Prevalence and determinants of depression among old age: a systematic review and meta-analysis

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Abstract

Background: Depression is a leading cause of disability worldwide and is a major contributor to the overall global burden of disease. It is also one of the most common geriatric psychiatric disorders and a major risk factor for disability and mortality in elderly patients. Even though depression is a common mental health problem in the elderly population, it is undiagnosed in half of the cases. Several studies showed different and inconsistent prevalence rates in the world. Hence, this study aimed to fill the above gap by producing an average prevalence of depression and associated factors in old age.

Objective: This study aims to conduct a systematic review and meta-analysis to provide a precise estimate of the prevalence of depression and its determinants among old age.

Method: A comprehensive search of PubMed, Scopus, Web of sciences, Google Scholar, and Psych-info from database inception to January 2020. Moreover, the reference list of selected articles was looked at manually to have further eligible articles. The random-effects model was employed during the analysis. Stata-11 was used to determine the average prevalence of depression among old age. A sub-group analysis and sensitivity analysis were also run. A graphical inspection of the funnel plots and Egger’s publication bias plot test were checked for the occurrence of publication bias.

Result: A search of the electronic and manual system resulted in 1263 articles. Nevertheless, after the huge screening, 42 relevant studies were identified, including, for this meta-analysis, n = 57,486 elderly populations. The average expected prevalence of depression among old age was 31.74% (95% CI 27.90, 35.59). In the sub-group analysis, the pooled prevalence was higher among developing countries; 40.78% than developed countries; 17.05%), studies utilized Geriatrics Depression Scale-30 (GDS-30); 40.60% than studies that used GMS; 18.85%, study instrument, and studies having a lower sample size (40.12%) than studies with the higher sample; 20.19%.

Conclusion: A high prevalence rate of depression among the old population in the world was unraveled. This study can be considered as an early warning and advised health professionals, health policymakers, and other pertinent stakeholders to take effective control measures and periodic care for the elderly population.

Keywords: Depression, Elderly, Global

Background

The elderly people are matured and experienced persons of any community. Their experience, wisdom, and foresight can be useful for development and progress; they are a valuable asset for any nation [1]. Despite their
invaluable wisdom and insight, the aging of the world’s population is causing extensive economic and social consequences globally [2]. The aging population has increased rapidly over the last decades owing to two significant factors, namely, the reduction in mortality and fertility rates and improved quality of life, leading to an increase in life expectancy worldwide [3–5]. Globally, the number and proportion of people aged 60 years and older in the population are increasing. In 2019, the number of people aged 60 years and older was 1 billion. This number will increase to 1.4 billion by 2030 and 2.1 billion by 2050. By 2050, 80% of all older people will live in low- and middle-income countries [6–8].

A high geriatric population leads to high geriatric psychiatric problems [9]. The elderly, in general, face various challenges that are associated with physical and psychological changes commonly associated with the aging process [10]. The incidence of mental health problems is expected to increase among adults in general as well as in older populations in particular [11].

Depression is a leading cause of disability worldwide and is a major contributor to the overall global burden of disease [12]. It is also one of the most common geriatric psychiatric disorders [13] and a major risk factor for disability and mortality in older patients [14]. Even though depression is a common mental health problem in the elderly population, it is undiagnosed in about 50% of cases. The estimates for the prevalence of depression in the aging differ greatly [15–17]. WHO estimated that the global depressive disorder among older adults ranged between 10 and 20% [18–21]. Among all mentally ill individuals, 40% were diagnosed to have a depressive disorder [22]. People with depressive disorder have a 40% greater chance of premature death than their counterparts [20].

Most of the time, the clinical picture of depression in old age is masked by memory difficulties with distress and anxiety symptoms; however, these problems are secondary to depression [23–25]. Numerous community-based studies showed that older adults experienced depression-related complications [26–30]. Depression amplifies the functional disabilities caused by physical illness, interferes with treatment and rehabilitation, and further contributes to a decline in the physical functioning of a person [31, 32]. It also has an economic impact on older adults due to its significant contribution to the rise of direct annual livelihood costs [33]. Hence, improvement of mental health among people in late life is considered to be medically urgent to prevent an increase in suicides in a progressively aging society.

Although real causes of depression remain not clear, psychological, social, and biological processes are thought to determine the etiology of depression and comorbid psychiatric diagnoses (e.g., anxiety and various personality disorders) [34]. Social scientists, postulating the psychosocial theory, posited that depression could be caused by a lack of interpersonal and communication skills, social support, and coping mechanisms [35]. Old biological theories stated depression is caused by a lack of monoamines in the brain. However, recent theories underscore the role of Brain-derived neurotrophic factor (BDNF) in the pathogenesis of depression [36]. In general, depression in the elderly is the result of a complex interaction of social, psychological, and biological factors [37, 38].

Different factors associated with geriatric depression, such as female sex [39–47], increasing age [37, 40, 41, 44, 46–49], being single or divorced [42], religion [50], lower educational attainment [39–42, 44], unemployment [38, 42], low income [37, 39, 40, 42, 44, 46, 51, 52], low self-esteem [53], childhood traumatic experiences [54], loneliness or living alone [40, 50, 51, 55], social deprivation [45, 46, 56], bereavement [39, 43, 57, 58], presence of chronic illness or poor health status [37, 39, 43–46, 49, 50, 56, 59–64], lack of health insurance [42], smoking habit [48], cognitive impairment [39, 43–47, 61] and a history of depression [43, 44, 47].

Compared with other health services, evidence of depressive disorders tends to be relatively poor. Therefore, the level of its burden among older adults is not well addressed in the world. Lack of adequate evidence about depression in older adults may be a factor that contributes to poor or inconsistent mental health care at the community level [21, 65]. In addition to the poor setting for mental health care services, there are no up-to-date systematic reviews and meta-analysis studies conducted that could vividly show the global prevalence and determinants of depression among old age. Several studies also revealed different and inconsistent prevalence rates in the world. Therefore, this systematic review and meta-analysis aimed to summarize the existing evidence on the prevalence of depression among old age and to formulate possible suggestions for clinicians, the research community, and policymakers.

Methods

Search process
A systematic search of the literature in September 2020 using both international [PubMed, Scopus, Web of sciences, Google Scholar, Psych-info, and national scientific databases] was conducted to identify English language studies, published between August 1994 and January 2020, that examined the prevalence of depression among old age. We searched English keywords of “epidemiology” OR “prevalence” OR “magnitude” OR “incidence” AND “factor” OR “associated factor” OR “risk” OR “risk factor”
OR “determinant”, “depression”, “depressive disorder” OR “major depressive disorder” AND “old age” OR “elderly” OR “geriatrics”, “community”, “hospital” and “global”. In addition, the reference lists of the studies were manually checked to obtain further studies.

Inclusion and exclusion criteria
Original quantitative studies that examined the prevalence and determinants of depression among old age were included. The included studies were randomized controlled trials, cohort, case–control, cross-sectional, articles written in English, full-text articles, and published between August 1994 and January 2020. The exclusion criteria were studies which published as review articles, qualitative studies, brief reports, letter to the editor or editorial comments, working papers articles published in a language other than English, researches conducted in non-human subjects, and studies having duplicate data with other studies. The literature search was conducted based on the PRISMA (preferred reporting items for systematic reviews and meta-analyses) guideline [66]. All articles were independently reviewed by four researchers against inclusion and exclusion criteria. Any initial disagreement was resolved.

Data extraction and appraisal of study quality
After eliminating the duplicates, four investigators reviewed study titles and abstracts for eligibility. If at least one of them considered an article as potentially eligible, the full texts were assessed by the same reviewers. Any disagreements were resolved by discussion. Detailed information on the country, data source, study population, and results were extracted from each included study into a standardized spreadsheet by two authors and checked by the other two authors. EndNote X7.3.1 was used to organize the identified articles. Two investigators independently assessed the risk of bias of each of the included studies. The quality of studies included in the final analysis was evaluated with the Newcastle Ottawa quality assessment checklist [67]. The components of the quality assessment checklist include study participants and setting, research design, recruitment strategy, response rate, representativeness of the sample, the convention of valid measurement, reliability of measurement, and appropriate statistical analyses.

Statistical analysis
The data were analyzed with STATA 12.0 [68]. Prevalence standard errors were calculated using the standard formula for proportions: \( \sqrt{\frac{p(1-p)}{n}} \); The heterogeneity across the studies in proportion of depression in the elderly population and the contribution of studies attributing to total heterogeneity was estimated by the I^2 statistic. The point estimates from each study were combined using a random-effects meta-analysis model to obtain the overall estimate with the DerSimonian–Laird method. Sources of heterogeneity across studies were examined with meta-regression. Publication bias and small study effects were assessed with the Egger test.

Results
Search result
The search procedure primarily obtained \( n=1263 \) results, which after reading the title and abstract, full-text, and the application of the inclusion and exclusion criteria were reduced to \( n=42 \). The selection process is shown in Fig. 1.

Characteristics of the study subjects
A total of 42 studies [38, 42, 50, 57, 69–105] studied our outcome of interest; A total sample size of fifty-seven thousand four hundred and eighty-six (57,486) elderly populations were included in the present study. The geographical province of studies was assessed. We found: Six studies in India [72, 86, 94, 95, 98, 102], five studies in China [50, 77, 84, 89], three studies in Turkey [71, 82, 105], three studies in Nepal [76, 90, 97], three studies in Thailand [70, 75, 83], two studies in the USA [91, 100], two studies in Australia [57, 99], two studies in Malaysia [42, 96], two studies in Ethiopia [81, 93], one study in German [103], one study in the UK [104], one study in Norway [85], one study in Italy [79], one study in Japan [87], one study in Mexico [78], one study in Brazil [92], one study in Finland [74], one study in Singapore [101], one study in Saudi Arabia [69], one study in the United Arab Emirates [80], one study in Ghana [88], one study in Sudan [73] and one study in Egypt [38]. Most of the studies in the present analysis were cross-sectional [38, 42, 50, 57, 69–79, 81, 82, 84–90, 92, 93, 95–98, 101–103, 105] and four studies were Cohort [85, 94, 99, 104].

Sixteen studies [70, 73, 74, 81, 86, 88, 90, 92–94, 97, 98, 102–105] used Geriatric Depression Scale-15 (GDS-15), 12 studies [38, 69, 71, 72, 75–77, 82, 84, 89, 96] used Geriatric Depression Scale-30 (GDS-30), four studies [50, 80, 83, 101] used Geriatric Mental State Schedule (GMS) and ten studies [42, 57, 78, 79, 85, 87, 91, 95, 99, 100] used others (ICD-10, CIDI, DASS-21, KICA, CES-D, Euro-D, DSM-III, MCS and HADS) tools to measure depression in old age (Table 1).

Quality of included studies
The quality of 42 studies [38, 42, 50, 57, 69–105] was assessed with the modified Newcastle Ottawa quality assessment scale. This scale divides the total quality score into 3 ranges; a score of 7 to 10 as very good/good, a score of 5 to 6 as having satisfactory quality, and a quality
score less than 5 as unsatisfactory. The majority (28 from the 42 studies) had scored good quality, nine had a satisfactory quality, and four of the studies had unsatisfactory quality.

The prevalence of depression among old age
The reported prevalence of elderly depression among 42 studies [38, 42, 50, 57, 69–105] included in this study ranges from 7.7% in a study from Malaysia and Australia [57, 96] to 81.1% in India [72]. The average prevalence of depression among old age using the random effect model was found to be 31.74% (95% CI 27.90, 35.59). This average prevalence of depression was with the heterogeneity of \( I^2 = 100\% \) \(, p \text{ value} = 0.000 \) from the difference between the 42 studies (Fig. 2).

Subgroup analysis of the prevalence of depression among old age
A subgroup analysis was done considering the economic status of countries, the study instrument and the sample size of each study. The cumulative prevalence of depression in elderly population among developing countries; 40.78% [38, 42, 69–73, 75, 76, 78, 81–83, 86, 88, 90, 92–98, 101, 102, 105] was higher than the prevalence in developed countries; 17.05% [50, 57, 74, 77, 79, 80, 84, 85, 87, 89, 91, 99, 100, 103, 104] (Fig. 3). The
| Author, year of publication | Country                  | Study design | Sample size | Tools with cut off points | Sampling technique | Response rate | Characteristics of respondents | Overall prevalence (%) |
|-----------------------------|--------------------------|--------------|-------------|----------------------------|-------------------|---------------|-------------------------------|------------------------|
| Boman et al. 2015           | Anland, Finnish          | CS           | 1452        | GDS-15 ≥ 5                 | NR                | 93.5%         | F ≥ 65 years                   | 11.2                   |
| Guzel et al. 2020           | Burdur, Turkey           | CS           | 770         | GDS-30 ≥ 14                | Cluster sampling  | NR            | M & F ≥ 65 years               | 51.8                   |
| Swarnalatha N et al. 2013   | Chittoor District, India | CS           | 400         | GDS-15 > 5                 | Random sampling   | 100%          | M & F ≥ 60 years               | 47                     |
| Ashe et al. 2019            | Cuttack district, India  | CS           | 354         | GDS-30 ≥ 10                | Simple random sampling | 97.5%         | M & F ≥ 60 years               | 81.1                   |
| Girma et al. 2016           | Harar, Ethiopia          | CS           | 344         | GDS-15 ≥ 5                 | Systematic random sampling technique | 97.7%         | M & F ≥ 60 years               | 28.5                   |
| Mirkena et al. 2018         | Ambo, Ethiopia           | CS           | 800         | GDS-15 ≥ 5                 | Multi-stage sampling technique | 94.8%         | M & F ≥ 60 years               | 41.8                   |
| He et al. 2016              | Rural China              | CS           | 509         | GDS-30 ≥ 11                | NR                | 96.8%         | M & F > 65 years               | 36.94                  |
| Cong et al. 2015            | Fuzhou, China            | CS           | 1910        | GDS-30 ≥ 11                | Randomly selected | 98.0%         | M & F > 65 years               | 10.5                   |
| Feng et al. 2014            | Xinjiang, China          | CS           | 1329        | GMS ≥ 3                    | Multistage random sampling technique | 91.3%         | M & F > 60 years               | 10.61                  |
| Kugbey et al. 2018          | Ghana                    | CS           | 262         | GDS-15 ≥ 5                 | Stratified random sampling | 100%          | M & F > 65 years               | 37.8                   |
| Rajkumar et al. 2009        | Southern Indian, Tamil Nadu | CS          | 978         | ICD-10                     | NR                | 97.75%        | M & F > 65 years               | 12.7                   |
| Choulagai P S et al. 2013   | Kathmandu Valley, Nepal  | CS           | 78          | GDS-30 ≥ 10                | Purposively selected | 100%          | M & F > 65 years               | 51.3                   |
| Simkhada et al. 2017        | Kathmandu, Nepal         | CS           | 300         | GDS-15 ≥ 5                 | Randomly selected | 99.0%         | M & F > 60 years               | 60.6                   |
| Manandhar et al. 2019       | Kavre district, Nepal    | CS           | 439         | GDS-15 ≥ 6                 | Randomly selected | 95.4%         | M & F > 60 years               | 53.1                   |
| Arslantas et al. 2014       | Middle Anatolia, Turkey  | CS           | 203         | GDS-30 ≥ 13                | NR               | 80.8%         | M & F > 65 years               | 45.8                   |
| Yaka et al. 2014            | Turkey                   | CS           | 482         | GDS-15 ≥ 8                 | Cluster sampling method | 100%          | M & F > 65 years               | 18.5                   |
| Charoenakulchai et al. 2019 | Thailand                 | CS           | 416         | GDS-30 ≥ 13                | NR               | 100%          | M & F > 60 years               | 18.5                   |
| Forlani et al. 2012         | Bologna, Italy           | CS           | 359         | ICD-10                     | Randomly chosen sample | 100%          | M & F > 74 years               | 25.1                   |
| Wilson et al. 2007          | UK                       | Cohort       | 376         | GDS-15 ≥ 5                 | NR               | 100%          | M & F 80 to 90 years           | 21                     |
| Steffens et al. 2009        | USA                      | Cohort       | 775         | CIDI-SF ≥ 5                | Stratified sampling method | 90.5%         | M & F > 71 years               | 11.19                  |
| Manaf et al. 2016           | Perak, Malaysia          | CS           | 230         | DASS-21 ≥ 5                | Convenient sampling | 100%          | M & F > 60 years               | 27.8                   |
| Almeida et al. 2014         | Kimberley and Derby, Australia | CS          | 235         | KICA-dep ≥ 9               | NR               | 94.0%         | M & F ≥ 45 years               | 7.7                    |
| Weyerer et al. 2008         | German                   | CS           | 3242        | GDS-15 ≥ 6                 | NR               | 100%          | M & F ≥ 75 years               | 9.7                    |
| Jadav et al. 2017           | Vadodara, Gujarat, India | CS           | 176         | GDS-15 ≥ 5                 | Simple random sampling | 88%           | M & F ≥ 60 years               | 34.1                   |
| Sinha et al. 2013           | Tamil Nadu, India        | CS           | 103         | GDS-15 ≥ 5                 | Universal sampling technique | 100%          | M & F ≥ 60 years               | 42.7                   |
average prevalence of depression was 40.60% in studies that used GDS-30 [38, 69, 71, 72, 75–77, 82, 84, 89, 96] which is higher than the prevalence in studies that utilized GDS-15;35.72% [70, 73, 74, 81, 86, 88, 90, 92–94, 97, 98, 102–105], GMS;18.85% [50, 80, 83, 101] and other tools;19.91% [42, 57, 78, 79, 85, 87, 91, 95, 99, 100] (Fig. 4). Moreover, studies which had a sample size of below 450 [38, 42, 57, 70–73, 75, 76, 79, 81, 86, 88, 90, 92, 94, 96–99, 102, 104] provided higher prevalence of depression; 40.12% than those who had a sample size ranges from 450 to 999 [74, 80, 82, 84, 85, 91, 93, 95, 100, 105]; 25.38% and above 1000 [50, 69, 74, 77, 78, 83, 87, 89, 101, 103]; 20.19% (Fig. 5).

Sensitivity analysis

The sensitivity analysis was performed to identify whether one or more of the 42 studies had out-weighted the average prevalence of depression among old age. However, the result showed that there was no single influential study, since the 95% CI interval result was obtained when each of the 42 studies was excluded at a time (Fig. 6).
Publication bias
There was no significant publication bias detected and Egger’s test $p$ value was ($p = 0.644$) showing the absence of publication bias for the prevalence of depression among old age. This was also supported by asymmetrical distribution on the funnel plot for a Logit event rate of prevalence of depression among old age against its standard error (Fig. 7).

Factors associated with depression among old age
Among 42 studies [38, 42, 50, 57, 69–105] included in the present meta-analysis, only 32 [38, 42, 50, 57, 69, 72, 73, 75, 77–81, 83, 84, 86–98, 101–105] reported about the associated factors for depression among old age. Our qualitative synthesis for the sociodemographic factors associated with depression in elderly populations
showed that female gender [38, 69, 72, 75, 80, 86, 89, 93, 98, 102, 105], age older than 75 years [38, 69, 101, 102], being single, divorced or widowed [38, 42, 69, 80, 81, 87, 89, 98, 105], being unemployed [69, 86, 96, 105], retired [95], no educational background [75, 81, 86, 89, 90, 97, 102], OR low level of education [69, 81, 84, 91, 92, 105], low level of income [69, 72, 78, 80, 94, 95, 105], substance use [75, 81, 103], poverty [95, 102],
Injury, such as diabetes, heart diseases, stroke and head

cognitive impairment [81, 103], presence of physical ill-

can be associated with daily life activities [81, 83, 84, 86–89, 95, 97, 106],

caregivers were living alone [88, 102, 104], disturbed sleep [77, 89], lack of

![Fig. 4](image)

Fig. 4 Sub-group analysis of depression based on study instruments
Fig. 5 Sub-group analysis of depression based on sample size of studies

or more serious life events [72, 83, 96], poor daily physical exercise [89] and exposure to verbal and/or physical abuse were strongly and positively associated with depression [90] (Table 2).
Discussion
As to the researcher’s knowledge, this review and meta-analysis on the prevalence and determinants of depression among old age are the first of their kind in the world. Therefore, the knowledge generated from this meta-analysis on the pooled prevalence and associated factors for depression among old age could be important evidence to different stakeholders aiming to plan policy in the area. The average prevalence of depression among old age using the random effect model was found to be 31.74%. A subgroup analysis was done considering the economic status of countries, the study instrument, and the sample size of each study.

In the present systematic review and meta-analysis, the existing available information varies by the region, where the study was conducted, data collection tools used to screen depression, and the sample size assimilated in the study. Sixty-two percent ($n=26$) of the studies were found in developing countries. About 38% ($n=16$) of the incorporated studies utilized GDS-15 to screen depression, around 28% ($n=12$) studies used GDS-30 to screen depression, ten percent ($n=4$) studies used GMS to screen depression, whereas the rest utilized other tools. More than half ($n=22$) of the included studies utilized a sample size of below 450.

The result of this meta-analysis revealed that depression in the elderly populations in the world was high (31.74%). This pooled prevalence of depression among old age in the world (31.74%; 95% CI 27.90 to 35.59%) was higher than a global systematic review and meta-analysis study on 95,073 elderly populations aged > 75 years and 24 articles in which a pooled prevalence of depression was 17.1% (95% CI 9.7 to 26.1%) [107], a global systematic review and meta-analysis study on 41,344 outpatients and 83 articles in which a pooled prevalence of depression was 27.0% (95% CI: 24.0% to 29.0%) [108], WHO reports on mental health of older adults over 60 years old with 7% prevalence of depression in the general older population [106], a Brazilian systematic review and meta-analysis study on 15,491 community-dwelling elderly people average age 66.5 to 84.0 years and 17 articles with a pooled prevalence rates of 7.0% for major depression, 26.0% for CSDS (clinically significant depressive symptoms), and 3.3% for dysthymia [109] and an Iranian meta-analysis study on 3948 individuals aged 50 to 90 years and 13 articles with a pooled prevalence rates of 7.0% for major depression, 26.0% for CSDS (clinically significant depressive symptoms), and 3.3% for dysthymia [109] and an Iranian meta-analysis study on 3948 individuals aged 50 to 90 years and 13 articles with a pooled prevalence rates of 7.0% for major depression, 26.0% for CSDS (clinically significant depressive symptoms), and 3.3% for dysthymia [109] and an Iranian meta-analysis study on 3948 individuals aged 50 to 90 years and 13 articles with a pooled prevalence of severe depression was 8.2% (95% CI 4.14 to 6.3%) [110]. The reason for such a high prevalence of depression in the globe would be due to the difference in sample size, study subjects, the severity of depression, study area, study instruments, and the means of administration of the tools employed in the studies [111].

In contrast to our current systematic review and meta-analysis study, the pooled prevalence of depression was lower than a Chinese Meta-Analysis of Observational Studies on 36,791 subjects and 46 articles with a pooled prevalence of depression was 38.6% (95% CI 31.5–46.3%) [112], and an Indian systematic review and meta-analysis study on 22,005 study subjects aged 60 years and above,
## Table 2: Associated factors for depression among elderly populations

| Factor category                          | Associated factors                                      | AOR  | 95% CI  | Strength of association | Author, year of publication |
|------------------------------------------|---------------------------------------------------------|------|---------|-------------------------|-----------------------------|
| Demography                               | >80 years                                               | NR   | NR      | NR                      | Swarnalatha et al. 2013     |
|                                          | Females                                                 | NR   | NR      | NR                      |                             |
|                                          | Illiterates                                             | NR   | NR      | NR                      |                             |
| Socioeconomic status                     | Those who were below the poverty line                   | NR   | NR      | NR                      |                             |
|                                          | Those who were living alone                             | NR   | NR      | NR                      |                             |
| Economic dependency                      | Those who were economically partially dependent         | NR   | NR      | NR                      |                             |
| ADL                                      | Those depended totally for the activities of daily living| NR   | NR      | NR                      |                             |
| Sociodemographic characteristics         | Female gender                                           | 4.75 | 2.1, 10.7| Strong                 | Ashe et al. 2019            |
|                                          | Low socioeconomic class                                 | 9.36 | 3.69, 23.76| Strong                |                             |
| Health conditions and comorbidities      | Diabetes mellitus                                       | 2.76 | 1.27, 5.98| Moderate               |                             |
|                                          | Hypertension                                            | 2.15 | 1.06, 4.36| Moderate               |                             |
| Life events                              | Death in family members                                 | 5.52 | 2.08, 14.65| Strong                |                             |
|                                          | Conflicts in family                                     | 5.78 | 2.55, 13.09| Strong                |                             |
|                                          | Chronic illness in family members                       | 6.77 | 1.47, 31.13| Strong                |                             |
| Socio-demographic characteristics        | Not married                                             | 10.1 | 3.89, 26.18| Strong                | Girma et al. 2016           |
|                                          | Those with no formal education                          | 3.6  | 1.45, 9.07| Strong                |                             |
|                                          | Elderly who attended primary school                     | 0.28 | 0.1, 0.78 | Weak                  |                             |
| Substance use and clinical related       | Those who had chronic illness                           | 3.47 | 1.5, 7.7 | Strong                |                             |
|                                          | Elderly with cognitive impairments                      | 2.77 | 1.18, 6.47| Moderate              |                             |
|                                          | Substance use                                           | 2.6  | 1.07, 6.28| Moderate              |                             |
| Socio-demographic characteristics        | Female sex                                              | 1.72 | 1.12, 2.66| Weak                  | Mirkena et al. 2018         |
|                                          | Trading                                                 | 2.44 | 1.32, 4.57| Moderate              |                             |
|                                          | Living with children                                    | 3.19 | 1.14, 8.93| Strong                |                             |
|                                          | Retirement                                              | 3.94 | 2.11, 7.35| Strong                |                             |
| Characteristics of the participants      | Frequency of children’s visits                          | NR   | NR      | NR                      | He et al. 2016              |
|                                          | Living situation                                        | NR   | NR      | NR                      |                             |
|                                          | Physical activity                                       | NR   | NR      | NR                      |                             |
|                                          | Number of chronic diseases                              | NR   | NR      | NR                      |                             |
|                                          | Education level                                         | NR   | NR      | NR                      |                             |
| Demographic characteristics              | Lack of social engagement                               | 0.313| 0.134, 0.731| Weak                 | Cong et al. 2015            |
|                                          | Low family support                                      | 0.431| 0.292, 0.636| Weak                |                             |
|                                          | Chronic disease                                         | 2.378| 1.588, 3.561| Moderate             |                             |
|                                          | Disturbed sleep                                         | 1.822| 1.187, 2.798| Weak                 |                             |
| Behaviors and life events                | Religious belief                                        | 3.92 | 1.18, 13.03| Strong                | Feng et al. 2014            |
|                                          | Suffering from more chronic diseases                    | 1.70 | 1.42, 2.04| Weak                  |                             |
|                                          | Lack of ability to take self-care                       | 2.20 | 1.09, 4.48| Moderate              |                             |
| Socio-demographic characteristics        | Religion (Non-Christians)                               | 5.67 | 2.10, 15.27| Strong                | Kugbey et al. 2018          |
|                                          | Living arrangement (Alone)                              | 2.36 | 1.16, 4.83| Moderate              |                             |
|                                          | Chronic illness (Not having chronic illness)            | 0.25 | 0.13, 0.47| Weak                  | Rajkumar et al. 2009        |
| Socio-demographic and psychosocial profiles | Low income                                             | 1.78 | 1.08, 2.91| Weak                  | Rajkumar et al. 2009        |
|                                          | Experiencing hunger                                     | 2.58 | 1.56, 4.26| Moderate              |                             |
|                                          | History of cardiac illnesses                            | 4.75 | 1.96, 11.52| Strong                |                             |
|                                          | Transient ischemic attack                               | 2.43 | 1.17–5.05| Moderate              |                             |
|                                          | Past head injury                                        | 2.70 | 1.36, 5.36| Moderate              |                             |
|                                          | Diabetes                                                | 2.33 | 1.15, 4.72| Moderate              |                             |
|                                          | Having more confidants                                  | 0.13 | 0.06, 0.26| Weak                  |                             |
Table 2 (continued)

| Factor category | Associated factors                                      | AOR  | 95% CI       | Strength of association | Author, year of publication  |
|-----------------|---------------------------------------------------------|------|--------------|--------------------------|-----------------------------|
| Socio-demographic characteristics | Illiteracy                                              | 2.01 | 1.08, 3.75   | Moderate                 | Simkhada et al. 2017        |
|                  | Physical immobility                                     | 5.62 | 1.76, 17.99  | Strong                   |                             |
|                  | The presence of physical health problems               | 1.97 | 1.03, 3.77   | Weak                     |                             |
|                  | Not having any time spent with family members          | 3.55 | 1.29, 9.76   | Strong                   |                             |
|                  | Not being considered in family decision-making        | 4.02 | 2.01, 8.04   | Strong                   |                             |
| Socio-demographic characteristics | Rural habitation                                        | 1.6  | 1.1, 2.4     | Weak                     | Manandhar et al. 2019       |
|                  | Illiteracy                                              | 2.1  | 1.1, 4.0     | Moderate                 |                             |
| Family support  | Limited time provided by families                      | 1.8  | 1.1, 2.9     | Weak                     |                             |
|                  | Exposure to verbal and/or physical abuse               | 2.6  | 1.4, 4.8     | Moderate                 |                             |
| Socio-demographic–economic characteristics | Female gender                                          | NR   | NR           | NR                       | Yaka et al. 2014            |
|                  | Being single or divorced                               | NR   | NR           | NR                       |                             |
|                  | Lower educational status                               | NR   | NR           | NR                       |                             |
|                  | Low income                                              | NR   | NR           | NR                       |                             |
|                  | Unemployment                                            | NR   | NR           | NR                       |                             |
|                  | Lack of health insurance                               | NR   | NR           | NR                       |                             |
| Baseline characteristics and family relationship | Female sex                                              | 2.78 | 1.54, 7.49   | Moderate                 | Charoensakulchai et al. 2019|
|                  | Illiteracy                                              | 2.86 | 1.19, 6.17   | Moderate                 |                             |
|                  | Current smoker                                          | 4.25 | 2.12, 10.18  | Strong                   |                             |
|                  | Imbalanced family type (low attachment, low cooperation and poor alignment between each member) | 4.52 | 2.14, 7.86   | Strong                   |                             |
| Sociodemographic characteristics | Not having a main daily activity in men               | 3.01 | 1.00, 9.13   | Strong                   | Forlani et al. 2012         |
| Health-Related Variables | Stroke in men                                          | 7.25 | 2.19, 24.06  | Strong                   |                             |
| Sociodemographic characteristics | Not living close to friends and family                | 2.54 | 1.44, 4.466  | Moderate                 | Wilson et al. 2007          |
|                  | Poor satisfaction with living accommodation            | 0.840| 0.735, 0.961 | Weak                     |                             |
|                  | Poor satisfaction with finances                        | 0.841| 0.735, 0.961 | Weak                     |                             |
|                  | Subsequent development of clinically significant depressive symptoms was associated with base line increased scores in depression | 1.68 | 1.206, 2.341 | Weak                     |                             |
| Socio-demographic characteristics | Single elderly                                         | 3.27 | 1.66, 6.44   | Strong                   | Manaf et al. 2016           |
|                  | Living with family                                      | 4.98 | 2.05, 12.10  | Strong                   |                             |
|                  | Poor general health status                             | 2.28 | 1.20, 4.36   | Moderate                 |                             |
| Clinical characteristics | Heart problems                                          | 3.3  | 1.2, 8.8     | Strong                   | Almeida et al. 2014         |
| ADL             | Functional impairment                                   | 2.9  | 2.26, 3.78   | Moderate                 | Weyerer et al. 2008         |
| Socio-demographic characteristics | Smoking                                                 | 1.6  | 1.03, 2.36   | Weak                     |                             |
|                  | Multi-domain mild cognitive impairment                  | 2.1  | 1.30, 3.43   | Moderate                 |                             |
| Socio-demographic characteristics | Female gender                                          | 10.64| 5.09–21.82   | Strong                   | Jadav et al. 2017           |
|                  | Unemployed/retired                                      | 7.37 | 2.49, 21.79  | Strong                   |                             |
|                  | Illiterate                                              | 4.17 | 1.99, 8.72   | Strong                   |                             |
| Clinical related | Respiratory problems                                    | 5.47 | 2.63, 11.37  | Strong                   |                             |
| Socio-demographic characteristics | Female sex                                              | NR   | NR           | NR                       | Sinha et al. 2013           |
|                  | Widowhood                                               | NR   | NR           | NR                       |                             |
### Table 2 (continued)

| Factor category                                      | Associated factors                                           | AOR  | 95% CI     | Strength of association | Author, year of publication |
|------------------------------------------------------|--------------------------------------------------------------|------|------------|-------------------------|-----------------------------|
| Problems related to social environment              | Having no one to talk to (Mild to moderate depression)       | 3.3  | 2.5, 4.4   | Strong                  | Kaji et al. 2010            |
|                                                      | Having no one to talk to (Severe depression)                 | 5.0  | 3.6, 6.9   | Strong                  |                             |
| Problems with primary support group                 | Separation/divorce(Mild to moderate depression)              | 2.8  | 1.4, 5.3   | Moderate                |                             |
|                                                      | Health/illness/care of self(Severe depression)               | 0.8  | 0.6, 0.9   | Weak                    |                             |
| Socioeconomic characteristics                      | Socioeconomic deprivation at municipal levels                | 1.16 | 1.04, 1.30 | Weak                    | Fernández et al. 2014       |
| Socio-demographic characteristics                   | Poor education                                               | NR   | NR         | NR                      | Al-Shammari et al. 1999     |
|                                                      | Unemployment                                                 | NR   | NR         | NR                      |                             |
|                                                      | Divorced or widowed status                                   | NR   | NR         | NR                      |                             |
|                                                      | Old age                                                      | NR   | NR         | NR                      |                             |
|                                                      | Being a female                                               | NR   | NR         | NR                      |                             |
|                                                      | Living in a remote rural area with poor housing arrangements | NR   | NR         | NR                      |                             |
|                                                      | Limited accessibility within the house and poor interior conditions | NR | NR | NR |                             |
|                                                      | Limited privacy, such as having a particular room specified for the elderly | NR | NR | NR |                             |
|                                                      | Lower incomes inadequate for personal needs as well as depending on charity or other relatives | NR | NR | NR |                             |
| Socio demographic Profile                          | Unemployment                                                 | NR   | NR         | NR                      | Sidik et al. 2004           |
| Socio-demographic Status                            | Aged 75 to 84 years                                          | 2.1  | 1.1, 3.9   | Moderate                | Subramaniam et al. 2016     |
|                                                      | Those of Indian ethnicity                                     | 4.1  | 1.1, 14.9  | Strong                  |                             |
|                                                      | Those of Malay ethnicity                                      | 5.2  | 3.1, 8.7   | Strong                  |                             |
| Other Health Conditions                             | Those who had a history of depression diagnosis by a doctor   | 3.2  | 1.9, 5.4   | Strong                  |                             |
| Socio-demographic characteristics                   | Being retired                                                | 3.88 | 1.27, 11.76| Strong                  | Assil et al. 2013           |
|                                                      | Having social problems                                        | 3.27 | 1.45, 7.41 | Strong                  |                             |
|                                                      | Having living problems                                        | 2.19 | 1.19, 3.94 | Moderate                |                             |
| Physical Illness                                    | Those who had 4 or more infirmity                             | 2.08 | NR         | Moderate                | Haseen et al. 2011          |
| Disability Assessment                               | Those who had medium disability                               | 3.12 | NR         | Strong                  |                             |
| Serious life events                                 | Those who had 3 or more serious life events                   | 5.25 | NR         | Strong                  |                             |
| Socio-demographic characteristics                   | Female gender                                                | 1.8  | NR         | Weak                    | Ghubash et al. 2004         |
|                                                      | Insufficient income                                           | 3.8  | NR         | Strong                  |                             |
|                                                      | Being single, separated, divorced or widowed                  | 2.1  | NR         | Moderate                |                             |
| Socio-demographic Characteristics                   | Age ≥ 75 years                                                | 5.08 | 2.21, 11.89| Strong                  | Abdo et al. 2011            |
|                                                      | Being female                                                 | 2.56 | 1.55, 4.24 | Moderate                |                             |
|                                                      | Not married                                                   | 4.47 | 2.52, 7.97 | Strong                  |                             |
|                                                      | Having previous death event among the surrounding             | 7.68 | 3.57, 16.93| Strong                  |                             |
| Respondent characteristics                          | Years of education                                            | 0.87 | NR         | Weak                    | McCall et al. 2002          |
|                                                      | Difficulties performing activities of daily living            | 1.72 | NR         | Weak                    |                             |
|                                                      | Enrolled in medicaid                                          | 2.67 | NR         | Moderate                |                             |
and 51 articles with a pooled prevalence of depression was 34.4% (95% CI 29.3 to 39.6) [113]. The reason for the discrepancy might be due to the wide coverage of the study and the higher sample size utilized in the present study. Furthermore, differences could be due to the poor health care coverage and significant population makes a destitute life both in China and India. In addition, both China and India have a rapidly aging population. Old age causes enforced retirement which may lead to marginalizing older people. Elders are regarded as incompetent and less valuable by potential employers. This attitude serves as a social stratification between the young and old and can prevent older men and women from fully participating in social, political, economic, cultural, spiritual, civic, and other activities [114–116].

A significant regional variation on the pooled prevalence of depression in the elder population was observed in this review and meta-analysis study. The aggregate prevalence of depression in elderly population among developing countries; 40.78% [38, 42, 57, 70–73, 75, 76, 79, 81, 86, 88, 90, 92, 94, 96–99, 102, 104] than the pooled prevalence of depression in elders that used a sample size of 450–999 (25.38%) [74, 80, 82, 84, 85, 91, 93, 95, 100, 105], and above 1000 (20.19%) [50, 69, 74, 77, 78, 83, 87, 89, 101, 103]. The reason could be a smaller sample size increases the probability of a standard error thus providing a less precise and reliable result with weak power.

Regarding the associated factors; being female, age older than 75 years, being single, divorced or widowed, being unemployed, retired, no educational background, low level of education, low level of income, lack of social support, living with family, current smoker, presence of physical illness, such as diabetes, heart diseases, stroke, and head injury, poor sleep quality, physical immobility and a history of serious life events, such as a death in family members, conflict in the family, chronic illness in family members and those who had 3 or more serious life events were found to have a strong and positive association with depression among old age.

Difference between included studies in the meta-analysis
This meta-analysis study was obtained to have a high degree of heterogeneity between the studies incorporated in pooling the prevalence of depression in the elderly population of the world. The analysis of subgroups for detection of sources of heterogeneity was done and the economic status of the country, where the study was done, data collection instruments, and sample size were identified to contribute to the existing

| Factor category                  | Associated factors                     | AOR | 95% CI   | Strength of association | Author, year of publication |
|----------------------------------|----------------------------------------|-----|----------|--------------------------|-----------------------------|
| Socio-demographic variables      | Being female                           | 1.25| 1.02, 1.54| Weak                     | Li et al. 2016              |
|                                  | Residing in rural or suburb             | 2.31| 1.88, 2.86| Moderate                 |                             |
|                                  | Currently not married or not living with spouse | 1.45| 1.17, 1.80| Weak                     |                             |
|                                  | Poor physical health                    | 5.23| 3.97, 6.88| Strong                   |                             |
|                                  | Poor daily physical exercise            | 1.79| 1.39, 2.29| Weak                     |                             |
|                                  | Poor sleep quality                      | 2.76| 2.14, 3.56| Moderate                 |                             |
| Socio-demographic variables      | Low educational level                   | 5.9 | 1.5, 22.6 | Strong                   | Mendes-Chiloff et al. 2008  |
|                                  | Death                                   | 5.5 | 1.7, 17.1 | Strong                   |                             |
| ADL                              | Dependence regarding basic ADL          | 5.1 | 2.2, 11.0 | Strong                   |                             |
| Socio-demographic variables      | Illiterate or elementary school         | 1.68| 1.2, 2.29 | Weak                     | Li et al. 2016              |
|                                  | Poor physical health                    | 4.49| 3.15, 6.38| Strong                   |                             |
|                                  | Poor daily physical exercise            | 1.51| 1.07, 2.11| Weak                     |                             |
|                                  | Poor sleep quality                      | 3.25| 2.33, 4.53| Strong                   |                             |
| Socio-demographic                | Financial fears regarding future         | NR  | NR       | NR                       | Prashanth et al. 2015       |
|                                  | Income insufficiency                    | NR  | NR       | NR                       |                             |

AOR: Adjusted Odds Ratio; CI: Confidence Interval; NR: Not Reported
variation between the studies incorporated in the analysis. Besides, a sensitivity analysis was performed using the random-effects model to identify the effect of individual studies on the pooled estimate. No significant changes in the pooled prevalence were found on the removal of a single study.

Limitations should be considered when interpreting the results of this study. Screening tools cannot take the place of a comprehensive clinical interview for confirmatory diagnosis of depression. Nevertheless, it is a useful tool for public health programs. Screening provides optimum results when linked with confirmation by mental health experts, treatment, and follow-up. As this meta-analysis included studies done using screening tools, a further meta-analysis done with diagnostic tools will help to assess the true burden of depression and to determine the need for pharmacological and non-pharmacological interventions. Furthermore, because of the lack of access to the full text of some studies, the researchers failed to include these research findings.

Conclusion
This review and meta-analysis study obtained a pooled prevalence of depression in the elderly population in the world to be very high, 31.74% (95% CI 27.90, 35.59). This pooled effect size of depression in the elderly population in the world obtained is very important as it showed aggregated evidence of the burden of depression in the targeted population. Since the high prevalence of depression among the old population in the world, this study can be considered as an early warning and advice to health professionals, health policymakers, and other pertinent stakeholders to take effective control measures and periodic assessment for the elderly population.

Abbreviations
ADL: Activities of daily living; AOR: Adjusted odds ratio; CDEP: Community-dwelling elderly people; CES-D: Center for Epidemiologic Studies Depression Scale; CI: Confidence interval; CIDI-SF: Composite International Diagnostic Interview Short Form; CS: Cross-sectional; DASS-21: Depression, Anxiety, and Stress Scale; DSM-III: Diagnostic and Statistical Manual of Mental Disorders; EMI: Elderly medical inpatients; GDS: Geriatric Depression Scale; GMS: Geriatric Mental State Schedule; HADS: Hospital Anxiety and Depression Scale; KICA-dep: Kimberley Indigenous Cognitive Assessment of Depression; MCS: Mental Component Summary; NR: Not reported; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-analysis; UK: United Kingdom, USA: United States of America; WHO: World Health Organization.

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Declarations

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Not applicable.

Consent for publication
Not Applicable.

Competing interests
The authors have no competing interests to declare.

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