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Review

Intolerance of uncertainty, aging, and anxiety and mental health concerns: A scoping review and meta-analysis

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ABSTRACT

Although intolerance of uncertainty (IU) is associated with negative outcomes, studies focusing on older adults are still emerging. Specifically, the relationship between IU and psychological health in this population remains unclear. Moreover, no review has focused on understanding the unique contributions of IU and aging to anxiety and mental health in older adults. This scoping review and meta-analysis addressed this gap and provided a comprehensive understanding of the relationship between IU, aging, and mental health. Among 45 studies reviewed, 37 were included in the meta-analysis using mixed effect analysis to examine the relationship between IU and age across adulthood. The remaining eight studies, along with seven selected from the meta-analysis, were included in the scoping review to evaluate the relationship between IU, anxiety, and mental health. Among these, 12 studies focused on late adulthood, two on overall adulthood, and one included both late and overall adulthood. Results of the meta-analysis revealed an overall significant age difference in IU throughout adulthood. Moreover, results of the scoping review indicated a direct correlation between IU and anxiety, and other psychological issues in elderly. These findings provide insights for future research and interventions aimed at reducing IU and improving mental health among older adults.

1. Introduction

1.1. Intolerance of uncertainty

Intolerance of uncertainty (IU) refers to a dispositional attribute that reflects an individual's propensity to experience increased discomfort and fear in uncertain situations (Carleton et al., 2007). In recent years, researchers have increasingly focused on understanding the influence of IU on the development and maintenance of various mental disorders such as anxiety, across different age groups. However, the exploration of IU during late adulthood has received limited attention. Furthermore, although studies have examined the influence of age on IU in children and adults, few studies have specifically investigated differences in IU between young and older adults or across different life stages. Thus, this study addressed this gap in the literature by exploring the unique characteristics of IU in the aging population and investigating the complex interplay between aging, IU, and psychological health.

1.2. IU and mental health

Previous studies have consistently demonstrated a strong relationship between IU and various negative outcomes across different life stages, from childhood to adulthood. IU has been identified as a significant predictor of generalized anxiety disorder (GAD; Carleton, 2012; McEvoy & Mahoney, 2012), worry (Boelen, 2010; Dugas et al., 1997, 2004), and obsessive-compulsive disorder (OCD; Gentes & Ruscio, 2011; Tolin et al., 2003). Moreover, extensive empirical evidence has highlighted correlations between IU and eating disorders (Konstantellou et al., 2022; Sternheim et al., 2011), stress (Bakioğlu et al., 2021; Boelen, 2010), and depression (Bakioğlu et al., 2021; Dugas et al., 2004; McEvoy & Mahoney, 2012). These findings highlight the critical relationship between IU and these specific mental health issues, indicating the need for additional research and interventions targeting IU.

The significant impact of IU on mental health has resulted in increasing interest in developing interventions targeting this risk factor.

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Numerous studies have provided evidence supporting the effectiveness of interventions addressing IU as the mechanistic target for reducing worry in the treatment of GAD (Bomyea et al., 2015; Hebert & Dugas, 2019; Koerner & Dugas, 2006; Robichaud, 2013; van der Heiden et al., 2012) and OCD (Grayson, 2010; Hewitt et al., 2009). These interventions primarily use cognitive–behavioral therapies to help individuals develop adaptive coping strategies when confronting uncertain situations, including cognitive restructuring (Bomyea et al., 2015), exposure therapy (Grayson, 2010), and metacognitive therapy (van der Heiden et al., 2012). These therapies have shown effectiveness in reducing specific symptoms by improving individuals' skills and abilities to effectively cope with uncertainty in their daily lives. These studies have important implications for understanding the role of IU in anxiety-related and other psychological conditions. By identifying its mechanisms and developing effective interventions, researchers and clinicians can contribute to improving individuals' overall well-being and life satisfaction. Despite the extensive research and interventions across various age groups, the specific role of IU and its influence on the aging population remain unclear.

1.3. Aging and IU

The aging process significantly influences mental well-being, both positively and negatively. Mental conditions can arise at any stage of life, including late adulthood (Lebowitz & Niederehe, 1992; Segal et al., 2018). This population is typically divided into three age groups by decades: "young-old" (55–64 years), "middle-old" (65–74 years), and "old-old" (75 years and above) (Hummert, 1994; Reynolds et al., 2015; Takata et al., 2008). According to Lebowitz and Niederehe (1992) and Smyer and Qualls (1999), multiple factors contribute to the effects of aging on these three stages, including cognitive function decline, changes in social support networks, and limited access to care. With the global population aging, an increasing number of individuals are experiencing mental conditions in later life. Anxiety-related disorders, such as social anxiety disorder and GAD (Birren et al., 2013; Lebowitz & Niederehe, 1992), depression (Birren et al., 2013; Lebowitz & Niederehe, 1992), substance use disorders (SUD; Birren et al., 2013), and OCD (Segal et al., 2018; Smyer & Qualls, 1999) are prevalent in this life stage. The prevalence of these mental issues in later life highlights the importance of addressing mental well-being and providing appropriate care for older individuals.

Regarding the influence of IU on mental health, a systematic review and meta-analysis supported that IU-based interventions yield positive outcomes in the treatment of anxiety-related disorders (Miller & McGuire, 2023), highlighting the significance of IU in mental health treatment. However, a review conducted by Frank and Seaman (2023) highlights the limited research on IU specifically within the older population, despite its potential relevance to the mental health and behavior of older adults, particularly in uncertain situations. Several studies have explored the impact of aging on IU and its relationship with psychological health. Birren et al. (2013), Segal et al. (2018) and Smyer and Qualls (1999) reported that certain mental conditions, particularly anxiety-related disorders, may be more prevalent among older individuals. However, the findings of previous studies focusing on the relationship between IU and aging have been inconsistent. Basevitz et al. (2008), Bavolar et al. (2021), and Gerolimatos and Edelstein (2012b) found that IU tends to decrease with age in later adulthood compared with early adulthood, suggesting the presence of lower IU levels in the older population. Conversely, Merlo et al. (2021) discovered no significant correlation between age and IU, suggesting that IU levels do not necessarily decrease with age across adulthood. Thus, the lack of consensus regarding the relationship between IU and age calls for further research to investigate this relationship, particularly in older individuals. In addition to the lower IU levels observed in the older population, the aforementioned studies have also found that higher levels of IU are associated with increased anxiety-related conditions, worry, and stress among older individuals. These findings highlight the potential impact of IU on mental health issues in the older population. Therefore, understanding the inter-relationship between aging, IU, and psychological health is essential for developing targeted interventions and strategies to promote mental well-being in this population.

1.4. Review aims

To address the aforementioned research gap, the choice of review methodology was determined based on the potential number of results in the two specific areas of interest. Although a sufficient number of studies have examined the correlation between IU and age from a demographic perspective, research specifically focusing on the impact of IU on mental health in the aging population is lacking. For instance, a previous meta-analysis included only children and adults when examining the influence of age on IU (McEvoy et al., 2019). This limitation can be attributed to the predominant emphasis on studying IU in younger populations. Therefore, we conducted a scoping review to investigate the identified research gap, with the option of incorporating a meta-analysis if a sufficient number of relevant studies were available.

This scoping review with a meta-analysis reviewed the literature on aging and IU as well as its association with mental health. This review addressed three primary research questions:

1. Does IU change with age in adulthood?
2. How does IU differ between young and old adulthood?
3. What are the interrelationships between IU, aging, and mental health?

2. Method

To select relevant literature on aging and IU and its relationship with psychological health, this scoping review followed the methodological framework outlined by Arksey and O'Malley (2005) and adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Extension for Scoping Reviews guidelines (Tricco et al., 2018). The PRISMA checklist is provided in Table A.1. The scoping review protocol was registered on the Open Science Framework (https://doi.org/10.17605/OSF.IO/9EBJW). During the scoping review, we determined that there were adequate studies to conduct a quantitative meta-analysis. This meta-analysis helped to identify age-related differences, whereas the scoping review allowed us to summarize the current research and provide insights into future research directions.

2.1. Search strategy

Five electronic databases, namely, Embase, PsycINFO, PubMed, Scopus, and Web of Science, were searched from their inception to April 2, 2024. Search terms related to IU, aging, and psychological health were used to retrieve relevant titles and abstracts from these databases. An overview of the search strategy and key search terms is provided in Table 1. A complete list of full search terms and their synonyms is provided in Table A.2. In addition, Table A.3 provides additional details on the synonym terms used in the search strategy.

No restrictions were imposed on the publication date or the mental health status of the populations studied (i.e., clinical and nonclinical populations). Only full-text articles in English were included in the review. To emphasize the impact of aging on IU, studies focusing on populations aged 55 years or older were selected. Furthermore, research studies including patients aged 18–55 years were included to investigate potential differences throughout adulthood and the course of the relationship.

2.2. Inclusion and exclusion criteria

To be eligible for inclusion in this review, articles needed to meet the

Table 1
Overview of the strategy and key search terms.

Overview of the strategy:				
(1) Intolerance of uncertainty AND older adults				
(2) Intolerance of uncertainty AND older adults AND mental health				
Key search terms:				
Intolerance of uncertainty (IU)	AND	*Older adults*	AND	*Mental health*
"intolerance of uncertainty"		"aged"		"mental health"
"intolerance of ambiguity"		"aged patient"		"mental condition"
"tolerance of ambiguity"		"age people"		"mental state"
"intolerance to uncertainty"		"aged subject"		"mental status"
"Intolerance towards uncertainty"		"aged 55 or 55 +"		"mental illness"
"Tolerance of uncertainty"		"age 55 and older"		"mental wellbeing"
"need for certainty"		"adults over age 55"		"mental well-being"
"need for predictability"		"adults 55 years or"		"mental disorder"
"need for cognitive closure"		"elderly"		"mental hygiene"
"uncertainty"		"elderly patient"		"psychological wellbeing"
"intolerance"		"elderly people"		"psychic health"
"unpredictability		"elderly subject"		"psychiatric illness"
		"elder care"		"psychiatric medication"
		"elderly population"		"psychiatric hospital"
		"senior*"		"abnormal psychology"
		"senior citizen"		"psychiatry"
		"old age"		"psychology"
		"older adult*"		"well-being"
		"older individual"		"schizophrenia"
		"older people"		"Emotional health"
		"older patient"		"spiritual well-being"
		"older subject"		"anxiety"
		"older ages"		"anxious"
		"older age groups"		"worry"
		"older participants"		"depress*"
		"older adulthood"		"loneliness"
		"older-aged"		"fear"
		"old participants"		"generalized anxiety disorder"
		"late adulthood"		"GAD"
		"aging"		"anxiety sensitivity"
		"aging in place"		"health anxiety"
		"ageing"		"OCD"
		"ageism"		"compulsive disorder"
		"geriatric*"		"panic"
		"gerontology"		"hypochondriasis"
		"age-difference"		
		"age difference"		

following criteria: (1) involve older populations (either aging-focused studies or comparative studies from early to late adulthood); (2) present original research using scales or behavioral tasks for measuring IU or both IU and related psychological health; (3) demonstrate a relationship involving (3a) IU and age, (3b) IU, age, and related mental health indicators, (3c) age-differences in IU (from young to older populations), or (3d) the influence of age on both IU and mental health disorder; and (4) be available in English.

The purpose of this review was to investigate the influence of age on IU and correlations between IU, aging, and mental health indicators. Therefore, we considered experimental, correlational, comparative, interventional, and observational studies during our search. Regarding exclusion criteria, we excluded (1) studies that did not provide IU scores for different age groups; (2) literature that was not in English and lacked full-text availability; and (3) nonprimary studies, previous studies, study protocols, reviews, and meta-analyses.

2.3. Data extraction

During the initial stage of this review, two independent reviewers screened the titles and abstracts of the articles. Subsequently, the full texts of the selected articles were evaluated by the same two reviewers, with a third reviewer being involved to resolve any disagreements between them. Data extraction was performed independently by two reviewers, and consensus was reached through discussion.

A custom data extraction form was designed specifically for this review. The form included the following information: (1) author's name, (2) year of publication, (3) study population, (4) sample size, (5) age range and mean ages, (6) country where data were collected, (7) research design, (8) recruitment strategy, (9) participant characteristics, (10) type of mental health disorder included in the study, (11) measurement tools used for IU, (12) data collection methods, (13) diagnosis categories, and (14) results pertaining to IU as well as other relevant findings; e.g., the relationship between IU and aging, the relationship between IU, aging, and mental health problems, and age differences in IU. Missing information was marked as "N/A".

2.4. Quality appraisal

To evaluate the quality of each selected study, we used the assessment tool developed by The National Institute for Health and Clinical Excellence (NICE, 2012). As the focus of this review was on examining the relationship between IU, age, and psychological mental health, we specifically used the checklist for qualitative research from NICE for the evaluation. During the quality assessment process, we considered only data relevant to the selected findings. This approach ensured a rigorous evaluation of the included studies.

The checklist allowed us to assign a score to each study based on how well it met the criteria for each applicable item. For scoring purposes, we used a double cross (++; 2 points) for studies that fully conformed to the criteria on an item, a single cross (+; 1 point) for studies that partially met the criteria, and a minus sign (−; 0 points) for studies that completely deviated from the criteria. To facilitate comparisons between studies, we calculated the total score for each study by summing the scores of relevant items, dividing by the maximum achievable score, and then multiplying by 100. In addition, two summary items (5.1 and 5.2) were included in the checklist to appraise the overall internal and external validity of the studies.

3. Results

The search initially yielded 4918 articles, and after removing 227 duplicates, a total of 4691 articles were screened for eligibility. Among these, 4604 articles were deemed irrelevant and excluded, resulting in 87 articles for full-text screening. Based on the specified inclusion and exclusion criteria, 45 papers comprising 46 studies were included in this scoping review (Fig. 1). Among the included papers, the majority (number of papers [k] = 41) used a cross-sectional study design. The remaining studies used different designs, such as experimental, longitudinal ($k = 3$), and mixed study designs. The Intolerance of Uncertainty Scale (IUS) was the primary assessment tool used to measure IU across the selected papers. Multiple versions of the IUS were used, including the 27-item (Freeston et al., 1994), 17-item (Del Valle et al., 2020), 12-item (Carleton et al., 2007), 5-item (Shao et al., 2021), and 2-item (Glowacz & Schmits, 2020) versions.

Among the selected studies, 37 papers provided age-related results with sufficient data, and these papers were included in the meta-analysis. In the scoping review, 13 studies examined the association between IU and psychological health, specifically among older adults,

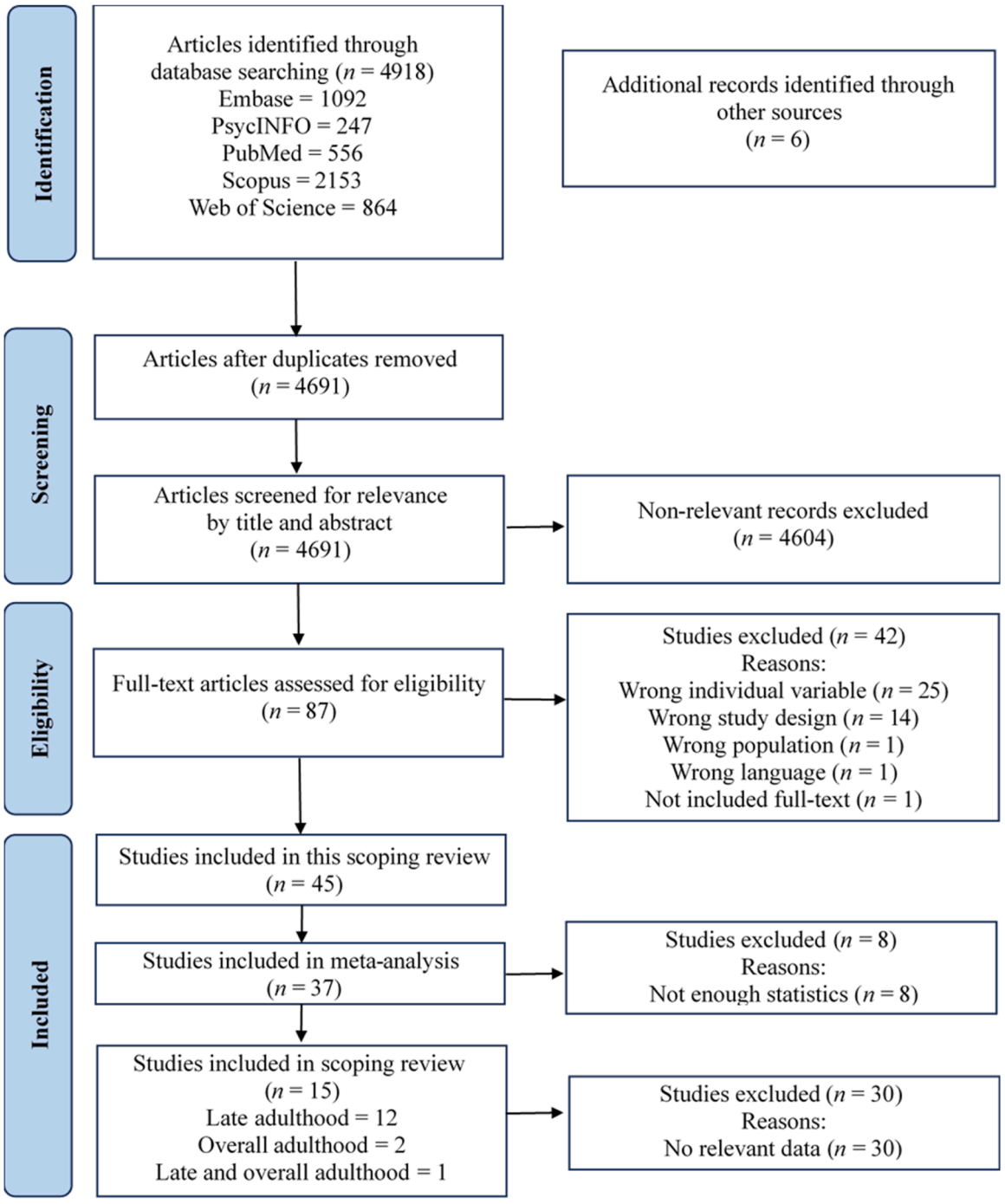


Fig. 1. PRISMA flow diagram showing the selection of articles included in the scoping review.

and three studies investigated the relationship between aging, IU, and mental health indicators. Effect sizes (Cohen's *d*), and unweighted average statistics were calculated.

3.1. Quality appraisal summary

The inter-rater reliability score (κ) of this scoping review generally indicated good reliability for the quality assessment. The overall κ value of 0.62, internal validity κ of 0.67, external validity κ of 0.78 (95 % CI [0.44, 0.77], [0.44, 0.90], [0.57, 0.95]), respectively, demonstrated substantial to good agreement between the two reviewers. The final score for each study was determined through discussion to reach a consensus. Because no intervention studies were included in this review, six items (2.1, 2.3, 2.5, 3.3, 3.4, and 3.5) related to intervention were removed from the checklist. The revised checklist was used to assess the overall validity of the included papers, resulting in an average validity score of 69.94 % (69.75 % for the meta-analysis), with scores ranging from 30 % to 86.36 %. The overall, internal, and external validity scores for each included study are listed in Tables 2–5. Because the quality appraisal in this review focused on assessing the quality of the reported findings in the selected papers, some studies received lower scores because they reported only the relationship between IU and age as demographic results without further explanation.

Table 2
Descriptive information and summary of results on selected studies: meta-analysis in continuous age difference.

Study	Country, Research design	Age means (SD), range	Sample size, gender,	IU measure	Correlation r; Regression X → Y, β	Quality
Continuous age difference across adulthood						
Akbari et al. (2021)	Iran, Cross-sectional	41.3 (13.2), 23–78	$N = 541$, 52.3 % female,	IUS-12	0.04	77 % (+,+)
Altan-Atalay et al. (2023)	Turkey, Cross-sectional	20.82 (5.2), 18–63	$N = 292$, 52.4 % female	IUS-12	− 0.003	50 % (-,-)
Banducci et al. (2016)	North America, Cross-sectional	49.4 (11.6), 22–68	$N = 70$, 4.5 % female	IUS-12	IUS: − 0.063 IUS-P: − 0.044 IUS-I: − 0.084	73 % (+,-)
Bavolar et al. (2021) **Study 1**	Slovakia, Cross-sectional	31.37 (11.39), 15–76	$N = 1011$, 84 % female	IUS-12	IUS: − 0.08* IUS-P: − 0.04 IUS-I: − 0.10**	59 % (+,+)
Bottesi et al. (2022)	Italy, Cross-sectional	Sample 1: 29.6 (13.2), 18–72 Sample 2: 31.9 (13.4), 18–81	Sample 1: $N = 556$, 69.3 % female Sample 2: $N = 575$, 74 % female	IUS-12	Sample 1: − 0.16** Sample 2: − 0.16***	75 % (+,+)
Broos et al., (2024)	United States, Longitudinal	47.09 (18.02), 18–94	$N = 2124$, 64 % female	IUS-12	IUS: − 0.26** IUS-P: − 0.15** IUS-I: − 0.33** COVID-IUS: − 0.13** SM: Age → IUS-P: − 3.54** Age → IUS-I: − 6.77** Age → COVID-IUS: − 0.004	77 % (+,++)
Cho et al., (2022)	South Korea, Cross-sectional	41.6 (10.8), 18–60 +	$N = 400$, 64 % female	IUS-12	− 0.085	80 % (+,++)
Chung et al., (2022)	South Korea, Cross-sectional	35.8 (14.3), 20–60 +	$N = 329$, 64 % female	IUS-12	− 0.10	60 % (+,+)
Del-Valle et al. (2022)	Argentina, Cross-sectional	41.62 (13.81), 18–77	$N = 1230$, 81.7 % female	IUS-17	− 0.08**	86 % (+,+)
Fetzner et al. (2016)	Canada, Cross-sectional	25.59 (11.28), 18–66	$N = 1477$, 72 % female	IUS-12	IUS: 0.07** IUS-P: 0.07** IUS-I: 0.06* IUS → Age: 0.07** IUS-P → Age: 0.07** IUS-I → Age: 0.91**	86 % (+,++)
Fiorenzato and Cona (2022)	Italy, Cross-sectional	34.8 (12.72), 18–73	$N = 586$, 67.75 % female	IUS-12	− 0.248***	64 % (+,+)
Gozansky et al. (2021) **Phase 1**	Israel, Cross-sectional	41.02 (16.1), 18–87	$N = 551$, 69.4 % female	IUS-12	− 0.141**	73 % (+,+)
Groves et al. (2020)	Australia, Cross-sectional	34.66 (11.46), 18–65	N = 160, 72.5 % female	IUS-12	IUS: − 0.321** IUS-P: − 0.289** IUS-I: − 0.317**	68 % (+,+)
Howell et al. (2019)	United States, Cross-sectional	48.29 (11.76), 18–68	$N = 473$, 48.2 % female	IUS-12	IUS: − 0.16** IUS-P: − 0.11* IUS-I: − 0.18***	86 % (+,+)
Hwang et al. (2020)	Australia, Cross-sectional	ASD: 41.7 (12.8), 25–78; Non-ASD: 43 (13.2), 25–77	ASD: $N = 176$, 60.1 % female Non-ASD: $N = 116$ 78.4 % female	IUS-12	ASD: − 0.13 Non-ASD: − 0.15	77 % (++,+)
Liao et al. (2016)	United States, Cross-sectional	30.2 (12), 18–64	$N = 126$, 79 % female	IUS-12	− 0.16; Age → IU, − 0.19*	77 % (+,+)
Maftei (2023)	Romania, Cross-sectional	24.62 (8.29), 18–70	$N = 763$, 73.9 % female	IUS-12	− 0.07*	68 % (-,-)
Maftei and Holman (2022)	Romania, Cross-sectional	30.5 (12), 18–65 +	$N = 245$, 78.4 % female	IUS-12	− 0.04	63 % (+,+)
Malouf et al. (2023)	Australia, Cross-sectional	38.87 (10.65), 23–70	$N = 252$, 88.5 % female	IUS-12	− 0.17**	73 % (-,+)
Merlo et al. (2021)	Italy, Cross-sectional	36.51 (13.08), 18–78	$N = 355$, 70.3 % female	IUS-12	− 0.04	50 % (-,-)
Mertens et al. (2020)	Worldwide, Cross-sectional	N/A, 16–80	$N = 439$, 69.93 % female	IUS-12	− 0.36**	64 % (-,+)
Moore et al. (2021)	United Kingdom, Cross-sectional	42.78 (13.89), 18–77	$N = 426$, 52.35 % female	IUS-12	− 0.02	64 % (+,-)

(*continued on next page*)

Table 2 (*continued*)

Study	Country, Research design	Age means (SD), range	Sample size, gender,	IU measure	Correlation r; Regression X → Y, β	Quality
Pepperdine et al. (2018)	United Kingdom, Cross-sectional	N/A, 18–75	$N = 224$, 67 % female	IUS-12	− 0.137*	68 % (+,+)
Pinciotti et al. (2021)	United States, Cross-sectional	30.2 (12.1), 18–73	$N = 974$, 50.2 % female	IUS-12	IUS: 0.04 IUS-P: 0.02 IUS-I: 0.05	73 % (++,-)
Shihata et al. (2014)	Australia, United States, Canada, United Kingdom, Cross-sectional	29.98 (11.57), 18–73	$N = 502$, 65 % female	IUS-12	− 0.18***	82 % (++,++)
Torbit et al. (2016)	Canada, Cross-sectional	52.53 (14.49), 23–86	$N = 128$, 100 % female	IUS-12	− 0.236**	55 % (-,-)
Continuous age difference from young-old to old-old aged						
Basevitz et al. (2008)	Canada, Cross-sectional	74.18 (6.13), 65–92	$N = 111$, 61 % female	IUS-27	0.08	64 % (+,-)
Bavolar et al. (2021) **Study 3**	Slovakia, Cross-sectional	69.09 (4.89) 61–93	$N = 655$, 71 % female	IUS-12	IUS: 0.06 IUS-P: 0.07 IUS-I: 0.04	68 % (+,+)
Chung et al., (2024)	South Korea, Cross-sectional	68.2 (3.5) 65–85	$N = 300$, 38 % female	IUS-12	IUS: − 0.08	82 % (++,++)
Nuevo et al. (2009)	Spain, Cross-sectional	71 (6.3), 55–88	$N = 120$, 58.3 % female	IUS-27	− 0.041	55 % (+,++)
Shao et al. (2021)	Mainland China, Cross-sectional	68.1 (6.43), 60–88	$N = 251$, 50.6 % female	IUS-5	− 0.21** Age → IU, − 0.12*	77 % (++,+)

Note. *SD* standard deviation, IU Intolerance of uncertainty, *X →Y* Independent variable predicted dependent variable, *% female* Percentage of female participants, *N* Sample size, *ASD* Autism spectrum disorder), *N/A* Missing information *IUS-number* Intolerance of Uncertainty Scale-number of items, *IUS-P* Intolerance of Uncertainty Scale-Prospective subscale, *IUS-I* Intolerance of Uncertainty Scale-Inhibitory subscale, *SM* Structural Model *Quality %* (,) Average validity score of quality (overall rating of the internal validity, overall rating of external validity), ++ 2 points, + 1 points, - 0 points.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

3.2. Meta-analysis results: relationship between IU and age

Using the Comprehensive Meta-Analysis (Version 3.3.070; Borenstein et al., 2014) software, a total of 37 studies underwent mixed-effects analysis in this meta-analysis, exploring both continuous and categorical age differences. Continuous analyses comprised two approaches: one focusing on aging from early to later adulthood (k= 26), and the other focusing on aging within the older population ($k = 5$). For categorical age differences, six studies investigated IU variations between young and older adults. Four articles investigated multiple age differences in IU focusing on adulthood. To address the inconsistent age group classification, three groups were identified by their classifications: 18–30 years classified as "young adults," 31–50 years classified as "middle adults," and 50 or above grouped as "older adults." The effect size and variance for each comparison group were classified and calculated using a web-based effect size calculator (Wilson, 2024).

3.2.1. Meta-analysis results: characteristics of selected studies

3.2.1.1. Continuous age difference: the whole adulthood. Twenty-six papers including 28 findings, with participant ages ranging from 15 to 94 years, provided evidence on the correlation between age and IU. These studies included a total of 15,091 participants, with sample sizes ranging from 70 to 2124. Among these studies, 12 focused on healthy adults, nine on clinical samples, and six on both clinical and non-clinical adults. Moreover, nearly one-third of the selected studies were conducted in Europe (k= 10), followed by seven in North America, three in Oceania, two each in the Middle East and Asia, and one each in South America and worldwide. Most of the included papers were cross-sectional studies ($k = 23$), with three being longitudinal. The 12-item version of the IUS was the commonly used measurement for IU ($k = 25$, average Cronbach's alpha [α] = 0.89), with one study using a 17-item version (α = 0.93). A summary of their main characteristics is presented in Table 2.

3.2.1.2. Continuous age difference: older population. Five cross-sectional studies examined age-related changes in IU among 1437 individuals from the young-old to old-old age groups (ages 55–93). Four studies investigated the correlation between IU and age in late adulthood. Basevitz et al. (2008) and Nuevo et al. (2009) used IUS-27 ($\alpha = 0.91$, one research did not report α) to measure IU in Canadians and Spanish individuals, respectively, whereas Bavolar et al. (2021) and Chung et al. (2024) used the IUS-12 (average $\alpha = 0.88$) to assess IU in Slovakians and Koreans, respectively. Moreover, Shao et al. (2021) used IUS-5 (α = 0.67) to examine the correlation between age and IU and the regression effects of age on IU among Chinese participants. Table 2 provides a summary of their key characteristics.

3.2.1.3. Categorial age difference: young, middle and older adults. Ten studies focusing on categorical age groups analyzed a total of 8484 participants, including 4736 young individuals (aged 18–38 years), 2487 middle individuals (aged 30–60) and 1261 older individuals (aged 50–92 years or above). Nine of the selected studies were cross-sectional, and one was experimental. Five studies were conducted in the United States, two in Canada, with one each in Europe, Greece and Turkey. The IUS-27 ($k = 4$, average α = 0.94), IUS-12 ($k = 5$, average α = 0.90) and IUS-2 ($k = 1$, α = 0.74) were used to measure IU in the selected studies. In terms of analytical methods, four each included studies used the independent-sample t tests and analysis of variance, whereas others used multivariate analysis of variance and correlations with age group, each in one study. A summary of their main characteristics is presented in Tables 3 and 4.

3.2.2. Meta-analysis results: mixed-effects analysis

The utilization of mixed-effects analysis with age group as the moderator was necessitated by the presence of inconsistent analytic methods and varying age populations across the dataset, from continuous data with two targeted age ranges to categorical data with three comparison groups. This approach allowed for the incorporation of age

Table 3
Descriptive information and summary of results on selected studies: meta-analysis in categorial age difference on young and older population.

Study	Country, Research design	Young sample size, gender, Age means (SD), range, IU Means (SD)	Older sample size, gender, Age means (SD), range, IU Means (SD)	IU measure	Analysis method, Results,	Quality
Basevitz et al. (2008)	Canada, Cross-sectional	$N = 106$, 59 % female, 24.18 (4.22), 19–37, 62.24 (16.77)	$N = 111$, 61 % female, 74.18 (6.13), 65–92, 49.03 (12.68)	IUS-27,	MANOVA $F(1, 215) = 43.12^{***}$, $\eta^2 = 0.17$	64 % (+,-)
Corbett et al. (2020)	United States, Experimental	$N = 22$, 59 % female, 22.68 (5.75), 18–38, 25.81 (6.41)	$N = 20$, 50 % female, 67.6 (5.06), 60–76, 20.94 (5.82)	IUS-12	*t*-test $t(32) = 2.32^{*}$	30 % (-,+)
Crittendon and Hopko (2006)	United States, Cross-sectional	$N = 183$, 69 % female, 21.3 (3.2), N/A, 57.3 (19.4)	$N = 115$, 73 % female, 71.6 (10.9), N/A, 41.6 (13.2)	IUS-27	*t*-test $t = 8.3^{***}$	75 % (+,+)
Gerolimatos and Edelstein (2012a)	United States, Cross-sectional	$N = 86$, 51 % female, 20.42 (2.13), 18–30, 63.55 (22.06)	$N = 86$, 52 % female, 69.94 (8.11), 60–90, 52.15 (18.87)	IUS-27	*t*-test $t(201) = 3.86^{*}$	77 % (++,+)
Gerolimatos and Edelstein (2012b)	United States, Cross-sectional	$N = 86$, 51 % female, 20.42 (2.13), 18–30, 63.55 (22.06)	$N = 86$, 52 % female, 69.94 (8.11), 60–90, 52.15 (18.87)	IUS-27	*t*-test $t(201) = 3.86^{**}$	86 % (++,+)
Luong et al. (2023)	United States, Cross-sectional	$N = 56$, 58.9 % female, 27.93 (3.89), 19–35, 2.64 (0.76)	$N = 106$, 55.7 % female, 69.79 (6.59), 60–90, 2.2 (0.65)	IUS-12	Correlation Age is dummy-coded: 0 = young adults, 1 = older adults -0.29^{**}	86 % (++,+)

Note. *SD* standard deviation, *IU* Intolerance of uncertainty, *X →Y* Independent variable predicted dependent variable, *% female* Percentage of female participants, *N* Sample size, *IUS-number* Intolerance of Uncertainty Scale-number of items, *IUS-P* Intolerance of Uncertainty Scale-Prospective subscale, *IUS-I* Intolerance of Uncertainty Scale-Inhibitory subscale, *MANOVA* Multivariate analysis of variance, *ANOVA* Analysis of variance, *N/A* Missing information, *Quality %* (,) Average validity score of quality (overall rating of the internal validity, overall rating of external validity), ++ 2 points, + 1 points, - 0 points.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

as a moderator to account for these variations from the subgroups, enhancing the strength of the analysis (Borenstein et al., 2021). Concerning the overall findings on the relationship between IU and age, the effect size was − 0.21, 95 % CI [-0.27, − 0.14], indicating a significant outcome. In subgroup analyses, the combined effect sizes for the comparison between young and older adults and the entire adulthood cohort were − 0.51, 95 % CI [-0.74, − 0.28] and − 0.24, 95 % CI [-0.34, − 0.15], respectively. These results demonstrated significant age differences in IU between young and older populations and across the entire adulthood range (both $p < 0.001$). However, other subgroups exhibited weak combined effect sizes with no statistical significance. For instance, the effect size for the comparison between young and middle-aged individuals was − 0.15, 95 % CI [-0.32, 0.01], the comparison between middle-aged and older individuals was − 0.06, 95 % CI [-0.23, 0.12], and the correlation within the older population was − 0.083, 95 % CI [-0.31, 0.14]. A forest plot demonstrating the heterogeneity of these findings is presented in Fig. 2, and Fig. 3 shows the publication bias of the included studies. The additional mixed-effects analysis on standard moderators further supported the above overall result. Notably, significant age differences in IU (with *p*-values < 0.05 for all overall and subgroup analyses) were observed across different study designs ($d = -0.24$ to -0.80), versions of the IUS ($d = -0.16$ to -0.50), and regions ($d = -0.16$ to -0.77). Moreover, meta-regression analysis found that age differences were not significantly affected by sample size ($R^2 = -0.06$), study rating ($R^2 = -0.06$), year of publication ($R^2 = -0.02$), or percentage of female participants ($R^2 = -0.04$). Forest plots for categorical moderators are shown in Figs. A.1–A.3, while meta-regression results on continuous moderators are summarized in Figs. A.4–A.7.

3.3. Scoping review results: the interrelationships between IU, aging and mental health

The reviews identified a relationship between IU and mental health issues, specifically in the older population ($k = 13$) and across adulthood ($k = 3$), with large effect sizes and unweighted average statistics supporting these associations. Table 5 provides an overview of the characteristics and results of these studies. In assessing the quality of the above studies, the average score obtained was 72.94 %, indicating a moderate level of quality. Most of these studies demonstrated clarity in identifying and explaining the relationships being investigated, supported by multiple analyses.

3.3.1. Anxiety-related constructs

3.3.1.1. Characteristics of selected studies. Eight cross-sectional studies with 2602 participants aged 60–95 examined the relationship between IU and anxiety. Sample sizes ranged from 86 to 763 across studies conducted in various countries. While two studies solely used regression, six studies commonly employed correlation analysis, with three studies incorporating regression analysis and one study integrating

Table 4
Descriptive information and summary of results on selected studies: meta-analysis in categorial age difference on multiple age groups.

Study	Country Research design	Total sample size, Number of age group gender, Age means (SD), range	Each group sample size, gender, range, IU means (SD)	IU measure	Analysis method, Results	Quality
Fetzner et al. (2016)	Canada Cross-sectional	$N = 1477$, 5 age groups, 72 % female, 25.59 (11.28), 18–66	$N = 507$, 18–19, 30.84 (NA); $N = 581$, 20–29, 30.81 (NA); $N = 160$, 30–39, 32.04 (NA); $N = 121$, 40–49, 31.63 (NA); $N = 108$, 50–66, 33.73 (NA)	IUS-12	ANOVA, IUS: $F(4,1476) = 1.82$ IUS-P: $F(4,1476) = 1.69$ IUS-I: $F(4,1476) = 1.80$	86 % (+,++)
Glowacz and Schmits (2020)	Europe Cross-sectional	$N = 2871$, 3 age groups, 80.8 % female, 18–85	$N = 1479$, 18–30, 7.19 (1.97); $N = 885$, 30–50, 6.6 (1.93); $N = 507$, 50–85, 6.31 (2.11)	IUS-2	ANOVA, 47.56***	77 % (+,++)
Gülden (2023)	Turkey Cross-sectional	$N = 201$, 4 age groups, 54.7 % female, 19–62	$N = 78$, 19–30, 39.05 (9.75); N=57, 31–40, 36.07 (7.81); $N = 39$, 41–50, 37.44 (9.07); $N = 27$, 51–62, 33.48 (9.54)	IUS-12	ANOVA, IUS: $F = 2.89$* IUS-P: $F = 1.79$ IUS-I: $F = 3.22$*	82 % (+,++)
Voitsidis et al. (2021)	Greece Cross-sectional	$N = 2818$, 5 age groups, 73.7 % female, 18–75 +	$N = 1496$, 18–30, 33.77 (9.83); $N = 709$, 31–45, 32.39 (9.79); $N = 516$, 46–60, 31.84 (9.44); $N = 87$, 61–75, 31.97 (8.41); $N = 10$, 75 +, 33.4 (12.20)	IUS-12	ANOVA, IUS: $F(4,2813) = 5.12$*** $\eta^2_p = 0.01$	50 % (+,-)

Note. *SD* standard deviation, *IU* Intolerance of uncertainty, *X →Y* Independent variable predicted dependent variable, *% female* Percentage of female participants, *N* Sample size, *IUS-number* Intolerance of Uncertainty Scale-number of items, *IUS-P* Intolerance of Uncertainty Scale-Prospective subscale, *IUS-I* Intolerance of Uncertainty Scale-Inhibitory subscale, *ANOVA* Analysis of variance, *N/A* Missing information, η^2_p partial eta-squared, *Quality %* (,) Average validity score of quality (overall rating of the internal validity, overall rating of external validity), ++ 2 points, + 1 points, - 0 points.
** $p < 0.01$.
* $p < 0.05$.
*** $p < 0.001$.

mediation analysis. IU was measured using both the 12-item version ($k = 5$, average $\alpha = 0.86$) and 27 items ($k = 3$, average $\alpha = 0.94$) of the IUS. Five studies focused on general anxiety and used different measures for assessing anxiety levels, including the State-Trait Anxiety Inventory ($k = 3$, average $\alpha = 0.91$, Spielberger et al., 1971), the Trait Anxiety Inventory ($k = 1$, $\alpha = 0.82$, MacLeod & Rutherford, 1992), the Geriatric Anxiety Scale ($k = 1$, $\alpha = 0.8$, Mueller et al., 2015) and the Beck Anxiety Inventory ($k = 1$, $\alpha = 0.9$, Beck & Steer, 1993). Moreover, Gerolimatos and Edelstein (2012a, 2012b) investigated anxiety control using the Anxiety Control Questionnaire ($\alpha = 0.70$, Rapee et al., 1996), anxiety sensitivity utilizing the Anxiety Sensitivity Index ($\alpha = 0.91$, Reiss et al., 1986), and health anxiety using the Short Health Anxiety Inventory (SHAI, $\alpha = 0.90$, Salkovskis et al., 2002). Furthermore, Crittendon and Hopko (2006) examined the relationship of IU with GAD using Generalized Anxiety Disorder Questionnaire–IV ($\alpha = 0.76$, Roemer et al., 1995), and Chung et al. (2024) investigated viral anxiety utilizing Stress and Anxiety to Viral Epidemics-6 items ($\alpha = 0.89$, Chung et al., 2021).

3.3.1.2. Key findings. All of the included studies demonstrated significant findings regarding the aforementioned relationships. Four studies reported a positive correlation between anxiety and IU (average $r = 0.47$; p values ranging from < 0.01 to < 0.001), with large effect size (average $d = 1.12$). Furthermore, Barnett et al. (2019) and Köverová et al. (2021) found that IU directly predicted anxiety (average $\beta = 0.30$; p values ranging from < 0.01 to < 0.001). Although Crittendon and Hopko (2006) found a strong correlation between IU and GAD ($d = 1.86$, $r = 0.68$, $p < 0.01$) and Chung et al. (2024) reported positive correlation of IU with viral anxiety ($d = 0.65$, $r = 0.31$, $p < 0.01$), Gerolimatos and Edelstein (2012b) explored the influence of IU on other anxiety-related conditions and its relationship with age. First, they found that anxiety control was negatively correlated with IU ($d = -1.81$, $r = -0.67$, $p < 0.01$), whereas both anxiety sensitivity ($d = 1.07$, $r = 0.47$, $p < 0.01$) and health anxiety ($d = 1.42$, $r = 0.58$, $p < 0.01$) were positively correlated with IU. Second, Gerolimatos and Edelstein (2012a) identified a partial mediation effect of IU on the relationship between health anxiety and age (age predicted IU: $\beta = 0.26$, $p < 0.01$; IU predicted health anxiety: $\beta = 0.24$, $p < 0.01$; age predicted health anxiety: $\beta = 0.07$, $p = 0.27$), indicating that age influences health anxiety through its association with IU. Collectively, these findings provide support for the significant influence of IU on various factors related to anxiety among older individuals.

3.3.2. Other mental health conditions

3.3.2.1. Characteristics of selected studies. A total of 4190 participants were included in 11 cross-sectional studies and one mixed study exploring the impact of IU on various aspects of psychological health in older individuals aged 60–95. Four studies focused on worry-related issues, whereas two studies examined stress and loneliness, respectively. Moreover, depression, hypochondriasis, fear of aging, social distancing phobia, spiritual well-being, and general mental health were investigated in relation to IU. These studies were conducted in different countries, including two in the United States and two in Slovakia. Other studies were conducted in Australia, Canada, Greece, Hungary, mainland China, Philippines, and South Korea.

3.3.2.2. Measurement of selected studies. The IUS-5 ($k = 1$, $\alpha = 0.67$), IUS-12 ($k = 9$, McDonald's $\omega = 0.89$, average $\alpha = 0.87$) and IUS-27 ($k = 2$, average $\alpha = 0.92$) were used to measure the level of IU. The Penn State Worry Questionnaire (average $\alpha = 0.90$, Meyer et al., 1990) measured participants' level of worry in all studies. Crittendon and Hopko (2006) additionally used the Penn State Worry

Table 5
Descriptive information and summary of results on selected studies: scoping review on the relation of IU and mental health among older population and across adulthood.

Older population Study	Country	Research design	Sample size, gender Age means (SD), range	IU measure	Mental health, measure	Correlation IV: r, Cohen's d Regression X → Y, β	Quality
Barnett et al. (2019)	United States	Cross-sectional	*N* = 280, 64.4 % female, 76.08 (7.59), 65–95	IUS-12	Anxious symptoms, GAS-10; Hypochondriasis, IAS; Loneliness, TILS	GAS-10: 0.31***, 0.65 IAS: 0.48***, 1.09 TILS:0.21**, 0.43 IUS → GAS, 0.21*** IUS → IAS, 0.34*** TILS → IUS, 0.19*	68 % (+,+)
Basevitz et al. (2008)	Canada	Cross-sectional	*N* = 111, 61 % female, 74.18 (6.13), 65–92	IUS-27	Trait worry, PSWQ	0.56**, 1.35	64 % (+,-)
Bavolar et al. (2021) **Study 3**	Slovakia	Cross-sectional	*N* = 655, 71 % female, 69.09 (4.89), 61–93	IUS-12	Anxiety, STAI-S; Stress, PSS4	STAI: 0.39***, 0.85 PSS4: 0.31***, 0.65 IUS → STAI, 0.533*** IUS → PSS4, 0.507***	68 % (+,+)
Chung et al., (2024)	South Korea	Cross-sectional	*N* = 300, 38 % female, 68.2 (3.5) 65–85	IUS-12	Viral anxiety, SAVE-6; Social Distancing Phobia, SDPS	SAVE-6: 0.31**, 0.65 SDPS: 0.31**, 0.65 IUS → SDPS: 0.18**	81.82 % (++,++)
Crittendon and Hopko (2006)	United States	Cross-sectional	*N* = 115, 73 % female, 71.6 (10.9), N/A	IUS-27	Chronic worry, PSWQ-A Worry, PSWQ; Trait Anxiety, STAI-T; Anxiety, BAI; GAD, GADQ-IV; Non-pathological worries, WDQ; Depression, BDI	PSWQ-A: 0.46** PSWQ: 0.60**; STAI-T: 0.51**; BAI: 0.60**; GADQ-IV: 0.68**; WDQ: 0.82**; BDI: 0.46**	75 % (+,+)
de Guzman et al. (2015)	Philippines	Cross-sectional	*N* = 219, 64.8 % female, 60 (N/A), 60–90	IUS-12	Worry, PSWQ	SEM: IUS → PSEQ, 0.82**	68 % (+,+)
Gerolimatos and Edelstein (2012b)	United States	Cross-sectional	*N* = 86, 52 % female, 69.94 (8.11), 60–90	IUS-27	Anxiety control, ACQ; Anxiety sensitivity, ASI; Health anxiety, SHAI	ACQ: − 0.67**, − 1.81 ASI: 0.47**, 1.07 SHAI-IL: 0.52**, 1.22 SHAI-NC: 0.51**, 1.19 SHAI: 0.58**, 1.42	86 % (++,+)
Köverová et al. (2021)	Slovakia	Cross-sectional	S1: *N* = 607, 71 % female, 68.97 (4.76), 61–93 S2: *N*= 156 80 % female, 67.75 (4.09), 60–81	IUS-12	Anxiety, STAI-S; Stress, PSS4	S1: IUS → STAI, 0.15*** IUS → PSS4, 0.06 S2: IUS → STAI, 0.21** IUS → PSS4, 0.19**	77 % (+,+)
Lábadi et al. (2022)	Hungary	Cross-sectional	*N* = 589, 74.9 % female, 68.1 (4.46), 60–83	IUS-12	Mental Health, WHO; STAI; BDI	SEM: IUS → WHO STAI SDI − 0.08***	70 % (+,+)
Parlapani et al. (2020)	Greece	Cross-sectional	*N* = 103, 61 % female, 69.85 (5.26), 60 +	IUS-12	Loneliness, JGLS	0.34**, 0.71 IUS → DJGLS, 0.28*	64 % (+,+)
Şahin et al. (2023)	Turkey	Mixed	*N* = 302, 48 % female, N/A (N/A), 65–95 +	IUS-12	Spiritual Well-Being, SIWB	IUS: SIWB: − 0.08, − 0.16 SIWB-SE: − 0.05, − 0.10 SIWB-LS: − 0.09, − 0.18 IUS-P: SIWB: < 0.01, < 0.01 SIWB-SE: 0.03, 0.07 SIWB-LS: − 0.03, − 0.07 IUS-I: SIWB: − 0.14*, − 0.29 SIWB-SE: − 0.12*, − 0.25 SIWB-LS: − 0.13*, − 0.26	73 % (-,++)
Shao et al. (2021)	Mainland China	Cross-sectional	*N* = 251, 50.6 % female,	IUS-5	Fear of aging, AAS-FLS	0.51**, 1.19 AAS-FLS → IUS, 0.5***	77 % (++,+)

(*continued on next page*)

Table 5 (*continued*)

			68.1 (6.43), 60–88				
Song and Li (2019)	Mainland China	Cross-sectional	*N* = 317, 58.36 % female, 66.42 (2.66) 62–75	IUS-12	Anxiety, T-AI	0.59**, 1.46	59 % (+,-)
Across adulthood							
Study	**Country**	**Research design**	**Sample type, sample size, gender, Age means (SD), range**	**IU measure**	**Mental health, measure**	**Relation Type: Regression Y = X1 + X2, *β*, Mediation X→ M→ Y, Type of test (Bootstrapped sampling), *β***	**Quality**
Gerolimatos and Edelstein (2012a)	United States	Cross-sectional	Older sample: *N* = 86, 52 % female, 69.94 (8.11), 60–90; Young sample: *N* = 86, 51 % female 20.42 (2.13), 18–30	IUS-27	Health anxiety, SHAI	Partial mediation: Age → IUS, $\beta = 0.26$** IUS → SHAI, $\beta = 0.24$** Age→ IUS→ SHAI, Bootstrapping (1000), 0.07	77 % (++,+)
Gerolimatos and Edelstein (2012b)	United States	Cross-sectional	Older sample: *N* = 86, 52 % female, 69.94 (8.11), 60–90; Young sample: *N* = 86, 51 % female, 20.42 (2.13), 18–30	IUS-27	Health anxiety, SHAI	Hierarchical regressions: SHAI-IL = Age + IUS, $\beta = 0.07$; SHAI-NC = Age + IUS, $\beta = 0.01$	86 % (++,+)
Shihata et al. (2014)	Australia	Cross-sectional	General population: N = 502, 65 % female 29.98 (11.57), 18–73	IUS-12	Pathological worry, PSWQ	Multiple regression: Worry = Gender + age + IU, $\Delta R = 0.362$, F(4, 498)= 342.89***, age: $\beta = -0.13$*** IU: $\beta = 0.61$***	82 % (++,++)

Note. *SD* standard deviation, *IU* Intolerance of uncertainty, *X →Y* Independent variable predicted dependent variable, *% female* Percentage of female participants, *N* Sample size, *S1* Sample 1, *S2* Sample 2, *IUS-number* Intolerance of Uncertainty Scale-number of items, *IUS-P* Intolerance of Uncertainty Scale-Prospective subscale, *IUS-I* Intolerance of Uncertainty Scale-Inhibitory subscale, Average validity score of quality (overall rating of the internal validity, overall rating of external validity), *GAS-10* Geriatric Anxiety Scale-10 items, *IAS* The Illness Attitudes Scale, *TILS* The Three-Item Loneliness Scale, *PSWQ* Penn State Worry Questionnaire, *STAI-S* State-Trait Anxiety Inventory-State, *GADQ-IV* Generalized Anxiety Disorder Questionnaire—IV, *WDQ* Worry Domains Questionnaire, *BDI* Beck Depression Inventory, *PSS4* the 4-items version of Perceived Stress Scale, *SAVE-6* The Stress and Anxiety to Viral Epidemics-6 Items, *SDPS* Social-Distancing Phobia Scale, *PSWQ-A* Penn State Worry Questionnaire-abbreviated, *PSWQ* Penn State Worry Questionnaire, *STAI-T* State-Trait Anxiety Inventory-Trait, *WHO* World Health Organization Well-Being Index, *BDI* Beck Depression Inventory, *ACQ* The Anxiety Control Questionnaire, *ASI* Anxiety Sensitivity Index, *SHAI* Short Health Anxiety Inventory, *SHAI-IL* Short Health Anxiety Inventory-Illness likelihood, *SHAI-NC* Short Health Anxiety Inventory-negative consequences, *JGLS* De Jong Gierveld Loneliness Scale, *SIWB* Spiritual Well-Being scale, *SIWB-SE* Spiritual Well-Being scale - Self-efficacy, *SIWB-SE* Spiritual Well-Being scale - Life scheme, *AAS-FLS* Anxiety about Aging Scale-Fear of Losses Subscale, *T-AI* Trait Anxiety Inventory, *SEM* Structural equation modelling, *Quality %* (,), ++ 2 points, + 1 points, - 0 points.

* $p < 0.05$.

** $p < 0.01$.

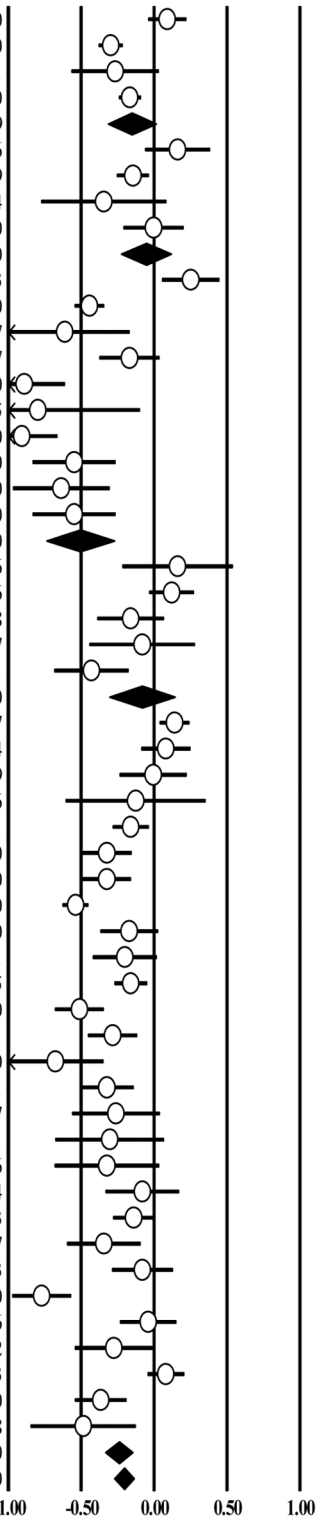
*** $p < 0.001$.

Questionnaire-Abbreviated (α = 89, Hopko et al., 2003) for chronic worry and the Worry Domains Questionnaire (α = 0.94, Tallis et al., 1992) for non-pathological worry. Stress levels were measured using the 4-item version of Perceived Stress Scale (average $\alpha = 0.79$, Cohen et al., 1983). The Three-Item Loneliness Scale ($\alpha = 0.79$, Hughes et al., 2004) and De Jong Gierveld Loneliness Scale ($\alpha = 0.70$, Gierveld & Tilburg, 2006) were used to measure loneliness. For other mental health constructs, the Beck Depression Inventory ($\alpha = 0.73$, Beck & Steer, 1987) was used to measure depression, The Illness Attitudes Scale ($\alpha = 0.85$, Kellner, 1986) was used to assess hypochondriasis, the Fear of Losses Subscale ($\alpha = 0.82$, Lasher & Faulkender, 1993) was used to evaluate the fear of aging, social distancing phobia was measured by Social Distancing Phobia Scale ($\alpha = 0.94$, Cho et al., 2022), and the Spiritual Well-Being Scale (α = 0.898, Daaleman & Frey, 2004) was used to examine spiritual well-being. General mental health was measured using the World Health Organization Well-Being Index ($\omega = 0.79$, Topp et al., 2015) for well-being, the short version of Spielberger State-Trait Anxiety Inventory ($\omega = 0.86$, Zsido et al., 2020) for anxiety, and Beck Depression Inventory ($\omega = 0.72$, Blom et al., 2012) for depression.

3.3.2.3. Key findings. Overall, the studies reviewed consistently supported a significant association between IU and various mental health issues. Four studies using different analysis methods reported a significant relationship between IU and worry. Basevitz et al. (2008) reported a significantly positive correlation of IU with worry ($d = 1.352$, $r = 0.56$, $p < 0.01$). Crittendon and Hopko (2006) found that IU was positively correlated with different type of worry (average d = 1.80, average $r = 0.63$, all $p < 0.01$). Using structural equation model, de Guzman et al. (2015) showed a direct relationship between IU and worry (β = 0.82, $p < 0.01$). Moreover, using hierarchical multiple regression, Shihata et al. (2014) identified IU as the strongest predictor of worry after controlling for age and gender ($\Delta R = 0.36$, $p < 0.001$, $n = 502$), or adding additional controlled predictors ($\Delta R = 0.14$, $p < 0.001$, $n = 502$). The large effect sizes in these studies provide strong evidence for the significant influence of IU on worry.

Bavolar et al. (2021) and Köverová et al. (2021) examined the influence of the COVID-19 pandemic on the relationship between IU and stress. Bavolar et al. (2021) specifically focused on the first wave of the pandemic (March–May 2020) and found a significant positive

Group by Subgroup within study	Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
1 Young&Middle	Fetzner et al., 2016	0.090	0.067	0.005	-0.041	0.221	1.342	0.180
1 Young&Middle	Glowacz & Schmits, 2020	-0.298	0.042	0.002	-0.381	-0.215	-7.024	0.000
1 Young&Middle	Gülden, 2023	-0.267	0.153	0.023	-0.567	0.033	-1.745	0.081
1 Young&Middle	Voitsidis et al., 2021	-0.166	0.039	0.002	-0.242	-0.090	-4.286	0.000
1 Young&Middle		-0.153	0.084	0.007	-0.318	0.012	-1.817	0.069
2 Middle&Older	Fetzner et al., 2016	0.161	0.114	0.013	-0.062	0.384	1.418	0.156
2 Middle&Older	Glowacz & Schmits, 2020	-0.146	0.056	0.003	-0.255	-0.037	-2.622	0.009
2 Middle&Older	Gülden, 2023	-0.346	0.219	0.048	-0.775	0.083	-1.581	0.114
2 Middle&Older	Voitsidis et al., 2021	-0.004	0.105	0.011	-0.210	0.202	-0.038	0.970
2 Middle&Older		-0.055	0.087	0.008	-0.226	0.116	-0.629	0.530
3 Young&Older	Fetzner et al., 2016	0.251	0.101	0.010	0.053	0.449	2.485	0.013
3 Young&Older	Glowacz & Schmits, 2020	-0.444	0.052	0.003	-0.546	-0.342	-8.545	0.000
3 Young&Older	Gülden, 2023	-0.613	0.227	0.052	-1.058	-0.168	-2.699	0.007
3 Young&Older	Voitsidis et al., 2021	-0.169	0.105	0.011	-0.375	0.036	-1.613	0.107
3 Young&Older	Basevitz et al., 2008	-0.891	0.142	0.020	-1.170	-0.612	-6.261	0.000
3 Young&Older	Corbett et al., 2020	-0.798	0.357	0.127	-1.498	-0.098	-2.235	0.025
3 Young&Older	Crittendon & Hopko, 2006	-0.909	0.125	0.016	-1.153	-0.664	-7.288	0.000
3 Young&Older	Gerolimatos & Edelstein, 2012a	-0.549	0.145	0.021	-0.832	-0.265	-3.795	0.000
3 Young&Older	Luong et al., 2023	-0.638	0.169	0.029	-0.969	-0.307	-3.775	0.000
3 Young&Older	Gerolimatos & Edelstein, 2012b	-0.549	0.145	0.021	-0.832	-0.265	-3.795	0.000
3 Young&Older		-0.507	0.119	0.014	-0.740	-0.275	-4.278	0.000
4 Older population	Basevitz et al., 2008	0.161	0.193	0.037	-0.218	0.539	0.831	0.406
4 Older population	Bavolar et al., 2021 Study 3	0.120	0.078	0.006	-0.034	0.274	1.532	0.126
4 Older population	Chung et al., 2024	-0.161	0.116	0.014	-0.389	0.068	-1.379	0.168
4 Older population	Nuevo et al., 2009	-0.082	0.185	0.034	-0.445	0.281	-0.443	0.657
4 Older population	Shao et al., 2021	-0.430	0.130	0.017	-0.684	-0.175	-3.307	0.001
4 Older population		-0.083	0.115	0.013	-0.307	0.142	-0.723	0.470
5 Adulthood	Fetzner et al., 2016	0.140	0.052	0.003	0.038	0.243	2.687	0.007
5 Adulthood	Akbari et al., 2021	0.080	0.086	0.007	-0.089	0.249	0.928	0.354
5 Adulthood	Altan-Atalay et al., 2023	-0.006	0.118	0.014	-0.237	0.225	-0.051	0.959
5 Adulthood	Banducci et al., 2016	-0.126	0.245	0.060	-0.606	0.354	-0.516	0.606
5 Adulthood	Bavolar et al., 2021 study 1	-0.161	0.063	0.004	-0.284	-0.037	-2.540	0.011
5 Adulthood	Bottesi et al., 2022 Sample 1	-0.324	0.086	0.007	-0.493	-0.155	-3.763	0.000
5 Adulthood	Bottesi et al., 2022 Sample 2	-0.324	0.085	0.007	-0.490	-0.158	-3.827	0.000
5 Adulthood	Broos et al., 2024	-0.539	0.045	0.002	-0.627	-0.450	-11.974	0.000
5 Adulthood	Cho et al., 2022	-0.171	0.101	0.010	-0.368	0.027	-1.694	0.090
5 Adulthood	Chung et al., 2022	-0.201	0.111	0.012	-0.419	0.017	-1.806	0.071
5 Adulthood	Del-Valle et al., 2022	-0.161	0.057	0.003	-0.273	-0.048	-2.802	0.005
5 Adulthood	Fiorenzato & Cona, 2022	-0.512	0.086	0.007	-0.680	-0.344	-5.988	0.000
5 Adulthood	Gozansky et al., 2021	-0.285	0.086	0.007	-0.454	-0.116	-3.301	0.001
5 Adulthood	Groves et al., 2020	-0.678	0.169	0.028	-1.008	-0.348	-4.022	0.000
5 Adulthood	Howell et al., 2019	-0.324	0.093	0.009	-0.507	-0.141	-3.469	0.001
5 Adulthood	Hwang et al., 2020 ASD	-0.262	0.153	0.024	-0.563	0.038	-1.710	0.087
5 Adulthood	Hwang et al., 2020 non-ASD	-0.303	0.190	0.036	-0.676	0.070	-1.595	0.111
5 Adulthood	Liao et al., 2016	-0.324	0.183	0.033	-0.682	0.034	-1.774	0.076
5 Adulthood	Maftei & Holman, 2022	-0.080	0.129	0.017	-0.332	0.172	-0.622	0.534
5 Adulthood	Maftei, 2023	-0.140	0.073	0.005	-0.283	0.002	-1.934	0.053
5 Adulthood	Malouf et al., 2023	-0.345	0.129	0.017	-0.597	-0.093	-2.683	0.007
5 Adulthood	Merlo et al., 2021	-0.080	0.107	0.011	-0.289	0.129	-0.750	0.453
5 Adulthood	Mertens et al., 2020	-0.772	0.103	0.011	-0.973	-0.571	-7.517	0.000
5 Adulthood	Moore et al., 2021	-0.040	0.099	0.010	-0.234	0.154	-0.405	0.686
5 Adulthood	Pepperdine et al., 2018	-0.277	0.136	0.018	-0.543	-0.010	-2.037	0.042
5 Adulthood	Pinciotti et al., 2021	0.080	0.064	0.004	-0.046	0.206	1.246	0.213
5 Adulthood	Shihata et al., 2014	-0.366	0.091	0.008	-0.544	-0.188	-4.021	0.000
5 Adulthood	Torbit et al., 2016	-0.486	0.184	0.034	-0.847	-0.125	-2.639	0.008
5 Adulthood		-0.242	0.048	0.002	-0.336	-0.148	-5.060	0.000
Overall		-0.207	0.034	0.001	-0.274	-0.140	-6.045	0.000



Heterogeneity: $I^2 = 87.17$, $\tau^2 = 0.05$, $p < 0.001$

Fig. 2. Forest plot reporting individual and overall effect size for age difference among different age population.

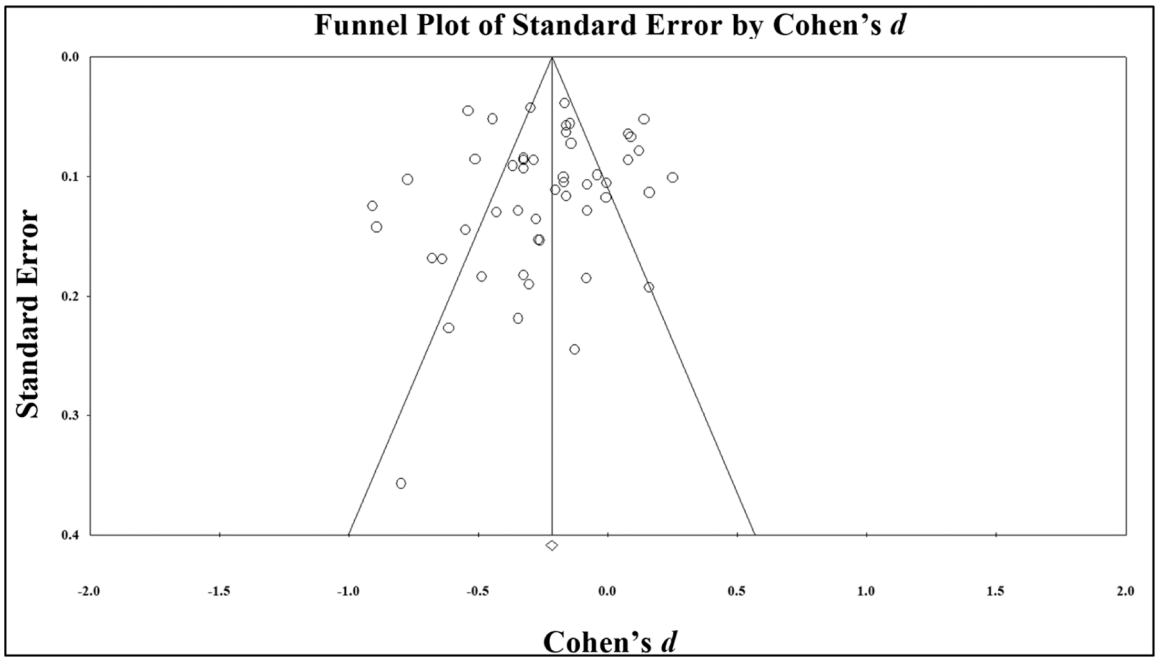


Fig. 3. Funnel Plot for age difference to show publication bias.

relationship with a large effect size, using both correlation ($d = 0.65$, $r = 0.31$, $p < 0.01$) and regression analysis ($\beta = 0.507$, $p < 0.01$). However, Köverová et al. (2021) obtained inconsistent results across two samples during different waves of the COVID-19 pandemic. they obtained weaker evidence of the influence of IU on stress ($\beta = 0.06$, $p = 0.09$). IU was identified as a significant positive predictor of stress ($\beta = 0.19$, $p < 0.01$) during the second wave of the pandemic (October–December 2020). Despite one instance of weaker evidence, these findings suggest that the effect of IU on the stress levels of older adults may be strengthened by environmental changes, such as the pandemic.

Regarding other psychological well-being, Barnett et al. (2019) and Parlapani et al. (2020) found that IU was significantly correlated with (average $d = 0.57$, average $r = 0.27$, both $p < 0.01$) and predicted by (average $\beta = 0.24$, both $p < 0.05$) loneliness. Barnett et al. (2019) also reported that IU was found to mediate the relationship between loneliness and hypochondriasis ($\beta = 0.06$, $p < 0.05$). Moreover, Crittendon and Hopko (2006) revealed a significant positive correlation between IU and depression ($d = 1.04$, $r = 0.46$, $p < 0.01$). Barnett et al. (2019) reported that hypochondriasis was strongly correlated with ($r = 0.48$, $d = 1.09$, $p < 0.01$) and predicted by IU ($\beta = 0.34$, $p < 0.01$). Shao et al. (2021) found that IU was positively correlated with ($d = 1.19$, $r = 0.51$, $p < 0.01$) and predicted by fear of aging ($\beta = 0.5$, $p < 0.01$). Chung et al. (2024) reported that social distancing phobia was positively correlated with ($d = 0.85$, $r = 0.39$, $p < 0.01$) and predicted by IU ($\beta = 0.18$, $p = 0.003$). Şahin et al. (2023) indicated a significant negative correlation between spiritual well-being and inhibitory IU ($d = -0.29$, $r = -0.14$, $p < 0.05$). However, no significant correlations were found between spiritual well-being and the total level of IU or prospective IU (both $p > 0.05$). Finally, Lábadi et al. (2022) demonstrated a direct impact of IU on general mental health in older adults ($\beta = 0.08$, $p = 0.03$), demonstrating that a large amount of variance is explained by IU in relation to general mental health ($R^2 = 0.60$).

In summary, eight studies provided strong evidence associating IU with anxiety-related conditions, indicating the significance of IU in understanding anxiety among older individuals. The included papers also emphasized the impact of IU on other mental health issues in late adulthood, including worry, stress, loneliness, depression, hypochondriasis, fear of aging, social distancing phobia, spiritual well-being, and general mental health, all supported by robust statistical evidence. Furthermore, three papers reported the influence of aging on the relationship between IU and health anxiety or worry, highlighting the interconnectedness of IU, aging, and psychological health.

4. Discussion

As the review to focus on aging and IU and their relationships with psychological health, we aimed to address three research questions using data from the 45 studies included in this review. First, our meta-analysis provided significant insights into the impact of age on IU. Mixed-effects analysis found a linear correlation between IU and age throughout adulthood, with IU levels being significantly lower among older adults than in young adults. However, IU levels tended to decrease slowly from young to middle age and from middle to older age, with the older population remaining relatively stable in late life. These findings suggest possible mechanisms underlying the relationship between IU and age, indicating a linear relationship with staged influences. Furthermore, 15 articles provided strong evidence on the influence of IU on several mental conditions among the older population, particularly on anxiety-related issues, highlighting the importance of IU in modulating mental health in old age. These findings may serve as a foundation for future interventions, which we discuss below.

4.1. A linear and staged pattern of IU across adulthood

This review found inconsistent support for the relationship between IU and age with significant result of the overall meta-analysis. The findings of mixed-effects analysis revealed significant differences in IU levels across adulthood, whether considering continuous age differences or categorizing participants of young and older adults. However, the subgroups on continuous age differences in late adulthood and comparison of age groups between the young and middle populations, and the middle and older populations, did not yield significant results. This suggests that IU levels may decrease with age throughout adulthood slowly and then stabilize in late adulthood, following a linear trend with staged influences. During the transition from young to older adulthood, individuals may experience a gradual decrease in IU levels, with a larger

reduction from young to middle-aged ($d = -0.15$) and a lesser decline or even stability from middle to older age ($d = -0.06$). This decline could be attributed to the development of adaptive coping mechanisms with age and the accumulation of life experiences (Aldwin, 2009). Ouellet et al. (2019) further support this explanation, suggesting that individuals with more effective coping mechanisms and emotion regulation skills may experience lower levels of IU. According to Gross et al. (1997), the capacity of individuals to regulate their emotions increases with age. This enhancement in emotion regulation skills can be attributed to the accumulation of life experiences and the development of adaptive coping strategies over time. Teachman (2006) further supports this notion by proposing a comparable curvilinear association between age and symptoms of anxiety and depression, indicating an initial increase during youth, a slight decrease from middle to older age, and a subsequent rise after age 75. This correlation is attributed to advancements in emotion regulation as individuals age. Moreover, as individuals enter middle age, they experience increased stability in several life domains, including career and relationships (Carstensen et al., 2000). This stability in life may contribute to a sense of emotional control, decreased ambiguity in life, and hence lower or stable levels of IU.

Stability in IU levels in late adulthood, from young-old to old-old, may suggest a complex interplay between factors that influence emotional regulation, adaptive coping mechanisms, and emotional response toward uncertainty. Although related life experiences may strengthen the ability of older adults to navigate uncertain situations, the degeneration of emotional regulation and cognitive abilities may impact their effective use of coping strategies. Gross et al. (1997) examined emotion regulation in different age groups and found that older adults demonstrated higher levels of emotional regulation than younger adults. They proposed that the increased emotional regulation abilities among the older population may result from their exposure to various emotional situations throughout their lives, allowing them to develop more effective coping strategies and regulatory mechanisms. However, the degeneration of emotional regulation in this population may be influenced by various factors, such as changes in cognitive abilities and health conditions (Labouvie-Vief, 2003). As individuals age, they may encounter new challenges and stressors that require different coping strategies; however, their established coping mechanisms may become less effective (Aldwin, 2009). Therefore, although older adults may experience a decline in certain cognitive abilities, the enhancement of emotion regulation through experience-based learning provides a compensatory mechanism. The accumulation of life experiences and the development of adaptive coping strategies contribute to the strengthening of emotion regulation abilities, thereby enabling older individuals to navigate uncertainty and regulate emotions more effectively. Therefore, stability in IU levels among older adults can be attributed to the strengthening of adaptive coping mechanisms through rich life experiences, despite the possibility of the simultaneous degeneration of emotional regulation and cognitive abilities. These factors may contribute to a decreased ability to effectively use coping strategies and regulate emotions, leading to a stable level of IU in older adulthood.

4.2. *Influence of IU on mental health among the older population*

The findings of this scoping review revealed a strong association between IU and anxiety-related issues among older adults. The results indicated that IU has a significant influence on anxiety in this population. This finding aligns with the results of previous research across different age groups, from childhood to adulthood, identifying IU as a contributing factor to anxiety symptoms (Carleton, 2012; McEvoy & Mahoney, 2012). The large effect sizes (average $d = 0.85$) reported in the studies underscore the substantial impact of IU on anxiety-related issues among older individuals. This strong influence of IU on anxiety can be explained in the context of aging and its associated challenges. As individuals age, they often encounter various uncertainties related to health, financial stability, social support, and life transitions (Lebowitz & Niederehe, 1992). Life stressors tend to stabilize during middle age but can increase again in later life due to significant transitions such as retirement. Retirement, in particular, is a major life transition filled with uncertainties that can trigger anxiety (Teachman, 2006). Older individuals with high IU levels may be particularly vulnerable to experiencing increased anxiety symptoms. IU reflects an individual's negative reaction to uncertainty, and older adults with high IU levels may experience difficulty in tolerating the discomfort and uncertainty associated with aging-related challenges.

This review also demonstrated the relationship between IU and other mental health problems among older individuals. The scoping review identified IU as a factor influencing worry, stress, loneliness, depression, hypochondriasis, fear of aging, social distancing phobia, spiritual well-being, and general mental health in this population. In particular, the relationship between IU and worry can be interpreted as older adults with high IU levels tending to engage in excessive worry as a coping mechanism to reduce uncertainty and gain a sense of control (Basevitz et al., 2008; de Guzman et al., 2015; Shihata et al., 2014). This persistent worry contributes to increased anxiety and exacerbates anxiety-related symptoms among older individuals (Basevitz et al., 2008). In terms of stress, Köverová et al. (2021) found that the relationship between IU and stress among older individuals was strengthened during the second wave of the COVID-19 pandemic. This finding can be attributed to increased uncertainties, health risks, and disruptions caused by the second wave of the pandemic compared with the first wave. These factors intensified the perception of uncertainty as a stressor, resulting in higher stress levels among older adults with high IU levels. Moreover, the impact of IU may stem from the social and interpersonal implications of uncertainty. Older adults with high IU may experience difficulty in forming and maintaining social relationships due to the fear of uncertain outcomes, rejection, or disappointment (Smyer & Qualls, 1999). This social isolation and lack of social support can contribute to depression, fear of aging, social distancing phobia and feelings of loneliness, which negatively impact mental well-being (Chung et al., 2024; Lábadi et al., 2022; Parlapani et al., 2020). Similarly, uncertainty regarding one's own health status can trigger excessive worry with physical symptoms, leading to hypochondriacal tendencies in this population (Barnett et al., 2019; Lábadi et al., 2022). Although previous studies have shown significant effects of IU on specific mental conditions, such as anxiety, worry, and loneliness, the findings regarding spiritual well-being and general health revealed a more substantial influence of IU on the overall mental health of older individuals. High levels of inhibitory IU can significantly affect spiritual well-being, including the sense of purpose and existential fulfillment (Şahin et al., 2023). Moreover, IU can profoundly impact general mental health, including several aspects of psychological well-being (Lábadi et al., 2022). These results indicate that IU could serve as a mediator for individuals in managing their mental health concerns throughout their lives. Supported by IU-focused interventions, reducing IU levels significantly decreases symptoms of several mental disorders among younger population from childhood to adulthood, including anxiety disorders (Sperling, 2023; Miller & McGuire, 2023), OCD (Sperling, 2023), posttraumatic stress disorder (Badawi et al., 2022). In older populations, a consistently strong relationship between IU and mental health has been observed in this review, indicating the potential for IU-based interventions to alleviate relevant disorders among older adults. However, there is limited research establishing a causal relationship/effective interventions for addressing IU among older adults. Only one intervention focusing on the elderly (Hui & Zhihui, 2017) was included in a meta-analysis on IU-focused interventions (Miller & McGuire, 2023), highlighting the importance of and need for such studies for enhancing the comprehensive mental health of older adults.

4.3. Main inferences and generalizations for guiding future research

4.3.1. Unraveling the complexities of age-related differences

The evidence of this current review indicates a linear relationship between IU and age with staged influences, emphasizing the need for further research. Consistent findings have shown higher levels of IU in the young population than in the older population as well as continuous age differences across adulthood. With a medium effect size for the former ($d = -0.51$) and a small effect size for the latter ($d = -0.24$), age alone may not be a strong predictor of IU, and other factors across the lifespan, such as life events experienced at different age stages, may influence IU levels through the mechanism of emotion regulation (Carstensen et al., 2000).

To gain a better understanding of this relationship, future studies should identify factors contributing to changes in IU over time. This could involve examining the impact of life events that occur in each age stage on IU levels. Specifically, employing a longitudinal design in future research would enable the examination of whether there exists a causal relationship between aging and IU. Changes in cognitive function and social support networks have been associated with mental health and emotion regulation in the older population (Birren et al., 2013; Segal et al., 2018; Smyer & Qualls, 1999). Although these conditions are closely related to age, the specific effects of life events on the relationship between IU and age should be investigated. By exploring the influence of life events occurring at different ages, researchers can gain insights into the complex interplay between age, IU, and contextual factors that shape the experiences of individuals.

4.3.2. Mechanisms and implications of IU on psychological health among the older population

Consistent with studies conducted among younger populations, the available evidence suggests that IU plays a significant role in anxiety-related issues among older individuals. Because this meta-analysis on age differences in IU explored the possibility of a staged relationship, future research should investigate specific mechanisms underlying this relationship in the older population. Such research should explore the impact of IU on cognitive processes and strategies to cope with anxiety. Moreover, given that interventions targeting IU have been implemented to reduce anxiety levels in younger populations (Bomyea et al., 2015; Hebert & Dugas, 2019; Koerner & Dugas, 2006; Robichaud, 2013; van der Heiden et al., 2012), future studies should examine whether these interventions can also be effective in older adults. This exploration could contribute to the development of customized interventions for older individuals.

IU has shown correlations with other mental health issues often experienced in late life, such as loneliness (Barnett et al., 2019; Parlapani et al., 2020), stress (Bavolar et al., 2021; Köverová et al., 2021), and worry (Basevitz et al., 2008; de Guzman et al., 2015; Shihata et al., 2014). These findings align with those of research conducted among younger individuals (e.g. Allan et al., 2021; Boelen, 2010). Although supporting studies are limited, they indicate the significance of IU as a critical construct for investigating mental well-being across the lifespan. In addition, previous studies have demonstrated a significant association between IU and mental conditions in younger populations with SUDs (Banducci et al., 2016; Bottesi et al., 2021; Xie et al., 2021) and depression (Boelen, 2010; McEvoy & Mahoney, 2012; Xie et al., 2021). Given the prevalence of depression and SUDs among older adults (Birren et al., 2013), future studies should investigate the effects of IU on these psychological disorders in this population. By exploring these factors, researchers can gain a more comprehensive understanding of how IU influences the lives and overall well-being of older adults.

4.3.3. Integrating objective measures with self-report scales

Although IUS was the only measurement tool used to assess IU levels in individuals in the included papers, it is important to consider potential biases that may impact the reliability and validity of the collected data. Self-report measures, such as the IUS, are susceptible to biases such as social desirability and impression management, which can lead to distorted responses (Paulhus & Vazire, 2007). These biases can introduce inaccuracies or inconsistencies in the data, compromising their reliability. Although the studies included in this review demonstrated high reliability of the IUS (average weighted $\alpha = 0.87$, 95 % CI [0.872, 0.874], average weighted $\omega = 0.89$, 95 % CI [0.891, 0.892]), self-report measures may not fully capture the entire range of individuals' experiences and behaviors related to IU, thereby impacting the validity of the findings. To enhance the reliability and validity of studies examining IU in aging, objective measures or task-based data should be incorporated in conjunction with self-report measures. Objective measures, such as behavioral observations or cognitive performance tasks, provide an alternative to self-report data and offer valuable insights into the IU levels of individuals (Vazire & Mehl, 2008). While several studies had used behavioral tasks for measuring IU, none have integrated age as a variable in IU assessment, and they were therefore excluded from this review. Specifically, uncertainty levels in risk-taking tasks, such as the revised Balloon Analogue Risk Task (Bartoszek et al., 2022; Lejuez et al., 2002) or the Beads Task (Jacoby et al., 2014), and threat task (No-Predictable-Unpredictable threat task, Schmitz & Grillon, 2012) can be utilized to assess IU levels. Previous research consistently shows an association between IU and risk-taking behavior (Carleton et al., 2016; Jensen et al., 2014), as well as between IU and threat perception with response (Correa et al., 2022). By including these objective measurements, researchers can perform a more comprehensive assessment of IU and reduce the potential influence of self-report biases.

5. Limitations

This study has several limitations that should be considered when interpreting the findings. First, the limited quantity of available data may weaken the level of evidence supporting the conclusions. Koricheva et al. (2013) recommends the inclusion of a large number of studies, ideally around 20–30, to ensure a more robust meta-analysis. However, in this study, only four papers were included in the meta-analysis examining the correlation between IU and age in late adulthood and ten studies were included in the analysis of categorical age differences. This small number of studies may compromise the strength and generalizability of the conclusions drawn from the analysis. Moreover, this scoping review is limited by the inclusion and exclusion criteria for selecting papers. A considerable number of papers were excluded from the review because they did not separately report the scores of different age groups in their investigation of IU (e.g. Becerra et al., 2023). Furthermore, several of the included papers primarily approached the association between age and IU from a demographic perspective (e.g. Basevitz et al., 2008; Corbett et al., 2020; Voitsidis et al., 2021), focusing primarily on presenting demographic results without examining the effects of age on IU in depth. Finally, a potential limitation of this scoping review is the exclusion of studies not published in English. By limiting the review to studies published only in English, relevant studies published in other languages or in non-English journals (e.g. Eidman, 2021; Levent-Krauskopff & Guedj, 2023; Moran et al., 2019; Sandin et al., 2021) may have been missed, leading to potential gaps in knowledge and bias.

6. Conclusions

This scoping review included 45 studies, of which 37 were included in the meta-analysis, providing insights into the relationship between IU, aging, and mental health. The meta-analysis reported inconsistent findings regarding the relationship between IU and age, with variations observed between continuous and categorical age differences. These results suggest a linear relationship with a staged pattern and underscore the influence of life events on this relationship. Moreover, the significant outcomes concerning the association between IU and mental

issues in the older population, particularly anxiety-related concerns, highlight the pivotal role of IU in understanding the mental well-being of older adults. This scoping review contributes to the expanding literature on the intersection of IU and aging, highlighting the importance of considering IU as a relevant factor in mental health research and interventions for older adults. By recognizing the impact of IU on mental conditions, researchers and healthcare professionals can develop effective interventions to enhance the psychological well-being of older adults.

CRediT authorship contribution statement

Mandy H. M. Yu: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Yuan Cao:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. **Sylvia S. Y. Fung:** Writing – review & editing, Validation, Investigation, Data curation, Conceptualization. **Gerald S. Y. Kwan:** Writing – review & editing, Validation, Investigation, Data curation, Conceptualization. **Zita C. K. Tse:** Visualization, Validation, Formal analysis. **David H. K. Shum:** Writing – review & editing, Supervision, Resources, Project administration, Conceptualization.

Declaration of Competing Interest

None.

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Conflict of Interest statement

None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.janxdis.2025.102975.

Data availability

The data for this review paper is made publicly available at https://osf.io/px6fc/.

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