The association of loneliness with health and social care utilisation in older adults: A systematic review

Running title: Health and social care utilisation and loneliness

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Abstract

Background and Objectives: Loneliness is proposed to be linked with increased service use. This review examined the proposed association between loneliness and health and social care utilisation (HSCU) in older adults from the general population.

Methods: Four databases were screened for studies that examined the association between loneliness (predictor) with HSCU (outcome) in older adults (defined as majority of sample 60 or older). Study quality was assessed with the NIH scale for observational cohorts and cross-sectional studies.

Results: We identified 32 studies, of which 9 prospective studies were evaluated as being of good or good-fair quality. Two good-fair quality studies suggested that loneliness at baseline was associated with subsequent admission to a residential care home. There was emerging evidence that loneliness was associated with emergency department use (n=1), and CVD-specific hospitalisation (n=1). Once adjusted for confounders the highest quality studies found no association between baseline loneliness with physician utilisation, outpatient service utilisation, skilled nursing facility use, and planned or unplanned hospital admissions. The remaining, studies were cross-sectional, or of fair to poor quality, and inadequate to reliably determine whether loneliness was associated with a subsequent change in HSCU.

Discussion and implications: There was heterogeneity in study design, measurement, and study quality. This generated an inconsistent evidence base where we cannot determine clear inferences about the relationship between loneliness and HSCU. Only one consistent finding was observed between two good-fair quality studies regarding care home admission. To determine clinical implications and make reliable inferences additional good quality longitudinal research is needed.

Keywords: Lonely, healthcare, service use

Introduction

Loneliness is a negative subjective state that arises from a perception that one does not have the social relationships or companionship that one desires (Victor et al., 2000). Loneliness is increasingly framed as a public health issue (Cacioppo & Cacioppo, 2018), in large part due to evidence linking loneliness with an increased risk of experiencing a range of negative health outcomes such as cardiovascular disease (CVD) (Valtorta, et al., 2016), dementia (Lara et al., 2019), depression (Martin-Maria et al., 2021) and mortality (Holt-Lunstad et al., 2015). An additional health-related outcome that is often referred to when defining loneliness as a public health issue is increased health and social care utilisation (Cacioppo & Cacioppo, 2018; Gerst-Emerson & Jayawardhana, 2015).

Health and social care utilisation (HSCU) is a term used to define the point at which a person uses any health or social care service including primary, secondary and community-based services as well as specific services such as dentistry. HSCU is linked to a range of socio-demographic factors including older age, gender, ethnicity, socio-economic status as well as pre-existing health problems and healthcare financing (OECD, 2020). There is also some evidence suggesting that loneliness may also be linked with increased HSCU amongst older adults (Ellaway et al., 1999; Gerst-Emerson & Jayawardhana, 2015). This evidence has been used to promote the importance of signposting older adults to community services to help alleviate their loneliness, and the development of new ways of working (e.g., social prescribing) which guides lonely people towards community resources rather than relying on resources such as primary care (Reinhardt et al., 2021). However, while this evidence can be used to help improve provision for issues of loneliness, there is the potential it could also have a broader negative impact. Victor (2021) suggested that the representation of lonely older adults as a "burden" on health and social care services forms part of an ageist societal narrative

termed a "modern moral panic". In addition, two facets of ageism identified in previous work include attitudes and beliefs that older adults place an excess burden on healthcare, and that all older adults are lonely and socially isolated (Swift et al., 2017). This is despite research indicating that older adults often have high levels of unmet health and social care needs (Age UK., 2019) and loneliness is a common experience across the lifecourse (Barreto et al., 2020; Victor and Yang., 2012). Given the potentially negative implications in terms of attitudes and stigmatisation we need to determine systematically whether existing evidence supports this proposition that lonely older adults utilise health and social care services disproportionately.

Previous syntheses do not unequivocally indicate whether loneliness is associated with HSCU amongst older adults. Owens & Sirois (2019) conducted a review and meta-analysis suggesting that loneliness was associated with increased physician visits. We cannot extrapolate their findings to older populations as the meta-analysis synthesised both cross-sectional and longitudinal studies, and included studies in people across all ages. Valtorta et al (2018) in their review of older adults, suggested there was no evidence to support the assumption that older adults with lower levels of social support place an extra burden on healthcare services but did not specifically examine whether loneliness was associated with HSCU. Amongst the issues that can be identified in individual studies that have been included within these syntheses are cross-sectional study design (Cheng., 1992; Ellaway et al., 1999), or the sampling of existing service users or non-representative populations (Geller et al., 1999). These studies would not be sufficient to allow us to reliably determine whether loneliness is linked to subsequent HSCU in the general population.

Therefore, the goal of this study was to provide the first comprehensive systematic assessment of existing research examining loneliness and HSCU in older adults. Our objective was to determine whether loneliness was associated with increased HSCU in older adults sampled from the general population and critically evaluating the quality of the evidence-base.

Methods

Search strategy

The initial search was undertaken in December 2020, with update searches completed in June 2021 and August 2021. Search terms were created for the core topics of 'HSCU' and 'loneliness' (see Supplementary Table 1). We searched 4 databases: PubMed (United States National Library of Medicine, Bethesda, MD, USA), ISI Web of Science (Thomson Reuters, New York, NY, USA), Scopus (Elsevier, Amsterdam, Netherlands) and EBSCOHost (EBSCO Industries, Ipswich, MA, USA). In addition, we hand-searched the reference lists (and citation lists) of existing systematic and narrative reviews on healthcare utilization and social relationships (Owens & Sirois, 2019; Valtorta et al., 2018) and all papers identified for full-text screening to identify any additional papers. No time or geographical limitations were imposed, but only studies published in English were included. The study protocol was registered on PROSPERO (ID CRD42017065986). The initial screening of studies was completed by KS, and full-text articles reviewed by both KS and CV to determine which studies should be included in the review, any disagreements were resolved by consensus.

Study Selection

We used PICOS criteria to define our study question: Do observational quantitative (**S**tudy design) studies find that loneliness (**I**ntervention/**C**omparison) is associated with HSCU (**O**utcome) in older adults sampled from the general population (**P**opulation). For the sake of this research general population was defined as a study that sampled a representative sample of older adults from the general population including those living in the community. This could include studies that used representative community-based samples, or insurance databases. However, we excluded studies from specific clinical population (e.g. those with a specific

diagnosis), or studies that exclusively sampled existing service users (e.g. surveys of attenders at emergency departments or primary care samples). Studies were also eligible if more than 50% of the sample (or a sub-group sample if age stratified analyses were provided) was older than 60 or the mean age of the sample was older than 60 in line with previous work (Valtorta et al., 2018).

Studies were required to measure loneliness with either an established loneliness scale or single item measure. HSCU could use any measure indicative of health and social care use including primary care and secondary care, social care, tertiary care and nursing/care home use. Additional inclusion criteria stipulated that articles be published in peer reviewed journals.

Data extraction and quality assessment

Data extraction was performed using a standardised form which included: population studied (Age, sex, country), study design (design, length of follow-up) loneliness measurement (loneliness measurement, timeframe assessed), HSCU measurement (health or social care use , timeframe assessed), statistical analysis, confounders adjusted for and results (crude association and fully-adjusted association). Data extraction was completed by KS and verified by CV (supplementary table 2).

Study quality was assessed using the National Institutes for Health (NIH) scale for observational cohorts and cross-sectional studies as recommended by Cochrane (NIH, 2014). This assesses study quality across 14 questions related to sampling, methodology and measurement and generates an evaluative judgement of quality as good, fair or poor rather than a numerical score. These were agreed by consensus discussion between the authors, using four key study parameters (supplementary file 3 provides more information):

Measurement of loneliness: Good quality evidence uses a validated way of measuring loneliness: either a single-item question or multidimensional scale reported by severity to facilitate examination of dose-response associations.

Measurement of health service utilisation: Good quality evidence measures healthcare utilization in an objective way (i.e., linked medical or social care records), and have a period of follow-up long enough to capture the outcome of interest (defined as 1 year). Furthermore, studies should have an analytical strategy that accounts for the nature of this kind of data (i.e., accounts for a zero-inflated distribution).

Causal inference: Good quality evidence able to demonstrate temporality by using a longitudinal study design that assesses the exposure (loneliness) at baseline and the outcome (HSCU) at follow-up. Good-fair quality evidence will examine how the predictor and outcome co-vary over time. Any study using a cross-sectional design will not be able to demonstrate temporality as the outcome measure would be assessed retrospectively from baseline.

Confounder control: Good quality studies control for confounders associated with both loneliness and healthcare utilization that could potentially explain the relationship. Important confounders identified by established research are: age, sex, marital status, household composition, physical health (e.g., chronic conditions and/or physical functioning), mental health (e.g., depressive symptoms, psychological distress), cognition (e.g., presence of dementia) and health behaviours (e.g., smoking status, physical activity, diet, sleep). To be considered good quality we required studies to have controlled for at least 75% (6 of the 8) important confounders.

Results

Search strategy

After removing duplicates, the titles and abstracts of 3,283 papers were screened and 3,125 were removed (reasons included studies conducted in younger population, no measurement of loneliness or HSCU, non-community sample, and intervention or RCT studies). Full-text screening was conducted with 156 papers, with 128 excluded (reasons for exclusion are listed in Figure 1). An additional 4 papers were identified through additional sources, giving us 32 eligible published studies.

Study summary

The 32 studies were published between 1981-2021, and used 25 datasets. The two most commonly used datasets were the English Longitudinal Study of Ageing (n=4) and the US Health and Retirement Study (n=4) (see supplementary table 2). Sample sizes ranged from 162 (Wang et al., 2019) to 18,557 (Mosen et al., 2020). Included studies were from 10 countries (Denmark, Germany, United Kingdom, United States of America, Ireland, China, Singapore, Sweden, Switzerland and Canada) (see Supplementary Table 2). Ages ranged from 40 or older (Bock et al,, 2018) to 85 and older (Nägga et al., 2012) with the majority of studies sampling those aged 60-65 plus (see Supplementary Table 2).

Included studies assessed a range of indicators of HSCU including contact with physicians, outpatient service use, planned and unplanned hospital use, inpatient service use, accident and emergency use, moving to a residential care home, use of skilled nursing facilities, dental services and use of community services (see Tables 1-3). HSCU was measured through linked medical, residential or healthcare records in 11 studies, with the remaining studies relying on self-report (see Tables 1-3). Loneliness was measured with single-item questions, a 3, 4, 5 or 10-item version of the UCLA-loneliness scale, the De-Jong Jierveld scale, or both multidimensional and single item measures (see Tables 1-3). Some studies using a cut-off to define loneliness and others treated loneliness as a continuous predictor (see Tables 1-3). No studies provided estimates that adjusted for all important confounders, but 21 studies adjusted

for a minimum of 6 of the 8 important confounders, and 5 provided only unadjusted estimates (see Supplementary Table 3).

Study quality

The highest quality studies were those that employed a sampling technique that recruited a representative sample, and employed appropriate methodological and statistical designs (see Supplementary Table 3 and Tables 1-3). Six studies were evaluated as good quality (Bu, Abell, et al., 2020; Bu, Philip et al , 2020; Bu, Zaninotto et al., 2020; Dahlberg et al., 2018; Newall, et al., 2015;Shaw et al., 2017) these longitudinal studies utilized loneliness data from national or provincial ageing cohorts, accounted for the majority of important health and sociodemographic confounders in their analysis and measured HSCU through linked medical records (see Supplementary Table 3). An additional three studies were rated as good-fair quality due to limited sampling (Hanratty, et al., 2018), inadequate confounder adjustment (Mosen et al., 2020) and use of UCLA scale in non-validated way (Russell et al., 1997). Two longitudinal studies were rated as fair as they had non-representative sampling methods, and measured self-reported indicators of HSCU retrospectively over multiple waves rather than prospectively (Bock et al., 2018; Wang et al., 2019), with the remaining longitudinal study being rated fair-poor as in addition to the aforementioned issues they also had inadequate confounder adjustment (Spinler et al., 2019).

The remaining studies were evaluated as fair to poor quality, and inferences were limited by the employment of cross-sectional designs (see Tables 1-3 and supplementary table 3). These studies were not adequate to determine that loneliness as an exposure variable caused a difference in HSCU as an outcome variable because either they measure loneliness retrospectively and HSCU at the time of data collection (or vice versa) or both factors contemporaneously.

Loneliness and healthcare utilization: Qualitative synthesis

Summary of key results from highest quality studies

Of the nine good or good-fair quality studies there was no evidence of a confounder-adjusted association between loneliness with subsequent utilisation of physicians (Newall et al., 2015; Wang et al., 2019), skilled nursing facilities (Shaw et al., 2017), or outpatient services (Shaw et al., 2017). Evidence for an association between loneliness with subsequent inpatient service use or hospitalisation was inconclusive (Bu, Abell et al, 2020; Bu, Philip et al., 2020; Bu, Zaninotto, et al., 2020; Dahlberg et al., 2018; Newall et al., 2015; Mosen et al., 2020). Two studies reported that that baseline loneliness was associated with an increased likelihood of moving to a residential care home (Hanratty et al., 2018; Russell et al., 1997) and one that it was associated with subsequent emergency department utilisation (Mosen et al., 2020).

The remaining studies were all cross-sectional, or fair to poor quality limiting the extent to which we can reliably infer whether loneliness causes a subsequent change in HSCU. Findings from all studies are synthesised by commonalities in the type of HSCU below and results discussed in more detail. We retain cross-sectional designs in this synthesis to highlight the limitations inherent in these designs when assessing the health outcomes of loneliness and to demonstrate the lack of robust longitudinal studies requried to be able to assess these relationships.

Loneliness and contact with physicians

We identified 14 studies that examined the relationship between loneliness and physician visits of which only 3 were longitudinal and only one of sufficient quality to determine whether loneliness was associated with subsequent HSCU (See table 1 and supplementary table 2).

The one good quality longitudinal study found an unadjusted, but not confounder-adjusted association between baseline loneliness with making one or more visit to any physician over 2.5 years (Newall et al., 2015).

The remaining thirteen studies were of fair to poor quality. There were two longitudinal studies that assessed physician visits in different ways. Wang et al (2019) found those who were slightly lonely at baseline (not often lonely at baseline) reported significantly shorter times since seeing their GP over three waves than people who were not lonely at baseline. Bock et al (2018) indicated that over time changes in loneliness were not associated with the number of visits made to the GP over three waves.

Eight cross-sectional studies indicated loneliness (single timepoint and/or chronic) was associated with an increased number of physician visits (Burns et al., 2020; Cheng., 1992; Ellaway et al., 1999; Gerst-Emerson and Jaywarha., 2015; Houle et al., 2001), or an increased likelihood of having seen a physician (Mosen et al., 2020; Richard et al., 2018; Zhang et al., 2018). One study found no association between loneliness with home visits from a physician in the previous year (Ellaway et al., 1999), and another that people who were sometimes or often lonely were more likely to have seen a physician in the previous month (Almind et al., 1991). Two studies indicated no association between loneliness and physician visits (Burns et al., 2021; Lim and Chan., 2017).

Overall, there is no existing evidence to suggest that loneliness in older adults causes a subsequent increase in the number of physician visits.

[Insert Table 1]

Loneliness and outpatient service use/use of specialist services

Four studies assessed loneliness and outpatient/specialist service use of which 2 were longitudinal and 2 cross-sectional (see table 2 and supplementary table 2). The one good quality longitudinal study found no confounder-adjusted association between baseline loneliness with outpatient visits over a median of 4.5 years (Shaw et al., 2017).

A fair quality longitudinal study found that over time changes in loneliness were not associated with changes in the use of specialist services (Bock et al., 2018). Two fair-poor quality cross-sectional studies found a confounder-adjusted association between loneliness and outpatient service use (Denkinger et al., 2012; Jiang et al., 2018). However, these studies are not adequate to infer temporality.

Taken together there is no evidence to suggest that loneliness is associated with a subsequent difference in the use of general outpatient or specialist facilities amongst older adults.

Loneliness and hospitalization

We identified 13 studies addressing loneliness and hospitalisation (which were general, planned, unplanned or for specific conditions), of which 8 were longitudinal and 5 cross-sectional (see table 2 and supplementary table 2).

Seven good to good/fair quality longitudinal studies examined the association between loneliness with hospitalisation measured using linked medical records (see table 2). Three examined general hospitalisation, but findings were inconsistent. One good-fair quality study indicated that people who were sometimes lonely at baseline (but not often lonely) were more likely to be hospitalised during a 1-year follow-up (Mosen et al., 2020). A second good quality study from Newall et al, (2015) found no association with any hospitalization or the length of stay in hospital over 2.5 years, but evidence for an increased likelihood of re-hospitalisation

over time. Running contrary to both of these Shaw et al (2017) found that loneliness was associated with significantly fewer all-cause hospitalisations.

One good quality study from Dahlberg et al (2018) examined planned and unplanned hospitalisations over 1-2 years of follow-up and found no confounder-adjusted association. Three good quality studies examined cause-specific hospitalisation using baseline data from the English Longitudinal Study of Ageing (ELSA) and linked medical records, and after adjusting for confounders found that loneliness at baseline was associated with an increased risk of hospitalisation over a median of 9 years due to incident CVD (Bu, Zaninotto, et al., 2020), but not falls (Bu, Abell, et al., 2020) or respiratory-disease related hospitalisation (Bu, Philip, et al., 2020).

Six fair to poor quality studies examined the association between loneliness with hospitalisation. Of these six studies, five examined general hospitalisation. One fair quality longitudinal study indicated no association between loneliness with general hospitalisation (Wang et al., 2019), with one other cross-sectional study also finding no association between loneliness with hospitalisation in the previous year (Jiang et al., 2018). Two cross-sectional studies found that people who were lonely were more likely to have been hospitalised in the previous year (Nagga et al., 2012; Zhang et al., 2018). One additional fair-poor quality cross-sectional study found no association between loneliness with length of stay in hospital in the previous 12 months (Denkinger et al., 2012).

One cross-sectional study examined planned and unplanned (emergency) hospitalisation in the previous 12 months and found that loneliness was associated with unplanned but not planned hospitalisation (Molloy et al., 2010).

Taken together there is no consistent evidence to suggest that loneliness is associated with subsequent in-patient hospitalisation in older adults. Some studies indicated decreased utilisation, some increased utilisation and others no difference (see table 2).

Loneliness and accident and emergency admission

Four studies addressed loneliness and accident and emergency admissions of which one was longitudinal and three cross-sectional (see table 2 and supplementary table 2). The one good-fair quality longitudinal study from Mosen et al (2020) found that being either sometimes or often/always loneliness at baseline were associated with a greater adjusted odds of emergency department utilisation in the year following loneliness assessment.

Two fair/fair-poor quality cross-sectional studies examined the association between both a multidimensional and single-item measure of loneliness with accident and emergency service utilisation, and found mostly non-significant associations after adjusting for confounders (Burns et al., 2020; 2021). A third fair-poor quality study found that people who were lonely and socially isolated had a higher likelihood of having visited an emergency department in the previous 12 months than people who were neither lonely nor isolated (Barnes et al., 2021).

Taken together the one longitudinal study provides some evidence to suggest that loneliness might be associated with subsequent accident and emergency use, but this finding is not consistently replicated in cross-sectional studies. There is a need for further research to confirm or refute before reliable conclusions can be drawn.

[Insert Table 2]

Loneliness and dental service use

Three studies addressed loneliness and dental service use, however these were all of fair to poor quality limiting inferences (see table 3 and supplementary table 2).

One poor quality longitudinal study indicated no association between changes in loneliness with dental visits in the previous year over 3 waves (Spinler et al., 2019). One unadjusted poor quality cross-sectional found that loneliness was associated with a decreased likelihood of being a regular dentist user (Lungren et al., 1995) whilst second fair quality cross-sectional study found an unadjusted association between loneliness and dental service utilisation which was attenuated after adjustment for confounders (Burr and Lee., 2012). The evidence gathered from this review is not of sufficient quality to determine whether loneliness is associated with later dental service use in older adults.

Loneliness and residential care or skilled nursing facilities

Three good/good-fair quality studies examined the association between loneliness with subsequent admission to residential care or use of skilled nursing facilities (see table 3 and supplementary table 2). Two good-fair quality longitudinal studies found that older adults who were identified as being lonely at baseline had an increased likelihood of being admitted to a residential care home at follow-up when compared with older adults who were not lonely (Hanratty et al., 2018; Russell et al., 1997). One good quality longitudinal study examined use of skilled nursing facilities (any specialist nursing and therapy care for specific issues) over a median of 4.5 years and found no adjusted association between baseline loneliness with these facilities (Shaw et al., 2017).

There is some evidence from this review to suggest that loneliness at baseline could be associated with residential care home admission during follow-up. This finding was consistent across two studies, both studies were able to demonstrate temporality and the one study that examined different levels of loneliness found a dose-response relationship (Russell et al., 1997). However, one of these studies identified people who had been admitted to a residential care home during follow-up and then compared them to age-and-sex matched participants at

baseline for loneliness (Hanratty et al., 2018), and the second used a loneliness scale in an unorthodox way (Russell et al., 1997). Additional good quality prospective research is needed to confirm or refute these findings before reliable conclusions can be made. There is not sufficient evidence to indicate that loneliness is associated with subsequent use of skilled-nursing facilities.

Loneliness and use of community services

Three studies assessed loneliness and use of community services, however these were all of fair to poor quality limiting inferences (see table 3 and supplementary table 2).

One fair quality longitudinal study from Wang et al (2019) found baseline loneliness was not associated with self-reported utilisation of any of the following services in the previous week (measured over three time-points over 7 years): home help, community nurse, meals on wheels or use of day centre. Two poor quality cross-sectional studies examined the association of loneliness with community services, and both found loneliness was associated with use of community care. The evidence from this review is not of sufficient quality to determine whether loneliness is associated with later community care in older adults.

General medical utilisation (not specified)

Two studies examined loneliness and dental service use, however these both cross-sectional and poor quality limiting inferences (see table 3 and supplementary table 2).

One study indicated loneliness was associated with a higher frequency of seeking medical advice, whereas the second reported no correlation between social or emotional loneliness with the receipt of any medical care over the previous month. The evidence from this review is not of sufficient quality to determine whether loneliness is associated with later general medical utilisation.

[Insert Table 3]

Discussion

The lack of consistency in findings and study heterogeneity makes it difficult to robustly elucidate whether loneliness as an exposure predicts increased HSCU as an outcome in older adults. Of the 32 studies identified 20 were cross sectional and not adequate to infer temporality. Only nine longitudinal studies were of sufficient quality to determine if loneliness was associated with subsequent HSCU, and the only consistent finding was that loneliness at baseline increased the likelihood of being admitted to a residential care home (Hanratty et al., 2018; Russell et al., 1997). There was also notable heterogeneity between all examined studies in terms of indicators of HSCU, controlling for different confounders, different statistical methodologies and measurement of both loneliness and the outcome HSCU.

Loneliness and HSCU: The longitudinal relationship

The only consistent finding from two good-fair quality studies was that loneliness predicted care home admission even after adjusting for confounders (Hanratty et al., 2018; Russell et al., 1997). However, there are methodological issues with both studies that mean additional good quality prospective research is needed before reliable conclusions can be drawn. Interestingly, this finding has also been replicated in an additional study not eligible for inclusion in this review, which found that homecare service users who were lonely at baseline had an increased hazards of care home admission over 3 years (Jamieson et al., 2019). Russell et al (1997) proposed this increased risk could be due to loneliness increasing the risk of worsened health, and further proposed that care home placement was implemented to provide lonely older adults with social support. This has been supported by findings from a qualitative study which identified that social factors such as loneliness were key factors that influenced the decision of

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older adults to move into residential care (Heppenstall et al., 2014). However, one additional good quality study did not find an association between loneliness with subsequent use of skilled nursing facilities (Shaw et al., 2017). This emphasises the need for future research to examine the association between loneliness with a range of long-term residential care options to determine whether loneliness could be associated with specific residential provision.

Of the seven good/good-fair quality studies that examined hospitalisation there was no consistency in findings with one study indicating decreased hospitalisation (Shaw et al., 2017), one study indicating an increased likelihood of re-hospitalisation but not hospitalisation (Newall et al., 2015), one study indicating that being sometimes lonely (but not often lonely) was associated with hospitalisation (Mosen et al., 2020), one study indicating an increased risk of hospitalisation due to incident CVD (Bu, Zaninotto, et al., 2020) and three studies indicating no association between loneliness with different kinds of hospitalisation (Bu, Abell, et al., 2020; Bu, Philip, et al., 2020; Dahlberg et al., 2018). This lack of consistency could be due to large part to the measurement of hospitalisation, as well as methodological and statistical heterogeneity. These are discussed in more detail in the section: critical considerations for design and methods.

There is some emerging evidence that examining the reason for hospitalisation could uncover interesting nuances in hospitalisation. In a series of studies utilising data from the English Longitudinal Study of Ageing the risk of in-patient hospitalisation for lonely older adults differed based on the reasons for hospitalization: with a higher risk for CVD-related (Bu, Zaninotto, et al., 2020) but not respiratory-disease-related (Bu, Philip, et al., 2020) or falls-related (Bu, Abell, et al., 2020) hospitalizations. There is further evidence from other studies conducted in populations referred for social care assessment that loneliness was associated with a higher risk of hospitalization due to general 'geriatric symptoms' (i.e., malaise, dizziness, syncope) (Rönneikkö et al,, 2018). This emerging evidence indicates that a more nuanced

understanding of the link between loneliness and HSCU could be revealed by examining the reasons for hospitalisation.

There was evidence from one longitudinal study that loneliness could be associated with later emergency department use in the USA (Mosen et al., 2020), however this finding was not supported by included cross-sectional studies, though two studies not eligible for inclusion in this review have found a cross-sectional association between loneliness with emergency department use (Geller et al., 1999; Wee et al., 2019). Commentaries and physician surveys also both indicate that there is a belief that loneliness could be associated with increased use of emergency departments (Lederman, 2020), and that high rates of people presenting at emergency departments are lonely (Agarwal et al., 2019). This indicates that there is a need for more robust work to examine the association between loneliness with emergency department use before we can determine clinical implications.

We found no evidence for a prospective association between loneliness with subsequent use of physicians or primary care, despite the commonly held view that lonely older adults use primary care services more than non-lonely older adults. Examination of the broader loneliness and HSCU literature reveals an estimated 20-26% of primary care service users report loneliness (Mullen et al., 2019; Zhong et al., 2018), suggesting a high proportion of people utilising primary care services experience loneliness. Many of the risk factors for loneliness in older adults such as worsened health, experiencing major life events and poorer functioning (Cohen-Mansfield et al. , 2016) are also common reasons for utilising primary care (Vedsted & Christensen, 2005). Therefore, it is plausible that loneliness is linked with the reasons that people visit primary care (i.e., worsened health), rather than being the reason that people visit primary care.

Loneliness and HSCU: Critical considerations for design and methods

The majority of studies (n=20) utilised a cross-sectional design where loneliness was measured at baseline, and HSCU was assessed retrospectively from baseline (or vice versa or at the same time). This meant that HSCU was assessed over a period that took place before the measurement of loneliness, limiting our ability to be able to ascertain whether loneliness could be associated with a change in HSCU.

The different modelling of loneliness and HSCU could have a direct impact on observed associations as illustrated by two studies examining hospitalisation using data from the Health and Retirement Study (Gerst-Emerson & Jayawardhana, 2015; Shaw et al., 2017). One study examined loneliness as a chronic exposure, but looked at self-reported hospitalisation cross-sectionally (Gerst-Emerson & Jayawardhana, 2015), whereas the second looked at loneliness at a single timepoint but examined hospitalisation longitudinally using medical records (Shaw et al., 2017). Gerst-Emerson and Jayawarda (2015) found that loneliness was not associated with hospital visits, whereas Shaw et al (2017) found that loneliness was associated with a decreased likelihood of hospitalisation. Furthermore, two cross-sectional studies from Ireland found that associations between loneliness and HSCU were not always robust to different ways of classifying and categorising loneliness (Burns et al., 2021; Burns et al., 2020). These studies all show directly the impact that heterogeneity in study design and measurement can have on results.

A further critical consideration is the measurement of loneliness. An expert working group recently published an article stating that there is no clear, common definition of loneliness and no consistently agreed upon way to best measure loneliness (Fried et al., 2020). Even when studies have used a validated measure of loneliness there still remain questions about how valid these measures are. The lack of harmonisation across studies for the measurement of loneliness also made synthesising the evidence-base difficult. Even where studies used the same measure (UCLA loneliness scale) there were differences in which version

was used, and how these were scored with some studies using scales in a customised approach (e.g., Russell et al., 1997). There have also been suggestions that chronic loneliness is associated with worsened health, however none of the studies we examined provided evidence that could be used to determine whether chronic loneliness is associated with a subsequent change in HSCU (Burns et al., 2020; Gerst-Emerson & Jayawardhana, 2015; Lim & Chan, 2017).

Beyond the notable differences in the kinds of HSCU assessed, there were also issues regarding the measurement and modelling of HSCU. The majority of studies measured this outcome subjectively, and asked participants to retrospectively recall the number of visits they made to particular services. Previous work has demonstrated that recall of HSCU can be subject to error and bias (Ansah & Powell-Jackson, 2013), and that there can be errors in recall for periods of 1-year or more (Short et al., 2009). A further notable difference between studies for HSCU was how this outcome was measured. Some studies examined whether a service was used at all in a pre-determined timeframe that varied from 2 weeks (Wang et al., 2019) to up to 9 years (Bu, Abell, et al., 2020; Bu, Philip, et al., 2020; Bu, Zaninotto, et al., 2020; Hanratty et al., 2018). Other studies looked at the number of visits made over a pre-specified period which ranged in duration from 1 week (Wang et al., 2019) to 2 years (Gerst-Emerson & Jayawardhana, 2015). Other measures included the length of stay in hospital (Denkinger et al., 2012; Newall et al., 2015) and the length of time since the last visit (Almind et al., 1991; Wang et al., 2019). These differences in timeframe and measurement all lead to differences in the likelihood of capturing the outcome of interest.

There were also notable differences in terms of statistical analysis and confounder control between studies, which had a major impact on the underlying quality of evidence. Most studies did control for a range of important health and sociodemographic confounders, and

conducted an analysis that did account for the distribution of healthcare data, however this was not done consistently.

Possible issues with this broader review include language bias (only English papers reviewed), publication bias (only published studies included) and the fact the review was conducted primarily by one researcher. Additional considerations include the fact that our review question meant that studies in existing service users could not be included, which included samples of people in the community using services such as home care. There is some interesting evidence from home care assessment databases that loneliness could be associated with later HSCU (Jamieson et al., 2019; Ronneiko et al., 2018), indicating that loneliness could be associated with HSCU in higher risk populations. This could be an important avenue for future research to examine in more detail.

Implications of findings

There is little evidence from this review that would currently suggest that lonely older people place an excess burden of health and social care. Based on our review, and that of Valtorta et al (2018) we feel it is important to change the narrative of debate about loneliness among older adults being a major factor in excess service use. Such discourse may deter older adults from seeking the services they need and contribute to them not enjoying 'a good old age' (Victor., 2021).

However, being able to reliably determine whether loneliness is linked with HSCU is important for service provision and helping us know where we can orient extra support for older adults who are lonely. In order to do this, we suggest there is little point in repeating small scale, cross-sectional studies with customised exposure measures and self-reported outcomes. We need to ensure that we gather the high-quality evidence needed to build up a compelling and robust evidence-base. We suggest future research in this area must take a longitudinal approach, be sufficiently powered to detect effects if present, ensure representative sampling

and control for all important confounders. Only once we have this good quality evidence-base will we be able to make implications about this work for health and social care.

Conclusions

The results from this systematic review suggest that more high-quality research examining loneliness as an exposure and HSCU as a longitudinal exposure is necessitated. There is some evidence that loneliness could be linked with an increased risk of care home admission, but no consistent replicated good-quality evidence that links loneliness to an increased likelihood of using any other services. More high-quality longitudinal work that utilises more homogenous methodologies is needed to accurately determine whether loneliness causes a change in HSCU.

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Conflict of Interest

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Identification of studies via databases

Identification

Records identified from*:
Databases (n = 4,240)
Other sources (n = 6)

→ Records removed *before screening*:
Duplicate records removed (n = 957)

Screening

Records screened
(n = 3,283)

→ Records excluded
(n = 3,125)

Reports sought for retrieval
(n = 156)

→ Reports not retrieved
(n = 0)

Reports assessed for eligibility
(n = 156)

→ Reports excluded (n=128):

Didn't examine association loneliness and HCU (n = 20)
No measure HCU (n = 22)
No measure loneliness (n = 56)
Loneliness modelled as outcome (n = 4)
Sample of existing service users (n = 9)
Qualitative study (n =1)
Age of sample (n=4)
Not peer reviewed (n=3)
Commentary (n=1)
Protocol (n=1)
Review (n=3)
Baseline RCT (n=2)
Statistical analysis did not allow examination of loneliness as IV (n = 2)

Studies included through reference list of full-text papers and/or update search
(n = 4)

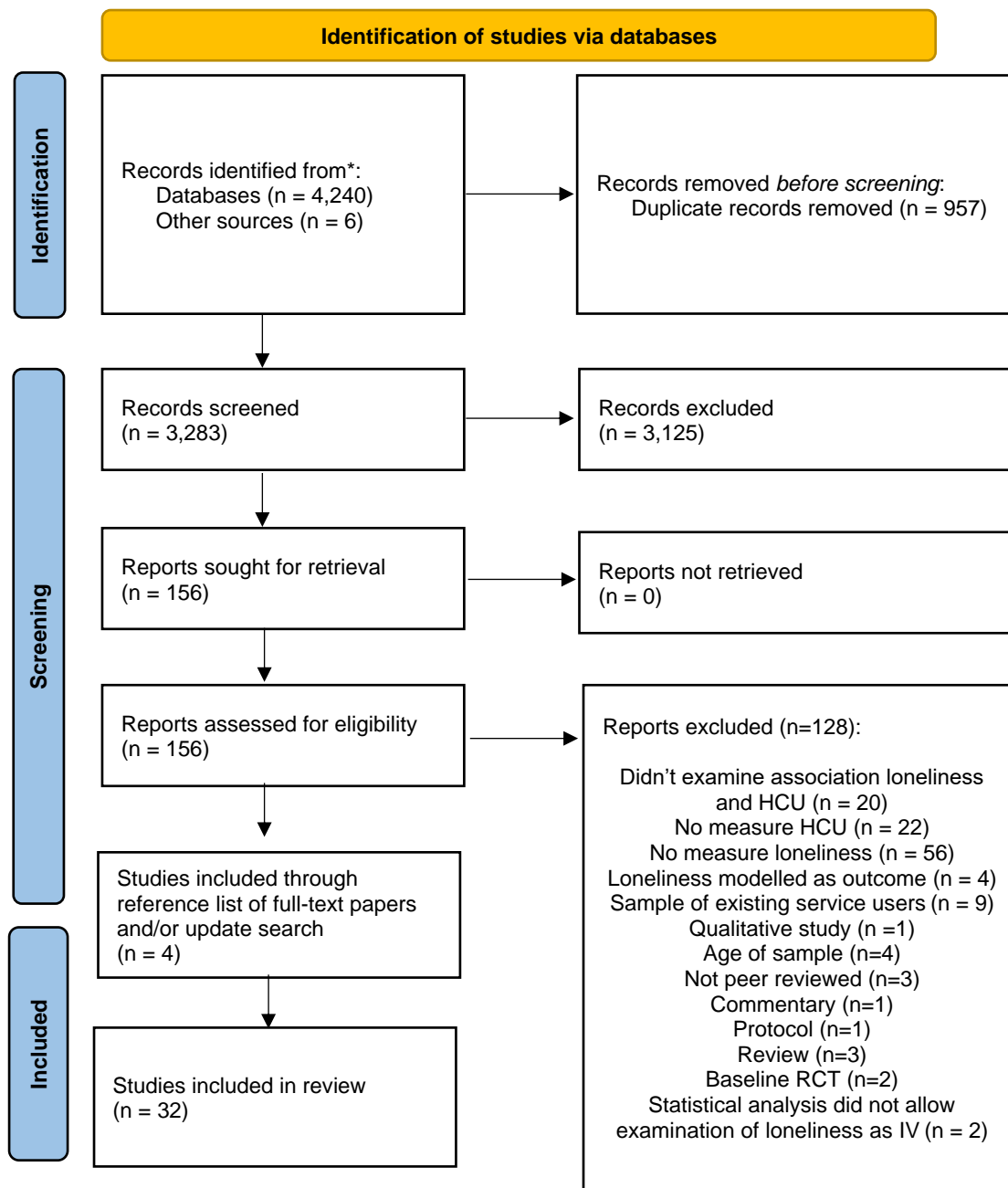**Included**

Studies included in review
(n = 32)

Figure 1: PRISMA flow diagram

Note. HCU =

Table 1: Papers that examined the association between loneliness with physician use

Study design	N of studies	Healthcare utilization measure	Loneliness measure	Population	Statistical analysis	Quality rating	Relationship between loneliness and healthcare utilization
Type of healthcare utilization: Family physician/GP utilization/primary care							
Number of visits: panel data	1	Self-report – visits previous 12 months over 3 waves (Bock et al., 2018)	Multi-dimensional (Bock et al., 2018)	Community sample – representative sampling (Bock et al., 2018)	Appropriate analysis (zero-inflated binomial distribution), and adequate confounder adjustment (Bock et al., 2018)	Fair-good (Bock et al., 2018)	One study found no association between changes in loneliness with number of visits in previous year over 3 waves (Bock et al., 2018)
Number of visits: cross-sectional	4	Self-report – visits previous 12 months (Burns et al., 2020; 2021; Ellaway et al., 1999; Houle et al., 2001) Self-report -home visit from GP previous 12 months (Ellaway et al., 1999)	Single-item (Ellaway et al., 1999; Houle et al., 2001) Single-item & multi-dimensional at one (Burns et al., 2021) or multiple timepoints (Burns et al., 2020)	Community sample – representative sampling (Burns et al., 2020; 2021; Houle et al., 2001) unrepresentative sampling (Ellaway et al., 1999)	Appropriate analysis (zero-inflated binomial distribution), and adequate confounder adjustment (Burns et al., 2020a, 2021) Inadequate analysis (did not account for data distribution), with adequate confounder adjustment (Ellaway et al., 1999; Houle et al., 2001)	Fair (Burns et al., 2020; 2021; Ellaway et al., 1999; Houle et al., 2001)	Three studies found loneliness associated with increased visits in previous year (Burns et al., 2020; Ellaway et al., 1999; Houle et al., 2001), one study also found this association for chronic loneliness (Burns et al., 2020) One study found no association between loneliness with number of visits in previous year (Burns et al., 2021) One study found no association between loneliness with the number of home visits from a GP in the previous 12 months (Ellaway et al., 1999)
Whether service used at all: cross-sectional	1	Self-report – previous 12 months (Mosen et al., 2020)	Single-item (Mosen et al., 2020)	General population sample (Medicaid database) – representative sampling (Mosen et al., 2020)	Inadequate analysis (unadjusted Chi-Square analysis) (Mosen et al., 2020)	Poor (Mosen et al., 2020)	One study found that those people who were sometimes or often/always lonely were more likely to have visited primary care once or more in the previous year than those who were never lonely (Mosen et al., 2020).
Last reported contact: longitudinal	1	Self-report - when had last contact with physician (Wang et al., 2019)	Single-item (Wang et al., 2019)	Community sample – unrepresentative sampling (Wang et al., 2019)	Appropriate analysis with adequate confounder control – but baseline HSCU included with follow-up HSCU so not fully prospective study (Wang et al., 2019)	Fair (Wang et al., 2019)	One study found evidence for shorter time since last contact for slightly lonely group when compared with never lonely group. No difference for often lonely group (Wang et al., 2019)
Last reported contact: cross-sectional	1	Self-report - when had last contact with physician (Almind et al., 1991)	Not specified (likely single-item) (Almind et al., 1991)	Community sample – representative sampling (Almind et al., 1991)	Inadequate analysis (unadjusted Chi-Square analysis) (Almind et al., 1991)	Poor (Almind et al., 1991)	One study found people who were sometimes or often lonely more likely to have seen a family physician in the past month than people who were never lonely (Almind et al., 1991)
Type of healthcare utilization: Any physician utilisation							
Number of visits: cross-sectional *	3	Self-report – previous 24 months (Gerst-Emerson and Jaywarha., 2015), 12 months	Multi-dimensional at one timepoint (Cheng et al., 1992) or multiple timepoints	Community sample – representative sampling (Gerst-Emerson and Jaywarha., 2015;	Appropriate analysis (Negative binomial regression) with adequate confounder adjustment (Gerst-Emerson and Jaywarha., 2015), or	Fair (Gerst-Emerson and Jaywarha., 2015) Fair-poor (Lim and Chan., 2017)	One study found loneliness at one timepoint linked with increased number of visits (Cheng., 1992). One study found that chronic loneliness was associated with an increased number of visits in the previous 24 months (Gerst-Emerson and

Study design	N of studies	Healthcare utilization measure	Loneliness measure	Population	Statistical analysis	Quality rating	Relationship between loneliness and healthcare utilization
		(Cheng., 1992), 1 month (Lim and Chan., 2017)	(Gerst-Emerson and Jaywarha., 2015; Lim and Chan., 2017)	Lim and Chan., 2017) Community sample – unrepresentative sampling (Cheng., 1992)	inadequate confounder adjustment (Lim and Chan., 2017) Inadequate analysis (did not account for data distribution), with minimal confounder adjustment (Cheng., 1992)		Jaywarha., 2015)., whereas a second study found no association over the previous month (Lim and Chan., 2017). One study found that people who were no longer lonely reported significantly fewer visits in the previous month than people who were never lonely (Lim and Chan., 2017), whereas a second study found no association over 24 months (Gerst-Emerson and Jaywarha., 2015). Two studies found no association between becoming lonely and physician visits in the previous 1-24 months when compared to people who were never lonely (Gerst-Emerson and Jaywarha., 2015; Lim and Chan., 2017)
Whether service used at all: longitudinal	1	Linked medical records 2.5 years (Newall et al., 2015)	Single-item (Newall et al., 2015)	Community sample – representative sampling (Newall et al., 2015)	Appropriate categorical statistical model (regression) with adequate confounder adjustment (Newall et al., 2015)	Good (Newall et al., 2015)	One study found no association between baseline loneliness and the likelihood of seeing a physician over 2.5 years (Newall et al., 2015)
Whether service used at all: cross-sectional	3	Self-report whether used service at all over 1 year (Richard et al., 2018), 1 month (Lim and Chan., 2017) or 2 weeks (Zhang et al., 2018)	Multi-dimensional at multiple timepoints (Lim and Chan., 2017) Single item (Richard et al., 2018; Zhang et al., 2018)	Community sample – representative sampling (all studies)	Appropriate categorical statistical model (regression) with adequate confounder adjustment (Zhang et al., 2018), or inadequate confounder adjustment (Lim and Chan., 2017; Richard et al., 2018)	Fair-poor (Lim and Chan., 2017; Richard et al., 2018; Zhang et al., 2018)	Two studies found those people who were lonely were more likely to have seen a physician in the previous 2 weeks (Zhang et al., 2018), or 1 year Richard et al., 2018) when compared to those who were not lonely. One study found that those people who became lonely, or were chronically lonely were less likely to have seen a physician in the previous month than people who were never lonely (Lim and Chan., 2017)

Note. HSCU = healthcare utilisation. An additional study also examined the link between loneliness and physician visits (Theeke., 2010), but as that used the same data as a higher quality paper (Gerst-Emerson and Jayawarha., 2015) we only extracted data from the higher quality paper. Findings between both papers pointed to the same direction of association (i.e., loneliness associated with more visits).

Important confounders: Sociodemographics (Age, sex, marital status, household composition) Health (physical health status as indicated by chronic conditions and/or functioning, mental health (e.g., depressive symptoms), cognition and health behaviours). Appropriate analysis: For studies that examined the number of visits to healthcare settings these should account for the data distribution (i.e., there would be a very high proportion of people who do not visit healthcare settings/visit less often so it is important that analyses account for this by using an analysis that allows for this kind of distribution such as zero-inflated model or negative binomial model. Some studies could also use Poisson regression as that analyses count data – however this would be adequate unless the authors can justify why they did not need to account for potentially skewed data distribution). Furthermore, for studies that examine loneliness as a categorical variable, using an appropriate statistical model would be a model that allowed for confounder-adjustment (e.g., a logistic regression model). Across both kinds of analyses the best statistical model would also adjust for a range of health-related and sociodemographic confounders (we have set this to a minimum of 6/8 important confounders as listed above).)

Table 2: Papers that examined the association between loneliness with outpatient, inpatient and emergency department utilisation

Study design	N of studies	Healthcare utilization measure	Loneliness measure	Population	Statistical analysis	Quality rating	Relationship between loneliness and healthcare utilization
Type of healthcare utilization: Outpatient service utilization / outpatient specialists							
Number of visits: longitudinal	2	Linked medical records 4.5 years (Shaw et al., 2015) Self-report – number of specialist visits (Bock et al., 2018) over previous 12 months	Multi-dimensional (Bock et al., 2018; Shaw et al., 2015)	Community sample – representative sampling (Shaw et al., 2015) unrepresentative sampling (Bock et al., 2018	Appropriate analysis (loneliness modelled categorical due to non-normal distribution) with adequate confounder adjustment (Shaw et al., 2015) Adequate analysis (Poisson regression) but did not account for binomial/zero-inflated distribution (Bock et al., 2018)	Good (Shaw et al., 2015) Fair (Bock et al., 2018)	One study found loneliness was not associated with any difference in number of visits made to outpatient facilities when compared with those who were not lonely (Shaw et al., 2015), and a second found changes in loneliness were not associated with changes in the number of visits to a specialist over time (Bock et al., 2018)
Number of visits: cross-sectional	1	Self-report – number of outpatient physician contacts (Denkinger et al., 2012) over previous 12 months	Single item (Denkinger et al., 2012)	Community sample – unrepresentative sampling (Denkinger et al., 2012)	Appropriate analysis (negative binomial regression), adequate confounder adjustment (Denkinger et al., 2012)	Fair-poor (Denkinger et al., 2012)	One study found as loneliness increased that there was a small but significant increase in the number of visits made to an outpatient physician in the previous year (Denkinger et al., 2012)
Whether service used at all: cross-sectional	1	Self-report – previous 2 weeks (Jiang et al., 2018)	Single-item (Jiang et al., 2018)	Community sample – representative sampling (Jiang et al., 2018)	Inadequate statistical model (unadjusted Chi-Square analysis) (Jiang et al., 2018)	Poor (Jiang et al., 2018)	One study found that those people who were lonely were more likely to have used outpatient facilities in the previous 2 weeks (Jiang et al., 2018)
Number of visits: longitudinal *	2	Linked medical records 4.5 years (Shaw et al., 2015) Self-report visits over previous 12 months across 3 waves (1 baseline, 2 follow-up waves) (Wang et al., 2019)	Multi-dimensional (Shaw et al., 2015) Single-item (Wang et al., 2019)	Community sample – representative sampling (Shaw et al., 2018), unrepresentative sampling (Wang et al., 2019)	Appropriate analysis (loneliness modelled categorical due to non-normal distribution) with adequate confounder adjustment (Shaw et al., 2015) Appropriate analysis (negative binomial modelling) with adequate confounder control – but baseline HSCU included with follow-up HSCU so not fully prospective study (Wang et al., 2019)	Good (Shaw et al., 2015) Good-fair (Wang et al., 2019)	One study found that those people who were lonely had significantly fewer hospitalisations than those who were not lonely (Shaw et al., 2015) One study found no association between loneliness with the number of hospital visits (Wang et al., 2019)
Whether hospitalized at all: longitudinal	2	Linked medical records 2.5 years for both any hospitalisation or multiple hospitalisations (Newall et al., 2015), and over 1 year (Mosen et al., 2020)	Single-item (Mosen et al., 2020; Newall et al., 2015)	Community sample – representative sampling (Newall et al., 2015) General population sample (Medicaid database) – representative sampling (Mosen et al., 2020)	Appropriate categorical statistical model (regression) with adequate confounder adjustment (Newall et al., 2015) Adequate categorical statistical model (logistic regression), but inadequate confounder adjustment (Mosen et al., 2020)	Good (Newall et al., 2015) Good-fair (Mosen et al., 2020)	One study found that those people who were lonely were no more likely to be hospitalised over 2.5 years, but were more likely to be re-hospitalized (if they were hospitalised a first time during follow-up) (Newall et al., 2015) One study found that those people who reported being sometimes lonely were more likely to be hospitalised over 1 year than those who were never lonely (Mosen et al., 2020). This association was not observed for people who were often lonely.
Whether hospitalized at	4	Self-report – previous 12 months	Single-item (Jiang et al.,	Community sample – representative	Inadequate statistical model (unadjusted Chi-Square	Fair (Zhang et al., 2018)	Two studies found that those people who were lonely were more likely to have been

Study design	N of studies	Healthcare utilization measure	Loneliness measure	Population	Statistical analysis	Quality rating	Relationship between loneliness and healthcare utilization
all: cross-sectional		(Barnes et al., 2021; Jiang et al., 2018; Zhang et al., 2018) Health care utilization database, previous 12 months (Nagga et al., 2012)	2018; Nagga et al., 2012; Zhang et al., 2018) Multi-dimensional (Barnes et al., 2021)	sampling (Jiang et al., 2018; Nagga et al., 2012; Zhang et al., 2018) General population sample (Medicare database) - unrepresentative sampling (Barnes et al., 2021)	analysis) (Nagga et al., 2012) or appropriate model with minimal confounder adjustment (Barnes et al., 2021) Appropriate categorical statistical model with adequate confounder adjustment (Jiang et al., 2018; Zhang et al., 2018)	Fair-poor (Jiang et al., 2018) Poor (Nagga et al., 2012)	hospitalised or used in-patient services in the previous 12 months that people who were not lonely (Nagga et al., 2012; Zhang et al., 2018) One study found that those people who reported being sometimes or often lonely had no difference in the likelihood of being hospitalised in the previous year when compared with people with were never lonely (Jiang et al., 2018) One study found no difference in the likelihood of being hospitalised in the previous 12 months for groups who were lonely, or lonely and socially isolated when compared to people who were neither lonely nor isolated (Barnes et al., 2021)
Length of stay in hospital: longitudinal	1	Linked medical records 2.5 years, whether hospital stay was 2 days or longer (Newall et al., 2015)	Single-item (Newall et al., 2015)	Community sample – representative sampling (Newall et al., 2015)	Appropriate categorical statistical model (regression) with adequate confounder adjustment (Newall et al., 2015)	Good (Newall et al., 2015)	One study found that those people who were lonely were no more likely to have stayed in hospital for 2 days or more than people who were not lonely (Newall et al., 2015)
Length of stay in hospital: cross-sectional	1	Self-report - total length of stay in hospital in previous 12 months (Denkinger et al., 2012)	Single item (Denkinger et al., 2012)	Community sample – unrepresentative sampling (Denkinger et al., 2012)	Appropriate analysis (negative binomial regression) with adequate confounder adjustment (Denkinger et al., 2012)	Fair-poor (Denkinger et al., 2012)	One study found no association between loneliness and the number of days spent in a hospital over the previous 12 months (Denkinger et al., 2012)
Type of healthcare utilization: Specific hospitalisation							
Whether had any planned or unplanned hospital admissions: longitudinal	1	Linked medical records – Any planned or unplanned visit over 1-2 years (inclusive of both outpatient and inpatient care) (Dahlberg et al., 2018)	Single-item (Dahlberg et al., 2018)	General population sample – representative sampling (Dahlberg et al., 2018)	Appropriate categorical risk analysis (Cox proportional hazards) with adequate confounder control (Dahlberg et al., 2018)	Good (Dahlberg et al., 2018)	One study found no association between loneliness with the risk of planned or unplanned hospital admissions over follow-up (Dahlberg et al., 2018)
Whether had any planned or unplanned hospital admissions: cross-sectional	1	Self-report - whether had planned or emergency inpatient admission in previous 12 months (Molloy et al., 2010)	Single-item (Molloy et al., 2010)	Community sample – representative sampling (Molloy et al., 2010)	Appropriate categorical analysis (regression) with inadequate confounder adjustment (Molloy et al., 2010)	Fair-poor (Molloy et al., 2010)	One study found people who were lonely were more likely to have an emergency (unplanned) hospital admission in the previous 12 months than people who were not lonely. This association was not observed for planned hospital admissions. (Molloy et al., 2010)
Whether hospitalised for specific	3	Linked medical records – Any hospitalisation over	Multi-dimensional (Bu et al.,	Community sample (all ELSA) – representative	Appropriate categorical risk analysis (Cox proportional hazards) with adequate	Good (Bu et al., 2020a;	One study found increasing levels of loneliness predicted an increased confounder-

Study design	N of studies	Healthcare utilization measure	Loneliness measure	Population	Statistical analysis	Quality rating	Relationship between loneliness and healthcare utilization
condition: longitudinal		9 years for CVD (Bu et al., 2020), falls (Bu et al., 2020), or respiratory disease (Bu et al., 2020)	2020a; 2020b, 2020c)	sampling (Bu et al., 2020a; 2020b, 2020c)	confounder control (Bu et al., 2020a; 2020b, 2020c)	2020b, 2020c)	adjusted risk of being hospitalised for CVD over follow-up (Bu et al., 2020) One study found increasing levels of loneliness predicted an increased risk of being hospitalised due to falls, though this association was attenuated after adjustment for confounders (Bu et al., 2020) One study found increasing levels of loneliness were not associated with the risk of hospitalisation due to respiratory disease over a median of 9 years (Bu et al., 2020)
Type of healthcare utilization: Accident and emergency utilization							
Number of visits: cross-sectional	2	Self-report – previous 12 months (Burns et al., 2020; Burns et al., 2021)	Multi-dimensional and single-item at a single time-point (Burns et al., 2020; Burns et al., 2021) & chronic over 3 waves (Burns et al., 2020)	Community sample – representative sampling (Burns et al., 2020), unrepresentative sampling Burns et al., 2021)	Appropriate analysis (zero-inflated binomial distribution), and adequate confounder adjustment (Burns et al., 2020; Burns et al., 2021)	Fair (Burns et al., 2020) Fair-poor (Burns et al., 2021)	Two studies found non-significant adjusted associations (there were some significant unadjusted associations) between loneliness and emergency department visits over the previous 12 months robust to how loneliness was measured and gender stratification (Burns et al., 2020; Burns et al., 2021).
Whether service used at all: longitudinal	1	Linked medical records over 1 year (Mosen et al., 2020)	Single-item (Mosen et al., 2020)	General population sample (Medicaid database) – representative sampling (Mosen et al., 2020)	Adequate categorical statistical model (logistic regression), but inadequate confounder adjustment (Mosen et al., 2020)	Good-fair (Mosen et al., 2020)	One study found that those people who were sometimes lonely, or often/always lonely were more likely to use emergency department services over 1 year than people who were never lonely (Mosen et al., 2020)
Whether service used at all: cross-sectional	3	Self-report – previous 12 months (Barnes et al., 2021; Burns et al., 2020; Burns et al., 2021)	Multi-dimensional (Barnes et al., 2021), multi-dimensional and single-item at a single time-point (Burns et al., 2020; Burns et al., 2021) and chronic over 3 waves) (Burns et al., 2020)	Community sample – representative sampling (Burns et al., 2020), unrepresentative sampling (Burns et al., 2021; Burns et al., 2021) General population sample (Medicare database) - unrepresentative sampling (Barnes et al., 2021)	Appropriate categorical analysis (regression), and adequate confounder adjustment (Burns et al., 2020; Burns et al., 2021) Appropriate categorical analysis (regression), and inadequate confounder adjustment (Barnes et al., 2021)	Fair (Burns et al., 2020) Fair-poor (Barnes., 2021; Burns et al., 2021)	Two studies found mostly non-significant adjusted associations between loneliness and emergency department use in the previous 12 months (Burns et al., 2020; Burns et al., 2021). However, one study uncovered two significant associations; in females a 1.) multidimensional measure score at one timepoint and 2.) chronic loneliness as measured with a single item associated with increased likelihood of visiting emergency department in previous 12 months) (Burns et al., 2020). One study found that those people who were lonely and isolated had a higher likelihood of having visited an emergency department in the previous 12 months that people who were neither lonely or isolated (Barnes et al., 2021). There was no association observed for people who were lonely but not isolated.

Note. CVD = cardiovascular disease; HSCU = healthcare utilisation. There was one cross-sectional study that also explored this association (Gerst-Emerson and Jaywarha., 2015), but as this kind of hospitalisation was covered in a better-quality longitudinal paper (Shaw et al., 2015) data were not extracted here. Findings between both papers were not consistent (i.e., Shaw et al (2015) indicated loneliness predicted decreased utilisation whereas Gerst-Emerson and Jaywarha (2015) found no association). Important confounders: Sociodemographics (Age, sex, marital status, household composition) Health (physical health status as indicated by chronic conditions and/or functioning, mental health (e.g., depressive symptoms), cognition and health behaviours). Appropriate analysis: For studies that examined the number of visits to healthcare settings these should account for the data distribution (i.e., there would be a very high proportion of people who do not visit healthcare settings/visit less often so it is important that analyses account for this by using an analysis that allows for this kind of distribution such as zero-inflated model or negative binomial model. Some studies could also use Poisson regression as that analyses count data – however this would be adequate unless the authors can justify why they did not need to account for potentially skewed data distribution). Furthermore, for studies that examine loneliness as a categorical variable, using an appropriate statistical model would be a model that allowed for confounder-adjustment (e.g., a logistic regression model). Across both kinds of analyses the best statistical model would also adjust for a range of health-related and sociodemographic confounders (we have set this to a minimum of 6/8 important confounders as listed above).

Table 3: Papers that examined the association between loneliness with residential care, social care, community care and general medical use

Study design	N of studies	Healthcare utilization measure	Loneliness measure	Population	Statistical analysis	Quality rating	Relationship between loneliness and healthcare utilization
Type of healthcare utilization: Care home admission							
Whether admitted to care home: longitudinal	2	Linked medical/residential records - 4 years (Russell et al., 1997) or 2-10 years (Hanratty et al., 2018)	Multi-dimensional (Hanratty et al., 2018; Russell et al., 1997) and single-item (Hanratty et al., 2018)	Community sample - retrospective matched sampling (Hanratty et al., 2018)	Appropriate categorical analysis (regression) with adequate confounder adjustment (Hanratty et al., 2018; Russell et al., 1997)	Good-fair (Hanratty et al., 2018; Russell et al., 1997	Two studies found that loneliness at baseline predicted an increased likelihood of later care home admission (Hanratty et al., 2018; Russell et al., 1997)
Whether service used at all: longitudinal	1	Linked medical records (skilled nursing facilities) 4.5 years (Shaw et al., 2015)	Multi-dimensional (Shaw et al., 2015)	Community sample – representative sampling (Shaw et al., 2015)	Appropriate categorical statistical model with adequate confounder adjustment (Shaw et al., 2015)	Good (Shaw et al., 2015)	One study found loneliness was not associated with use of skilled nursing facilities over follow-up (Shaw et al., 2015)
Type of healthcare utilization: Dental service utilization							
Number of visits: panel data	1	Self-report previous 1 year, over 3 waves (Spinler et al., 2019)	Multi-dimensional (Spinler et al., 2019)	Community sample – unrepresentative sampling (Spinler et al., 2019)	Appropriate analysis (fixed-effects regression), with no confounder control (Spinler et al., 2019)	Fair-poor (Spinler et al., 2019)	One study found that changes in loneliness had no association with dental service utilisation over time (Spinler et al., 2019).
Whether used service at all: Cross-sectional	2	Self-report – previous 2 years (Burr & Lee., 2012) or time not specified (Lungren et al., 1995)	Multi-dimensional (Burr & Lee., 2012) Not specified (Lungren et al., 1995)	Community sample – representative sampling (Burr & Lee., 2012) General population - unrepresentative sampling (Lungren et al., 1995)	Appropriate categorical analysis (regression) with adequate confounder adjustment (Burr and Lee., 2012) Adequate categorical analysis (stepwise regression, only significant variables entered) with inadequate confounder adjustment (Lungren et al., 1995)	Fair (Burr & Lee., 2012) Poor (Lungren et al., 1995)	Two studies found that after minimal/no confounder adjustment that loneliness was associated with decreased dental service utilisation (Burr & Lee., 2012; Lungren et al., 1995). However, after health and sociodemographic confounder adjustment there was no longer an association for the one study that accounted for these confounders (Burr and Lee., 2012)
Type of healthcare utilization: Community services							
General community care whether used at all: cross-sectional	1	Self-report – past month (Dahlberg & McKee., 2013)	Multidimensional (Dahlberg & McKee., 2013)	Community sample – representative sampling (Dahlberg & McKee., 2013)	Inadequate analysis with no confounder adjustment (correlation) (Dahlberg & McKee., 2013)	Poor (Dahlberg & McKee., 2013)	One study found a significant positive correlation of both social and emotional loneliness with receipt of community care in the previous month (Dahlberg & McKee., 2013)
Use of specific services: longitudinal	1	Self-report (past week) – home help, community nurse, meals on wheels and/or day centre (Wang et al., 2019)	Single-item (Wang et al., 2019)	Community sample – unrepresentative sampling (Wang et al., 2019)	Appropriate analysis with adequate confounder control – baseline HSCU included with follow-up so not fully prospective (Wang et al., 2019)	Fair (Wang et al., 2019)	One study found no association between loneliness with use of a range of community service in the past week (Wang et al., 2019)

Study design	N of studies	Healthcare utilization measure	Loneliness measure	Population	Statistical analysis	Quality rating	Relationship between loneliness and healthcare utilization
Use of specific services: cross-sectional	1	Self-report – use of homecare past 2 years (Theeke., 2009)	Single-item (Theeke., 2009)	Community sample – representative sampling (Theeke., 2009)	Inadequate categorical analysis with no confounder adjustment (Theeke., 2009)	Poor (Theeke., 2009)	One study found those people who were lonely were more likely to have used homecare in the past 2 years than people who were not lonely (Theeke., 2009)
Type of healthcare utilization: General medical care							
Seeking general medical care: cross-sectional	1	Self-report – past month (Dahlberg & McKee., 2013)	Multidimensional (Dahlberg & McKee., 2013)	Community sample – representative sampling (Dahlberg & McKee., 2013)	Inadequate analysis with no confounder adjustment (correlation) (Dahlberg & McKee., 2013)	Poor (Dahlberg & McKee., 2013)	One study found no correlation between either social or emotional loneliness with receipt of any medical care in the previous month (Dahlberg & McKee., 2013)
Seeking medical advice: cross-sectional	1	Self-report - frequency (timeframe not defined) (Berg et al., 1981)	Single item (Berg et al., 1981)	Community sample – representative sampling (Berg et al., 1981)	Inadequate categorical analysis with no confounder adjustment (Berg et al., 1981)	Poor (Berg et al., 1981)	One study found those people who were lonely reported a higher frequency of seeking medical advice than people who were not lonely. Gender-stratified analyses indicated this association was only observed in females (Berg et al., 1981)

Note. CVD = cardiovascular disease; HSCU = healthcare utilisation. Important confounders: Sociodemographics (Age, sex, marital status, household composition) Health (physical health status as indicated by chronic conditions and/or functioning, mental health (e.g., depressive symptoms), cognition and health behaviours). Appropriate analysis: For studies that examined the number of visits to healthcare settings these should account for the data distribution (i.e., there would be a very high proportion of people who do not visit healthcare settings/visit less often so it is important that analyses account for this by using an analysis that allows for this kind of distribution such as zero-inflated model or negative binomial model. Some studies could also use Poisson regression as that analyses count data – however this would be adequate unless the authors can justify why they did not need to account for potentially skewed data distribution). Furthermore, for studies that examine loneliness as a categorical variable, using an appropriate statistical model would be a model that allowed for confounder-adjustment (e.g., a logistic regression model). Across both kinds of analyses the best statistical model would also adjust for a range of health-related and sociodemographic confounders (we have set this to a minimum of 6/8 important confounders as listed above).

Online Supplementary file 1: Search terms

PubMed

(("healthcare utilisation"[Title/Abstract] OR "health-care utilisation"[Title/Abstract] OR "health utilisation"[Title/Abstract] OR ((health* NEAR/3 (use OR utilisation OR utilization OR service* OR visit*[Title/Abstract])) OR ((medical NEAR/3 (care OR use OR utilisation OR utilization OR service* OR visit*[Title/Abstract])) OR ((physician NEAR/3 (care OR use OR utilisation OR utilization OR service*[Title/Abstract])) OR ((doctor NEAR/3 (care OR use OR utilisation OR utilization OR service*[Title/Abstract])) OR ((nurse* NEAR/3 (care OR use OR utilisation OR utilization OR service*[Title/Abstract])) OR dentist*[Title/Abstract] OR pharmacy[Title/Abstract] OR "community service*"[Title/Abstract] OR "social work*"[Title/Abstract] OR "psychiatric service*"[Title/Abstract] OR "psychiatric care"[Title/Abstract] OR "hospital admission*"[Title/Abstract] OR "medical care" [Title/Abstract] OR "health provider*"[Title/Abstract] OR "healthcare use"[Title/Abstract] OR "health use"[Title/Abstract] OR "service use"[Title/Abstract] OR "healthcare utilization"[Title/Abstract] OR "health utilization"[Title/Abstract] OR "service utilization"[Title/Abstract] OR "service utilisation"[Title/Abstract] OR "service use"[Title/Abstract] OR GP[Title/Abstract] OR "general practice"[Title/Abstract] OR "primary care" [Title/Abstract] OR "secondary care" [Title/Abstract] OR "tertiary care" [Title/Abstract] OR "emergency department"[Title/Abstract] OR "accident and emergency" [Title/Abstract] OR "A and E" [Title/Abstract] OR "A&E" [Title/Abstract] OR healthcare[Title/Abstract] OR health-care[Title/Abstract] OR "accident and emergency"[Title/Abstract] OR inpatient*[Title/Abstract] OR outpatient*[Title/Abstract] OR "primary care"[Title/Abstract] OR "secondary care"[Title/Abstract] OR "tertiary care"[Title/Abstract] OR "community care"[Title/Abstract] OR "social care"[Title/Abstract] OR "care home"[Title/Abstract] OR "residential care"[Title/Abstract] OR "skilled nursing"[Title/Abstract] OR "community nurs*"[Title/Abstract]) AND (loneliness[MeSH major topic] OR lone*[Title/Abstract]))

EBSCOHOST ABSTRACT

Medline, Cinahl, PsychInfo, Behavioural sciences collection, Psycharticles

((("healthcare utilisation" OR "health utilisation" OR ((health* NEAR/3 (use OR utilisation OR service*))

OR ((service* NEAR/3 (use OR utilisation)) OR "psychiatric service*" OR "hospital admission*"

"healthcare use" OR "health use" OR "service use" OR "healthcare utilization" OR "health utilization"

OR "service utilization" OR "service utilisation" OR "service use" OR GP OR "general practice" OR

"emergency department" OR "accident and emergency" OR "A and E" OR "A&E" OR healthcare OR

"accident and emergency" OR inpatient* OR outpatient* OR "primary care" OR "secondary care" OR

"tertiary care" OR "community care" OR "social care" OR "care home" OR "residential care" OR

"skilled nursing" OR "community nurs*") AND (loneliness[MeSH] OR lone*))

Web of science TOPICS

((("healthcare utilisation" OR "health utilisation" OR "psychiatric service*" OR "hospital admission*"

"healthcare use" OR "health use" OR "service use" OR "healthcare utilization" OR "health utilization"

OR "service utilization" OR "service utilisation" OR "service use" OR GP OR "general practice" OR

"emergency department" OR "accident and emergency" OR "A and E" OR "A&E" OR healthcare OR

"accident and emergency" OR inpatient* OR outpatient* OR "primary care" OR "secondary care" OR

"tertiary care" OR "community care" OR "social care" OR "care home" OR "residential care" OR

"skilled nursing" OR "community nurs*") AND (loneliness OR lone*))

SCOPUS

((**TITLE-ABS-KEY-AUTH** "healthcare utilisation") OR **TITLE-ABS-KEY-AUTH** ("health

utilisation") OR **TITLE-ABS-KEY-AUTH** ("psychiatric service*") OR **TITLE-ABS-KEY-AUTH**

("hospital admission*") OR **TITLE-ABS-KEY-AUTH** ("healthcare use") OR **TITLE-ABS-KEY-

AUTH** ("health use") OR **TITLE-ABS-KEY-AUTH** ("service use") OR **TITLE-ABS-KEY-AUTH**

("healthcare utilization") OR **TITLE-ABS-KEY-AUTH** ("health utilization") OR **TITLE-ABS-KEY-AUTH** ("service utilization") OR **TITLE-ABS-KEY-AUTH** ("service utilisation") OR **TITLE-ABS-KEY-AUTH** ("service use") OR **TITLE-ABS-KEY-AUTH** (GP) OR **TITLE-ABS-KEY-AUTH** ("general practice") OR **TITLE-ABS-KEY-AUTH** ("primary care") OR **TITLE-ABS-KEY-AUTH** ("emergency department") OR **TITLE-ABS-KEY-AUTH** ("accident and emergency") OR **TITLE-ABS-KEY-AUTH** ("A and E") OR **TITLE-ABS-KEY-AUTH** ("A&E") OR **TITLE-ABS-KEY-AUTH** (healthcare) OR **TITLE-ABS-KEY-AUTH** ("accident and emergency") OR **TITLE-ABS-KEY-AUTH** (inpatient*) OR **TITLE-ABS-KEY-AUTH** (outpatient*) OR **TITLE-ABS-KEY-AUTH** ("primary care") OR **TITLE-ABS-KEY-AUTH** ("secondary care") OR **TITLE-ABS-KEY-AUTH** ("tertiary care") OR **TITLE-ABS-KEY-AUTH** ("community care") OR **TITLE-ABS-KEY-AUTH** ("social care") OR **TITLE-ABS-KEY-AUTH** ("care home") OR **TITLE-ABS-KEY-AUTH** ("residential care") OR **TITLE-ABS-KEY-AUTH** ("skilled nursing") OR **TITLE-ABS-KEY-AUTH** ("community nurs*")) AND (**TITLE-ABS-KEY-AUTH** (loneliness) OR **TITLE-ABS-KEY-AUTH** (lone*))

Supplementary file 2: Data extraction

First author, year	Study name, Country, N	Baseline Sample Age, sex	Study design	Loneliness		Health Service Utilization		Statistical Analysis	Confounders adjusted	Results	
		Age % Female	Type of study, follow-up	Loneliness measure	Timeframe assessed	Health services (assessment method)	Timeframe assessed			Least adjusted	Most adjusted
Almind et al, 1992	Community study Denmark N=1,259	Aged 70-95 F: 61%	Cross-sectional survey N/A	Only specifies 'loneliness' (often, sometimes, never)	Not specified	When last in contact with GP (self-report)	Over 1 year (retrospective)	Chi-square	N/A	**Contact within last month** Never lonely: 56.7% Sometimes lonely: 51.3% Often lonely: 34.9% **Contact within last half year** Never lonely: 23.9% Sometimes lonely: 31.7% Often lonely: 32.9% **Contact within last year** Never lonely: 7.5% Sometimes lonely: 9.6% Often lonely: 13.2% **Contact over 1 year ago** Never lonely: 11.9% Sometimes lonely: 7.4% Often lonely: 19.3% P<.001	**N/A**
Barnes et al., 2021	Insurance database linked study USA N= 6,994	Aged 65 + F: 55%	Cross-sectional survey N/A	3-item UCLA loneliness scale	Not specified	A.) Any in-patient hospitalization (self-report) B.) Any emergency room visit (past-year)	1 year (retrospective)	Multivariate logistic regression (reference group not lonely or isolated)	Age, gender, Charlson co-morbidity index	**N/A**	**A.)** **Lonely** OR 1.151 (95% CI: 0.963-1.374) **Lonely and isolated** OR 1.096 (95% CI: 0.911-1.314) **B.)** **Lonely** OR 0.979 (95% CI: 0.751-1.262)

											Lonely and isolated OR 1.360 (95% CI: 1.069-1.720)
Berg et al, 1981	Community study Sweden N=1,007	Aged 70 F: 53.3%	Cross-sectional survey N/A	Single-item question (often, sometimes, rarely, never) People who responded often or sometimes = lonely	Not specified	Frequency of seeking medical advice (self-report)	No information	Chi-squared test	N/A	**High frequency of seeking medical advice** Lonely: 34% Not lonely: 31% P<.001	N/A
Bock et al, 2018	German Ageing Survey Germany N varied based on outcome (1 = GP visits; 2 = specialist visits; 3= hospitalisation) 1 = 3,100 2 = 3,199 3 = 1,002	Aged 40+ (mean 1= 63.1, SD 11; mean 2= 63.5, SD 11; mean 3= 65.2, SD 10.8) Female 1 = 51.2% Female 2 = 49.9% Female 3= 54.1%	Cross-sectional (over 3 waves)	11-item De Jong Jierveld Scale	Not specified	1=GP visits 2=Specialist visits 3=Hospitalisation All self-report	Over 1 year (retrospective)	A.) Fixed-effects Poisson regression B.) Fixed-effects logistic regression	Age, (log) monthly equivalent net income, self-rated health, number of chronic diseases,marital status, employment status, weight categories, and smoking status.	N/A	**A.)** **GP visits** 0.0378 (0.0275), ns **Specialist visits** 0.00525 (0.0343), ns **B.)** **Hospitalisation** OR 1.066 (95% CI: 0.734-1.161)
Bu et al (2020a)	English Longitudinal Study of Ageing England N=4,478	Aged 50+ (72.02% ≥ 60) F: 53.7%	Longitudinal cohort 9.6 years	3-item UCLA loneliness scale	Not specified	Hospital admission related to respiratory disease (linked HES records captured acute respiratory disease, chronic respiratory disease, pleural respiratory disease and other	Maximum 9.6 years	Cox Proportional Hazards Regression	Gender, age, ethnicity, socio-economic status, living environment deprivation, pre-existing respiratory disease conditions, depressive symptoms, smoking,	HR 1.05 (95% CI: 0.96-1.14), p=.271	HR 0.95 (95% CI: 0.86-1.05), p=.317

Study	Sample	Age/Sex	Design	Loneliness measure		Outcome	Follow-up	Analysis	Covariates	Results 1	Results 2
						respiratory disease ICD-10 codes J00-J99)			heavy drinking, healthy diet, physical activity.		
Bu et al (2020b)	English Longitudinal Study of Ageing England N=4,587	Aged 50+ F: 56.22%	Longitudinal cohort 9.6 years	3-item UCLA loneliness scale	Not specified	Hospital admission related to CVD (linked HES records ICD-10 codes I00-I99 or mortality linked to CVD as this assumed to have been linked with hospitalisation)	Maximum 9.6 years	Cox Proportional Hazards Regression	Age, ethnicity, socioeconomic status, social isolation, obesity, high cholesterol, hypertension, diabetes, smoking, diet, physical activity, abnormal sleep, depression	HR 1.09 (95% CI: 1.04-1.14)	HR 1.08 (95% CI: 1.03-1.14)
Bu et al (2020c)	English Longitudinal Study of Ageing England N=9,285	Aged 50+ F: 53.6%	Longitudinal cohort Maximum 14 years (median not specified)	3-item UCLA loneliness scale	Not specified	Hospital admission related to falls (linked HES records ICD-10 codes W00 to W19)		1.) Cox-cause specific hazards model 2.) Subdistribution hazards model	Age, gender, ethnicity, socioeconomic status, self-reported long-standing illness, mobility, functional disability, vision, depression, physical activity	1.) HR: 1.08 (95% CI: 1.03-1.13) 2.) HR: 1.07 (95% CI: 1.02-1.12) *Nb: Adjusted for sociodemographic characteristics*	1.) HR: 1.03 (95% CI: 0.98-1.08) 2.) HR: 1.03 (95% CI: 0.98-1.08)
Burns et al (2020)	The Irish Longitudinal Study on Ageing Ireland N=6,829 (wave 1), 4,380 (waves 1-3)	Aged 50+ F: 50%	Cohort study (assessed loneliness waves 1-3)	1.) 5-item UCLA loneliness score 2.) 3-item UCLA loneliness scale People who responded "some of the time" or "often" to any of the 3 questions = lonely	Not specified	Number of visits to GP (self-report) Number of visits to emergency department (self-report) Whether visited emergency department at all: yes/no (self-report)	12 months (retrospective)	Negative binomial multivariate regression (count data) Logistic regression (binary emergency department visit data) NB: All results presented as overall, but also stratified for sex	Age, sex, education, marital status, presence of doctor diagnosed chronic condition (included dementia), pain, fall in the past year, BMI, waist circumference, anxiety, depressive symptoms, smoking	***All adjusted for age, sex, education and marital status*** **Number of visits to GP** 1.) UCLA score Overall: IRR 1.08 (1.06-1.09), p<.001 Men: IRR 1.07 (1.04-1.10), p<.001 Women: IRR 1.07 (1.06-1.09), p<.001 2.) UCLA threshold	**Number of visits to GP** 1.) UCLA score Overall: IRR 1.03 (1.01-1.05), p=.004 Men: IRR 1.01 (0.98-1.04), p=.668 Women: IRR 1.05 (1.02-1.07), p<.001 2.) UCLA threshold Overall: IRR 1.11 (1.03-1.20), p=.007 Men: IRR 1.04 (0.91-1.18), p=.584

| | | | | 3.) Direct single item measure

NB: Examined loneliness both at one timepoint, and chronicity of loneliness over 3 waves | | | | | | status, alcohol problems, physical activity | Overall: IRR 1.27 (1.18-1.36), p<.001
Men: IRR 1.17 (1.05-1.31), p=.005
Women: IRR 1.33 (1.22-1.45), p<.001

3.) Direct item

Overall: IRR 1.30 (1.21-1.40), p<.001
Men: IRR 1.30 (1.21-1.40), p<.001
Women: IRR 1.33 (1.22-1.45), p<.001

Number of emergency department visits

1.) UCLA score

Overall: IRR 1.06 (1.02-1.11), p=.003
Men: IRR 1.07 (1.02-1.13), p=.010
Women: IRR 1.05 (0.99-1.12), p=.109

2.) UCLA threshold

Overall: IRR 1.16 (0.92-1.47), p=.202
Men: IRR 1.05 (0.80-1.38), p=.707
Women: IRR 1.23 (0.86-1.76), p=.256

3.) Direct item

Overall: IRR 1.24 (0.98-1.56), p=.073
Men: IRR 1.16 (0.89-1.51), p=.273
Women: IRR 1.29 (0.92-1.81), p=.141

Whether visited emergency department in past year

1.) UCLA score | Women: IRR 1.16 (1.07-1.26), p<.001

3.) Direct item

Overall: IRR 1.06 (0.97-1.15), p=.204
Men: IRR 0.95 (0.84-1.09), p=.482
Women: IRR 1.14 (1.03-1.26), p=.011

Number of emergency department visits

1.) UCLA score

Overall: IRR 0.99 (0.93-1.06), p=874
Men: IRR 1.01 (0.94-1.08), p=.856
Women: IRR 1.01 (0.93-1.10), p=.824

2.) UCLA threshold

Overall: IRR 0.82 (0.63-1.07), p=.137
Men: IRR 0.89 (0.65-1.21), p=.453
Women: IRR 0.82 (0.58-1.16), p=.260

3.) Direct item

Overall: IRR 0.90 (0.66-1.22), p=.487
Men: IRR 1.00 (0.74-1.35), p=.981
Women: IRR 0.93 (0.64-1.34), p=.692

Whether visited emergency department in past year

1.) UCLA score

Overall: OR 1.04 (0.98-1.09), p=.169 |

											Overall: OR 1.07 (1.03-1.10), p<.001 Men: OR 1.06 (1.01-1.11), p=.015 Women: OR 1.07 (1.02-1.12), p=.004 2.) UCLA threshold Overall: OR 1.18 (1.01-1.37), p=.035 Men: OR 1.10 (0.89-1.37), p=.379 Women: OR 1.25 (1.08-1.46), p=.036 3.) Direct item Overall: OR 1.25 (1.08-1.46), p=.003 Men: OR 1.21 (0.97-1.51), p=.098 Women: OR 1.29 (1.05-1.59), p=.017 **Chronicity of loneliness (waves 1-3) modelled with healthcare utilisation at wave 3** **Number of visits to GP** 1.) Chronically lonely UCLA threshold Overall: IRR 1.28 (1.18-1.38), p<.001 Men: IRR 1.28 (1.12-1.47), p<.001 Women: IRR 1.25 (1.15-1.36), p<.001 2.) Chronically lonely single-item Overall: IRR 1.33 (1.21-1.47), p<.001 Men: IRR 1.45 (1.20-1.76), p<.001	Men: OR 1.00 (0.92-1.08), p=.923 Women: OR 1.08 (1.01-1.16), p=.028 2.) UCLA threshold Overall: OR 1.03 (0.84-1.26), p=.761 Men: OR 0.96 (0.71-1.30), p=.779 Women: OR 1.14 (0.85-1.51), p=.383 3.) Direct item Overall: OR 1.13 (0.90-1.41), p=.306 Men: OR 1.07 (0.77-1.49), p=.690 Women: OR 1.18 (0.87-1.59), p=.296 **Chronicity of loneliness (waves 1-3) modelled with healthcare utilisation at wave 3** **Number of visits to GP** 1.) Chronically lonely UCLA threshold Overall: IRR 1.10 (1.01-1.19), p=.028 Men: IRR 1.10 (0.97-1.24), p=.140 Women: IRR 1.11 (1.01-1.23), p=.030 2.) Chronically lonely single-item Overall: IRR 1.03 (0.94-1.13), p=.544 Men: IRR 1.09 (0.93-1.27), p=.288 Women: IRR 1.01 (0.90-1.12), p=.914

											Women: IRR 1.23 (1.11-1.36), p<.001	Number of emergency department visits
											Number of emergency department visits	1.) Chronically lonely UCLA threshold
											1.) Chronically lonely UCLA threshold	Overall: IRR 0.88 (0.70-1.11), p=.277 Men: IRR 0.89 (0.62-1.29), p=.553 Women: IRR 0.88 (0.68-1.15), p=.362
											Overall: IRR 1.11 (0.90-1.36), p=.333 Men: IRR 1.08 (0.78-1.50), p=.643 Women: IRR 1.15 (0.89-1.48), p=.278	2.) Chronically lonely single-item
											2.) Chronically lonely single-item	Overall: IRR 1.25 (0.95-1.65), p=.117 Men: IRR 1.35 (0.83-2.20), p=.226 Women: IRR 1.22 (0.90-1.64), p=.194
											Overall: IRR 1.47 (1.16-1.85), p=.001 Men: IRR 1.56 (1.06-2.28), p=.024 Women: IRR 1.42 (1.07-1.87), p=.014	**Whether visited emergency department in past year**
											Whether visited emergency department in past year	1.) Chronically lonely UCLA threshold
											1.) Chronically lonely UCLA threshold	Overall: OR 0.87 (0.68-1.11), p=.271 Men: OR 0.78 (0.52-1.17), p=.225 Women: OR 0.94 (0.68-1.29), p=.685
											Overall: OR 1.11 (0.90-1.37), p=.311 Men: OR 1.06 (0.77-1.46), p=.730 Women: OR 1.16 (0.89-1.52), p=.271	2.) Chronically lonely single-item
											2.) Chronically lonely single-item	Overall: OR 1.29 (0.97-1.73), p=.085 Men: OR 1.24 (0.76-2.00), p=.389 Women: OR 1.36 (0.94-1.96), p=.036
											Overall: OR 1.47 (1.17-1.85), p=.001 Men: OR 1.51 (1.04-2.20), p=.031 Women: OR 1.47 (1.09-1.97), p=.010	

| Burns et al 2021 | NICOLA

Northern Ireland

N= 8,309 (but 2,523 to 2,466 included in fully adjusted analyses) | Aged 50+ (approximately 60% of sample aged 60 or older) | Cross sectional survey | 1.) 5-item UCLA loneliness score

2.) 3-item UCLA loneliness scale

People who responded "some of the time" or "often" to any of the 3 questions = lonely

3.) Direct single item measure | Not specified | Number of visits to GP (self-report)

Number of visits to emergency department (self-report)

Whether visited emergency department at all: yes/no (self-report) | 12 months | Negative binomial multivariate regression (count data)

Logistic regression (binary emergency department visit data)

NB: All results presented as overall, but also stratified for sex | Age, sex, education, marital status, chronic conditions (included dementia), pain, falls, BMI, waist circumference, depressive symptoms, smoking status, alcohol consumption, physical activity | ***All adjusted for age, sex, education and marital status***

Number of visits to GP

1.) UCLA score

Overall: IRR 1.10 (1.08-1.12), p<.001
Men: IRR 1.10 (1.07-1.13), p<.001
Women: IRR 1.10 (1.07-1.13), p<.001

2.) UCLA threshold

Overall: IRR 1.35 (1.25-1.46), p<.001
Men: IRR 1.31 (1.25-1.46), p<.001
Women: IRR 1.39 (1.26-1.53), p<.001

3.) Direct item

Overall: IRR 1.49 (1.37-1.61), p<.001
Men: IRR 1.57 (1.38-1.79), p<.001
Women: IRR 1.44 (1.30-1.59), p<.001

Number of emergency department visits

1.) UCLA score

Overall: IRR 1.16 (1.11-1.22), p<.001
Men: IRR 1.15 (1.09-1.22), p<.001
Women: IRR 1.18 (1.11-1.25), p<.001

2.) UCLA threshold

Overall: IRR 1.56 (1.29-1.89), p<.001
Men: IRR 1.39 (1.08-1.78), p=.010 | **Number of visits to GP**

1.) UCLA score

Overall: IRR 1.03 (1.01-1.05), p=.013
Men: IRR 1.03 (0.99-1.06), p-.143
Women: IRR 1.03 (1.00-1.05), p=.056

2.) UCLA threshold

Overall: IRR 1.04 (0.95-1.14), p=.404
Men: IRR 0.97 (0.85-1.11), p=.649
Women: IRR 1.10 (0.98-1.23), p=.091

3.) Direct item

Overall: IRR 1.05 (0.96-1.16), p=.294
Men: IRR 1.03 (0.89-1.21), p=.665
Women: IRR 1.06 (0.94-1.19), p=.352

Number of emergency department visits

1.) UCLA score

Overall: IRR 1.03 (0.96-1.09), p=.411
Men: IRR 0.99 (0.92-1.08), p=.922
Women: IRR 1.07 (0.98-1.17), p=.130

2.) UCLA threshold

Overall: IRR 0.95 (0.75-1.21), p=.674
Men: IRR 0.86 (0.61-1.22), p=.405
Women: IRR 1.12 (1.84-1.49), p=.444

3.) Direct item |

										Women: IRR 1.75 (1.36-2.25), p<.001 3.) Direct item Overall: IRR 1.98 (1.63-2.39), p<.001 Men: IRR 2.01 (1.56-2.58), p<.001 Women: IRR 1.93 (1.49-2.59), p<.001 **Whether visited emergency department in past year** 1.) UCLA score Overall: OR 1.13 (1.09-1.17), p<.001 Men: OR 1.13 (1.07-1.19), p<.001 Women: OR 1.14 (1.07-1.20), p<.001 2.) UCLA threshold Overall: OR 1.38 (1.18-1.61), p<.001 Men: OR 1.31 (1.04-1.66), p=.021 Women: OR 1.44 (1.17-1.76), p=.001 3.) Direct item Overall: OR 1.51 (1.29-1.78), p<.001 Men: OR 1.65 (1.28-2.12), p<.001 Women: OR 1.44 (1.17-1.77), p=.001	Overall: IRR 1.23 (0.97-1.54), p=.083 Men: IRR 1.21 (0.85-1.73), p=.289 Women: IRR 1.23 (0.92-1.66), p=.168 **Whether visited emergency department in past year** 1.) UCLA score Overall: OR 1.02 (0.96-1.09), p=.457 Men: OR 1.00 (0.92-1.10), p=.924 Women: OR 1.04 (0.96-1.13), p=.349 2.) UCLA threshold Overall: OR 0.98 (0.77-1.26), p=.889 Men: OR 0.99 (0.69-1.43), p=.971 Women: OR 0.99 (0.70-1.38), p=.933 3.) Direct item Overall: OR 1.05 (0.81-1.36), p=.700 Men: OR 1.07 (0.70-1.63), p=.762 Women: OR 1.08 (0.77-1.52), p=.666
Burr and Lee (2013)	Health and Retirement Study (2008) USA N=2,978	Aged 65+	Cross sectional survey	5-item derived questionnaire (4 items from shortened UCLA scale plus how	Not specified	Dental service utilization (whether visited dentist for any dental care in past 2 years)	2 years (retrospective)	A.) Mean level loneliness B.) Binomial logistic regression	Age, gender, race/ethnicity, education, household income, ADL limitations, IADL limitations, self-reported	A.) Did not visit dentist mean loneliness score: 1.7 Did visit dentist mean loneliness score: 1.6 P=.01	B.) OR 1.181 (95% CI: 0.893-1.562)

Study	Setting	Age	Design	Loneliness measure		Outcome	Time frame	Analysis	Covariates	Results	Results
				often feel lonely)		Coded as binary outcome: yes or no			health, short version CES-D, health conditions, smoking behaviour	B.) OR 0.762 (95% CI: 0.583-0.996)	
Cheng, 1992	Community study USA Sample A: 112 Sample B: 115	Aged 65-80 (Sample A Mean 72.7; Sample B Mean 73.1) F: 100%	Cross-sectional survey N/A	10-item scale derived from UCLA loneliness scale (adapted so questions rated on 6-point scale)	Not specified	Number of visits to physician or osteopath (self-report)	12 months (retrospective)	A.) Pearson's correlation B.) Multiple linear regression	IADL, number of chronic conditions, stress, somatisation	A.) Sample A r=0.43, p<.001 Sample B r=0.34, p<.001	B.) Sample A B=0.27 (SE 0.08), P<.01 Sample B B=0.31 (SE 0.10), P<.01
Dahlberg and McKee, 2014	Community sample UK N=1255	Aged 65+ (Mean 75.7, SD 7.29) F: 61.8%	Cross-sectional survey N/A	11-item De-Jong Jierveld loneliness scale		Receipt of medical care (self-report) Receipt of community care (self-report)	1 month (retrospective)	Bivariate correlation *Nb: While a confounder adjusted association was examined loneliness was outcome*	N/A	**Receipt of medical care** Emotional loneliness, r=0.01, p=.664 Social loneliness r=0.04, p=.157 **Receipt of community care** Emotional loneliness, r=0.08, p=.004 Social loneliness r=0.11, p<.001	*Not possible to extract as loneliness was outcome*
Dahlberg et al, 2018	Swedish Panel Study of Living Conditions of the Oldest Old Sweden N=931	Aged 76+	Longi-tudinal study (baseline survey with patient data examined at follow-up) 1-2 years	Single-item question asking whether bothered by feelings of loneliness (nearly always, often, seldom and almost never). People responding nearly always or	Not specified	Planned hospital admission (medical records) Unplanned hospital admission (medical records)	1-2 years	Cox Proportional Hazards Regression (reference group = never/ infrequently lonely)	Living and care situation, marital status, contact with children, social contacts, social activities, age, gender, education, ability to deal with public authorities, self-rated health, illnesses	Planned hospital admissions Frequently lonely: 11.9% Unplanned hospital admissions Frequently lonely: 43.4%	Planned hospital admission HR 0.61 (95% CI: 0.33, 1.11) Unplanned hospital admission HR 0.90 (95% CI: 0.65, 1.25)

				often = lonely							
Denkinger et al (2012)	ActiFE Ulm Study, Germany, N= 1,059 44.9% female	65+ (mean 75.84, SD 6.55)	Cross-sectional observational study	Single-item question rated from 0 (not lonely)-10 (very lonely)		A.) Number of physician contacts B.) Length of stay in hospital	1 year (retrospective)	A.) Negative binomial regression model B.) Zero-inflated negative binomial regression	Age, sex, profession, social network, cognition, depression, BMI, physical activity, SRH, n of drugs, co-morbidity, falls, ADL's		A.) Rooted x2 2.19, estimate 0.030, p=.029 B.) t-value 0.62, estimate 0.028, p=.537
Ellaway et al, 1999	The West of Scotland Twenty-07 Study: Health in the Community UK N=691	Aged 40 (n=318 46%) or 60 (n=373 54%) F: 55.3%	Cross-sectional survey	Single-item question asking about whether they felt lonely (most of the time, quite often, only occasionally, seldom/never).	Present moment	Number of visits to GP surgery (self-report) Number of home visits from GP (self-report)	1 year (retrospective)	ANOVA	Number of symptoms, anxiety symptoms, depressive symptoms, gender, cohort, social class, housing tenure, neighbourhood, car access, self-assessed health, whether lives alone, feelings about partner status.	**Number of visits to GP surgery** Most of the time/often lonely: Mean 9.5 Occasionally lonely: Mean 4.1 Seldom/never lonely: Mean 4.1 P<.001 **Number of home visits from GP** Most of the time/often lonely: Mean 0.94 Occasionally lonely: Mean 0.30 Seldom/never lonely: Mean 0.38 P<.05	**Number of visits to GP surgery** Most of the time/often lonely: Adjusted mean 7.8 Occasionally lonely: Adjusted mean 3.4 Seldom/never lonely: Adjusted mean 4.2 P<.01 **Number of home visits from GP** Most of the time/often lonely: Adjusted mean 0.57 Occasionally lonely: Adjusted mean 0.21 Seldom/never lonely: Adjusted mean 0.39 P=ns
Gerst-Emerson and Jayawardhana, 2015	Health and Retirement Study USA N=3,530	Aged ≥ 50 (Mean 71.2, SD 7.14). F: 61.52%	Cohort study (assessed loneliness at 2008 and 2012)	3-item UCLA loneliness scale. People who responded "some of the time" or	Not specified	Number of hospitalisations (self-report) Number of physician visits (self-report)	2 years (retrospective)	Panel negative binomial regression analysis	Age, gender, marital status, race, education, satisfaction with income, questionnaire year 2008, high	N/A	**Number of hospitalisations** Lonely both years: β=0.048 (SE=0.060), p=.423

Author	Sample	Age	Design	Loneliness measure	Loneliness time frame	Outcome	Outcome time frame	Analysis	Covariates	Results	Results
				"often" to any of the 3 questions = lonely					depressive symptoms, insured, ADL disabilities, number of chronic conditions, good health.		Lonely 2008 only: β=0.218 (SE=0.101), p=.013 Lonely 2012 only: β=0.136 (SE=0.080), p=.09 **Number of physician visits** Lonely both years: β=0.075 (SE=0.034), p=.029 Lonely 2008 only: β=0.063 (SE=0.051), p=.215 Lonely 2012 only: β=0.015 (SE=0.036), p=.683
Hanratty et al, 2018	English Long-itudinal Study of Ageing UK N=1,270 (n=254 people who moved into care homes, n=1,016 matched controls who remained in community)	Aged ≥ 50 (Mean 82.1, SD 7.9) F: 68.5%	Longitudinal case-control study (identified retrospectively)	3-item UCLA loneliness scale. Score ≥ 6= lonely Single-item question whether felt lonely in the past week. Yes=lonely	UCLA= not specified Single-item= past week	Admission into care home	2 to 10 years	Weighted logistic regression (reference = control group)	Sex, age, wave, social isolation, depressive symptoms, psychiatric problems, cognitive scores, self-rated health, long-term physical conditions, dementia, wealth, disability.	**UCLA loneliness measure** OR: 1.81 (1.01-3.57), p=.049 **Single-item measure** OR: 2.13 (1.43-3.17), p<.001 *NB adjusted for age, wave and gender*	**UCLA loneliness measure** OR: 1.73 (1.17-2.57), p=.006 **Single-item measure** OR: 2.12 (1.49-3.00), p<.001
Houle et al (2001)	1990 Ontario Health Survey, Canada, N=7,112 *(nb analysis weighted to*	65 + (mean 72.69) 58.6% female	Cross-sectional	Single-item question whether felt lonely in the past 12 months: most of the time, more than half of	12 months (retrospective)	Total number of visits to a general practitioner/ family physician *(nb 13 or more visits coded as 13)*	12 months (retrospective)	Multiple regression analyses	Age, gender, education, living arrangements, health worries, physical activity, family functioning,		β=0.03, p=.0006

represent data for 455,628 people)			the time, less than half of the time, hardly ever. Dichotomised lonely/not lonely (not specified how)						housechold income, medical coverage, ability to drive, size of community, general activity limitations, functional disability, number of health problems, self-rated health, sum of disability days, feelings of loneliness, emotional state		
Jiang et al, 2018	Community study China N=2000	≥ 60 (Mean 71.6). F: 57.8%	Cross sectional survey	Single-item question "Do you feel lonely or nervous?" Responses never, sometimes or always.	Not specified	Use of out-patient services (self-report) Hospitalization (self-report)	Use of out-patient services: two weeks Hospitalization: past year	A.) Chi-squared analysis B.) Logistic regression (for hospitalization only). Reference group = never.	B.) Age, income, location, health status, disability, physical health change, diabetes, heart disease, cerebrovascular disease, bronchitis, regional economic level, outdoor activities	**A.)** **Use of out-patient services** Never: 13.3% Sometimes: 21.3% Always: 16.4% P=.017 **Hospitalization** Never: 14.7% Sometimes: 27.0% Always: 19.2% P<.001 B.) **Hospitalization** Sometimes OR 1.39 (95% CI: 0.97-1.98), p=.07 Always OR 0.59 (95% CI: 0.28-1.24), p=.12	B.) **Hospitalization** Sometimes OR 1.20 (95% CI: 0.83-1.75), p=.34 Always OR 0.55 (95% CI: 0.25-1.20), p=.13

Lundgren et al (1995)	Swedish population study, Sweden, N=354	85 74.3% female	Cross-sectional survey	Not specified	Not specified	Use of dental services (options twice a year, once a year, every other year, symptoms only, never) Regular dentist use defined as twice a year to every other year.	Not specified	Stepwise logistic regression	Dental state, number of drugs, ADL impairment, school education		OR 0.655 (95% CI: 0.463-0.926), p=.016
Molloy et al, 2010	Community study Ireland N=2,033	65 or older (Mean 74.1, SD 6.8) F: 57%	Cross-sectional survey N/A	Single question to assess feelings of loneliness (very often, quite often, not very often or never). Scoring not specified.	12 months	Emergency in-patient admission (self-report) Planned in-patient admission (self-report) All variables coded as binary variables.	12 months (retrospective)	Logistic regression	Long-standing illness, gender, age, marital status, education, depressive symptoms, social participation, perceived social support.	Emergency in-patient admission OR 1.37 (95% CI: 1.17, 1.59) Planned in-patient admission OR 1.09 (95% CI: 0.94, 1.25)	Emergency in-patient admission OR 1.29 (95% CI: 1.08, 1.55) Planned in-patient admission OR 1.09 (95% CI: 0.92, 1.28)
Mosen et al, 2020	Medicare Total Health Assessment Survey USA N=18,557	65 or older (mean 73.4, SD 6.6) Female	Baseline survey linked to electronic healthcare records	Single item question "How often do you feel lonely or isolated from those around you/" Always/often vs sometimes vs rarely/never	Not specified	A.) Inpatient hospital admissions Emergency department visits Primary care visits B.) Inpatient hospital admissions Emergency department visits All variables coded as binary variables (0 vs 1 or more)	A.) 12 months (retrospective) B.) 12 months (prospective)	A Descriptive statistics, analysis not specified (% and p-value presented) B.) Multivariate logistic regression (reference never/rarely lonely)	Age, sex, Ethnicity, area deprivation, Charlson co-morbidity index, previous healthcare utilisation	A (year prior to loneliness assessment) ≥ 1 hospital admission Never/rarely: 5.8 Sometimes: 7.7 Often/always: 9.5 p <.0001 ≥ 1 emergency department visit Never/rarely: 13.0 Sometimes: 18.8 Often/always: 25.9 p <.0001 ≥ 1 primary care visits Never/rarely: 71.5 Sometimes: 76.1	**B (year following loneliness assessment)** ≥ 1 hospital admission Sometimes lonely/isolated OR 1.17 (95% CI: 1.01-1.54), p=.04 Often/Always lonely/isolated OR 1.30 (95% CI: 0.99-1.69), p=.06 ≥ 1 emergency department visit Sometimes lonely/isolated

Author	Study	Age/Sex	Design	Loneliness measure		Outcome	Timeframe	Analysis	Covariates	Results A	Results B
										Often/always: 79.1 p <.0001	OR 1.28 (95% CI: 1.15-1.41), p<.0001 Often/Always lonely/isolated OR 1.51 (95% CI: 1.25-1.84), p<.0001
Nagga et al, 2012	Elderly in Linköping Screening Assessment Sweden N=496	85 or older F: 62%	Cross-sectional postal survey N/A	Single question to assess feelings of loneliness (very often, sometimes, seldom or never). Scoring not specified.	Not specified	Use of in-patient care (self-report)	12-months	Chi-square	N/A	Lonely, used in-patient care: 50% Not lonely, used in-patient care: 50% Lonely, did not use in-patient care: 36% Not lonely, did not use in-patient care: 64% P<.01	N/A
Newall et al, 2015	Wellness Institute Service Evaluation Research Study Canada N=954	45 or older (Mean 63.5, SD 10.4) F: 53.8%	Long-itudinal survey (baseline survey with patient data examined at follow-up) 2.5 years	Single question to assess feelings of loneliness (not lonely, moderately lonely, severely lonely, or extremely lonely). People responding moderately to severely lonely = lonely (24%)	Not specified	Physician visits outside of hospital setting (medical records) Hospitalisation (medical records) Multiple hospitalisations (medical records) Average length of stay in hospital ≥ 2 days (medical records) All variables coded as binary variables.	2.5 years	A.) Spearman's Correlation B.) Regression	B.) Age, gender, education, living arrangements, social participation, perceived health, chronic conditions.	A.) Physician visits outside of hospital setting r_s=0.12, p≤.01 Hospitalisation r_s=0.03, p=ns Multiple hospitalisations r_s=0.13, p≤.05 Average length of stay in hospital r_s=0.07, p=ns	B.) Physician visits outside of hospital setting RR: 1.06 (95% CI: 0.95, 1.18), p=ns Hospitalisation RR: 0.86 (95% CI: 0.61, 1.21), p=ns Multiple hospitalisations RR: 1.74 (95% CI: 1.01, 1.18), p≤.05 Average length of stay in hospital RR: 1.09 (95% CI: 0.64, 1.87), p=ns
Lim And Chan, 2017	Panel on Health and Aging of Singapore Elderly	Aged 60 or older (Mean 73.1, SD 7.2)	Cohort study (assessed loneliness at two points	3-item UCLA loneliness scale (respond of 5 point scale	Not specified	Whether seen a doctor (self-report, wave 2) Number of visits to doctor	Past month	Hurdle negative binomial regression (reference group = never lonely)	Age, sex, ethnicity, monthly income, health insurance,	N/A	**Whether seen a doctor** Become lonely OR 0.71 (SE=0.08), p=.004

Author	Setting/Sample	Age/Sex	Study design	Loneliness measure		Outcome	Time frame	Analysis	Covariates	Results	Results
	Singapore N=2,738	F: 53.1%	over 2 waves and assessed healthcare at wave 2)	from never (5) to always (1)). People who responded 1 to 4 = lonely. Examined loneliness at year 0 and year 2.		(self-report, wave 2)			medical savings account, employment status, education, self-assessed health, pain, chronic diseases, limitation in ADL or IADL		No longer lonely OR 0.83 (SE=0.08), p=.057 Remain lonely OR 0.75 (SE=0.09), p=.014 **Number of visits to doctor** Become lonely -0.449 (SE=0.25), p=.071 No longer lonely -0.712 (SE=0.22), p=.001 Remain lonely -0.229 (SE=0.23), p=.315
Richard et al., 2018	Swiss Health Survey Switzerland Total n=20,007 (subgroup analysis ≥ 60 = 5,382)	60 or older (mean not specified) F (total sample, subgroup not defined):	Cross-sectional survey	Single-item self-rated question Lonely= responded sometimes, quite often, very often	Not specified	Whether seen a doctor in past year	Past year	Logistic regression	Age, sex, area of residence, nationality, education level, marital status, household size, social support	-	**OR 1.80 (95% CI: 1.40-2.31)**
Russell et al, 1997	Established Populations for Epidemiologic Studies of the Elderly – Iowa USA N=3097	65 or older (Mean 74) F: 63% 4 years	Long-itudinal survey 4 years	4-item scale derived from the UCLA loneliness scale. Scores ranged from 4 to 12.	Not specified	Nursing home admission. Coded as binary variable.	4 years	Chi-square and Logistic Regression (Reference group = loneliness score of 4)	Age, gender, education, income, marital status, employment status, prior nursing home admission, ADL scores, health status, number of chronic illnesses, no of prescriptions, whether hospitalised,	Loneliness score 5 X^2=5.69, P<.05 OR=1.48 Loneliness score 6 X^2=11.31, P<.001 OR=1.79 Loneliness score 7 X^2=17.92, P<.001 OR=2.50 Loneliness score 8 X^2=13.31, P<.001 OR=2.49 Loneliness score 9-12	Loneliness score 5 X^2=<1, P=ns OR=1.04 Loneliness score 6 X^2=<1, P=ns OR=1.19 Loneliness score 7 X^2=<1, P=ns OR=1.34 Loneliness score 8 X^2=2.05, P=ns OR=3.25 Loneliness score 9-12

Study	Data source / Country / N	Age	Design	Loneliness measure	Timeframe	Outcome measure	Outcome timeframe	Analysis	Covariates	Results	Results
									number of doctor visits, club involvement, religious activities, network size, social support.	X²=50.94, P<.001 OR=6.44	X²=7.06, P<.01 OR=6.44
Shaw et al, 2017	Health and Retirement Study (with linked Medicare data) USA N=5,270	≥ 65	Long-itudinal survey (with linked Medicare data) Median 4.5 years follow-up (range 1-7 years). Multiple rationale: role of relationships more broadly and link between loneliness with health and health behaviours	3-item UCLA loneliness scale. Lonely = people responded some of the time or often to any of the three items.	Not specified	Number of inpatient visits: Medicare data Number of outpatient visits: Medicare data Use of skilled nursing facilities: Medicare data	Only specified follow-up (which ranged from 1 to 7 years)	A.) Poisson regression (number of inpatient and outpatient visits) B.) Logistic regression (use of skilled nursing facilities)	Months of follow-up, age, sex, race, education, marital status, household income, net worth, comorbid disease, functional ability, substance use history, depressive symptoms, BMI.	-	A.) **Number of inpatient visits:** IRR 0.96, p<.001 **Number of outpatient visits:** IRR 0.96, ns B.) **Use of skilled nursing facilities:** OR 1.20, p=.05 (ns)
Spinler et al (2019)	German Ageing Survey Germany N=3331	Aged 40+ (mean 62.7, SD 10.9) Female 1 = 49.2%	Cross-sectional (over 3 waves)	11-item De Jong Jierveld Scale	Not specified	Number of dental visits (self-report) Never, once, 2-3 times, 4-6 times, 7-12 times, more often.	Number of dental visits in previous 12 months measured across 3 waves	Poisson fixed-effects regression (changes in loneliness over 3 waves modelled as predictor)	None	Overall -0.04 (0.04), ns Men -0.05 (0.05), ns Women -0.02 (0.05), ns	N/A
Theeke (2010)	Health and Retirement Study USA	≥65 (mean 74) Female: 49%	Cross-sectional	Single-item self-rated measure asked participants	Past week	Use of home care (self-report)	Use of home care: Not specified	A.) Chi-square analysis B.) T-test	None	Use of home care (A.) Lonely Yes: 12% No: 88%	N/A

	N=8,932			whether they have felt lonely for much of the past week (yes/no)		Number of doctor visits (self-report)	Number of doctor visits: Previous 2 years			Not Lonely Yes: 7% No: 93% p<.005 Number of doctor visits (B) Lonely: Mean 13.15 (SD 20.48) Not lonely: Mean 10.05 (SD 16.23) p<.005	
Wang et al, 2019	Cambridge City over-75s Cohort Study UK N=162 (of 665)	≥ 80 (80-84: 46%; 85-89: 40%; 90+ 14%) F: 69%	Longitudinal survey (7-years)	Single-item self-rated question (not at all, slightly, lonely and very lonely). People who responded lonely or very lonely = lonely. People who responded slightly lonely = slightly lonely.	Not specified	Home help past week (self-report) Community nurse past week (self-report) Meals on wheels past week (self-report) Use of day centre past week (self-report) Hospital visits past year (self-report) Time since last GP visit (self-report)	Community service contact (home help, community nurse, meals on wheels and use of day centre): past week Hospital visits: past year GP visit: time since last visit	A.) Generalised estimating equations with loneliness at baseline only, and healthcare utilization at follow-ups. B.) Generalised estimating equations with both loneliness and healthcare utilization at all follow-ups.	Age, sex, physical impairments, number of chronic conditions, depression, physical functioning and cognition		A.) **Home help** Lonely: IRR 2.4 (95% CI 0.8-7.3), ns Slightly lonely: IRR 1.3 (95% CI 0.5-3.6), ns **Community nurse** Lonely: IRR 1.1 (95% CI 0.5-2.5), ns Slightly lonely: IRR 0.6 (95% CI 0.2-2.2), ns **Meals on wheels** Lonely: IRR 2.0 (95% CI 0.9-4.5), ns Slightly lonely: IRR 1.9 (95% CI 0.8-4.9), ns **Use of day centre** Lonely: IRR 1.4 (95% CI 0.3-5.3), ns Slightly lonely: IRR 1.6 (95% CI 0.5-5.0), ns **Hospital visits**

											Lonely: IRR 1.2 (95% CI 0.8-1.9), ns
											Slightly lonely: IRR 1.3 (95% CI 0.8-2.1), ns
											Time since last GP visit
											Lonely: IRR -0.1 (95% CI -0.5-0.3), ns
											Slightly lonely: IRR -0.5 (95% CI -0.8- -0.2), p<.05
											B.)
											Home help
											Lonely: IRR 2.4 (95% CI 0.8-7.3), ns
											Slightly lonely: IRR 1.2 (95% CI 0.5-2.9), ns
											Community nurse
											Lonely: IRR 3.4 (95% CI 1.4-8.7), P<.05
											Slightly lonely: IRR 0.8 (95% CI 0.3-2.6), ns
											Meals on wheels
											Lonely: IRR 2.5 (95% CI 1.1-5.6), p<.05
											Slightly lonely: IRR 1.6 (95% CI 0.6-3.8), ns
											Use of day centre
											Lonely: IRR 1.4 (95% CI 0.4-5.3), ns
											Slightly lonely: IRR 1.7 (95% CI 0.5-5.5), ns

Author, year	Study/Setting	Age	Design	Loneliness measure	Other	Outcome	Follow-up/Timeframe	Analysis	Adjustments	Results A	Results B
											Hospital visits Lonely: IRR 1.5 (95% CI 0.9-2.4), ns Slightly lonely: IRR 1.4 (95% CI 0.9-2.1), ns **Time since last GP visit** Lonely: IRR -0.2 (95% CI -0.5-0.1), ns Slightly lonely: IRR -0.3 (95% CI -0.6-0.1), ns
Zhang et al, 2018	Survey of the Shandong Elderly Family Health Service China N=5514	≥ 60 (Mean 69.7, SD 6.5) F: 57.1%	Cross-sectional survey	Single-item self-rated question (never, rarely, sometimes and always) People who responded rarely, sometimes or always = lonely	Not specified	Outpatient service use (self-report) In-patient hospitalization (self-report)	Outpatient service use: 2 weeks In-patient hospitalization: past year	A.) Chi-squared analysis B.) Logistic regression *(reference = not lonely)*	Age, marital status, education, insurance, living arrangements, income, self-rated health, number of chronic conditions, issues with ADL's	A.) **Outpatient service use** Lonely: 26.1% Not lonely: 19.8% P<.001 **In-patient hospitalization** Lonely: 21.9% Not lonely: 16.2% P<.001	B.) **Outpatient service use** OR 1.26 (95% CI: 1.08, 1.47), p=.003 **In-patient hospitalization** OR 1.18 (95% CI: 1.00, 1.40), p=.047

Abbreviations: ADL (activities of daily living); BMI (body-mass index); CI (confidence interval); F (female); GP (general practitioner, also known as family physician); HSCU (healthcare utilisation); HR (hazard ratio); ICD (International Classification of Diseases); IRR (Incidence rate ratio); N (number); OR (odds ratio); SD (standard deviation);

Supplementary File 3: Quality assessment for included studies

	Almind et al, 1992	Barnes et al., 2021	Berg et al, 1981	Bock et al., 2018	Bu et al., 2020 falls	Bu et al, 2020 respiratory	Bu et al., CVD	Burns et al., 2020	Burns et al., 2021	Burr and Lee., 2013	Cheng, 1992
1. Was the research question or objective in this paper clearly stated?	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
2. Was the study population clearly specified and defined?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
3. Was the participation rate of eligible persons at least 50%?	CD	N	Y	N	Y	Y	Y	Y	Y for survey but N for analysis	Y	CD
4. Were all the subjects selected or recruited from the same/similar populations (including the same time period)? Were inclusion/ exclusion criteria prespecified and applied uniformly?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Was a sample size justification, power description, or variance and effect estimates provided?	N	N	N	N	N	N	N	N	N	N	N
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? *Cross-sectional and panel data marked as no*	N	N	N	N	Y	Y	Y	N	N	N	N
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? *Defined as a minimum of 1 year*	Y	Y	CD	Y	Y	Y	Y	Y	Y	Y	Y
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)? *If loneliness dichotomised (i.e., lonely vs not lonely) this marked as No*	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	N	Y	N	N	Y	Y	Y	Y	Y	N	Y
10. Was the exposure(s) assessed more than once over time?	N	N	N	Y	N	Y	Y	Y	N	N	N
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? *Indicated by linked medical records to measure HSCU*	N	Y	CD	N	Y	Y	Y	N	N	N	N

12. Were the outcome assessors blinded to the exposure status of participants?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13. Was loss to follow-up after baseline 20% or less?	N/A	N/A	N/A	N/A	Y	Y	Y	N/A	N/A	N/A	N/A
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)? *This was indicated by controlling for 6 of the 8 important confounders*	N	N	N	Y	Y	Y	Y	Y	Y	Y	N
Global assessment	**Poor**	**Poor-fair**	**Poor**	**Fair**	**Good**	**Good**	**Good**	**Fair**	**Fair-poor**	**Fair**	**Fair-poor**
Rationale for global assessment	Cross-sectional, self-report HSCU, non-valid use of UCLA scale, no adjustment confounders	Cross-sectional, inadequate confounder adjustment, less than 50% participation rate.	Cross-sectional, self-report HSCU, no adjustment confounders, no consideration dose-response	Panel data, self-report HSCU, less than 50% participation rate.	Longitudinal, HSCU medical records, adjustment confounding.	Longitudinal, HSCU medical records, adjustment confounding.	Longitudinal, HSCU medical records, adjustment confounding.	Cross-sectional and self-report HSCU	Cross-sectional and self-report HSCU, final analytical sample in fully adjusted analysis approximately 25% of initial sample	Cross-sectional, self-report HSCU, non-valid use of UCLA scale	Cross-sectional, self-report HSCU, inadequate adjustment confounders

	Dahlberg and McKee, 2013	Dahlberg et al, 2018	Denkinger et al., 2012	Ellaway et al, 1999	Gest-emerson & Jayawardhana, 2015	Hanratty et al, 2018	Houle et al., 2010	Jiang et al., 2018	Lundgren et al., 1995	Molloy et al, 2010
1. Was the research question or objective in this paper clearly stated?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Was the study population clearly specified and defined?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Was the participation rate of eligible persons at least 50%?	Y	Y	N	Y	Y	CD	Y	Y	N	Y
4. Were all the subjects selected or recruited from the same/similar populations (including the same time period)? Were inclusion/ exclusion criteria prespecified and applied uniformly?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Was a sample size justification, power description, or variance and effect estimates provided?	Y	N	N	N	N	N	N	N	N	N
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? *Cross-sectional marked as no*	N	Y	N	N	N	Y	N	N	N	N
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? *Defined as a minimum of 1 year*	N	Y	Y	Y	Y	Y	Y	N – outpatient / Y - hospitalization	Y	Y
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)? *If loneliness dichotomised (i.e., lonely vs not lonely) this marked as No*	Y	N	Y	Y	N	N	N	Y	CD	Y
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Y	Y	CD	Y	Y	Y	Y	N	CD	Y
10. Was the exposure(s) assessed more than once over time?	N	Y	N	N	Y	N	N	N	N	N
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? *Indicated by linked medical records to measure HSCU*	N	N	N	N	N	Y	N	N	N	N
12. Were the outcome assessors blinded to the exposure status of participants?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

13. Was loss to follow-up after baseline 20% or less?	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)? *This was indicated by controlling for 6 of the 8 important confounders*	N	Y	Y	Y	Y	Y	Y	Y – hospitalisation N - outpatient	N	N
Global assessment	**Poor**	**Good**	**Fair-poor**	**Fair**	**Fair**	**Good-fair**	**Fair**	**Hospitalisation: Fair-poor** **Outpatient: Poor**	**Poor**	**Fair-poor**
Rationale for global assessment	Cross-sectional, self-report HSCU, no adjustment confounders (only correlational data could be extracted for this paper), short timeframe **(nb: Fair for study but rating of poor due to analysis included)**	Longitudinal, HSCU medical records, adjustment confounding but did not examine range loneliness	Cross-sectional, self-report HSCU, less than 50% participation rate, loneliness question not clear	Cross-sectional and self-report HSCU	Cross-sectional and self-report HSCU, did not examine range loneliness but did examine chronicity of loneliness	Longitudinal, used both multi and single item loneliness questions, residence based off location (objective), sampled control participants retrospectively, did not examine different levels of loneliness	Cross-sectional and self-report HSCU, did not examine range loneliness	Cross-sectional, self-report HSCU over 2 weeks only for outpatient, loneliness not validated	Cross-sectional, self-report HSCU, inadequate confounder adjustment (only 1 important confounder), CD how loneliness measured.	Cross-sectional, self-report HSCU, inadequate confounder adjustment

	Mosen et al., 2020	Nagga et al, 2012	Newell et al, 2015	Lim and Chan, 2017	Richard et al., 2018	Russell et al, 1997	Shaw et al., 2017	Spinler et al., 2019	Theeke, 2009	Wang et al 2019	Zhang et al 2018
1. Was the research question or objective in this paper clearly stated?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Was the study population clearly specified and defined?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Was the participation rate of eligible persons at least 50%?	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y
4. Were all the subjects selected or recruited from the same/similar populations (including the same time period)? Were inclusion/ exclusion criteria prespecified and applied uniformly?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Was a sample size justification, power description, or variance and effect estimates provided?	N	N	N	N	N	N	N	N	N	N	N
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? *Cross-sectional marked as no*	Y	N	Y	N	N	Y	Y	N	N	N	N
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? *Defined as a minimum of 1 year*	Y	Y	Y	N	Y	Y	Y	Y	Y	Y - N - community	Y for hospitalization N for outpatient service use
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)? *If loneliness dichotomised (i.e., lonely vs not lonely) this marked as No*	Y	N	N	N	N	Y	N	Y	N	Y	N
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y
10. Was the exposure(s) assessed more than once over time?	N	N	N	Y	N	N	N	Y	N	N	N
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? *Indicated by linked medical records to measure HSCU unless move to nursing home in which case SR could suffice*	Y	N	Y	N	N	Y	Y	N	N	N	N
12. Were the outcome assessors blinded to the exposure status of participants?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13. Was loss to follow-up after baseline 20% or less?	Y	N/A	Y	N/A	N/A	N	Y	N/A	N/A	N	N/A
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)? *This was indicated by controlling for 6 of the 8 important confounders*	N	N	Y	Y	N	Y	Y	N	N	Y	Y

Global assessment	Good-fair	Poor	Good	Fair-poor	Fair-poor	Good-fair	Good	Fair-poor	Poor	Fair	**Fair hosptalisation** **Fair-poor outpatient service use**
Rationale for global assessment	Longitudinal, HSCU in medical records, but did not control for all important confounders *NB: There were data on primary care that was cross-sectional and unadjusted that was extracted – this was rated as poor*	Cross-sectional, basic descriptive analysis, no confounder adjustment, didn't examine different levels of loneliness *NB: Looking at loneliness and HSCU not primary objective of study*	Longitudinal, HSCU medical records, adjustment confounding but did not examine range loneliness	Cross-sectional, self-reported HSCU over 1 month only, did not examine range loneliness but did examine chronicity of loneliness	Cross-sectional, self-reported HSCU, did not control for all important confounders	Longitudinal, non-valid short version of UCLA loneliness scale, loss to follow-up greater than 20%	Longitudinal, HSCU in medical records, did not examine range of loneliness (but clear justification for this provided)	Panel data, self-reported HSCU, no confounder adjustment, participation rate < 50%	Cross-sectional, self-reported HSCU, no confounder adjustment, didn't examine different levels of loneliness	Longitudinal study, only asked about HSCU in previous week across 3 waves for community, self-reported HSCU, did not have 50% participation and also loss to follow-up	Cross-sectional, self-reported HSCU, did not examine range loneliness, as asked about hospitalisation over a year this was rated slightly higher than outpatient service use which was only assessed over 2 weeks

Important confounders: Sociodemographics (Age, sex, marital status, household composition) Health (physical health status as indicated by chronic conditions and/or functioning, mental health (e.g., depressive symptoms), cognition and health behaviours)

Any study that was cross-sectional was given an automatic rating of fair due to issues with inferring causality

Abbreviations: CD = cannot determine, HSCU = healthcare utilisation, N= No, N/A=Not applicable, Y= Yes

Additional information on key parameters for assessing study quality

Parameter A: Measurement of loneliness

There are two broad approaches to measuring loneliness: multi-dimensional scales and single item questions. The most commonly used multi-dimensional scales also validated for use in older adults are the UCLA-loneliness scale (Hughes., 2004; Russell et al., 1978) and De Jong Jierveld loneliness scale (*De Jong Gierveld* and Van Tilburg., 2006; De Jong Gierveld., 2006). These scales prompt indirectly about loneliness by referring to issues such as companionship, having someone to talk to and feeling alone or isolated. Single item measures differ in that they often ask directly about the experience of loneliness, but can differ in phrasing of the question and response scale (e.g., yes/no or severity rating). Both single-item and multidimensional measures can be treated continuously, or categorically. Key considerations will be whether studies use scales/questions in a valid way, and how they score loneliness. It will also be worth examining whether more recently published studies take the UK Office for Statistics (2018) suggested approach for harmonising measurement of loneliness by using both the 3-item UCLA loneliness scale and a direct measure of loneliness.

Parameter B: Measurement of healthcare utilization

There are three areas to examine when considering the quality of the measurement healthcare utilisation: method of collecting service use (self-report or data linkage, with the highest quality studies utilising more objective methods), types of service use and the time interval between measure of exposure and service use outcomes needing to be enough for any effect to be observed and recorded (defined as 1 year for this study).

Linkage to medical records is considered to be the most valid and reliable way of collecting information on healthcare utilization, as self-report recollection of healthcare utilisation could be prone to error and bias (Ansah and Powell-Jackson., 2013). When assessing the type of service use it will also be worth examining whether studies have examined the number of times that a service has been used or whether they look at whether a service has been used at all within a defined timeframe. However, it is worth noting that a robust finding should not be impacted by the type of analysis employed. Studies should also have a length of follow-up that is of sufficient length to detect the outcome, for this study we defined that minimum amount of time as 1-year.

Parameter C: Causal inference

Austin-Bradford Hill suggested there are various parameters we should assess evidence against to determine whether causality can be inferred. Of those parameters, the following are commonly applied to assess potential causality: the strength of the association, evidence of a biological gradient (dose-response relationship), temporality, consistency, biological plausibility, coherence, analogy and experiment (reversibility) (Rothman and Greenland., 2005).

The chosen quality assessment tool allowed us to formally assess the following indicators of causality:

Temporality: The best casual evidence will assess the predictor (in this case loneliness) at baseline and the outcome (in this case healthcare utilisation) at a later time-point (Fedak et al., 2015). Any study that employs a cross-sectional design will be limited by the fact that the outcome measure will be assessed prior to the exposure measure (i.e., healthcare utilization will need to be assessed retrospectively in a cross-sectional study). Therefore, only longitudinal studies would allow us to infer causality and any cross-sectional studies would not be suitable to determine whether loneliness as an exposure causes a change in healthcare utilization as an outcome.

Biological gradient (dose-response association): It has been suggested that causality is better indicated if the outcomes shows a stepwise increase/decrease as the outcome as the predictor increases. This would be indicated by healthcare utilisation either systematically increasing/decreasing as loneliness increases in severity, and would require the study to look at different levels of the exposure variable.

Parameter D: Confounder control

Previous work indicates that those sociodemographic factors linked with loneliness in older adults such as oldest age, living alone, being single or widowed and being female (Cohen-Mansfield et al, 2016; Savviko et al, 2005) are linked with increased healthcare utilization (Drayer et al, 2018; Vedsted and Christensen, 2005). Furthermore, loneliness is strongly linked with both worsened physical and mental health (Valtorta et al., 2016) which are amongst the strongest predictors of healthcare utilization (Vedsted and Christensen, 2005; Wammes et al., 2018; Zayas et al, 2016). In older adults, loneliness also shares a strong association with cognitive status (Victor et al., 2020), which is also associated with increased healthcare utilization (Weber et al., 2011). Finally, loneliness has been linked with worsened healthcare behaviours in older adults (Shankar et al., 2011) which also represent important predictors of healthcare utilization (Heron et al., 2019; Wacker et al., 2013).

Additional papers required for quality assessment

Assessment of Gerst-Emerson (1999) also meant that Hughes et al (2004) had to be examined as they referred to this study for more information about the HRS.

Assessment of Molloy et al (2010) meant that McGee et al (2005) had to also be examined as this study was referred to in the Molloy paper as containing more information about the study design.

Assessment of Newell et al (2015) meant that Bailis and Segall (2004) had to also be examined as this study was referred to in the Newell paper as containing more information about baseline study design and sampling.

Assessment of Lim and Chan (2017) meant that Leung et al (2016) had to also be examined as this study was referred to in the Lim paper as having additional information about the study design