BMC Psychiatry

SYSTEMATIC REVIEW

Open Access

Exploring depression in adults over a decade: a review of longitudinal studies

Rute Dinis de Sousa[1,2*], Daniela Mariana Zagalo[3], Teresa Costa[4], José Miguel Caldas de Almeida[5], Helena Canhão[1,2,3] and Ana Rodrigues[1,2,3]

Abstract

Depression, as a prevalent global mental health disorder, stands as one of the main causes of disability worldwide, imposing significant individual, societal, and economic burdens. While its heterogeneous nature is well recognized, growing evidence highlights the importance of understanding depression trajectories, which describe the long-term course and variability of depressive symptoms over time. These trajectories are shaped by a complex interplay of biological, psychological, and social factors. However, despite extensive research on depression's prevalence and risk factors, a comprehensive synthesis of trajectory patterns, their determinants, and their long-term implications remains limited. This review systematically examines the existing literature on depression trajectories in adults, identifying key influences such as age, gender, socioeconomic status, early life experiences, social support, physical health, lifestyle factors, and external stressors, including pandemics. By integrating findings from longitudinal and epidemiological studies, this review provides novel insights into the bidirectional relationship between depression and chronic health conditions, underscoring the need for a holistic, trajectory-based approach to mental health care. The findings have important implications for clinical practice, public health, and future research. Recognizing distinct trajectory patterns may facilitate earlier identification of high-risk individuals, inform the development of personalized interventions, and optimize the allocation of mental health resources. Furthermore, by elucidating the complex interconnections between depression and broader health determinants, this review establishes a foundation for advancing targeted, evidence-based interventions aimed at reducing the long-term burden of depression, particularly among vulnerable populations.

Highlights

- Depression affects millions of adults around the world.
- Adult depression trajectories and symptoms are multifaceted and diverse.
- Depression trajectories are shaped by biological, psychological, and social factors.
- Understanding depression's trajectories unveils critical insights into mitigating its impact.
- Every individual's trajectory should require personalized mental health care approaches.

Keywords Depression trajectories, Depressive symptoms, Mental health disparities, Adult population, Population-based trends

*Correspondence:
Rute Dinis de Sousa
rute.sousa@nms.unl.pt
Full list of author information is available at the end of the article

© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

Introduction

Depression stands as a prevalent mental health disorder impacting millions of adults worldwide. The World Health Organization (WHO) highlights depression as the leading cause of disability on a global scale, significantly contributing to the overall burden of disease [1]. Recent estimates reveal that 3.8% of the population experiences depression, with rates among adults at 5% (4% among men and 6% among women), and 5.7% among individuals aged over 60 years [2]. Notably, this disorder is roughly 50% more common among women than men. Moreover, over 10% of pregnant women and those recently postpartum are affected by depression [3]. The magnitude of depression's impact is staggering, affecting over 280 million individuals globally. Additionally, depression is a major risk factor for suicidality, with over 700,000 suicide deaths annually, making it the fourth leading cause of death among individuals aged 15–29 years [1]. Findings from the WHO World Mental Health (WMH) Surveys indicate that, despite the existence of established and effective therapies for mental disorders, over 75% of individuals in low- and middle-income countries do not receive treatment [4]. Obstacles to adequate care include insufficient funding for mental health services, a shortage of skilled healthcare professionals for all citizens, and the societal stigma associated with mental disorders that persists in the present day [1].

Depression is not a monolithic condition, but rather a highly heterogeneous disorder. Its presentation and progression vary significantly among individuals, reflecting diverse patterns and trajectories of depressive symptoms. Trajectories refer to the long-term courses of depressive symptoms and episodes experienced by individuals over time, ranging from transient low mood to chronic, severe depression. These trajectories capture the chronicity, fluctuations, and remission patterns of depressive episodes and are influenced by a complex interplay of biological, psychological, and social determinants throughout the lifespan. The consequences of depression extend far beyond individual suffering, imposing profound economic burdens and societal costs. Depression leads to reduced workforce productivity, increased healthcare expenditures, and significant disability-related costs, further amplifying its societal toll [5, 5–10].

A comprehensive understanding of depression trajectories is critical for the development of personalized interventions and prevention strategies tailored to the unique needs of individuals. Depression does not manifest uniformly, and its progression can vary significantly across different individuals, which underscores the importance of investigating the temporal patterns and underlying factors that shape these trajectories. Recent research has made substantial advances in elucidating how depression evolves, with particular emphasis on the need for longitudinal analyses to capture the dynamic nature of depressive symptoms. These studies underscore the multifaceted interplay of biological, psychological, and social factors that influence depression trajectories, highlighting that variables such as age, gender, socioeconomic status, physical health, and lifestyle factors all contribute to the observed variability in depressive symptom patterns across the adult population.

Longitudinal and epidemiological studies have shed light on the critical factors influencing depression trajectories. For instance, research studies demonstrate that advanced age is a significant factor associated with depression. Many older adults living in the community exhibit specific needs linked to various trajectories of depressive symptoms, underscoring the necessity for customized interventions to prevent, treat, and facilitate successful mental health aging. Variables such as pain limitation, mobility impairments, perceived stress, loneliness, retirement status, and levels of worry were found to be associated with distinct trajectory classes of depressive symptoms [11–17].

The relationship between physical health and depression represents another critical area of investigation. Chronic physical conditions such as dementia, coronary heart diseases, stroke, arthritis, musculoskeletal disorders have been associated with higher rates of depressive symptoms, suggesting a bidirectional relationship between physical and mental health [18–21]. This interplay underscores the significance of holistic healthcare approaches that address both physical and mental health needs. Notably, the role of physical activity in moderating depressive symptoms has been increasingly recognized, suggesting that personalized exercise regimens could play a crucial role in mitigating the severity and duration of depressive episodes [22–24].

Moreover, the impact of social determinants on depression trajectories is paramount. Lower socioeconomic status limited educational attainment, and reduced access to social support networks have all been identified as key factors influencing the onset and progression of depression [12, 23, 25, 26]. This is particularly evident in research focused on rural populations, where community involvement and social support play pivotal roles in sustaining mental well-being [27–30]. Emerging research also highlights the importance of early life experiences and socioeconomic factors in shaping depression trajectories. The correlation between childhood economic status and the likelihood of experiencing depressive symptoms later in life emphasizes the long-term impact of early adversity on mental health. Furthermore, the role of education and economic stability in adulthood suggests that interventions aimed at improving these areas

could have a positive effect on mental health outcomes [13, 26]. Similarly, gender differences in the prevalence and experience of depression underscore the necessity for gender-sensitive approaches to mental health care [12, 14, 16, 31].

The COVID- 19 pandemic has further underscored the dynamic nature of depression trajectories. In the context of the increase in mental health challenges following the COVID- 19 pandemic compared to pre-pandemic levels, recent studies have sought to provide a more comprehensive and granular understanding of the emergence and long-term trajectories of psychological symptoms across diverse populations and contexts. In particular, research has focused on the psychiatric consequences of SARS-CoV- 2 infection, exploring its long-term implications for mental health outcomes in affected adults [24, 31–38].

In light of these findings, this manuscript aims to synthesize current empirical research on depression trajectories, identify key risk and protective factors, and explore their implications for prevention and intervention strategies. By integrating findings from longitudinal epidemiological studies, clinical research, and public health data, this work seeks to advance the field's understanding of depression as a dynamic, multidimensional phenomenon rather than a static clinical entity. This endeavor has the potential to drive the development of targeted interventions by facilitating the identification of high-risk individuals, enabling the refinement of treatment strategies, and optimizing early intervention efforts. Moreover, it provides a critical foundation for the formulation of evidence-based policy initiatives and the delineation of future research directions aimed at supporting individuals across various stages of depression. Integrating trajectory-based insights into clinical practice and public health frameworks may further enhance mental health care accessibility, mitigate the long-term burden of disease, and promote overall well-being across the lifespan.

Methodology

This manuscript presents a systematic review of the literature on the trajectories of depression and depressive symptoms in adults, synthesizing evidence on the temporal patterns and progression of depression over the past decade. The aim of this review is to offer a comprehensive understanding of how depressive symptoms evolve over time, identify key depression trajectories within the adult population, and provide insights to inform future research and intervention strategies.

A comprehensive literature search was conducted on May 10, 2023, across three widely recognized academic databases: PubMed, Scopus, and Web of Science. The search targeted peer-reviewed studies published between 2013 and 2023, focusing on adults aged 19 years and older. Emphasis was placed on studies employing longitudinal or cohort designs, as these study types provide robust data on the trajectories of depressive symptoms over time. No language restrictions were applied to ensure inclusivity.

The search strategy was formulated using the following query: ("depressive symptom*" OR depression) AND ("trend*" OR "trajectory*") AND "mental health" AND adult* AND ("longitudinal study*") NOT ("RCT" OR "randomized clinical trial*") NOT ("matern*" OR postpartum) NOT adolescent* NOT ("hospitalized"). Filters were applied to restrict results to studies published between 2013 and 2023, focusing on human participants aged 19 years and older. Emphasis was placed on longitudinal and cohort studies, as these study designs provide robust insights into the temporal evolution of depressive symptoms. Randomized clinical trials (RCTs), studies on maternity or postpartum depression, and research involving adolescent populations were excluded. These exclusions were made based on the distinct clinical contexts of these populations, which fall outside the scope of this review.

The rationale for excluding these populations was grounded in several key considerations. First, depression trajectories in adolescents diverge significantly from those observed in adults, due to differences in clinical manifestations and underlying etiological factors. Second, depression during the maternity and postpartum period is influenced by unique physiological, psychological, and social factors specific to the perinatal phase, which are distinct from those driving depression trajectories in the general adult population. Finally, hospitalized patients generally represent more acute or severe cases of depression, which are not necessarily representative of the broader spectrum of depressive trajectories observed in the adult population at large. Thus, the inclusion criteria for this review were specifically designed to focus on studies employing longitudinal or cohort designs that explored the progression of depressive symptoms over time in adults. Studies involving children or adolescents, maternity or postpartum depression, and hospitalized populations were excluded due to the aforementioned differences in clinical contexts.

A rigorous and transparent study selection process was implemented to ensure objectivity and minimize bias. The initial search yielded 615 studies: 65 from PubMed, 372 from Scopus, and 178 from Web of Science. After the removal of 150 duplicates using Rayyan Professional software, 465 unique studies remained for further review. The study selection process was carried out in two stages.

In the first stage, titles and abstracts were screened for relevance based on the predefined inclusion and

exclusion criteria. This step was performed independently by two researchers. Discrepancies between the researchers were resolved through consensus or by consulting a third reviewer, ensuring a reliable and impartial process. The second stage involved a full-text assessment of the remaining studies. Studies were excluded in this stage based on the following criteria: (1) studies addressing depression trajectories in populations affected by specific traumatic events (e.g., abuse, bereavement); (2) studies focused on adolescents or children; and (3) studies with significant methodological limitations or insufficient data on depression trajectories.

This meticulous and transparent study selection process was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement for Scoping Reviews (PRISMA-ScR) guidelines [39]. The final selection included 37 articles, each contributing valuable insights into the evolution of depressive symptoms in the adult population over the past decade (Table 1). A detailed summary of the selected publications is presented in Table 2. The PRISMA flowchart illustrating the systematic review process and study selection for this review is depicted in Fig. 1.

Results

Table 1 provides a descriptive analysis of the total bibliographic corpus included in this review. The collection of studies provides a comprehensive examination of depressive symptoms across various populations, highlighting key trends related to age, sex, cohort characteristics, health behaviors, and sociodemographic factors. These findings underscore the complexity of depression trajectories in middle-aged and older adults, emphasizing the need for targeted interventions and a nuanced understanding of contributing factors.

Associated predictors in rural settings

Several studies [27–30] investigate the disparities in depression trajectories between rural and urban populations, focusing on the role of social isolation, health conditions, housing characteristics, and social support systems. These studies highlight the multifaceted nature of depression in rural settings and emphasize the need for community-based interventions to address mental health disparities. Handley et al. [27] identified several predictors of depression among rural Australian adults, including permanent inability to work, low social support, adverse life events, and higher levels of neuroticism. This study concluded that being permanently unable to work resulted in over a threefold increase in the odds of depression at the following survey wave. Self-rated financial hardship was associated with a fourfold increase in the odds of future depression, as was a high level of community concerns. Neuroticism and tobacco use also made a significant independent contribution to future depressive symptoms. Interpersonal support was a protective factor, reducing the odds of next-wave depression by 64%. These findings align with international research emphasizing the protective effect of social support and socio-economic factors against depression symptoms in rural settings. The study also highlighted poor social networks and community concerns as additional correlates of depression. The need for diverse approaches in prevention and treatment was emphasized, particularly for individuals with fewer direct supports.

On the other hand [29], conducted a study focusing on the trajectories of depressive symptoms among older adults with disabilities in rural China. Their research identified two distinct classes of trajectories, shedding light on the mental health challenges faced by this population. Over 40% of these individuals experienced moderate or severe depressive symptoms, indicating a high level of vulnerability. The study highlighted the role of prolonged instrumental support from adult children in decreasing depressive symptoms over time, underscoring the importance of family support for mental well-being in this context. Likewise [30], delved into depression trajectories in both urban and rural China, highlighting disparities between these settings. Their findings suggested that multimorbidity and physical disability were linked to rising depressive symptoms in both areas. However, an intriguing difference emerged: rural individuals with disabilities were more prone to maintaining elevated depression scores, indicating distinct disparities. This was attributed to uneven social resource distribution and challenges in accessing quality healthcare in rural regions, which perpetuated sustained high depression scores. The varying social environments and networks also played a role, with urban areas offering more standardized care and recreational activities. Additionally [28], contributed to the understanding of depressive trajectories among elderly individuals in rural China by investigating the impact of housing characteristics. The study identified distinct classes of depression trajectories, with housing quality and the number of floors in a residence playing significant roles. Living in multifloor and high-quality houses was found to be associated with persistently low levels of depression. Interestingly, unlike findings in urban areas, homeownership alone did not show a significant influence on depression among rural elderly individuals. This sheds light on the unique sociocultural context of rural China, characterized by an "acquaintance society," which influenced the mental health effects of housing characteristics.

Overall, these findings highlight the complex interplay of socioeconomic, familial, healthcare, and

Table 1 Results of the bibliographic corpus analysis

Ref	Title	Year	Type of Study	Population	Main Purpose	Methodology	Specific Tools/ Method	Key Results	Conclusions
[40]	**Depressive Symptoms Among Older Adults Pre- and Post-COVID- 19 Pandemic**	2021	Longitudinal	> 3,000 community-dwelling adults aged 60 + from The Irish Longitudinal Study on Ageing (TILDA)	Analyze trends in depressive symptoms before and during the COVID- 19 pandemic	Observational follow-up of older adults for 6 years (waves 4, 5, and the COVID period)	**Center for Epidemiologic Studies Depression Scale (CES-D)** (pontuação ≥ 9) Questionnaires, clinical interviews, and self-reported health data	Clinically significant depressive symptoms doubled (from 7.2% to 19.8%) during the pandemic. Older age (≥ 70) and living alone were associated with higher depressive symptoms in the COVID period	There was a major increase in depressive symptoms among older adults during COVID- 19, especially in those ≥ 70 and/or living alone. Importance of improving access to age-appropriate mental health care
[22]	**Impact of physical activity intensity on longitudinal trajectories of cognitive function and depressive symptoms…**	2022	Longitudinal	5,025 middle-aged and older adults (mean age 57) from the China Health and Retirement Longitudinal Study (CHARLS)	Describe how different intensities of physical activity impact the longitudinal trajectories of cognitive function and depressive symptoms	Nationally representative household study of Chinese population 45 +. Data every 2 years (2011–2018)	**10-item CES-D**; Telephone Interview of Cognitive Status (TICS); ADL measures; self-reported medical data	Cognitive function decreased by ~ 0.17 points every 2 years; depressive symptoms rose by 0.23 points. Frequent moderate/light PA was linked with slower cognitive decline and slower increase in depressive symptoms	Regular PA (≥ 6 dias/semana) was associated with benefits in cognitive function and delayed rise in depressive symptoms among middle-aged and older adults, suggesting a personalized PA intensity approach
[41]	**Depression and anger across 25 years: changing vulnerabilities in the VSA model**	2014	Longitudinal	341 Canadians (178 women, 163 men) from a 25-year prospective study starting in late adolescence/young adulthood	Analyze the association of mental health trajectories (depressive symptoms, expressed anger) from ages 18 to 25 with life stress and relationship outcomes later on	25-year prospective longitudinal data, starting at age 18, with follow-ups at 25, 32, 43 years, etc	Self-reported mental health scales (anger, depression), plus perceived stress scales; no single named depression scale cited	Depressive symptoms and anger at age 18 predicted higher life stress and relationship risk at age 43 (controlling for concurrent mental health)	Mental health deficits or strengths in the transition to adulthood can influence stress perception and intimate relationship outcomes decades later
[27]	**The predictors of depression in a longitudinal cohort of community dwelling rural adults in Australia**	2019	Longitudinal	2,639 rural/remote community residents from the Australian Rural Mental Health Study (5-year)	Explore the contribution of individual, social, and community factors on the trajectory of depressive symptoms	4 waves of data from a 5-year longitudinal study; generalized linear mixed models	**PHQ- 9**; social support measures; employment/ financial variables; community-level factors	~ 6.3% had moderate/severe depression at baseline. Financial difficulties and unemployment raised future depression risk significantly; interpersonal support was protective	Targeting those with financial/ employment difficulties may reduce depression. Interpersonal support at community level protects against future episodes

Table 1 (continued)

Ref	Title	Year	Type of Study	Population	Main Purpose	Methodology	Specific Tools/ Method	Key Results	Conclusions
[42]	**Development of a prognostic model for predicting depression severity… (diamond longitudinal study)**	2018	Longitudinal	593 primary care patients with depressive symptoms from 30 Australian general practices (diamond study)	Develop a tool to predict future depression severity in primary care patients at 3 months follow-up	Prospective cohort (diamond) of patients who screened positive on PHQ- 9 (≥ 1 item from first 2 questions). Multivariable linear regression to build prognostic model	**PHQ- 9** for depression screening; structured patient questionnaires; 20 predetermined predictors	Model included 8 baseline predictors (sex, baseline depression, anxiety, history of depression, self-rated health, chronic illness, living alone, perceived income). Good discrimination (c = 0.74)	A brief algorithm can help clinicians tailor treatment for depressed patients in primary care
[16]	**Age and sex trends in depressive symptoms across middle and older adulthood…**	2021	Cross sectional	~ 138,000 adults 45–95 from national cohorts in Canada, Europe, and the US	Compare differences in depressive symptoms with age and sex across three international cohorts	Cross-sectional observational design combining data from the Canadian Longitudinal Study on Aging, US (CES-D), and European (EURO-D) cohorts	**CES-D** (Canada/US) and **EURO-D** (Europe)	Non-linear age trend in depression; women reported more symptoms than men. The gap was larger after age 70 (Canada, US) or around 60 (Europe)	Characterizing depression patterns in mid-late adulthood for men and women helps focus interventions and resource allocation
[26]	**The effect of childhood and current economic status on depressive symptoms… in South Korean individuals: a longitudinal study**	2016	Longitudinal	9,645 adults aged ≥ 20 from Korean Welfare Panel Study (KOWEPS), analyzed 2010–2013	Investigate how current and childhood economic status influences likelihood of depressive symptoms	Data from KOWEPS (2010–2013); individuals without depression at baseline. Subgroup analyses by education level	**CES-D 11**; self-reported economic status (childhood and current); logistic regression	Low–low childhood/current status → higher odds of depression (OR ~ 1.88). High–high group → lower odds (OR ~ 0.45). Prolonged poverty has adverse mental health effects	Mental health inequalities exist across economic strata; low-income individuals need targeted mental health approaches
[43]	**Latent class growth modeling of depression and anxiety in older adults… (8-year follow-up)**	2021	Longitudinal	3,983 adults aged 65 + from the Korean Health Panel Study (2008–2015)	Identify trajectories of depression and anxiety in older adults and assess interrelationships + predictors of each trajectory	8-year follow-up. Latent class growth modeling to classify depression/anxiety trajectories	Depression/anxiety "scores" from Korean Health Panel data; classification using growth-based trajectory modeling (GBDTM)	4 trajectory groups for depression (low-flat, low-medium, low–high, high-stable) and for anxiety (low-flat, low-medium, high-low, high). Women, ≥ 3 chronic diseases, and no income-generating activity increased risk	Depression and anxiety frequently co-occur, especially in higher-risk demographic groups. Data can inform strategies to prevent late-life depression/anxiety

Table 1 (continued)

Ref	Title	Year	Type of Study	Population	Main Purpose	Methodology	Specific Tools/ Method	Key Results	Conclusions
[19]	**How do different chronic condition comorbidities affect changes in depressive symptoms…**	2020	Longitudinal	11,457 adults aged 45 + from CHARLS (2011–2015)	Examine how different chronic conditions impact trajectories of depressive symptoms over time	National survey data (CHARLS) across multiple waves (2011–2015) to track comorbidities and depressive symptoms	Repeated CHARLS measures for depressive symptoms; analysis of comorbidity patterns across waves	Certain comorbidities (dyslipidemia, asthma, arthritis, stroke, etc.) significantly worsened or hindered improvement in depressive symptoms	Specific physical health conditions can notably affect mental health trajectories over time, suggesting integrated care
[35]	**Psychosocial predictors of trajectories of mental health distress during the COVID- 19 pandemic…**	2023	Longitudinal	3,931 Italian adults assessed for depressive, anxiety, and stress symptoms (Apr 2020–May 2021)	Examine joint trajectories of depression, anxiety, and stress during COVID- 19 and identify psychosocial predictors of distress	Four-wave panel data. Latent Class Growth Analysis (LCGA) + multinomial regression for predictors	Standardized questionnaires for depression/ anxiety/stress (unnamed). LCGA used to identify distinct symptom trajectories	54% had a "resilient" trajectory; two subgroups had elevated or worsening combined depression/anxiety/stress. Risk factors included expressive suppression, intolerance of uncertainty, fear of COVID- 19, female gender, younger age, unemployment	Mental distress trajectories were heterogeneous. Recognizing subgroups at risk can guide targeted support during pandemics
[23]	**Physical activity mediates the effect of education on mental health trajectories in older age**	2023	Longitudinal	54,818 adults aged 50 + from Survey of Health, Ageing and Retirement in Europe (SHARE)	Test whether physical activity mediates the relationship between education and later-life mental health (depressive symptoms, well-being)	SHARE dataset with multiple waves; path analysis to see how PA mediates effect of education on depressive symptoms/well-being	Validated scales (depressive symptoms, well-being) in SHARE; repeated measures of PA	Lower education → lower PA levels over time → higher depressive symptoms and lower well-being. PA explained ~ 26.8% of the variance in depressive symptoms	Physical activity is crucial for mitigating mental health disparities linked to low educational attainment in older adults
[17]	**Associations between trajectories of depressive symptoms and rate of cognitive decline… 8-year longitudinal study**	2022	Longitudinal	9,264 middle-aged/ older adults from CHARLS (2011–2018)	Investigate link between different depressive symptom trajectories and cognitive decline rate	Population-based cohort with assessments in 2011, 2013, 2015, 2018. Growth mixture modeling identified 5 depression trajectories	**CES-D** or a variant used in CHARLS; episodic memory and executive function tests	"Increasing" depressive symptom group had the fastest decline in global cognition and episodic memory. Consistently medium/ high groups also declined faster vs. consistently low group	Escalating depressive symptoms may coincide with accelerated cognitive decline; targeting those with worsening depression could slow cognitive deterioration

Table 1 (continued)

Ref	Title	Year	Type of Study	Population	Main Purpose	Methodology	Specific Tools/ Method	Key Results	Conclusions
[15]	**Exploring the relationship between depression and multimorbidity in Chinese middle-aged and older people…**	2023	Cross sectional	19,761 adults aged 45 + from the 2018 wave of the China Longitudinal Study of Health and Retirement (CHARLS)	Explore the association between depression and multimorbidity using propensity score matching	Single-wave cross-sectional analysis (2018 CHARLS) with PSM to compare depressed vs. non-depressed groups; logistic regression, restricted cubic splines	One-time assessment using CHARLS data (self-reported depression symptoms), PSM for adjusting confounders	Prevalence of multimorbidity was 1.49 times higher in depressed vs. non-depressed. Higher depression scores ⟶ higher likelihood of multimorbidity	Middle-aged/older adults with depressive symptoms are more likely to have multiple chronic conditions, highlighting the need for integrated care
[21]	**The trajectories of depressive symptoms and subsequent incident dementia, coronary heart diseases…**	2022	Longitudinal	7,810 US adults ≥ 50 from the Health and Retirement Study (HRS), free of dementia/CHD/stroke at baseline	Evaluate how mid/late-life depressive symptom trajectories relate to incident dementia, CHD, stroke, mortality over ~ 10 + years	Longitudinal cohort from HRS (1994–2000 baseline CES-D, followed 2000–2018). Identified 5 depression symptom trajectory groups	**CES-D** (HRS standard); tracking incident dementia, CHD, stroke using follow-up interviews/health data	Worsening/persistent depressive symptoms ⟶ elevated risk for dementia, CHD, stroke, mortality. Improved symptoms group did not show higher CHD risk. Even mild sub-threshold symptoms were associated with diseases of aging	Persistent or increasing depression in mid-late life is linked to higher long-term risk of multiple diseases and mortality
[14]	**Sociodemographic dynamics and age trajectories of depressive symptoms… a cohort perspective**	2023	Longitudinal	US adults from the 1994–2016 HRS (multiple birth cohorts)	Explore how depressive symptom trajectories differ by age/cohort and by sociodemographic factors in middle and late adulthood	Data from the Health and Retirement Study across birth cohorts, using repeated CES-D measures from 1994–2016	**CES-D** from HRS (repeated waves 1994–2016)	Later-born cohorts had higher depression levels at given ages vs. earlier cohorts. Large sociodemographic disparities persist	The findings suggest persistent inequality and partial "age-as-leveler" effects. Gender gap in depression remains consistent; partnership gap narrows with age
[31]	**Changes in mental health outcomes in the general population 14 months into the COVID- 19 pandemic in Italy**	2023	Longitudinal	Italian adults (*N* = 18,147 baseline; 5,501 followed up) via web survey (Mar–Apr 2020 and Apr–May 2021)	Investigate trajectories of depression, anxiety, post-traumatic stress over 14 months in the general population; identify sociodemographic/contextual predictors	Two time-point follow-up survey. Symptoms considered clinically relevant if above cutoff in depression/anxiety/PTSD scales	Validated scales for depression, anxiety, PTSD (exact names not provided). Two-wave longitudinal survey design	52% showed resilience (no distress both times), 20.7% persistent distress, 6.8% new-onset, 20.5% remitting. Persistent distress more frequent in women, younger, prior MH history, low resilience, fewer social contacts	Overall distress decreased in the population, but a substantial subset continued experiencing clinically relevant symptoms. Suggests need for targeted mental health interventions

Table 1 (continued)

Ref	Title	Year	Type of Study	Population	Main Purpose	Methodology	Specific Tools/ Method	Key Results	Conclusions
[44]	**Trajectories of depressive symptoms among community-dwelling Korean older adults…**	2022	Longitudinal	2,016 adults aged 65 + from the Korean Longitudinal Study of Aging (KLoSA), 2006–2016	Identify distinct 10-year trajectories of depressive symptoms and predictive variables	KLoSA panel data over a decade (2006–2016). Growth mixture modeling to classify symptom trajectories	**KLoSA** depression items (likely CES-D or adapted scale); Mini-Mental State Examination for cognition, social activity measures, repeated over time	Five trajectories: None (28.9%), Slowly Worsening (24.3%), Rapidly Worsening (17.5%), Improving (12.4%), Persistently Severe (16.9%). Education level, chronic diseases, social activity predicted higher/lower symptom courses	Tailored interventions based on specific symptom trajectories are critical for preventing/treating late-life depression
[45]	**The changing relationship between health risk behaviors and depression among birth cohorts of Canadians 65 +, 1994–2014**	2022	Cross sectional	88,675 Canadian adults aged 65 + born between 1910–1914 and 1945–1949, from 11 national health surveys (1994–2014)	Analyze how physical inactivity, smoking, alcohol use relate to depression risk among older Canadians across different birth cohorts	Repeated cross-sectional data from 11 nationally representative surveys by Statistics Canada (CIDI-SF for depression)	**Composite International Diagnostic Interview – Short Form (CIDI-SF)** for depression; repeated cross-sectional design across multiple surveys	Physical inactivity and smoking strongly associated with depression, more so in recent cohorts; moderate alcohol use was protective in older cohorts but not in the most recent cohort	Behavioral risk factors for depression vary across birth cohorts; these findings can inform prevention strategies
[46]	**Trajectories of social isolation and depressive symptoms in mid- and later life…**	2023	Longitudinal	7,890 middle-aged/older adults from the 2006–2018 US Health and Retirement Study (HRS)	Examine how changes in objective and subjective social isolation relate to levels and changes in depressive symptoms	Parallel latent growth curve modeling of repeated HRS data (2006–2018) to track isolation and depression	**CES-D** for depressive symptoms in HRS; measures of social contact (objective) and loneliness (subjective)	Objective isolation increased slightly over time, subjective isolation decreased, depression was relatively stable. Higher isolation was associated with higher depression levels, but only changes in subjective isolation predicted changes in depression	Early detection of social isolation (especially subjective) could prevent or lessen depressive symptoms in middle-aged/older adults

Table 1 (continued)

Ref	Title	Year	Type of Study	Population	Main Purpose	Methodology	Specific Tools/ Method	Key Results	Conclusions
[25]	**A life course view on depression: Social determinants of depressive symptom trajectories over 25 Years of Americans'Changing Lives**	2022	Longitudinal	3,617 American adults (≥ 25) from the Americans'Changing Lives study, followed 1986–2011 (25 years)	Investigate heterogeneity in long-term depressive symptom trajectories and social determinants shaping them	National sample with up to 25-year follow-up, using 11-item CES-D	**Abbreviated 11-item CES-D**; repeated measures over 25 years in ACL study	Identified a U-shaped curve overall, with two latent classes (60% normative, 40% persistently high). Women, racial/ethnic minorities, lower SES more likely persistent	Confirms a U-shaped lifespan pattern; a large subgroup shows persistently high depression, implying focus on social determinants of mental health disparities
[13]	**Simultaneous employment and depressive symptom trajectories around retirement age in Chile**	2022	Longitudinal	2,927 Chilean adults aged 18–75, focusing on two subgroups (56–65, 66–75 at baseline)	Examine employment/depression trajectories before/after standard retirement age, identifying links with social/health characteristics	Population-representative panel data with longitudinal statistical methods to identify trajectory types	Self-reported depressive symptom scale (not named), combined with employment status over multiple waves	Those who remained employed had lower depressive symptoms overall, but that pattern was tied mainly to individuals with favorable social/health conditions from the start	Policies promoting later-life employment might inadvertently pressure disadvantaged people to keep working, possibly affecting mental health
[38]	**Pre-pandemic trajectories of depressive symptomatology and their relation to depression during the COVID- 19 pandemic…**	2023	Longitudinal	3,925 English older adults (50 +) from ELSA waves 4–9 (2008–2009 to 2018–2019), with depression assessed again in June/Nov 2020	Investigate how long-term depression trajectories before COVID- 19 relate to depression risks during the pandemic	Group-based trajectory modeling identified distinct elevated depressive symptom patterns pre-pandemic, then logistic models tested pandemic depression outcomes	**CES-D** (ELSA standard) over multiple waves; group-based trajectory modeling (GBTM), then pandemic follow-up of depression in 2020	Four classes: Long-lasting EDS (5%), Increasing EDS (8%), Decreasing EDS (10%), Absence of EDS (77%). Those with persistent or increasing EDS pre-pandemic were likelier to be depressed during COVID- 19. Frequency of prior EDS was more predictive than how recently it occurred	Knowing an older adult's pre-pandemic depression trajectory (especially if persistent/increasing) is key to identifying those at higher risk during crises like COVID- 19

Table 1 (continued)

Ref	Title	Year	Type of Study	Population	Main Purpose	Methodology	Specific Tools/ Method	Key Results	Conclusions
[28]	**Heterogeneity in the trajectories of depressive symptoms among elderly adults in rural China: The role of housing characteristics**	2020	Longitudinal	1,984 individuals aged 45 + in rural China from the 2011 baseline of CHARLS (growth mixture modeling)	Analyze how rural housing and living conditions influence varying depression trajectories among older adults	Panel data from CHARLS (multiple waves) with growth mixture modeling to identify trajectory classes	**CHARLS** depression measure (adapted from CES-D); housing/living arrangement variables; growth mixture modeling of depression trajectories	Stable high-quality multi-story housing correlated with remaining in a low depression trajectory class. Home ownership and space were less relevant, but multi-story environment had psychosocial benefits in rural China	The built environment in rural contexts can affect mental health through specific social/psychological mechanisms. Interventions may need to address housing quality to reduce long-term depression risk
[47]	**Late-life depressive symptoms: prediction models of change**	2013	Longitudinal	7,882 community-dwelling elderly (≥ 60), baseline + 2 more assessments (attrition 29.4%)	Determine predictors of change in depressive symptoms among older adults with/without significant baseline symptoms	Longitudinal design with a 30-item Geriatric Depression Scale (cutoff ≥ 11 for "significant" depression). Analyzed changes over time	**Geriatric Depression Scale (GDS-30)** (cutoff ≥ 11). Stratified analyses for those with/without baseline significant symptoms	Overall downward trend in depressive symptoms. Among those initially depressed, social support, chronic pain, and locus of control strongly influenced changes. Among non-depressed, anxiety and locus of control were strongest predictors	Highlights nuanced factors influencing depressive symptom changes, depending on baseline status (significant vs. non-significant depression)
[34]	**Predictors of longer-term depression trajectories during the COVID- 19 pandemic: a longitudinal study in four UK cohorts**	2022	Longitudinal	16,978 participants aged ~ 20, 30, 50, 62 at baseline from four UK cohorts (Millennium Cohort, Next Steps, British Cohort, NCDS)	Examine individual trajectories of depressive symptoms from May 2020 to early 2021, across different age cohorts, and identify risk factors	Three-wave data collection (May 2020, Sep/Oct 2020, Feb/Mar 2021). Depressive symptoms measured by self-report questionnaires (unspecified)	Self-reported depression scales (not named) repeated in 3 waves; multi-cohort analysis controlling for baseline mental health	Depression was higher in younger groups; overall stable from May–Autumn 2020 but rose by Spring 2021. Loneliness was the strongest predictor. Pre-pandemic mental health issues, long-term illness also associated with increased symptoms	Fostering social connection is key; social distancing compliance didn't predict depression changes, but loneliness did. Strategies to address isolation may reduce worsening mental health in crises

Table 1 (continued)

Ref	Title	Year	Type of Study	Population	Main Purpose	Methodology	Specific Tools/ Method	Key Results	Conclusions
[29]	**Instrumental support primarily provided by adult children and trajectories of depressive symptoms among older adults…**	2023	Longitudinal	1,466 older adults (≥ 60) with disabilities in rural China, from 3 waves of CHARLS (2011–2015)	Analyze 5-year depressive symptom trajectories in disabled older adults, focusing on duration of instrumental support from adult children	Repeated measures of depression in CHARLS; instrumental support coded by how many waves participants received help from children	**CES-D** from CHARLS (3 waves); measure of instrumental support from adult children; longitudinal trajectory analysis	Two main trajectories: high-but-decreasing and persistently low. Longer-term child-provided support was associated with elevated but decreasing symptoms over time	Family support (particularly from children) in rural areas influences depression trajectories of older disabled adults. However, formal long-term care programs remain scarce in rural China
[24]	**Using digital platform for physical activity practice attenuated the trajectory of depressive symptoms… (PAMPA cohort)**	2023	Longitudinal	663 adults from the PAMPA cohort (southern Brazil), baseline in June–July 2020 + two follow-ups (6-month intervals)	Examine how physical activity (in-person vs. digital) correlates with incidence of self-reported depression diagnoses during COVID- 19	Online self-administered questionnaire about depression diagnosis, physical activity habits, at baseline and follow-ups	Self-report of clinical depression diagnosis. PA measured in minutes/ week. Incidence rates tracked over 2 follow-up points	21.8% were diagnosed with depression over follow-up. Inactive participants had the highest incidence; even insufficient PA (< 150 min/week) reduced incidence compared to no PA. Doing PA both indoors and outdoors was protective	Any level of physical activity lowered depression incidence vs. inactivity. Digital platforms for PA might help mitigate depressive symptom trajectories in pandemic contexts
[18]	**The longitudinal relationship between mental health disorders and chronic disease for older adults: a population-based study**	2017	Longitudinal	86,000 older adults (≥ 65) from Kaohsiung City, Taiwan, completing 6 waves of research interviews	Investigate changes in mental disorders and chronic diseases over time, and their reciprocal interrelationship	6-wave data; mental health disorders scored via Short Psychiatric Assessment Schedule; chronic illness recorded every 2 years. Autoregressive latent trajectory + parallel LGCM	Short Psychiatric Assessment Schedule	Pre-existing mental health disorders predispose to more chronic diseases, and vice versa, in a reciprocal relationship. Monitoring/treating both is crucial to improve overall health and life quality	**Short Psychiatric Assessment Schedule** for mental health disorders; repeated measures every 2 years to track interplay with chronic illnesses

Table 2 Systematic overview of the bibliographic corpus

Ref	Year	Study Design	Sample Size (Population)	Setting/Country	Type of Depression	Diagnosis Method
[40]	2021	Longitudinal	> 3,000 community-dwelling adults (≥ 60 years)	Ireland	Depressive symptoms (clinically significant)	CES-D (cutoff ≥ 9)
[22]	2022	Longitudinal	5,025 middle-aged/older adults (mean age = 57)	China	Depressive symptoms	10-item CES-D (CHARLS)
[41]	2014	Longitudinal	341 Canadians (25-year follow-up, starting at age 18)	Canada	Depressive symptoms	Self-reported mental health scales (no single named scale)
[27]	2019	Longitudinal	2,639 rural/remote residents (5-year study)	Australia	Depressive symptoms (including "moderate/severe")	PHQ- 9
[42]	2018	Longitudinal	593 primary care patients with depressive symptoms (diamond study)	Australia	Depressive symptoms	PHQ- 9
[16]	2021	Cross Sectional	~ 138,000 adults (ages 45–95) from national cohorts in three regions	Canada, Europe, USA	Depressive symptoms	CES-D (Canada/US), EURO-D (Europe)
[26]	2016	Longitudinal	9,645 adults (≥ 20 years) from the Korean Welfare Panel Study (KOWEPS)	South Korea	Depressive symptoms	CES-D 11
[43]	2021	Longitudinal	3,983 older adults (≥ 65) from the Korean Health Panel Study (2008–2015)	South Korea	Depressive symptoms (various trajectories)	Depression score from Korean Health Panel (exact scale not specified)
[19]	2020	Longitudinal	11,457 adults (≥ 45) from CHARLS (2011–2015)	China	Depressive symptoms	CHARLS standard (CES-D type, unspecified)
[35]	2023	Longitudinal	3,931 Italian adults, 4-wave panel (COVID- 19 period)	Italy	Depressive, anxiety, and stress symptoms	Standardized questionnaires (names not cited)
[23]	2023	Longitudinal	54,818 adults (≥ 50) from the Survey of Health, Ageing and Retirement in Europe (SHARE)	Europe	Depressive symptoms/well-being	Validated scales in SHARE (names not specified)
[17]	2022	Longitudinal	9,264 middle-aged/older adults (CHARLS, 2011–2018)	China	Depressive symptoms	CES-D or adapted version in CHARLS
[15]	2023	Cross Sectional	19,761 adults (≥ 45) from CHARLS 2018	China	Depressive symptoms	Self-reported (single-wave data), CHARLS
[21]	2022	Longitudinal	7,810 adults (≥ 50) from HRS, free of dementia/CHD/stroke at baseline	USA	Depressive symptoms (mild, persistent, etc.)	CES-D (HRS)
[14]	2023	Longitudinal	US adults from HRS (1994–2016), multiple birth cohorts	USA	Depressive symptoms	CES-D (HRS)
[31]	2023	Longitudinal	5,501 Italian adults in follow-up (baseline n = 18,147), web survey (2020 & 2021)	Italy	Depression, anxiety, PTSD-stress symptoms	Validated scales (names not specified)
[44]	2022	Longitudinal	2,016 older adults (≥ 65) from the Korean Longitudinal Study of Aging (2006–2016)	South Korea	Depressive symptoms	Likely a scale similar to CES-D (KLoSA), exact name not specified
[45]	2022	Cross Sectional	88,675 Canadians (≥ 65) from 11 national surveys (1994–2014)	Canada	Depression	CIDI-SF (Composite International Diagnostic Interview – Short Form)
[46]	2023	Longitudinal	7,890 middle-aged/older adults (HRS 2006–2018)	USA	Depressive symptoms	CES-D (HRS)
[25]	2022	Longitudinal	3,617 US adults (≥ 25) from Americans'Changing Lives (1986–2011)	USA	Persistent vs. normative depressive symptoms	11-item CES-D (abbreviated)
[13]	2022	Longitudinal	2,927 Chilean adults (18–75), with focus on ages 56–65 and 66–75	Chile	Depressive symptoms	Self-reported scale (no specific name)
[38]	2023	Longitudinal	3,925 older English adults (≥ 50) from ELSA (2008–2019), reassessed during 2020	England	Elevated Depressive Symptoms (EDS)	CES-D (ELSA)

Table 2 (continued)

Ref	Year	Study Design	Sample Size (Population)	Setting/Country	Type of Depression	Diagnosis Method
[28]	2020	Longitudinal	1,984 older adults (≥ 45) in rural China (CHARLS, baseline 2011)	China	Depressive symptoms	CHARLS (CES-D-based scale)
[47]	2013	Longitudinal	7,882 older adults (≥ 60) in three assessments (29.4% attrition)		Late-life depression	Geriatric Depression Scale (GDS-30, cutoff ≥ 11)
[34]	2022	Longitudinal	16,978 participants across 4 UK cohorts (ages ~ 20, 30, 50, 62)	United Kingdom	Depressive symptoms	Self-reported questionnaires (unnamed)
[29]	2023	Longitudinal	1,466 older adults (≥ 60) with disabilities in rural China (CHARLS 2011–2015)	China	Depressive symptoms	CES-D (CHARLS)
[24]	2023	Longitudinal	663 adults (PAMPA cohort, southern Brazil)	Brazil	Self-reported diagnosed depression	Single question about prior clinical diagnosis
[18]	2017	Longitudinal	86,000 older adults (≥ 65) from Kaohsiung City, Taiwan (6 waves)	Taiwan	Mental health disorders (including depression)	Short Psychiatric Assessment Schedule

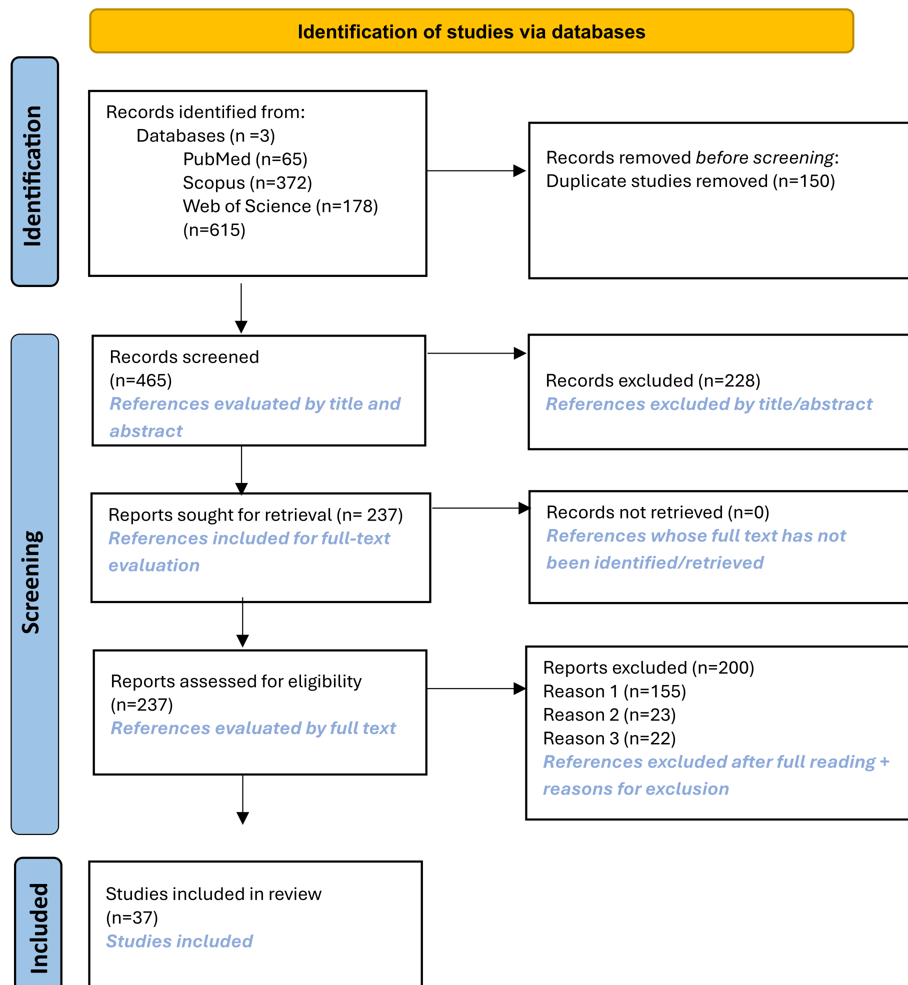

Fig. 1 PRISMA flowchart of systematic review process and study selection. Legend: Reason 1 [Description of depression trajectories after a traumatic event]. Reason 2 [Description of depression trajectories in children and/or adolescents]. Reason 3 [Other reason of misfit with the objectives of study]

environmental factors in shaping depression trajectories in rural settings. Addressing these disparities necessitates comprehensive strategies that enhance social support, improve healthcare access, and consider localized sociocultural dynamics to effectively mitigate mental health burdens.

Social isolation

A longitudinal study by [46] examined the trajectories of social isolation and depressive symptoms in middle and later life using a nationally representative sample of adults in the United States. The study employed parallel process latent growth curve analysis to examine how these two dimensions changed over time and their associations in terms of levels (intercept) and changes (slope) over a 12-year period. The study revealed a complex dynamic, with objective isolation increasing while subjective isolation decreasing over time. Depressive symptoms remained relatively stable. The study suggests implications for intervention research: interventions targeting subjective isolation may prevent the progression of depressive symptoms, given the significant associations between these variables; addressing objective social isolation is crucial, as it contributes to both levels of subjective isolation and depressive symptoms; and specific vulnerable subgroups, such as non-partnered individuals with low household income and worse physical health, were identified. In conclusion, the study provides valuable insights into the trajectories of social isolation and depressive symptoms in middle and later life.

The findings highlight the complex interplay between these dimensions and the importance of addressing both forms of social isolation in mental health interventions. Partnership status emerged as a significant factor influencing both subjective isolation and depressive symptoms, suggesting the potential benefits of social relationships for mental well-being in aging populations. Further research is needed to explore the underlying mechanisms and develop targeted interventions for vulnerable subgroups.

Chronic conditions and comorbidities

An increasing body of research has examined the interplay between chronic conditions, depressive symptoms, and anxiety in middle-aged and older populations, highlighting the bidirectional relationships between mental and physical health and the necessity for integrated care models.

The study conducted by [19] was designed to investigate the impact of various chronic condition comorbidities on changes in depressive symptoms among middle-aged and older adults. Utilizing data from the China Health and Retirement Longitudinal Study (CHARLS) 2011–2015, their analysis revealed substantial associations between different chronic conditions and depressive symptoms. The findings of the study emphasized the significant linkage between chronic conditions such as memory-related diseases, arthritis/rheumatism, asthma, and stroke with depressive symptoms. Of particular note was the observation that individuals with arthritis/rheumatism and lower initial depressive symptoms were more likely to experience an escalation in symptoms over time, while those with higher initial symptoms tended to persist with elevated levels of depression. These results underscore the intricate interplay between chronic conditions and mental health, with certain conditions exacerbating depressive symptoms over time. Furthermore, the study shed light on the imperative need for preventive frameworks to address depressive symptoms. It specifically emphasized the critical role of musculoskeletal disease management and pain interventions in mitigating the impact of these conditions on mental health. Arthritis/rheumatism emerged as a significant risk factor for the worsening of depressive symptoms, emphasizing the necessity for targeted interventions tailored to individuals with this condition.

Chen et al. [18] conducted a population-based study to explore the longitudinal relationship between mental health disorders and chronic diseases among older adults. The study presents compelling evidence of a bidirectional and reciprocal relationship between mental health disorders and chronic diseases among older adults. Their findings reveal that pre-existing mental health disorders can predispose older individuals to developing more mental health disorders over time; while pre-existing chronic diseases increase the likelihood of developing additional chronic diseases. This interplay highlights a vicious cycle where one condition can exacerbate the other. Additionally, the study identified disability and lack of exercise as notable factors contributing to the development of these health conditions.

As in the previous study [21], conducted a comprehensive longitudinal cohort study using the Health and Retirement Study (HRS) data of U.S. residents aged 50 years and above to investigate the trajectories of depressive symptoms and their association with incident dementia, coronary heart disease (CHD), stroke, and all-cause mortality. Crucially, the study's results demonstrated that individuals with mild, worsening, and persistent depressive symptoms had significantly greater hazards of developing incident dementia, CHD, stroke, and facing all-cause mortality compared to those in the non-depressed group. Specifically, participants with mild depressive symptoms had a 32% increased hazard of incident dementia, while those with worsening symptoms had a 58% increased hazard, and individuals with

persistent symptoms had an alarming 182% increased hazard. Similar trends were observed for CHD, stroke, and all-cause mortality, with progressively higher hazards associated with worsening and persistent depressive symptoms.

Additionally [43], delved into the trajectories of depression and anxiety among Korean older adults using Growth Mixture Modeling. The study identified significant predictors for depression and anxiety, including female sex, having more than three chronic diseases (hypertension, heart disease, diabetes, back pain, cataracts, osteoporosis, and arthritis, loss of hearing or vision), and not being involved in income-generating activities, highlighting higher vulnerability to developing both conditions over time. These findings suggest that when one condition is present, the likelihood of the other condition is increased. The study's dual trajectory analysis of depression and anxiety in older adults contributes valuable information for understanding the complexities of mental health in this demographic. By highlighting the associations between chronic diseases, sociodemographic factors, and mental health trajectories, the study provides a foundation for tailored interventions and policy initiatives to support the mental well-being of older adults.

On the other hand [20], investigated self-reported anxiety and depression in spondyloarthritis (SpA) patients, revealing intriguing dynamics between the two over time. Factors associated with deterioration or improvement were largely similar for both anxiety and depression, including fatigue, general health, quality of life (QoL), level of functioning, disease activity, and self-efficacy. The study notably highlighted the significant role of chronic widespread pain (CWP) at baseline, demonstrating that its presence increased the risk of developing depression and decreased the likelihood of recovering from anxiety. Thus [20], demonstrated that self-reported anxiety and depression are prevalent and relatively stable over time in SpA patients. The strong association between mental health and CWP emphasizes the need to acknowledge and treat both comorbidities effectively in clinical settings. These findings underscore the importance of holistic care approaches for SpA patients, integrating mental health screening and management alongside the treatment of physical symptoms. Further research should aim to develop targeted screening tools and interventions tailored to the unique needs of SpA patients.

Malhotra et al. [48] undertook an investigation into the short-term trajectories of depressive symptoms among stroke survivors and their caregivers. Utilizing group-based trajectory modeling (GBTM), they delineated three distinct depressive symptom trajectories for stroke survivors and two for caregivers. Their study unveiled that an increase in stroke survivor functional disability and caregiver depressive symptoms contributed to an escalation (indicating worsening) in stroke survivor depressive symptom trajectories. Conversely, a rise in stroke survivor depressive symptoms corresponded to an increase in caregiver depressive symptom trajectories, while foreign domestic worker (FDW) assistance was linked to a reduction (indicating improvement) in caregiver depressive symptoms. As a result, the study underscored the reciprocal relationship of depressive symptoms between stroke survivors and caregivers, emphasizing the significance of dyadic mental health interventions.

The recent study of [15] investigated the association between depression and multimorbidity among Chinese middle-aged and older individuals, concluding that middle-aged and older people with depressive symptoms are more likely to have multimorbidity than non-depressed individuals. Thus, their findings revealed a significant correlation, indicating that higher depression scores were linked to an increased likelihood of developing multimorbidity.

These findings underscore the necessity of early identification of depressive symptoms to prevent the onset and progression of chronic illnesses, reinforcing the importance of integrating mental health care into primary care settings for individuals with multiple morbidities.

Socioeconomic factors

The studies by [25, 26, 44] offer valuable insights into the association between socioeconomic factors and depressive symptoms in South Korea and the United States, respectively. These findings significantly contribute to our understanding of the intricate interplay among economic status, education, and mental health outcomes.

Kim et al. [26] delved into the impact of childhood and current economic status on depressive symptoms among South Korean individuals. Their results shed light on the substantial association between economic status and mental health outcomes, particularly depressive symptoms. Individuals with low current economic status exhibited heightened likelihoods of depressive symptoms compared to those in the middle current-middle childhood economic status group. Conversely, those with high current economic status demonstrated decreased probabilities of depressive symptoms. The results underscore the adverse mental health effects of prolonged poverty, particularly evident in the low current-low childhood economic status group with the highest likelihood of depressive symptoms. This economic disparity, coupled with the lack of a stable social safety net, contributes to higher levels of depression among low-income groups. Additionally, the study highlights income's role as a measure of social class, with significant implications for

mental health disparities. Kim et al. [26] also explored the lasting effects of childhood economic status on depressive symptoms, indicating that childhood economic status may influence mental health outcomes into adulthood. The study suggests that downward transfers of financial resources and bequests can perpetuate income inequality, particularly affecting offspring of lower-income groups. Furthermore, the study discusses the significance of education in moderating the relationship between economic status and depressive symptoms. Education levels strongly correlate with occupation and financial status in South Korea, with higher education levels associated with lower levels of depressive symptoms. However, the study notes challenges for children from low-income families, who may face academic burdens and lag behind academically. Shin et al. [44] contribute to this narrative by examining depressive symptom trajectories among community-dwelling older adults in South Korea. Their study identified trajectory groups for both depression and anxiety, emphasizing the nuanced dynamics of these conditions over a 10-year period. Notably, as in the previous study, individuals with higher education levels were less likely to experience rapidly worsening depressive symptoms, highlighting the role of education in mental health outcomes. The study also emphasized the importance of considering factors such as employment status, cognitive function, chronic diseases, and social activities in interventions targeting depressive symptoms.

Sinkewicz et al. [25] present an in-depth analysis of depressive symptom patterns over 25 years among a representative sample of Americans. Employing innovative growth mixture modeling, the study delineates distinct trajectories of depressive symptoms and their predictors, offering nuanced insights into mental health dynamics across adulthood. Two distinct paths of depressive symptoms emerged: one representing a typical course (60% of the sample) and the other (40% of the sample) characterized by persistently elevated symptoms into adulthood. This persistently depressed trajectory was linked to potentially avoidable adverse outcomes, such as psychiatric hospitalizations, housing instability, and involvement in the criminal legal system. The study also investigates the social determinants influencing membership in these depressive trajectory classes, including gender, race/ethnicity, education, income, and birth cohort. Membership in the persistently high depressive symptom class was more common among females and non-white racial/ethnic groups, highlighting the disproportionate burden of depression on these populations. Particularly noteworthy was the strong association between lower socioeconomic status and membership in the persistently high depressive symptom class, even after adjusting for gender and race/ethnicity. Sinkewicz et al. [25] emphasize the importance of a public health approach to mental health, advocating for community-based mental health and social services instead of the criminalization of mental illness. They suggest that investments in quality public education and living wage reforms could address the underlying causes of depression.

Lou et al. [14] investigation of depressive symptom trajectories among U.S. adults in mid- and later life provides a comprehensive view of how these symptoms evolve across different cohorts and sociodemographic groups. Their findings reveal intriguing patterns, with more recent cohorts displaying higher levels of depressive symptoms despite better physical health. This unexpected trend challenges assumptions about generational improvements in mental health and highlights the complex interplay between societal factors and psychological well-being. The study's focus on sociodemographic factors such as gender, race, education, and partnership status elucidate disparities in depressive symptoms. For instance, women, non-Hispanic Blacks, Hispanics, and individuals with lower education levels consistently reported higher levels of depressive symptoms. The varying trajectories across different cohorts suggest that historical and contextual factors play a significant role in shaping mental health outcomes.

Madero-Cabib et al. [13] also shed light on employment and depressive symptom trajectories among older adults in Chile, particularly focusing on the period around retirement age. Their study revealed distinct trajectories, with noteworthy differences based on health and social status. Trajectories characterized by permanent employment were associated with lower depressive symptoms compared to those indicating retirement or inactivity. Importantly, individuals with advantaged health and social statuses at baseline tended to follow trajectories with the absence of depressive symptoms. Conversely, those with disadvantaged health and social statuses tended to follow trajectories characterized by inactivity or retirement and higher depressive symptoms. These findings underscore the importance of considering social and health conditions in policies aimed at supporting older adults, especially as a rising proportion remain active in the labor market beyond retirement age due to financial constraints.

In line with these findings, a study by [11] delved into depression trajectories among older community-dwelling adults in Ireland using data from the Irish Longitudinal Study on Ageing (TILDA). The study identified four distinct trajectories of depressive symptoms: a stable low symptom level group (79%); a moderate but deteriorating symptoms group; a moderate but improving group (10.1%); and a vulnerable group with consistently high symptoms (3.1%). Demographic factors, psychological

states, and health conditions were associated with different trajectory classes, highlighting the diverse factors influencing depression in older Irish adults. Multinomial logistic regression revealed that factors such as restricted mobility, perceived stress, loneliness, and physical pain were predictive of being in the moderate and higher depressive symptom categories. Additionally, retirement status and elevated levels of worry were linked to a higher probability of being in the moderate symptom categories specifically. The findings underscore the importance of considering these factors in assessment, treatment, and prevention efforts.

Furthermore [47], focuses on the factors associated with predictors of change in depressive symptoms among elderly individuals, both with and without baseline significant depressive symptoms. Their study, which gathered data from a substantial population, identified various factors associated with depressive symptom trajectories, including sociodemographic data, social support, anxiety, cognition, positive affect, control locus, activities of daily living, recent traumatic life events, physical activity, comorbidities, and quality of life. The results, based on assessments of 7,882 subjects with a 29.42% attrition rate, revealed some notable findings. At baseline, the mean age of the participants was 70.96 years, with 61.15% being women. The trajectories of depressive symptoms showed a decreasing trend over time. Stronger associations were observed in those with significant depressive symptoms, particularly with social support (OR 0.971, $p<.001$), chronic pain (OR 2.277, $p<.001$), and higher locus of control (OR 0.581, $p<.001$). Conversely, for individuals without baseline significant depressive symptoms, anxiety and a higher locus of control were the strongest associations. These findings provide new insights into late-life depression, particularly highlighting the different factors that influence the trajectory of depressive symptoms when stratifying based on the baseline status of significant depressive symptoms.

Socioeconomic factors, including childhood and current economic status, education, and employment, significantly shape depressive symptom trajectories. Lower socioeconomic status is consistently linked to higher depression risk, with education and employment offering protective benefits. Addressing these disparities through policy and intervention could reduce the mental health burden, especially in lower-income and less-educated populations.

Physical health and activity

The studies by [22, 23] offer valuable insights into the relationship between physical activity, education, and mental health outcomes in older adults, emphasizing the significance of intensity and frequency of this activity.

Cheval et al. [23] highlight the mediating role of physical activity in the association between educational attainment and mental health trajectories in older age. Their study reveals that lower levels of education are linked to decreased physical activity, leading to steeper declines in physical activity over time. This decline, in turn, contributes to more pronounced declines in mental health and well-being among older adults. The study also underscores the importance of considering both socioeconomic and behavioral pathways in understanding mental health disparities related to educational attainment. While socioeconomic factors like wealth and occupation explain a significant portion of the association between education and mental health, the addition of physical activity as a mediator account for additional variance in mental health outcomes. Interventions promoting physical activity could play a crucial role in mitigating negative mental health impacts associated with lower educational attainment.

In contrast [22], focus on the impact of physical activity intensity on cognitive function and depressive symptom trajectories among middle-aged and older Chinese adults. Their eight-year prospective study, involving 5025 participants with a mean age of 57 years, reveals significant associations between physical activity frequency and intensity with cognitive function and depressive symptom trajectories. The results indicate that engaging in at least 6 days per week of moderate physical activity was associated with a slower decline in cognitive function, suggesting a protective effect against cognitive decline in this demographic. Additionally, a higher frequency of light physical activity was associated with a slower increase in depressive symptoms, indicating a potential protective effect against worsening depressive symptoms. The discussion explores potential mechanisms, suggesting an inverted U-shaped dose–response relationship between physical activity intensity and cognitive function. Moderate physical activity may enhance cognitive domains by activating the reticular system, while light physical activity social nature could contribute to reduced depressive symptoms.

Zhang et al. [17] longitudinal study among Chinese middle-aged and older adults sheds light on the dynamic nature of depressive symptoms and their association with the rate of decline in global cognitive function, episodic memory, and executive function. The study identified five distinct trajectories of depressive symptoms, ranging from constantly low to constantly high. One of the key findings was that global cognitive function and episodic memory declined most rapidly in participants reporting increasing depressive symptoms, followed by those with constantly high or medium depressive symptoms. However, compared with their counterparts with constantly

low depressive symptoms, subjects with increasing symptoms of depression showed significantly higher rates of decline in executive function. Interestingly, cognitive decline did not differ significantly between individuals demonstrating continuously low depressive symptoms and those showing decreasing depressive symptoms. This finding suggests that the trajectory of depressive symptoms is crucial in predicting cognitive decline, emphasizing the importance of considering changes in depressive symptoms over time.

Rote et al. [49] focused on the trajectories of depressive symptoms among elderly Mexican Americans, identifying distinct groups with varying symptom levels over time. The findings revealed that activity of daily living disability stood out as the most potent predictor of depressive symptoms, with social support following closely behind. The study's recommendations emphasize the importance of early detection and treatment of chronic disabling conditions such as heart disease, cancer, visual impairment, and cognitive impairment. Additionally, the findings highlight the need to increase access to social participation, which emerged as a significant factor associated with depressive symptom trajectories. It should be noted that this study also analyzed nativity status into immigration-related factors in order to gain a better understanding of depression in elderly Mexican Americans by examining specific symptom clusters and acculturation factors.

Physical activity, especially at moderate levels, plays a protective role in both cognitive function and depressive symptom trajectories, particularly in older adults. Interventions promoting physical activity, alongside managing physical disabilities and providing social support, are essential for mitigating the mental health risks associated with aging and chronic conditions.

Health behaviors

There is growing evidence that diet is associated with both depressive symptoms and clinical depression, probably through biological mechanisms. However, it is also plausible that depression impacts diet. Opie et al. [50] offer valuable insights into the associations between depressive symptoms and personal drivers of healthy eating behaviours, such as self-efficacy among women in the READI cohort study. This research sheds light on the complex interplay between mental health and dietary behaviours, particularly within socioeconomically disadvantaged populations. According to research by [50], higher self-efficacy is associated with healthier dietary patterns, which may, in turn, reduce the risk of depression. Conversely, depression can diminish self-efficacy, leading to poorer dietary habits. Future interventions should focus on strategies to enhance self-efficacy among individuals with or at risk of depressive symptoms to support healthier dietary practices, potentially contributing to the reduction of this highly burdensome mental health condition.

Several health risk behaviours, such as sedentary lifestyles, smoking, and alcohol consumption, have been associated with mental health issues [45]. Consistently, in the study by [45], physical inactivity and smoking were correlated with a significantly increased risk of depression among Canadian residents aged 65 and older, with smoking exhibiting a stronger connection to depression risk in more recent birth cohorts. Conversely, moderate alcohol consumption was linked to a reduced risk of depression in earlier birth cohorts, but this association weakened over time and disappeared in the most recent birth cohort.

The evidence highlights the complex relationship between diet, self-efficacy, and depression, emphasizing the need for interventions that boost self-efficacy to improve eating habits. Additionally, physical inactivity, smoking, and alcohol consumption are key health behaviours that influence depression risk, with evolving patterns over time, especially in older populations. Understanding the evolving relationships between health risk behaviours and depression is crucial for developing effective prevention strategies for depression and other emotional and mental health conditions.

Gender disparities

Best et al. [16] conducted a comparative study of age and sex trends in self-reported depressive symptoms across middle and older adulthood, examining data from the Canadian Longitudinal Study on Aging (CLSA) alongside American and European cohorts. The study encompassed over 138,000 individuals and estimated trends in depressive symptoms, adjusting for socioeconomic status and educational attainment. The study highlighted the prevalence of depressive symptoms, with women consistently reporting higher levels compared to men. Notable trends included an increase in depressive symptoms with age, particularly in late midlife and late-life stages, suggesting potential impacts of social isolation and bereavement in older age. An interaction between gender and age was also noted in the Canadian and European cohorts. Among Canadians, gender differences were most pronounced after age 70, whereas among Europeans, gender differences were most significant among those approximately aged 60.

Similarly [51], focused on mental health trajectories among American baby boomers, revealing a distinctive V-shaped curve in depression levels during middle age. As shown by [16], this study highlighted gender differences, noting that females were more prone to higher

depression levels, likely influenced by the multifaceted roles they often juggle. Economic factors such as employment and net worth were associated with depression at various stages, emphasizing the pivotal role of financial stability in mental well-being.

The findings of this study contribute valuable insights into the mental health dynamics of baby boomers, highlighting the need for tailored interventions. Specifically, the study suggests that specialized interventions targeting females' mental health concerns over time are warranted. Additionally, fostering and enhancing self-esteem before middle age could be pivotal in mitigating depression levels as individuals traverse through different life stages.

Relationship outcomes

The study conducted by [41] provides valuable insights into the long-term effects of mental health vulnerabilities, specifically depressive symptoms, perceptions of life and stress, on intimate relationship outcomes. The findings highlight the enduring impact of mental health challenges experienced during the transition to adulthood on midlife relationship functioning. Research by [41] concludes that deficits and poor mental health during the critical transition to adulthood contribute to higher levels of stress perception later in life. Expressions of anger, particularly the growth or reduction in anger control during early adulthood, also play a role in perceptions of relationship risk.

From a clinical perspective, the findings suggest potential interventions aimed at improving mental health indicators, such as anger control and stress management, to positively impact future relationship functioning. The study also underscores the importance of considering developmental trajectories and the interplay of mental health, stress, and intimate relationships across the lifespan.

COVID- 19 pandemic impact

A number of studies within the entire bibliographic corpus offer profound insights into the impact of the COVID- 19 pandemic on depression trajectories and symptoms across diverse populations, enhancing our comprehension of the multifaceted factors that influence mental health outcomes during this global crisis.

Briggs et al. [40] shed light on the prevalence of clinically significant depressive symptoms among older adults before and during the pandemic. Their findings revealed a notable increase in the burden of depressive symptoms from 7.2% to 19.8% in the early months of the COVID- 19 pandemic, indicating a substantial psychological toll, particularly among those aged 70 years and older and those living alone. This rise was mirrored in the mean CES-D scores, highlighting a widespread escalation of depressive symptoms exacerbated by factors such as excess alcohol consumption, smoking, functional impairment, and chronic diseases.

It is important to note that mental distress did not affect everyone equally during the COVID- 19 pandemic. Lo Coco et al. [35] conducted a comprehensive exploration of the trajectories of mental health distress during the pandemic. Their study identified three distinct trajectory classes for depression, anxiety, and stress symptoms: "Moderate-chronic," "Normal-increasing," and "Mild-vulnerable." The majority of individuals (54%) demonstrated a resilient pattern over time. Nonetheless, two subsets displayed vulnerable trajectories encompassing depression, anxiety, and stress. Factors such as expressive suppression, intolerance to uncertainty, and fear of COVID- 19 were identified as risks linked with these vulnerable trajectories for mental health distress. Additionally, susceptibility to mental health distress was more pronounced among women, younger age cohorts, and individuals who were unemployed during the initial lockdown. These findings highlight the heterogeneity in group trajectories of mental health distress during the pandemic and the importance of identifying subgroups at risk of worsening states. Additionally, the study underscores the significance of adaptive coping mechanisms, such as cognitive reappraisal, in mitigating the impact of distress during stressful events like the COVID- 19 pandemic.

Likewise, the research conducted by [34] provides valuable insights into the progression of depressive symptoms among adults in the UK during the COVID- 19 pandemic. The study reveals a troubling long-term escalation in depression symptoms across all age groups, with a noticeable variation seen among individuals aged 20. An important discovery from the research is the significant impact of loneliness on the rise in depression symptoms across all age groups during the pandemic. The feeling of loneliness emerged as the most potent predictor, both at the start of the pandemic and throughout its course. Surprisingly, adherence to social distancing measures did not correlate with increased depression symptoms in any group. In fact, adherence to these measures even served as a protective factor for individuals aged 30. These findings suggest that feeling connected is not solely reliant on face-to-face interactions among adults and can be nurtured through alternative avenues, such as meaningful social engagements. Additionally, chronic illness was associated with a rise in depression symptoms across all age groups, likely due to heightened health concerns during the pandemic. Financial challenges were also significantly linked to increased depression scores among individuals aged 30 and 50, highlighting the economic

strain brought about by COVID- 19. Furthermore, pre-pandemic mental health issues consistently correlated with increased depression symptoms across age groups 30–62, emphasizing the importance of considering individuals' mental health backgrounds. Nevertheless, protective factors such as being a keyworker or pregnancy in one's 30 s were also identified.

Nonetheless, pre-pandemic mental health can also exert a significant influence on depression trajectories during the pandemic crisis. Zhu et al. [38] conducted an investigation into the relationship between long-term trajectories of depressive symptomatology before the COVID- 19 pandemic and depression during the pandemic, extending beyond the latest pre-pandemic depression status. The researchers also examined whether individuals who experienced depression closer to the pandemic were at a greater risk during that time. Their study identified four distinct trajectories, with consistently elevated symptoms strongly associated with a heightened likelihood of depression during the pandemic. Within their study, approximately one in five people experienced at least one episode of clinically significant levels of depression between 2008–2009 and 2018–2019, placing them at a higher risk of also reporting depression during the pandemic in 2020. These findings underscore the importance of considering individuals' mental health backgrounds when predicting susceptibility to the psychological effects of crises.

Rossi et al. [31] reported encouraging changes in mental health outcomes in the general population of Italy over time during the pandemic. They observed a decrease in depression, anxiety, and stress-related symptoms in the general population 14 months after the start of the COVID- 19 pandemic, suggesting a potential adaptation or improvement in mental health as individuals adjusted to the challenges posed by the pandemic. However, a significant proportion of the sample continues to experience clinically relevant symptoms of distress over time. Various factors such as gender, age, education, geographic location, personal resilience, interpersonal resilience, history of mental disorder, and social interactions were associated with different mental health trajectories, showcasing the intricate web of influences on mental well-being. The findings from [31] offer valuable information for the design of structured interventions to mitigate the psychological impact and residual socioeconomic impact of the COVID- 19 pandemic on the general population and specific at-risk groups.

In a manner consistent with previous studies [24], shed light on the positive impact of digital platforms for physical activity on mitigating depressive and anxiety symptoms during the COVID- 19 pandemic in adults. Their investigation revealed that participants who utilized these platforms demonstrated a more favorable trajectory of depressive symptoms, particularly when engaging with streaming services and messaging applications. This emphasizes the potential of digital interventions as accessible tools to support mental health, offering convenience, personalization, and community support.

The COVID- 19 pandemic significantly impacted mental health, particularly increasing depression symptoms among older adults and those with pre-existing mental health conditions. However, mental distress was not universal, with distinct trajectories observed based on factors such as age, gender, employment status, and coping mechanisms. Digital platforms for physical activity also demonstrated potential in mitigating depressive symptoms, offering an accessible and supportive intervention during the pandemic.

Diagnostic models

The studies by [42, 52] contribute valuable insights into predicting depression severity and trajectory in adult primary care patients, offering complementary perspectives on prognostic modeling and transdiagnostic predictors. Chondros et al. [42] focused on developing a prognostic model for depression severity in primary care patients with current depressive symptoms. Their study resulted in two models: one with 15 predictor variables (Model 1) and another with 20 predictors, including potentially sensitive questions (Model 2). Model 1, with eight predictor variables, explained 39.2% of the variation in three-month depression severity. Notably, the severity of depressive symptoms at baseline was the most influential predictor, along with current anxiety, history of depression, and poor self-rated health. Despite including potentially sensitive questions in Model 2, the model's performance did not improve, possibly due to correlations with other indicators. The developed prognostic model showed acceptable discrimination and calibration, with a c-statistic of 0.74, indicating its potential clinical usefulness.

In contrast [52], aimed to identify predictors of depression severity and trajectory using data from the PCARES registry. They highlighted the importance of transdiagnostic factors in predicting depression severity over one year. The Level 1 symptom score, PTSD, and functional disability scores emerged as strong predictors. The study also found that patients with clinically significant depressive symptoms often did not have an initial diagnosis of MDD or BD, suggesting a need for a transdiagnostic approach. Functional impairment, as assessed by WHO-DAS, consistently predicted poor depression severity and trajectory outcomes. Furthermore [52], identified clinical predictors associated with depression outcomes. High levels of general psychopathology, anxiety symptoms,

difficulty sleeping, and diagnoses of BD or PTSD were linked to worse depression trajectory. Notably, anxiety symptoms, regardless of a formal GAD diagnosis, were associated with depression severity during follow-up, emphasizing the need for comprehensive assessment and treatment of both anxiety and depression. Sleep quality was also highlighted as a sensitive marker of well-being, with self-reported difficulty sleeping predicting depression severity during follow-up.

Solis et al. [53] conducted a thorough analysis of the nine-year clinical trajectory of depressive and anxiety disorders, revealing significant differences between categorical (DSM diagnoses) and dimensional (symptom severity) approaches. The research aimed to understand the course trajectories of affective disorders over a significant period, specifically comparing the outcomes between a categorical approach using diagnoses and a dimensional approach using symptom severity. Their study indicated a higher rate of chronicity when using the dimensional method, highlighting the limitations of relying solely on DSM diagnoses.

The studies highlight the importance of incorporating both prognostic modeling and transdiagnostic factors in predicting depression severity and trajectories. Key findings include the need for comprehensive assessments that consider symptom severity, anxiety, sleep quality, and functional impairment. The research emphasizes the value of a dimensional approach over the categorical DSM diagnoses for more accurate treatment planning and understanding the chronicity of affective disorders.

Discussion

This systematic review of the literature on depression trajectories within adult populations elucidates the multifactorial and complex nature of depression, shaped by an interplay of psychosocial, biological, and environmental determinants. Our review highlights that strong social support, higher socioeconomic status, and engagement in regular physical activity are facilitators of more favorable depression trajectories, while chronic comorbidities, socioeconomic disadvantage, and social isolation serve as key barriers that can exacerbate or prolong depressive episodes. Our findings demonstrate considerable heterogeneity in depression trajectories, with significant correlations between various factors such as gender, socioeconomic status, social support, health behaviors, and chronic comorbidities, all of which critically influence the onset, progression, and resolution of depressive episodes. Specifically, this review underscores the role of key facilitators such as social support, physical activity, and healthcare access, as well as barriers including socioeconomic disadvantage, chronic illness, and gender disparities. These factors are central to understanding depression trajectories and must be considered when designing interventions and shaping public health policies.

Compared to previous systematic reviews, our study confirms earlier findings that social support and physical activity can buffer against chronic or worsening depression, while also extending the evidence base by examining more diverse adult populations, including rural and middle-aged groups with multiple comorbidities. A central finding of our review is the significant role of social support, physical health, and community engagement in shaping depression trajectories, especially in rural and underserved populations. Strong social networks consistently act as a protective buffer against depressive symptoms, highlighting the importance of social connectivity in preventing and managing depression. Conversely, poor physical health, particularly the presence of chronic conditions such as cardiovascular disease, diabetes, and obesity, exacerbates the risk of depression. The bidirectional relationship between depression and chronic comorbidities warrants urgent attention, as depression not only exacerbates the progression of these conditions but also hinders recovery, creating a vicious cycle that compounds individuals' health outcomes. This underscores the need for integrated care models that simultaneously address both mental and physical health concerns, particularly in middle-aged and older adults, who are often disproportionately affected by chronic illness and depression.

Gender differences in depression trajectories represent another critical area of concern, with our review confirming that women, particularly those from lower socioeconomic backgrounds, are at higher risk of developing depression. This observation aligns with existing literature and reinforces the necessity for gender-sensitive mental health interventions that address the unique psychosocial stressors women face, including gender-based violence, caregiving responsibilities, and economic inequalities. Furthermore, our review underscores the significant role of socioeconomic status in shaping depression trajectories, with lower socioeconomic status serving as both a risk factor for the onset of depression and a barrier to recovery. This relationship highlights the urgent need to address the social determinants of health through policies aimed at reducing structural inequalities, thus mitigating the burden of depression, especially among marginalized populations.

Physical activity has emerged as a potent modulator of depressive symptoms, with tailored exercise interventions demonstrating efficacy in both mitigating the severity and shortening the duration of depression episodes. Moderate-intensity exercise and light physical activity, in particular, show promising results not only in improving mood but also in enhancing cognitive function,

particularly in older adults. Given the positive effects of physical activity on mental health, the promotion of self-efficacy in health-related behaviors—such as exercise and nutritional interventions—becomes critical in managing depressive symptoms, particularly among individuals with comorbid chronic conditions. While physical activity and nutritional support can serve as vital preventive strategies, they must be integrated into a broader, multifaceted approach that includes psychological and social interventions, in line with the evidence linking social isolation to depression across all age groups.

The COVID- 19 pandemic has further illuminated significant mental health vulnerabilities, particularly among older adults living in isolation. Loneliness, exacerbated by social distancing measures, has proven to be a major predictor of depression, with widespread effects across various demographic groups. This calls for the urgent integration of digital mental health platforms into care delivery systems, as these platforms have the potential to offer scalable and accessible interventions, particularly for isolated individuals. Cognitive behavioral strategies, such as cognitive reappraisal, have demonstrated efficacy in mitigating the emotional and psychological toll of prolonged isolation and should be further explored as part of crisis-response strategies.

The complex relationship between chronic conditions, anxiety, and depression in middle-aged and older adults necessitates the development of early screening tools and the identification of optimal intervention strategies. This is particularly critical for populations where comorbidity is high, as individuals with multiple health conditions are at an increased risk of depression and other poor health outcomes. Targeted interventions for these high-risk groups—such as those with disabilities, chronic illnesses, or caregivers—are essential not only for reducing the direct burden of depression but also for improving broader health outcomes. Moreover, early identification and intervention for individuals exhibiting depressive symptoms may significantly reduce the progression of cognitive decline and improve long-term quality of life.

The importance of early interventions cannot be overstated, particularly in the context of depression trajectories. Interventions should not only focus on managing symptoms but also emphasize prevention, particularly for populations vulnerable to developing chronic depression. Addressing early-life adversity and economic hardship through preventive mental health strategies could significantly alter the trajectory of depression and reduce its long-term burden on individuals and healthcare systems. The ability to predict and mitigate delayed-onset depression through early detection and intervention represents a promising avenue for both clinical practice and future research.

Digital health technologies, including predictive artificial intelligence (AI) models, chatbot interventions, and wearable devices, offer transformative potential for early detection and continuous monitoring of mental health conditions such as depression. By leveraging AI-driven algorithms, these technologies enable real-time data collection and analysis, facilitating personalized treatment plans that support both early intervention and ongoing care. The integration of AI and machine learning (ML) into digital platforms holds particular promise for identifying and tracking depression, offering dynamic, adaptive treatment strategies through the analysis of physiological and behavioral data.

A variety of AI models have demonstrated practical utility in predicting and monitoring mental health conditions. For example, wearable devices like the Galaxy Watch Active2 have been employed in pilot studies to predict imminent suicide risk by analyzing heart rate variability and mood ratings. These models have shown strong performance in identifying high-risk individuals, underscoring the value of real-time physiological data in improving risk assessment and timely intervention [54]. Similarly, AI-powered electroencephalogram (EEG) analysis has improved the accuracy of depression diagnoses, with machine learning techniques identifying pathophysiological markers associated with the disorder, offering a scalable and automated approach to diagnosis [55]. Digital phenotyping, powered by AI, has proven effective in monitoring depression in vulnerable populations, such as older adults. A study utilizing wearable sensors like the Fitbit Sense demonstrated that daily patterns in sleep, heart rate variability, and physical activity could predict depressive symptoms in socially vulnerable older adults. This approach not only enabled real-time feedback but also enhanced the support provided to caregivers, improving mental health outcomes for these individuals [56]. Additionally, machine learning models have proven effective in predicting depressive symptoms in older adults with cognitive impairment, highlighting the need for early, tailored interventions for this group [57]. AI-driven mobile health (mHealth) platforms also show promise in forecasting mental health symptoms, particularly in youth. Predictive models that integrate data from smartphones and wearables have demonstrated strong accuracy in detecting symptoms of depression and other mental health conditions, confirming their potential in real-time mental health monitoring [58].

Similarly, AI-driven chatbot interventions represent a promising tool for mental health care [59]. These systems, particularly those delivering cognitive-behavioral therapy (CBT), have shown effectiveness in treating depression and anxiety. For instance, a randomized trial comparing chatbot-delivered therapy to

bibliotherapy demonstrated that chatbot interventions led to greater reductions in both depressive and anxiety symptoms among university students, underlining the potential of chatbots as an affordable, accessible, and interactive self-help option for mental health care [60]. Other studies have shown that chatbot-based interventions significantly alleviate depression and anxiety symptoms in short-course treatments, with the most notable improvements occurring after 8 weeks [61], and are particularly effective in clinical populations, especially in contexts where human resources are limited [62]. Personalization, natural language processing (NLP), and tailored interventions are critical to the success of these chatbots, enhancing user engagement and improving therapeutic outcomes [63]. These factors are particularly important as they allow chatbots to provide more individualized support, which is a key factor in their effectiveness. However, despite these advancements, the long-term effects and safe integration of large language models (LLMs) in chatbot interventions remain an area that requires further exploration [62]. Moreover, user feedback from mobile mental health apps shows that while chatbots offer 24/7 accessibility and provide a judgment-free space for individuals to seek support, there are challenges with ensuring the quality of their responses. Improper chatbot responses and a lack of understanding during crisis moments have been identified as areas for improvement [59]. Therefore, the future design of AI-driven chatbots should aim for better contextual understanding and the ability to recognize and appropriately respond to crises.

Wearable technologies have emerged as crucial tools in the realm of digital mental health by enabling continuous and unobtrusive monitoring of key physiological indicators related to depression. Devices capable of tracking sleep patterns, heart rate variability, and physical activity provide real-time insights that are vital for diagnosing and managing mental health disorders, including depression [64–66]. These devices can detect subtle physiological changes that may signal the onset of depressive episodes, which is particularly valuable for early intervention [67].

Research has underscored the ability of wearables to track various markers of depression and anxiety. For instance, wrist-worn devices that measure physiological parameters such as pulse wave, skin conductance, and triaxial acceleration have shown potential in differentiating individuals with depression from healthy controls with high classification accuracy [68]. This continuous monitoring offers a novel approach for identifying mood fluctuations, which can guide personalized interventions and support treatment management. Additionally, wearable devices can play a significant role in managing anxiety, further expanding their utility in the broader spectrum of psychiatric disorders [68].

Despite the substantial promise of digital health technologies in offering scalable and cost-effective solutions for the monitoring, prediction, and treatment of mental health conditions like depression, several significant challenges persist. The inherent variability in mental health disorders, driven by individual differences, cultural factors, and the complex nature of symptoms, continues to undermine the reliability and accuracy of AI-based models. Additionally, challenges such as small sample sizes, limited reproducibility of findings, and the absence of standardized methodologies in research studies exacerbate the difficulty of developing robust, generalizable models. Furthermore, concerns regarding data privacy and security, alongside the ethical integration of these technologies into clinical practice, must be carefully addressed to ensure their responsible adoption [69].

Similarly, wearable devices, which have shown promise in complementing treatment monitoring and enabling early intervention, face challenges in optimizing algorithmic performance, ensuring privacy and security of data, and effectively integrating wearable data with other clinical modalities, such as neuroimaging. These interdisciplinary approaches hold the potential to enhance the accuracy of depression detection and improve patient outcomes [67, 70]. Therefore, continued research, development, and validation are essential to ensure that these digital health technologies are reliable, clinically effective, and ethically integrated into mental health care practices. To this end, addressing the existing limitations and fostering collaborations across disciplines will be critical to realizing the full potential of these technologies in advancing mental health care [67, 69, 70].

In the unique and specific context of the Portuguese population, this review provides a framework for understanding depression trajectories, shaped by distinct cultural, socioeconomic, and healthcare system factors. Our findings highlight that resilient and low-risk trajectories, characterized by consistently low depressive symptoms, are strongly supported by robust social networks and adaptive coping strategies. In contrast, episodic and recurrent trajectories underscore the impact of life stressors, personal losses, and health challenges in precipitating depressive episodes.

Notably, the identification of delayed-onset trajectories, where depressive symptoms emerge following a period of resilience, emphasizes the need for ongoing mental health monitoring, even among individuals initially presenting as symptom-free. Furthermore, chronic depression trajectories, particularly prevalent among individuals facing socioeconomic disadvantage and chronic illness, underscore the necessity of long-term,

integrated care approaches to address their complex needs.

From a practical standpoint, clinicians and policymakers should prioritize interventions that strengthen social support networks, facilitate access to mental health services, and integrate depression screening with chronic disease management. In particular, resource allocation for rural or underserved communities—where social isolation and economic barriers are more pronounced—could substantially reduce the burden of chronic or recurrent depression.

As research into the trajectories of depression in adult populations continues to evolve, it has become increasingly clear that understanding the neurobiological foundations of depression—particularly in relation to neuroplasticity, biomarkers, and neuroinflammatory processes—is essential for elucidating the diverse pathways individuals follow during depressive episodes. Neuroplasticity, which encompasses the brain's capacity to adapt and reorganize in response to environmental stimuli and experiences, is integral to both the onset and progression of depression [71, 72]. Recent studies have highlighted those alterations in key biomarkers, such as Brain-Derived Neurotrophic Factor (BDNF), are not only indicative of neuroplastic changes but also intimately linked to neuroinflammation and disrupted synaptic plasticity [71–75]. These neurobiological alterations are thought to contribute significantly to the severity of depressive symptoms and the heightened risk of relapse, underscoring the need for targeted and personalized therapeutic strategies.

Recent advancements in translational research, including studies on extracellular vesicles and immune-inflammatory pathways, have opened new avenues for understanding how these biomarkers can predict depression trajectories, particularly in individuals with chronic comorbidities or those exposed to prolonged stress [74, 75]. Studies examining BDNF levels in plasma and astrocyte-derived extracellular vesicles have shown that these biomarkers may be more stable and reliable than traditional plasma markers [75]. These findings are crucial for monitoring treatment responses in real time, especially for individuals with treatment-resistant depression (TRD), who often exhibit inconsistent or delayed responses to conventional therapies. Integrating biomarkers like BDNF into clinical practice could help refine the classification of TRD and improve personalized treatment strategies by predicting individual responses to specific pharmacological, behavioral, or neuromodulatory interventions.

The predictive value of biomarkers such as BDNF, CRP, and IL- 6 in treatment outcomes for TRD has been highlighted in several studies [76]. While there is promising evidence for these biomarkers, challenges remain due to the lack of standardization in biomarker testing, variability in study designs, and the biological heterogeneity of TRD patients. Despite these challenges, the integration of biomarkers like BDNF could facilitate more precise treatment strategies, allowing clinicians to personalize therapies and enhance treatment outcomes. Furthermore, BDNF is not only a marker for depression but may also serve as a prognostic indicator in other psychiatric disorders, such as schizophrenia and schizoaffective disorder. Reduced BDNF levels have been associated with more severe depressive symptoms in schizophrenia-spectrum disorders, suggesting that BDNF may reflect broader neurobiological dysfunction [77–79].

Research indicates that monitoring neurobiological markers, such as Brain-Derived Neurotrophic Factor (BDNF), can provide valuable insights into an individual's depressive state and predict treatment outcomes. For instance, a meta-analysis demonstrated that serum BDNF levels are decreased in acute Major Depressive Disorder (MDD) but recover after treatment, suggesting that serum BDNF could serve as a biomarker for successful treatment [80]. Additionally, a systematic review highlighted that early increases in BDNF levels after treatment initiation could indicate a positive response, underscoring the potential of BDNF as a predictor of treatment response in MDD [81]. These findings support the importance of BDNF as a biomarker for therapy selection, facilitating personalized interventions based on the patient's neurobiological profile and the unique pathophysiology of their depression.

Additionally, exploring the efficacy of early interventions—ranging from neuromodulatory techniques such as transcranial magnetic stimulation (TMS) to pharmacological agents designed to enhance neuroplasticity—holds promise for modifying depressive trajectories and preventing the transition from acute to chronic depression [72]. By utilizing biomarkers like BDNF to monitor neuroplastic changes during and after treatment, clinicians could better predict treatment response, allowing for real-time adjustments to therapies that optimize recovery and reduce relapse risk. Pharmacological agents that modulate neuroplasticity, such as ketamine and certain SSRIs, have shown promise in rapidly improving mood by stimulating BDNF production, which may be particularly beneficial for individuals with treatment-resistant depression.

Pharmacogenomic testing is emerging as an important tool for personalizing treatment in severe mental illnesses. While pharmacokinetic markers have shown promise in predicting treatment responses in these populations [76], their application in depression, particularly in TRD, remains underexplored. Integrating

pharmacogenomic testing with neurobiological markers like BDNF could further refine personalized treatment regimens, enabling clinicians to make therapeutic decisions based on an individual's genetic and neurobiological makeup.

Finally, initiatives like the PROMPT project aim to develop integrated precision medicine approaches for MDD, which could have significant implications for TRD management. By combining clinical, genomic, and transcriptomic data, these efforts seek to identify early predictors of treatment response, enabling clinicians to intervene before the onset of TRD [82]. Such integrative models could be particularly beneficial for TRD patients, enabling clinicians to fine-tune interventions and improve treatment success rates for this challenging patient population.

Looking ahead, future research should (1) conduct more cross-cultural comparisons, particularly examining whether the identified trajectories and correlates hold in low-income countries or migrant communities; (2) employ longitudinal designs that capture more frequent follow-up points to better delineate the onset and progression of depression; and (3) integrate biomarker-based methodologies to clarify the interplay between neuroinflammation, neuroplasticity, and psychosocial factors.

Addressing these neurobiological mechanisms in tandem with psychosocial and environmental factors is critical for developing more effective, individualized treatment approaches that not only alleviate symptoms but also reduce recurrence and improve long-term mental health outcomes.

Overall, this review differs from existing systematic reviews by its broader focus on adult populations with various comorbidities, providing expanded insights into facilitators and barriers to recovery, and by its emphasis on practical recommendations for integrated care and early intervention. It offers a comprehensive framework for understanding depression trajectories and sets the stage for future research tailored to Portugal's unique socio-cultural landscape.

Hence, policymakers and clinicians can draw upon these findings to design actionable initiatives—such as improving mental health outreach in primary care, funding community-based exercise programs, and crafting policies to reduce socioeconomic disparities—that can meaningfully alter the course of depression at both individual and population levels. Future studies should refine these trajectories by incorporating personalized interventions that account for cultural nuances, socioeconomic disparities, and the diverse mental health needs of different population subgroups. Additionally, targeted public health initiatives addressing these trajectories are essential to ensuring interventions are both effective and accessible, ultimately reducing the burden of depression on individuals and healthcare systems alike.

Conclusions and future perspectives

This systematic review underscores the intricate and multifactorial nature of depression trajectories, shaped by complex interactions between psychosocial, biological, and environmental factors. Effective interventions must extend beyond symptom management and address the underlying risk factors contributing to both the onset and chronicity of depression. Such interventions should be comprehensive, personalized, and tailored to the specific needs of high-risk populations, including older adults, individuals with chronic conditions, and those from disadvantaged socioeconomic backgrounds. Early screening and timely identification of depression within these groups are essential for preventing escalation and improving long-term outcomes. A visual summary (Fig. 2) is provided to illustrate the longitudinal trajectories of depression and key influencing factors.

Biopsychosocial models of care are pivotal in the treatment of depression, particularly for patients with comorbid physical conditions such as cardiovascular diseases, diabetes, and obesity. These models offer a holistic approach by addressing mental and physical health needs simultaneously, leading to better health outcomes. Personalizing interventions based on an individual's psychosocial, cultural, and environmental context is essential for optimizing treatment efficacy and ensuring targeted management of risk factors.

Digital health technologies have demonstrated substantial potential in expanding access to care, particularly for underserved and rural populations. Predictive artificial intelligence (AI) models, chatbot-based interventions, and wearable technologies, hold transformative potential for both early detection and continuous monitoring of depression trajectories. AI-driven algorithms can enhance risk identification by enabling real-time data collection and analysis, informing individualized treatment plans. The convergence of AI with longitudinal studies could significantly improve the efficiency of mental health monitoring and intervention strategies.

Despite these promising advancements, ethical and clinical implementation challenges remain. AI-driven mental health tools raise concerns regarding data privacy, algorithmic bias, and informed consent. Ensuring that AI models do not disproportionately misdiagnose or exclude certain demographic groups is crucial for equitable mental health care. Additionally, integrating these digital solutions into existing healthcare frameworks requires collaboration between technologists, clinicians, and policymakers to establish standardized guidelines and regulatory oversight. Addressing these challenges

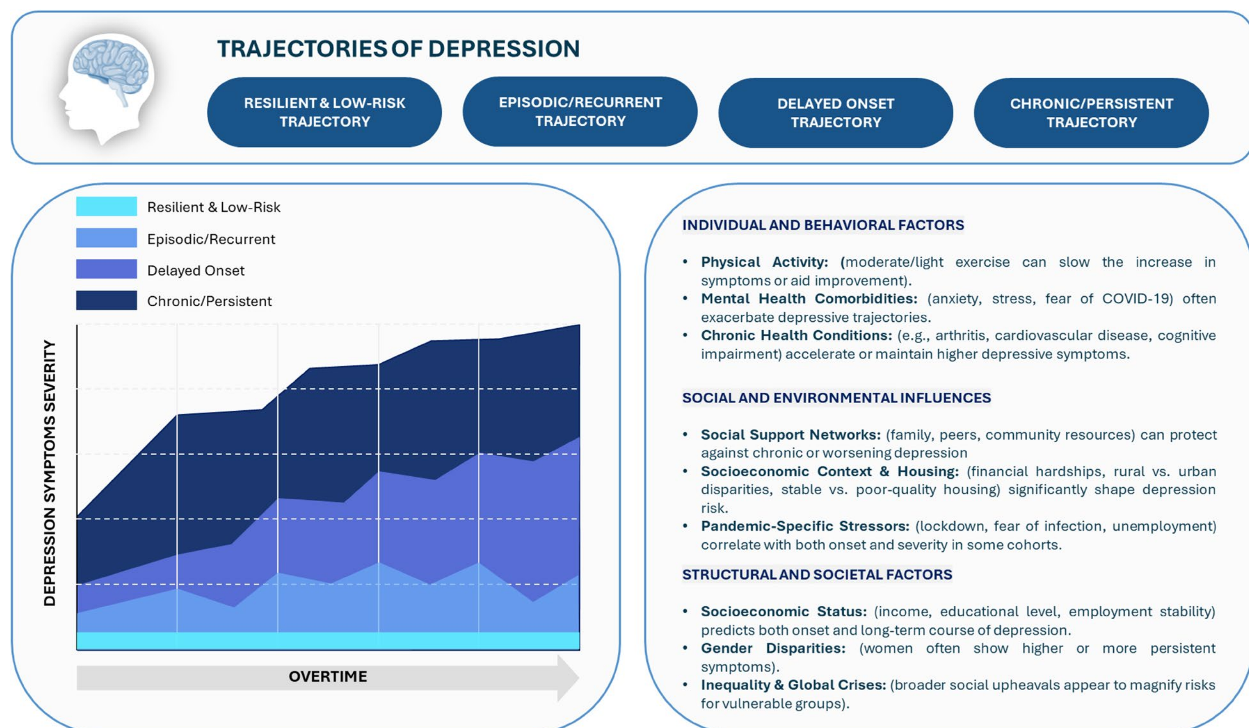

Fig. 2 Longitudinal trajectories of depression and key influencing factors: a comprehensive overview of patterns and determinants. Legend: Resilient & low-risk trajectory [Characterized by consistently low levels of depressive symptoms; Associated with high psychological resilience, adaptive coping strategies, and strong social support; Often linked to protective factors such as regular physical activity, stable socioeconomic conditions, and the absence of significant mental or physical health comorbidities]. Episodic/Recurrent Trajectory [Marked by fluctuating symptoms over time, indicative of episodic major depressive disorder (MDD) or recurrent depressive episodes; May be influenced by psychosocial stressors, life transitions, or mental health conditions such as anxiety; Social support networks and access to mental health care may help mitigate recurrence]. Delayed Onset Trajectory [Depression symptoms emerge gradually, often later in life or following prolonged exposure to stressors; Can be triggered by age-related factors (e.g., cognitive decline, chronic illness) or cumulative life stress; Prevention efforts may focus on early detection and intervention in at-risk populations]. Chronic/Persistent Trajectory [Characterized by severe and persistent symptoms, leading to substantial functional impairment; Often associated with underlying health conditions, socioeconomic adversity, and inadequate treatment response; Structural factors such as economic instability, gender disparities, and global crises may exacerbate long-term depression risk]

will be essential for fostering trust and adoption among both healthcare providers and patients. Thus, further research is required to assess the long-term effectiveness, scalability, and patient engagement of these technologies to ensure their successful integration into routine clinical practice.

Future research should prioritize large-scale, longitudinal studies to identify early biomarkers and predictors of depression onset, recurrence, and relapse. Biomarkers related to neuroplasticity, neuroinflammation, and Brain-Derived Neurotrophic Factor (BDNF) are particularly critical for developing personalized treatment strategies. Identifying these biomarkers will help clinicians select the most appropriate interventions, especially for patients with treatment-resistant depression. A deeper exploration of genetic, neurobiological, and hormonal mechanisms underlying depression trajectories is essential for advancing precision medicine and tailoring treatments to individual biological profiles.

Additionally, there is an urgent need to examine how emerging global challenges—such as climate change, economic instability, and political turmoil—affect depression trajectories. Longitudinal studies should investigate how these stressors impact mental health across different population groups, particularly in regions with limited mental health resources. Understanding how macro-level stressors interact with individual and community-level risk factors will provide critical insights into depression's evolving patterns amid global crises.

Understanding how social determinants—such as poverty, education, healthcare access, and social support—shape depression trajectories is vital for developing targeted interventions, particularly for marginalized populations. Longitudinal studies should focus on how conditions like economic hardship and inadequate social support contribute to depression's onset and persistence. Addressing these structural determinants will be

essential for reducing health disparities and improving intervention efficacy.

To fully capture the complexity of depression trajectories, future research should expand its scope to include diverse racial, ethnic, and culturally distinct populations, as well as the intersectionality of social determinants of health, including immigration status, disability, and sexual orientation. A broader research focus will be crucial for developing inclusive and culturally responsive interventions. Additionally, investigating how cultural, racial, and socioeconomic factors influence the experience of depression will help ensure that interventions are contextually appropriate and effective.

Finally, addressing the stigma surrounding depression remains a critical research priority. Stigma often deters individuals from seeking timely help, exacerbating symptoms and hindering treatment outcomes. Research into interventions that reduce stigma and promote help-seeking behavior, particularly among high-risk populations, is essential for improving early intervention and long-term outcomes. Understanding the cultural, social, and structural factors that contribute to stigma will be key in designing targeted public health strategies and mental health campaigns aimed at increasing awareness and reducing misconceptions about depression.

In conclusion, advancing our understanding of depression trajectories is essential for developing effective, individualized interventions that mitigate the long-term burden of depression. A holistic, multidimensional approach—integrating biological, psychological, and social dimensions—should guide future research and treatment strategies. Addressing the needs of high-risk populations, responding to global challenges, and leveraging emerging digital health technologies and AI will be critical in enhancing mental health care and reducing disparities. Integrating these advancements into clinical practice and public health policies will be essential for reducing the global burden of depression and ensuring equitable access to effective interventions.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12888-025-06828-x.

Supplementary Material 1.

Supplementary Material 2.

Acknowledgements
Not applicable.

Authors' contributions
R.D.S., H.C., and A.R. contributed to the conceptualization of the study. R.D.S. and M.Z. prepared the original draft of the manuscript. R.D.S., M.Z., T.C., A.R., H.C., and J.M.C.A. participated in reviewing and editing the manuscript. T.C. and M.Z. designed the figures. All authors have read and approved the final version of the manuscript.

Funding
The present publication was funded by Fundação Ciência e Tecnologia, IP national support, through UID/04923 - Comprehensive Health Research Centre.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study is a systematic review and, as such, did not involve the implementation of clinical trials or the use of animal or human subjects.
The systematic review was developed within the scope of the project titled "Predicting Depression in the Adult Portuguese Population: Development and Validation of a Prognostic Model" (No. 203/2021/CEFCM), which was unanimously approved by the Ethics Research Committee of Faculty of Medical Sciences of the NOVA University of Lisbon (CEFCM).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]CHRC, NOVA Medical School, Faculdade de Ciências Médicas, NMS, FCM, Universidade NOVA de Lisboa, Campo Mártires da Pátria, 130, Lisbon 1169 - 056, Portugal. [2]Episaúde - Associação Científica, Évora, Portugal. [3]CHRC, LA-REAL, NOVA Medical School, Faculdade de Ciências Médicas, NMS, FCM, Universidade NOVA de Lisboa, Lisbon, Portugal. [4]NOVA Medical School, Universidade NOVA de Lisboa, Lisbon, Portugal. [5]CHRC, Lisbon Institute of Global Mental Health, NOVA Medical School, Faculdade de Ciências Médicas, NMS, FCM, Universidade NOVA de Lisboa, Lisbon, Portugal.

Received: 16 January 2025 Accepted: 7 April 2025
Published online: 15 April 2025

References

1. WHO. Depressive disorder (depression): key facts. 2023. Available from: https://www.who.int/news-room/fact-sheets/detail/depression. Cited 2024 Apr 9.
2. Institute of Health Metrics and Evaluation. Global Health Data Exchange (GHDx). https://vizhub.healthdata.org/gbd-results/. Accessed 4 Mar 2023.
3. Woody CA, Ferrari AJ, Siskind DJ, Whiteford HA, Harris MG. A systematic review and meta-regression of the prevalence and incidence of perinatal depression. J Affect Disord. 2017;219:86–92. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032717307231. Cited 2024 Apr 9.
4. Evans-Lacko S, Aguilar-Gaxiola S, Al-Hamzawi A, Alonso J, Benjet C, Bruffaerts R, et al. Socio-economic variations in the mental health treatment gap for people with anxiety, mood, and substance use disorders: results from the WHO World Mental Health (WMH) surveys. Psychol Med. 2018;48(9):1560–71. Available from: https://www.cambridge.org/core/product/identifier/S0033291717003336/type/journal_article. Cited 2024 Apr 12.
5. Greenberg P, Chitnis A, Louie D, Suthoff E, Chen SY, Maitland J, et al. The economic burden of adults with major depressive disorder in the United States (2019). Adv Ther. 2023;40(10):4460–79.
6. Mercedes BPDC, Nunes da Silva E, Carregaro RL, Miasso AI. Economic burden of depression in Brazil: a cost-of-illness study based on productivity losses and healthcare costs between 2010 to 2018. Expert Rev Pharmacoecon Outcomes Res. 2023;23(2):181–9.

7. Greenberg PE, Fournier AA, Sisitsky T, Pike CT, Kessler RC. The economic burden of adults with major depressive disorder in the United States (2005 and 2010). J Clin Psychiatry. 2015;76(02):155–62.
8. Greenberg PE, Fournier AA, Sisitsky T, Simes M, Berman R, Koenigsberg SH, et al. The economic burden of adults with major depressive disorder in the United States (2010 and 2018). Pharmacoeconomics. 2021;39(6):653–65.
9. Vieta E, Alonso J, Pérez-Sola V, Roca M, Hernando T, Sicras-Mainar A, et al. Epidemiology and costs of depressive disorder in Spain: the EPICO study. Eur Neuropsychopharmacol. 2021;50:93–103.
10. Lopez-Saavedra J, Abad-Santos F. Cost-effectiveness of pharmacogenetic screening in the management of major depressive disorder in the Spanish healthcare system. J Affect Disord. 2024;365:597–605.
11. Mallett J, Redican E, Doherty AS, Shevlin M, Adamson G. Depression trajectories among older community dwelling adults: results from the Irish Longitudinal Study on Ageing (TILDA). J Affect Disord. 2022;298:345–54. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032721011964.
12. Sialino LD, van Oostrom SH, Wijnhoven HAH, Picavet S, Verschuren WMM, Visser M, et al. Sex differences in mental health among older adults: investigating time trends and possible risk groups with regard to age, educational level and ethnicity. Aging Ment Health. 2021;25(12):2355–64. Available from: https://www.tandfonline.com/doi/full/10.1080/13607863.2020.1847248.
13. Madero-Cabib I, Azar A, Guerra J. Simultaneous employment and depressive symptom trajectories around retirement age in Chile. Aging Ment Health. 2022;26(6):1143–52. Available from: https://www.tandfonline.com/doi/full/10.1080/13607863.2021.1929065.
14. Luo M, Li L, Liu Z, Li A. Sociodemographic dynamics and age trajectories of depressive symptoms among adults in mid- and later life: a cohort perspective. Aging Ment Health. 2023;27(1):18–28. Available from: https://www.tandfonline.com/doi/full/10.1080/13607863.2021.2010182.
15. Yang B, He H, Nie Q, Yang Y. Exploring the relationship between depression and multimorbidity in Chinese middle-aged and older people based on propensity score matching. J Psychosom Res. 2023;174:111490. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0022399923003471.
16. Best JR, Gan DRY, Wister AV, Cosco TD. Age and sex trends in depressive symptoms across middle and older adulthood: comparison of the Canadian longitudinal study on aging to American and European cohorts. J Affect Disord. 2021;295:1169–76. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032721009149.
17. Zhang B, Lin Y, Hu M, Sun Y, Xu M, Hao J, et al. Associations between trajectories of depressive symptoms and rate of cognitive decline among Chinese middle-aged and older adults: an 8-year longitudinal study. J Psychosom Res. 2022;160:110986. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0022399922002719.
18. Chen C, Lee I, Su Y, Mullan J, Chiu H. The longitudinal relationship between mental health disorders and chronic disease for older adults: a population-based study. Int J Geriatr Psychiatry. 2017;32(9):1017–26. Available from: https://onlinelibrary.wiley.com/doi/10.1002/gps.4561.
19. Leung J, Fan VS, Mahadevan R. How do different chronic condition comorbidities affect changes in depressive symptoms of middle aged and older adults? J Affect Disord. 2020;272:46–9. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032719321081.
20. Meesters J, Bergman S, Haglund E, Jacobsson L, Petersson I, Bremander A. Prognostic factors for change in self-reported anxiety and depression in spondyloarthritis patients: data from the population-based SpAScania cohort from southern Sweden. Scand J Rheumatol. 2018;47(3):185–93. Available from: https://www.tandfonline.com/doi/full/10.1080/03009742.2017.1350744.
21. Wu T, Li C, Zhu Y, Ma Y, Hua R, Zhong B, et al. The trajectories of depressive symptoms and subsequent incident dementia, coronary heart diseases, stroke and all-cause mortality. J Affect Disord. 2022;312:9–16. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032722006541.
22. Zhang W, Wang T, Wang A. Impact of physical activity intensity on longitudinal trajectories of cognitive function and depressive symptoms in middle-aged and older Chinese adults: eight-year prospective study. J Affect Disord. 2022;315:64–9. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032722007741.
23. Cheval B, Maltagliati S, Saoudi I, Fessler L, Farajzadeh A, Sieber S, et al. Physical activity mediates the effect of education on mental health trajectories in older age. J Affect Disord. 2023;336:64–73. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032723006936.
24. Feter N, Rocha JQS, Leite JS, Delpino FM, Caputo EL, Cassuriaga J, et al. Using digital platform for physical activity practice attenuated the trajectory of depressive symptoms during the Covid-19 pandemic: findings of the PAMPA cohort. Ment Health Phys Act. 2023;25:100543. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1755296623000418.
25. Sinkewicz M, Rostant O, Zivin K, McCammon R, Clarke P. A life course view on depression: social determinants of depressive symptom trajectories over 25 years of Americans' changing lives. SSM Popul Health. 2022;18:101125. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2352827322001045.
26. Kim W, Kim TH, Lee TH, Ju YJ, Park EC. The effect of childhood and current economic status on depressive symptoms in South Korean individuals: a longitudinal study. Int J Equity Health. 2016;15(1):111. Available from: http://equityhealthj.biomedcentral.com/articles/10.1186/s12939-016-0402-0.
27. Handley TE, Rich J, Lewin TJ, Kelly BJ. The predictors of depression in a longitudinal cohort of community dwelling rural adults in Australia. Soc Psychiatry Psychiatr Epidemiol. 2019;54(2):171–80. Available from: http://link.springer.com/10.1007/s00127-018-1591-1.
28. Liang Y. Heterogeneity in the trajectories of depressive symptoms among elderly adults in rural China: the role of housing characteristics. Health Place. 2020;66:102449. Available from: https://linkinghub.elsevier.com/retrieve/pii/S135382922030736X.
29. Wang J, Wu B, Pei Y, Zhong R. Instrumental support primarily provided by adult children and trajectories of depressive symptoms among older adults with disabilities in rural China. Aging Ment Health. 2023;27(3):646–52. Available from: https://www.tandfonline.com/doi/full/10.1080/13607863.2022.2056140.
30. Yan C, Liao H, Ma Y, Xiang Q, Wang J. Association among multimorbidity, physical disability and depression trajectories: a study of urban–rural differences in China. Qual Life Res. 2021;30(8):2149–60. Available from: https://link.springer.com/10.1007/s11136-021-02807-3.
31. Rossi R, Socci V, Jannini TB, D'Aurizio G, Mensi S, Pacitti F, et al. Changes in mental health outcomes in the general population 14 months into the COVID-19 pandemic in Italy. J Affect Disord. 2023;325:35–40. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032722014732.
32. Pellerin N, Raufaste E, Corman M, Teissedre F, Dambrun M. Psychological resources and flexibility predict resilient mental health trajectories during the French covid-19 lockdown. Sci Rep. 2022;12(1):10674. Available from: https://www.nature.com/articles/s41598-022-14572-5.
33. Fancourt D, Steptoe A, Bu F. Psychological consequences of long COVID: comparing trajectories of depressive and anxiety symptoms before and after contracting SARS-CoV-2 between matched long- and short-COVID groups. Br J Psychiatry. 2023;222(2):74–81. Available from: https://www.cambridge.org/core/product/identifier/S0007125022001556/type/journal_article.
34. Rosa L, Godwin HJ, Cortese S, Brandt V. Predictors of longer-term depression trajectories during the COVID-19 pandemic: a longitudinal study in four UK cohorts. Evid Based Mental Health. 2022;25(4):e3–e3. Available from: https://mentalhealth.bmj.com/lookup/doi/10.1136/ebmental-2022-300461.
35. Lo Coco G, Salerno L, Albano G, Pazzagli C, Lagetto G, Mancinelli E, et al. Psychosocial predictors of trajectories of mental health distress during the COVID-19 pandemic: a four-wave panel study. Psychiatry Res. 2023;326:115262. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165178123002123.
36. Ebrahimi OV, Hoffart A, Johnson SU. Mechanisms associated with the trajectory of depressive and anxiety symptoms: a linear mixed-effects model during the COVID-19 pandemic. Curr Psychol. 2023;42(34):30696–713. Available from: https://link.springer.com/10.1007/s12144-022-02732-9.
37. Mooldijk SS, Dommershuijsen LJ, de Feijter M, Luik AI. Trajectories of depression and anxiety during the COVID-19 pandemic in a population-based sample of middle-aged and older adults. J Psychiatr Res. 2022;149:274–80. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0022395622001248.
38. Zhu J, Zaninotto P, Di Gessa G. Pre-pandemic trajectories of depressive symptomatology and their relation to depression during the COVID-19

pandemic: longitudinal study of English older people. BJPsych Open. 2023;9(6):e195. Available from: https://www.cambridge.org/core/product/identifier/S2056472423005860/type/journal_article.
39. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;169(7):467–73. Available from: https://pubmed.ncbi.nlm.nih.gov/30178033/. Cited 2024 Mar 18.
40. Briggs R, McDowell CP, De Looze C, Kenny RA, Ward M. Depressive symptoms among older adults pre– and post–COVID-19 pandemic. J Am Med Dir Assoc. 2021;22(11):2251–7. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1525861021007830.
41. Johnson MD, Galambos NL, Krahn HJ. Depression and anger across 25 years: changing vulnerabilities in the VSA model. J Family Psychol. 2014;28(2):225–35. Available from: https://doi.apa.org/doi/10.1037/a0036087.
42. Chondros P, Davidson S, Wolfe R, Gilchrist G, Dowrick C, Griffiths F, et al. Development of a prognostic model for predicting depression severity in adult primary patients with depressive symptoms using the diamond longitudinal study. J Affect Disord. 2018;227:854–60. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032717312703.
43. Cheng Y, Thorpe L, Kabir R, Lim HJ. Latent class growth modeling of depression and anxiety in older adults: an 8-year follow-up of a population-based study. BMC Geriatr. 2021;21(1):550. Available from: https://bmcgeriatr.biomedcentral.com/articles/10.1186/s12877-021-02501-6.
44. Shin J, Cho E. Trajectories of depressive symptoms among community-dwelling Korean older adults: findings from the Korean longitudinal study of aging (2006–2016). BMC Psychiatry. 2022;22(1):246. Available from: https://bmcpsychiatry.biomedcentral.com/articles/10.1186/s12888-022-03905-3.
45. Yang G, D'Arcy C. The changing relationship between health risk behaviors and depression among birth cohorts of Canadians 65+, 1994–2014. Front Psychiatry. 2022;13. Available from: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.1078161/full.
46. Luo MS, Li LW. Trajectories of social isolation and depressive symptoms in mid- and later life: a parallel process latent growth curve analysis. Aging Ment Health. 2023;27(11):2211–9. Available from: https://www.tandfonline.com/doi/full/10.1080/13607863.2023.2214099.
47. García-Peña C, Wagner FA, Sánchez-García S, Espinel-Bermúdez C, Juárez-Cedillo T, Pérez-Zepeda M, et al. Late-life depressive symptoms: prediction models of change. J Affect Disord. 2013;150(3):886–94. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032713003650.
48. Malhotra R, Chei CL, Menon E, Chow WL, Quah S, Chan A, et al. Short-term trajectories of depressive symptoms in stroke survivors and their family caregivers. J Stroke Cerebrovasc Dis. 2016;25(1):172–81. Available from: https://linkinghub.elsevier.com/retrieve/pii/S105230571500498X.
49. Rote S, Chen N, Markides K. Trajectories of depressive symptoms in elderly Mexican Americans. J Am Geriatr Soc. 2015;63(7):1324–30. Available from: https://agsjournals.onlinelibrary.wiley.com/doi/10.1111/jgs.13480.
50. Opie R, Abbott G, Crawford D, Ball K. Exploring the associations of depressive symptoms with healthy eating self-efficacy over time amongst women in the READI cohort study. Int J Behav Nutr Phys Act. 2021;18(1):161. Available from: https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-021-01233-5.
51. Lee J. Trajectories of mental health across baby boomers: latent growth curve modeling for depression. Soc Work Ment Health. 2020;18(1):96–120. Available from: https://www.tandfonline.com/doi/full/10.1080/15332985.2019.1683674.
52. Gomaa H, Baweja R, Mukherjee D, He F, Pearl AM, Waschbusch DA, et al. Transdiagnostic and functional predictors of depression severity and trajectory in the Penn state psychiatry clinical assessment and rating evaluation system (PCARES) registry. J Affect Disord. 2022;298:86–94. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032721011307.
53. Solis EC, van Hemert AM, Carlier IVE, Wardenaar KJ, Schoevers RA, Beekman ATF, et al. The 9-year clinical course of depressive and anxiety disorders: new NESDA findings. J Affect Disord. 2021;295:1269–79. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0165032721009137.
54. Um J, Park J, Lee DE, Ahn JE, Baek JH. Machine learning models to identify individuals with imminent suicide risk using a wearable device: a pilot study. Psychiatry Investig. 2025;22(2):156–66.
55. Elnaggar K, El-Gayar M, Elmogy M. Depression detection and diagnosis based on electroencephalogram (EEG) analysis: a comprehensive review. Diagnostics. 2025;15(2):210.
56. Song S, Seo Y, Hwang S, Kim HY, Kim J. Digital phenotyping of geriatric depression using a community-based digital mental health monitoring platform for socially vulnerable older adults and their community caregivers: 6-week living lab single-arm pilot study. JMIR Mhealth Uhealth. 2024;17(12):e55842.
57. Li E, Ai F, Tian Q, Yang H, Tang P, Guo B. Develop and validate machine learning models to predict the risk of depressive symptoms in older adults with cognitive impairment. BMC Psychiatry. 2025;25(1):219.
58. Patel J, Hung C, Katapally TR. Evaluating predictive artificial intelligence approaches used in mobile health platforms to forecast mental health symptoms among youth: a systematic review. Psychiatry Res. 2025;343:116277.
59. Haque MDR, Rubya S. An overview of chatbot-based mobile mental health apps: insights from app description and user reviews. JMIR Mhealth Uhealth. 2023;22(11):e44838.
60. Liu H, Peng H, Song X, Xu C, Zhang M. Using AI chatbots to provide self-help depression interventions for university students: a randomized trial of effectiveness. Internet Interv. 2022;27:100495.
61. Zhong W, Luo J, Zhang H. The therapeutic effectiveness of artificial intelligence-based chatbots in alleviation of depressive and anxiety symptoms in short-course treatments: a systematic review and meta-analysis. J Affect Disord. 2024;356:459–69.
62. Li H, Zhang R, Lee YC, Kraut RE, Mohr DC. Systematic review and meta-analysis of AI-based conversational agents for promoting mental health and well-being. NPJ Digit Med. 2023;6(1):236.
63. Ahmed A, Hassan A, Aziz S, Abd-alrazaq AA, Ali N, Alzubaidi M, et al. Chatbot features for anxiety and depression: a scoping review. Health Inform J. 2023;29(1):14604582221146720.
64. Abd-Alrazaq A, AlSaad R, Shuweihdi F, Ahmed A, Aziz S, Sheikh J. Systematic review and meta-analysis of performance of wearable artificial intelligence in detecting and predicting depression. NPJ Digit Med. 2023;6(1):84.
65. Lee S, Kim H, Park MJ, Jeon HJ. Current advances in wearable devices and their sensors in patients with depression. Front Psychiatry. 2021;17:12.
66. Fedor S, Lewis R, Pedrelli P, Mischoulon D, Curtiss J, Picard RW. Wearable technology in clinical practice for depressive disorder. N Engl J Med. 2023;389(26):2457–66.
67. Walschots Q, Zarchev M, Unkel M, Kamperman A. Using wearable technology to detect, monitor, and predict major depressive disorder—a scoping review and introductory text for clinical professionals. Algorithms. 2024;17(9):408.
68. Shui X, Xu H, Tan S, Zhang D. Depression recognition using daily wearable-derived physiological data. Sensors. 2025;25(2):567.
69. Yan WJ, Ruan QN, Jiang K. challenges for artificial intelligence in recognizing mental disorders. Diagnostics. 2022;13(1):2.
70. Ahmed A, Aziz S, Alzubaidi M, Schneider J, Irshaidat S, Abu Serhan H, et al. Wearable devices for anxiety & depression: a scoping review. Comput Methods Programs Biomed Update. 2023;3:100095.
71. Blugeot A, Rivat C, Bouvier E, Molet J, Mouchard A, Zeau B, et al. Vulnerability to depression: from brain neuroplasticity to identification of biomarkers. J Neurosci. 2011;31(36):12889–99.
72. Goerigk S, Cretaz E, Sampaio-Junior B, Vieira ÉLM, Gattaz W, Klein I, et al. Effects of tDCS on neuroplasticity and inflammatory biomarkers in bipolar depression: results from a sham-controlled study. Prog Neuropsychopharmacol Biol Psychiatry. 2021;105:110119.
73. Jiao W, Lin J, Deng Y, Ji Y, Liang C, Wei S, et al. The immunological perspective of major depressive disorder: unveiling the interactions between central and peripheral immune mechanisms. J Neuroinflammation. 2025;22(1):10.
74. Lengvenyte A, Cognasse F, Hamzeh-Cognasse H, Sénèque M, Strumila R, Olié E, et al. Baseline circulating biomarkers, their changes, and subsequent suicidal ideation and depression severity at 6 months: a prospective analysis in patients with mood disorders. Psychoneuroendocrinology. 2024;168:107119.
75. Li K, Wang K, Xu SX, Xie XH, Tang Y, Zhang L, et al. Investigating neuroplasticity changes reflected by BDNF levels in astrocyte-derived extracellular vesicles in patients with depression. Int J Nanomedicine. 2024;19:8971–85.

76. Paribello P, Manchia M, Pinna F, Isayeva U, Squassina A, Pisanu C, et al. Pharmacokinetic markers of clinical outcomes in severe mental illness: a systematic review. Int J Mol Sci. 2023;24(5):4776.
77. Manchia M, Isayeva U, Collu R, Primavera D, Deriu L, Caboni E, et al. Converging evidence points to BDNF as biomarker of depressive symptoms in schizophrenia-spectrum disorders. Brain Sci. 2022;12(12):1666.
78. Primavera D, Manchia M, Deriu L, Tusconi M, Collu R, Scherma M, et al. Longitudinal assessment of brain-derived neurotrophic factor in Sardinian psychotic patients (LABSP): a protocol for a prospective observational study. BMJ Open. 2017;7(5):e014938.
79. Isayeva U, Manchia M, Collu R, Primavera D, Deriu L, Caboni E, et al. Exploring the association between brain-derived neurotrophic factor levels and longitudinal psychopathological and cognitive changes in Sardinian psychotic patients. Eur Psychiatry. 2022;65(1):e71.
80. Polyakova M, Stuke K, Schuemberg K, Mueller K, Schoenknecht P, Schroeter ML. BDNF as a biomarker for successful treatment of mood disorders: a systematic & quantitative meta-analysis. J Affect Disord. 2015;174:432–40.
81. Zelada MI, Garrido V, Liberona A, Jones N, Zúñiga K, Silva H, et al. Brain-Derived Neurotrophic Factor (BDNF) as a predictor of treatment response in Major Depressive Disorder (MDD): a systematic review. Int J Mol Sci. 2023;24(19):14810.
82. Baune BT, Minelli A, Carpiniello B, Contu M, DomínguezBarragán J, Donlo C, et al. An integrated precision medicine approach in major depressive disorder: a study protocol to create a new algorithm for the prediction of treatment response. Front Psychiatry. 2024;16:14.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.