe social isolation	0.6 (0.0, 7.6)	2.9 (0.5, 17.6)
Age (reference=70 – 74)		
75 – 79	0.5 (0.3, 0.9)	0.8 (0.5, 1.2)
80 – 84	0.7 (0.4, 1.4)	0.8 (0.5, 1.2)
85+	0.9 (0.4, 1.9)	0.6 (0.3, 1.0)
Race/ethnicity (reference=non-Hispanic white)		
Non-Hispanic black	0.4 (0.1, 0.9)	0.6 (0.4, 1.1)
Other	0.6 (0.2, 1.8)	0.9 (0.3, 2.6)
Hispanic	0.3 (0.1, 1.6)	1.4 (0.6, 3.5)
Education (reference=less than a high school education)		
High school or equivalent (includes post-HS vocational school)	0.9 (0.4, 2.2)	1.4 (0.7, 2.9)
Associate or bachelor's degree or some college	1.6 (0.7, 3.5)	2.2 (1.1, 4.5)
Master's or doctoral degree	2.1 (0.9, 4.9)	3.4 (1.5, 7.5)
Employment status (reference=retired)	0.6 (0.3, 1.4)	0.6 (0.3, 1.0)
Marital status (reference=married or living with partner)		
Separated or divorced	1.3 (0.4, 3.9)	1.7 (1.0, 2.8)
Widowed	1.1 (0.5, 2.5)	0.9 (0.6, 1.5)
Never married	0.6 (0.2, 2.0)	0.6 (0.1, 2.7)
Health status (reference=poor or fair health)		
Good	0.7 (0.3, 1.8)	0.9 (0.5, 1.5)
Very good	0.6 (0.3, 1.3)	0.7 (0.4, 1.4)
Excellent	0.4 (0.2, 1.0)	0.5 (0.2, 0.9)
Household size	1.1 (0.8, 1.4)	0.8 (0.7, 1.0)
Social network size (reference=0 people)	1.2 (1.0, 1.4)	1.1 (1.0, 1.3)
Community perception		
Feeling that know people well	0.9 (0.7, 1.3)	1.0 (0.7, 1.4)
Feeling that people are willing to help	0.9 (0.5, 1.7)	1.4 (0.9, 2.1)
Feeling that people can be trusted	1.1 (0.6, 2.0)	0.7 (0.5, 1.1)
Social activities in previous month		

Visiting with friends and family	1.0 (0.6, 1.8)	0.9 (0.4, 1.9)
Attending religious services	0.8 (0.4, 1.6)	1.2 (0.7, 2.1)
Participating in clubs, classes, or other organized activities	0.6 (0.2, 1.3)	0.8 (0.4, 1.4)
Covid risk reduction behaviors		
Frequently washing hands	0.9 (0.3, 3.0)	<0.001 (<0.001, <0.001)
Avoiding contact with people they live with	1.4 (0.8, 2.6)	1.2 (0.9, 1.7)
Avoiding contact with people they do not live with	0.9 (0.5, 1.7)	0.7 (0.4, 1.3)
Staying at least 6 feet away from people they do not live with	0.8 (0.3, 2.2)	0.9 (0.5, 1.3)
Limiting group gatherings with family they do not live with	0.5 (0.2, 1.0)	0.8 (0.5, 1.3)
Avoiding being in restaurants and bars	0.6 (0.2, 1.3)	0.7 (0.4, 1.2)
Limiting shopping and errands	1.0 (0.6, 1.8)	1.1 (0.5, 2.3)
Wearing a face mask when going out	0.8 (0.2, 3.5)	0.1 (0.0, 0.9)
Avoiding touching their face when they are out	1.0 (0.6, 1.7)	0.7 (0.4, 1.3)

Note: This data is sourced from the Round 10 (2020) iteration and COVID-19 supplementary module of the National Health and Aging Trends Survey (n=2,998) representative of community-dwelling Medicare beneficiary adults age 70+ residing in the United States. Loneliness was measured by asking participants how frequently they have felt lonely during the pandemic in comparison to before with response options: more often, less often, or about the same. Response options were dichotomized into lonely more often vs. not lonely more often. Social isolation was measured by asking participants if, in the previous month they had visited with family or friends, attended religious services, participated in clubs, classes, or other organized activities, or went out for enjoyment. A composite variable was created by summing the total number of questions to which one responded "no".

Table 1 reports the general distribution of characteristics within the sample and estimates the frequency of each characteristic within the target population which will provide context for later analyses. The analysis is generalizable to the approximately 26.2 million community-dwelling Medicare beneficiary adults age 70+ residing in the United States. Basic demographic information for sex, age, education, employment, and marital status are within the expected ranges for the study population. The distribution within race and ethnicity suggests that non-Hispanic black people may be underrepresented within this analysis. Contextualizing social isolation potential during covid lock downs, an estimated 72.0% (95% CI: 70.2, 73.9) lived with at least one other person. The study population demonstrated high coherence to covid risk reduction behaviors with eight of the nine sample behaviors seeing compliance from at least an

estimated 84.2% (95% CI: 82.3, 86.2) the exception being avoiding contact with others in the household which approximately only 13.4% (95% CI: 11.6, 15.1) of the population employed. The highest compliance measure was frequent handwashing estimated to be seen in about 98.1% (95% CI: 97.4, 98.8) of the population.

The average social isolation score was projected to be 1.7 (95% CI: 1.6, 1.7) indicating moderate social isolation. Additionally, the average social network size was only 2.6 people (95% CI: 2.5, 2.7). Prior to the pandemic, about one third of the population is estimated to have experienced loneliness some days, most days, or every day (26.4% (95% CI: 24.3, 28.5), 6.2% (95% CI: 4.7, 7.7), and 2.1% (95% CI: 1.4, 2.8) respectively) illustrating the relevance of further understanding this experience. While 22.5% (95% CI: 20.0, 25.0) are estimated to have experienced an increase in loneliness during the pandemic relative to their prior frequency of loneliness.

The proportion of those who experienced an increase in loneliness during the pandemic is defined in Table 2 segmented by the characteristics measured in this study. Groups with a notably higher distribution within those who experienced an increase in loneliness include females, 70 – 74 year olds, those with high education (especially a master's or doctoral degree), and those divorced. Of particular relevance to the research question, among those lonelier were those living with others (36.4% (95% CI: 31.2, 41.5) of those lonelier and 25.5% (95% CI: 23.4, 27.7) of those not lonelier) and those with a higher average social network size (3.0 (95% CI: 2.7, 3.2) and 2.5 (95% CI: 1.7, 3.2) of those lonelier and not lonelier respectively). Those who reported feeling lonely some days before the pandemic made up 64.9% (58.5, 71.3) of those lonelier during covid and only 15.2% (13.5, 16.9) of those not lonelier.

Table 3 presents the cross-tabulation of the frequency of loneliness reported before COVID-19 compared to the relative change in loneliness during the pandemic. Among those who never felt lonely, there were no reports of an increase in loneliness. It should be noted that 1.4% (95% CI: 0.8, 2.0) of people reported that they were lonely every day prior covid, yet also reported an increase in loneliness during covid. With only about 2.9% (95% CI: 2.0, 3.9) of people reporting a decrease in loneliness during covid, the distribution of the frequency of loneliness within this subgroup may not reliable due to the small sample size. Finally, the majority of those who reported no change in their levels on loneliness during covid had reported only feeling lonely rarely or never feeling lonely at all.

Table 4 presents the unweighted correlation coefficients between all variables included in the analysis. There were essentially no variables with correlations $\geq |0.75|$, however there was a surprising lack of association between household size and social network size ($r= -0.00365$, $p=0.8862$). The lack of correlations between social network and loneliness frequency ($r=0.05559$, $p=0.0081$) and loneliness change ($r=0.14009$, $p<0.0001$) are notable as they are quite low and you may expect those within one's household to be more likely to be part of one's social network.

Table 5 presents the weighted odds ratios and 95% confidence intervals for both the unadjusted and fully adjusted associations between social isolation and loneliness with an additional model which also accounts for the frequency of loneliness respondents reported before the pandemic. As including this additional loneliness variable in the model seems to have overcorrected the model, conclusions will be primarily drawn from the standard fully adjusted model not accounting for prior loneliness frequency. This is evident by the fact that the frequency of feeling lonely prior to the pandemic had dramatically significant odds of an

increase in loneliness during the pandemic in both the unadjusted (OR=6.3, 95% CI: 4.6, 8.6) and fully adjusted (OR=10.4, 95% CI: 7.6, 14.3) analyses.

Respondents who are socially integrated (score=0) were used as the reference for social isolation. While each of the four social isolation associations indicate a positive correlation with loneliness (with estimated odds ratios ranging 1.3 – 1.6) all associations cross the null in the adjusted model and should be interpreted with caution. Contrary to existing literature, older age categories (75+) suggested a reduced likelihood of an increase in loneliness compared to those 70-74. However, it should be noted that the confidence intervals for these odds ratios crossed or included the null. Female respondents had a significantly higher odds of reporting loneliness compared to males, both in the unadjusted (OR=2.2, 95% CI: 1.6, 2.9) and fully adjusted (OR=2.0, 95% CI: 1.5, 2.7).

While the adjusted model suggests that non-Hispanic black people are less likely to have an increase in loneliness compared to their non-Hispanic white counterparts, this result should be interpreted with caution as results shown in Table 1 indicated that this demographic may not have been effectively sampled. In an association not documented in the literature review, respondents with a higher educational attainment, those with an associate's degree, a bachelor's degree, or some college (OR=2.0, 95% CI: 1.1, 3.6), and a master's or doctoral degree (OR=2.8, 95% CI: 1.6, 5.2) were significantly more likely to report loneliness. Those with a high school or equivalent education (OR=1.3, 95% CI: 0.7, 2.3) had an odds ratio consistent with an increase in loneliness, however the confidence interval included the null.

Respective to retirement, working was associated with lower odds of loneliness in both the unadjusted and adjusted analyses (OR=0.6, 95% CI: 0.4, 0.9). Interestingly, the odds ratios and confidence intervals elicited in unadjusted and adjusted models were the same. In

comparison to those married or living with a life partner, those who were separated or divorced demonstrated a significantly increased odds of increased loneliness during covid. Improved health was increasingly associated with lower odds of loneliness during covid, however, when compared to those reporting poor or fair health, those with excellent health were the only group with a confidence interval supporting statistical significance (OR=0.4, 95% CI: 0.3, 0.7).

While all covid risk reduction behaviors had confidence intervals crossing or including the null in the adjusted model, the estimated odds ratios for seven of the nine suggested reduced odds of loneliness among those who complied with those guidelines. The exceptions were avoiding contact with people they live with (OR=1.3, 95% CI: 1.0, 1.7) as also seen in Table 2, and limiting shopping and errands (OR=1.1, 95% CI: 0.7, 1.7).

Table 6 displays the fully adjusted weighted odds ratios and 95% confidence intervals for the association between social isolation and loneliness, stratified by sex. The trends seen in Table 6 are largely similar to those seen in Table 5 and as such, only notable differences will be reported here. Arguably the most important difference seen when stratifying is that, among males, the association between social isolation and loneliness is reversed. Where before there was a slight, but increasingly positive association between the two, both odds ratios for scores representing severe social isolation among men suggest a reduced odds of loneliness (score 3: OR=0.8, 95% CI: 0.2, 3.7; score 4: OR=0.6, 95% CI: 0.0, 7.6). While associations with education level follow the same pattern as in Table 5, Table 6 suggests that the increases in loneliness are even more prominent among females. Finally, stratified associations suggest that wearing a face mask when going out was significantly correlated with a reduced odds of loneliness among females (OR=0.1, 95% CI: 0.0, 0.9). While this pattern is similar to that seen in Table 5, the difference seems to again be more prominent among females.

Chapter 5. Discussion

Loneliness and social isolation were existing issues among the older adult population prior to covid. During covid, many people experienced an increase in risk factors for experiencing loneliness and/or social isolation such as a change in living situation, change in marital status (through covid related loss), or change in social network size (due to inability to attend in-person events or loss of those in their social network to covid) making this issue one that is immediately relevant in caring for this demographic. The current study is the first to include social isolation and loneliness measures from the NHATS while also accounting for pandemic risk reduction behavioral measures. This work examines the relationship between social isolation and loneliness in a pandemic context and provides further insight into understanding the risk and protective factors for experiencing loneliness in older adulthood.

While unadjusted models suggest an increasingly positive correlation between social isolation and loneliness among older adults, associations from the fully adjusted model have weak and directionally variable correlations suggesting that the relationship between the two can be largely explained by other factors included in the model. This may also explain why existing literature is divided on the relationship between social isolation and loneliness. This analysis fails to reject the null hypothesis that there is no association between the two.

The frequency of loneliness prior to the pandemic has by far the largest positive association with the relative change in loneliness during covid. While this finding is relatively unsurprising, it confirms that this is a key group of people to target for intervention. Additionally, it also corroborates research suggesting that loneliness can be cumulative over the life course (Holt-Lunstad, 2017). Given this context, interventions to reduce or prevent loneliness in older adults

should not only be focused on those who are currently in older adulthood but should also include those across stages of life and therefore targeting a reduction in overall life course accumulation and which would ultimately reduce the prevalence of loneliness among older adults over time.

The weakness of the correlation between social network size and loneliness supports the lack of correlation between social isolation and loneliness. Conversely, those who were still in the workforce, those who participated in organized activities, and those who reported feeling that they could trust people in the community, each factors which could influence how often one interacts with others and/or the quality of those interactions, all had reduced odds of loneliness. Qualitative research could more deeply examine commonalities among each of these variables to inform future quantitative analyses. Additionally, further research should examine these correlations longitudinally to understand the role of temporality in these relationships.

The adjusted analytic model suggested higher odds of increased loneliness among females, those with a higher level of education, and those with better health. While existing literature supports females increased odds of experiencing loneliness, positive correlations between education and health status with loneliness have not previously been described to the best of my knowledge at the time this analysis was conducted (Barreto et al., 2021).

Analyses stratified by sex in relation to loneliness can further support tailored interventions. Results indicate that social isolation was a stronger predictor of loneliness among females rather than males. While the frequency of loneliness prior to covid was a strong predictor among both males and females, it was even stronger among females. Additionally, the association between health status and loneliness is more robust for females, underscoring the potentially detrimental effects of loneliness on well-being. While trust in others predicted less loneliness among females, engaging in social activities appears to be more beneficial in mitigating loneliness

among males. These sex-specific patterns suggest that addressing loneliness and its underlying factors may require tailored interventions that recognize and cater to the unique experiences and needs of both males and females. Further research is warranted to explore how sex impacts socialization and subsequently loneliness.

As supported in some existing literature there was no significant association between social isolation and loneliness. This confusing finding seems to be corroborated by the weak correlation between social networks and loneliness. It is worth considering that measurements for both social isolation and social network size are subject to social desirability bias, especially as responses to these variables were collected via in-person or phone interview format. In addition, the social isolation measure could be less sensitive during covid as many of the activities asked about were likely to have been impacted by the pandemic.

In contrast with existing literature, the results suggested that when compared to the younger, 70–74-year-old group, those in five-year age groups within 75-85+ were less likely to be lonely. However, this finding could be influenced by the fact that the exact age of respondents was not available in the dataset rather only five-year age groups. Additionally, the reference group used in this analysis was 70-74-year-olds and only includes the older adult population rather than adults of all ages. The positive correlation between education level and loneliness is also interesting and should be further investigated to understand what might explain this association.

Limitations of the study include the change in data collection mechanism from in-person to telephone interviews as this could reduce an interviewer's capability to sense confusion and increase the potential for miscommunication. This change could impact the quality of the data collected from those who did respond. It is also plausible that a group of people who would have responded to an in-person interview but did not respond to a phone survey are systematically

different from those who did respond. The response rate for the mail in covid module was 75% among those who responded to the round 10 administration of the study which could also induce response bias. Furthermore, as the covid module was conducted via a mail-in form, there was a higher incidence of missing data among those who did respond as interviewers. Finally, it should also be considered how socialization around gender and gender identity influence the degree to which people feel comfortable expressing certain emotions such as loneliness.

These findings support existing literature suggesting that there is little to no association between social isolation and loneliness. In addition, the findings point towards other indicators to further investigate. Qualitative research on the subject matter should be considered to further understand more sensitive and nuanced information to further guide more in-depth quantitative research.

Chapter 6. Public Health Impact

Given that the risks of social isolation are cumulative over the life course, the impact of risk factors on younger populations is pertinent as they will one day make up the older adult population (Holt-Lunstad, 2017). All populations should be considered to reduce loneliness and social isolation among older adults now and in generations to come.

In considering the prevention aspect of public health, these findings can be employed to reduce the risk of loneliness among older adults throughout the life course. This will not only support in reducing the overall burden of loneliness within the population, but will also help to reduce serious comorbidities associated with loneliness in older adults including cognitive decline, depression, heart disease, and loss of overall functionality resulting in healthier aging and better management of chronic conditions (Cacioppo et al., 2006; Cacioppo & Cacioppo, 2014; Shankar et al., 2017; N. K. Valtorta et al., 2016).

Employing interventions to target all age groups will have the dual impact of supporting the age group immediately and in the long term. In addition, the current cost and demand for care to support aging populations may be notably reduced particularly in cases where the reduction of loneliness will support prolonged cognitive function and independent functionality.

Addressing loneliness can yield numerous benefits for both mental and physical health. Mitigating loneliness has been linked to improved psychological well-being, with reduced rates of depression, anxiety, and stress. Additionally, a decline in loneliness has shown promise in enhancing physical health outcomes, contributing to a lowered risk of cardiovascular diseases, hypertension, and overall mortality. Reducing loneliness can lead to heightened life satisfaction and improved overall health. Public health initiatives focused on reducing loneliness may also yield financial benefits, with potential cost savings stemming from reduced healthcare utilization, including fewer hospitalizations and mental health service visits. Reducing loneliness will support overall health and improved quality of life.

Finally, the impacts of climate change and how they are already influencing our everyday lives must also be considered. Climate change will likely lead to greater risk and incidence of pandemics and poor air quality due to pollution and wildfires. Understanding how to prevent health detriments from occurring because of measures directly aimed at reducing the spread of infectious disease and reducing exposure to harmful environmental conditions will be of increasing importance.

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