Prevalence of depression among the elderly (60 years and above) population in India, 1997–2016: a systematic review and meta-analysis

Manju Pilania1†, Vikas Yadav2†, Mohan Bairwa3†, Priyamadhaba Behera4*, Shiv Dutt Gupta3, Hitesh Khurana5, Viswanathan Mohan6, Girish Baniya7 and S. Poongothai6

Abstract

Background: There is lack of information on the magnitude of depression among elderly population in India. This systematic review and meta-analysis aimed to estimate the prevalence of depression among elderly population in India.

Methods: PubMed, Scopus, Web of Science, Embase, PsycINFO, IndMed, and Google Scholar were searched to identify articles reported community-based prevalence of depression among elderly population using screening tools. This study included the articles published during the years 1997 to 2016. Studies conducted in the special population groups, hospitals, reported only a subcategory of depression, and not specified the screening tool were excluded. Data were extracted from published reports and any missing information was requested from authors. Estimates were pooled using random-effects meta-analyses. Subgroup and sensitivity analysis were performed. The publication bias was evaluated by using Egger’s test and visual inspection of the symmetry in funnel plots.

Results: Fifty-one studies from 16 States of India were included as 56 datasets, which estimated the prevalence of depression among Indian elderly population as 34.4% (95% CI: 29.3–39.7). In sub-group analysis, the pooled prevalence was higher among females, rural populations, and in the eastern part of the country. Studies using non-probability sampling, and GDS and CES-D screening tool showed higher prevalence. Exclusion of the studies with sample size less than 100 and low-quality studies (score < 5/8) had no effect on the estimate of the prevalence. The studies that excluded dementia before assessment of depression had lower prevalence.

Conclusion: About one third elderly population of India suffered from depression with female preponderance. The estimates varied with type of study tool, geographic region, sampling methods, and presence of dementia. The pooled estimate should be interpreted with caution as the studies included in this review had varied methodological approach and screening tools.

Keywords: Prevalence, Depression, India, Elderly, Systematic review, Meta-analysis

© The Author(s). 2019 Open Access This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated.
Background
Depression is a major mental health problem, which is yet to be recognised as an important public health challenge. About 322 million people affected with depression worldwide [1]. Depression is the single largest contributor to global disability (7.5%, 2015) and a major contributor to suicides (~ 800,000 annually) [2]. In India, elderly persons (60 years and above) constitute 8.6% of the total population (India Census 2011), which is projected to reach 19% by 2050 [3]. Thus, depression among elderly population is likely to be a major cause of disease burden in the future.

Depression is one of the most common illnesses in the elderly population. Among elderly people, chronic diseases, restricted mobility, bereavement, elderly abuse, isolation, and loss of income are major risk factors for depression, in addition to common risk factors in all age groups [4]. Depression in the elderly persons may have a varied presentation and may be difficult to diagnose [5]. It has devastating consequences and contributes significantly to misery in this phase of life [6]. It is associated with increased risk of morbidity, decreased physical, cognitive and social functioning, and greater self-neglect [4, 7]. Depression not only decreases the quality of life but also influence prognosis of other chronic diseases that further aggravates disability [8]. Consequently, elderly persons with depression have significantly higher suicidal and non-suicidal mortality [9]. Early identification and management of depression can improve quality of life. However, healthcare systems in low and middle income countries like India are not resilient enough to deal with mental health problems including depressive disorders [10].

There are no systematically conducted and nationally representative studies in India like China Biobank Study [11], which provide data on disease magnitude to address the nation’s need for developing the policies and strengthening programs [12]. Current epidemiological studies do not provide a solution to this challenge as there is a wide variation in estimated prevalence ranging from 6 to 80% depending on various factors like population studied, screening tool used etc. [13, 14]. Hence, we conducted this systematic review and meta-analysis with aim to estimate the prevalence of depression among elderly population in India.

Methods
Protocol and registration
This systematic review is reported in accordance with the PRISMA checklist [15], and is registered in the PROSPERO database (International Prospective Register of Systematic Reviews) (CRD42014014691) [16].

Information sources and search strategy
We searched PubMed, Scopus, Web of Science, Embase, PsycINFO, and IndMed for articles published during the years 1997 to 2016. One hundred pages of Google scholar were reviewed to enrich and supplement the search results [17, 18]. No language restriction was imposed in the searches. The cross-references of the identified studies were explored for additional studies. Keywords were identified with discussion among authors, and search query was developed for respective databases (Additional file 1).

Eligibility criteria
We included the studies reporting prevalence of depression using screening tools.

Inclusion criteria
1). Community-based studies; 2). Participant’s age - 60 years and above; 3). Type of studies - cross-sectional studies, and cohort studies; 4). Studies published during the years 1997 to 2016 to provide depression prevalence from previous two decades.

Exclusion criteria
1). Studies conducted in the special population groups such as chronic disease patients; 2). Studies conducted in special settings such as old age homes and hospitals; 3). Studies that reported only subcategory of depression; 4). Studies which have not reported the screening tool.

Data extraction (selection and coding)
Two authors (MP, PB) individually involved in the extraction of relevant studies from the databases. All the eligible studies were screened; in case of duplication of information, we chose the latest article with maximum information. After selection of eligible studies, study characteristics and relevant data, namely author (year of publication), study location and setting (State: rural and urban), study design, sampling method, sample size, response rate (%), screening tool, prevalence, and screening for dementia were extracted. We contacted authors through email for additional data whenever required. Discrepancies in data were resolved either by consensus or seeking additional information from the author(s) of the study. In case of disagreement between two reviewers (MP and PB), arbitration was done by other authors (MB and VY).

Risk of Bias assessment
We used Adapted New Castle Ottawa Scale for cross-sectional studies to assess the quality in terms of representativeness, sample size, comparability, non-response, ascertainment of outcome and statistical analysis [19, 20] and quality scores were assigned to each study (Additional file 2). Sensitivity analysis was done to remove the influence of low-quality studies, small studies, and presence of dementia.

Background
Depression is a major mental health problem, which is yet to be recognised as an important public health challenge. About 322 million people affected with depression worldwide [1]. Depression is the single largest contributor to global disability (7.5%, 2015) and a major contributor to suicides (~ 800,000 annually) [2]. In India, elderly persons (60 years and above) constitute 8.6% of the total population (India Census 2011), which is projected to reach 19% by 2050 [3]. Thus, depression among elderly population is likely to be a major cause of disease burden in the future.

Depression is one of the most common illnesses in the elderly population. Among elderly people, chronic diseases, restricted mobility, bereavement, elderly abuse, isolation, and loss of income are major risk factors for depression, in addition to common risk factors in all age groups [4]. Depression in the elderly persons may have a varied presentation and may be difficult to diagnose [5]. It has devastating consequences and contributes significantly to misery in this phase of life [6]. It is associated with increased risk of morbidity, decreased physical, cognitive and social functioning, and greater self-neglect [4, 7]. Depression not only decreases the quality of life but also influence prognosis of other chronic diseases that further aggravates disability [8]. Consequently, elderly persons with depression have significantly higher suicidal and non-suicidal mortality [9]. Early identification and management of depression can improve quality of life. However, healthcare systems in low and middle income countries like India are not resilient enough to deal with mental health problems including depressive disorders [10].

There are no systematically conducted and nationally representative studies in India like China Biobank Study [11], which provide data on disease magnitude to address the nation’s need for developing the policies and strengthening programs [12]. Current epidemiological studies do not provide a solution to this challenge as there is a wide variation in estimated prevalence ranging from 6 to 80% depending on various factors like population studied, screening tool used etc. [13, 14]. Hence, we conducted this systematic review and meta-analysis with aim to estimate the prevalence of depression among elderly population in India.

Methods
Protocol and registration
This systematic review is reported in accordance with the PRISMA checklist [15], and is registered in the PROSPERO database (International Prospective Register of Systematic Reviews) (CRD42014014691) [16].

Information sources and search strategy
We searched PubMed, Scopus, Web of Science, Embase, PsycINFO, and IndMed for articles published during the years 1997 to 2016. One hundred pages of Google scholar were reviewed to enrich and supplement the search results [17, 18]. No language restriction was imposed in the searches. The cross-references of the identified studies were explored for additional studies. Keywords were identified with discussion among authors, and search query was developed for respective databases (Additional file 1).

Eligibility criteria
We included the studies reporting prevalence of depression using screening tools.

Inclusion criteria
1). Community-based studies; 2). Participant’s age - 60 years and above; 3). Type of studies - cross-sectional studies, and cohort studies; 4). Studies published during the years 1997 to 2016 to provide depression prevalence from previous two decades.

Exclusion criteria
1). Studies conducted in the special population groups such as chronic disease patients; 2). Studies conducted in special settings such as old age homes and hospitals; 3). Studies that reported only subcategory of depression; 4). Studies which have not reported the screening tool.

Data extraction (selection and coding)
Two authors (MP, PB) individually involved in the extraction of relevant studies from the databases. All the eligible studies were screened; in case of duplication of information, we chose the latest article with maximum information. After selection of eligible studies, study characteristics and relevant data, namely author (year of publication), study location and setting (State: rural and urban), study design, sampling method, sample size, response rate (%), screening tool, prevalence, and screening for dementia were extracted. We contacted authors through email for additional data whenever required. Discrepancies in data were resolved either by consensus or seeking additional information from the author(s) of the study. In case of disagreement between two reviewers (MP and PB), arbitration was done by other authors (MB and VY).

Risk of Bias assessment
We used Adapted New Castle Ottawa Scale for cross-sectional studies to assess the quality in terms of representativeness, sample size, comparability, non-response, ascertainment of outcome and statistical analysis [19, 20] and quality scores were assigned to each study (Additional file 2). Sensitivity analysis was done to remove the influence of low-quality studies, small studies, and presence of dementia.
Strategy for data synthesis
The effect size of interest for this study was the prevalence of depression among elderly population. Pooled estimates were calculated separately for males, females, and combined population. Freeman-Tukey Double arcsine transformation of proportions are implemented to calculate all pooled estimates, as it is preferred method for calculating effect size for proportions [21]. Stata 13 was used to calculate of pooled effects, subgroup analysis, publication bias analysis, forest plot and sensitivity analysis (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.). Meta-regression analysis was done in R software using Meta and Metafor packages [22, 23]. Heterogeneity between studies was examined using the I squared statistic and Cochran’s Q test. Due to significant heterogeneity between the studies ($I^2 = 98.5\%$ and Cochran’s Q = 3574.8, df = 55, $p < 0.001$), we used random effects models for analysis [24, 25].

All pooled estimates were calculated using DerSimonian and Laird method of random effects models and reported as a proportion with 95% confidence interval [26, 27]. We assessed the publication bias by visual inspection of funnel plots and Eggers test. Funnel plot was made between transformed proportions and standard error of transformed proportions. Egger’s method for detecting publication bias was originally described for effect size based on odds ratio but this test can be applied to effect size calculated by any method. According to this method, asymmetry in funnel plots is tested by carrying out a simple linear regression of $y_i$ (the effect size in study $i$ divided by its standard error) on $x_i$ (the inverse of the standard error) and testing whether the intercept significantly differs (at $p < 0.1$) from zero. Statistical significance was set at $p$-value < 0.05. Subgroup analysis of combined estimate of the prevalence was done for residence, region, screening tools, time-period (1997–2006 and 2007–2016), and sampling methods.

India is a federal country comprising of 29 States and 7 Union Territories. It has been divided into four regions namely, the North and Central region included Jammu and Kashmir, Himachal Pradesh, Haryana, Delhi, Uttarakhand, Uttar Pradesh, Madhya Pradesh, and Chhattisgarh; the South region included Tamil Nadu, Andhra Pradesh, Karnataka, and Kerala; the East region included West Bengal, Bihar, Jharkhand, Odisha, Assam, and other north eastern states; and the West region included Gujarat, Goa, and Maharashtra. Based on socioeconomic status, the States have been divided into Empowered Action Group (EAG) states & non-EAG states in the country by Government of India. The eight socioeconomically backward States, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Odisha, Rajasthan, Uttarakhand and Uttar Pradesh are classified under the EAG states [28].

Results
In this systematic review, 51 studies fulfilled eligibility criteria (Fig. 1). We have planned a priori to estimate the prevalence of rural and urban separately. Of the 51 studies, 6 studies were conducted in both rural and urban community. We divided these 5 articles into two parts each, rural and urban; and 1 stood undivided due to lack of data. Hence, we analysed these 51 studies as 56 datasets [46 original datasets + 10 datasets from 5 studies (each had one urban and one rural dataset)]. In total, there were 22,005 study subjects, the smallest sample size being 41, and largest 2186. The main characteristics of the selected studies have been summarized in Table 1.

Most of the studies [29] were published in recent 5 years from 2012 to 2016, followed by 9 during 2007 to 2011, and only 3 from 1997 to 2006. Almost half ($n = 26$) of the studies were conducted in South India, followed by North ($n = 14$), West ($n = 9$), East ($n = 5$), North-East and Central ($n = 1$, each). Only 4 studies were conducted in EAG states and 1 in Assam. Most of the studies ($n = 43$) used probability sampling methods, and 6 studies used non-probability sampling methods. Seven studies did not mention the type of sampling method adopted.

Geriatric Depression Scale (GDS) was most commonly ($n = 41$) used screening tool [13, 29–65] followed by Public Health Questionnaire (PHQ) 4 studies [14, 66–68], Center for Epidemiologic Studies Depression Scale (CES-D) in 3 studies [72, 73], Mastering Depression in Primary Care Version 2.2 (MDIPCv2.2) in 2 studies [74, 75], and Beck Depression Inventory (BDI) [76], Goldberg and Bridges Scale [77], and definition based on WHO Technical Report Series 1960 [78] each in 1 study. Two studies provided prevalence in persons aged 65 years and above only. Only 14 studies excluded elderly having dementia before applying the screening tool for depression. Only 41 studies provided the prevalence of depression in males and females, separately.

Prevalence of depression in elderly
There was significant heterogeneity between the studies ($I^2 = 98.5\%$ and Cochran’s Q = 3574.8, df = 55, $p < 0.001$), therefore, we used random effects models for estimating the prevalence of depression in elderly. Overall pooled estimate (random effects models) of the prevalence of depression in the elderly was 34.4% (95% CI: 29.3–39.7) (Fig. 2). Pooled estimate of the prevalence was higher in the females than males (41.0%; 95% CI: 33.8–48.4 vs. 28.7%; 95% CI: 23.8–33.9) (Figs. 3 and 4).

Subgroup analysis
Subgroup analysis is presented in Table 2. Studies from rural areas showed slightly higher prevalence of depression (37.8%; 95% CI: 29.9–45.9) than urban areas (32.1%;
95% CI: 26.1–38.5), however, this difference was not significant (Additional file 3: Figure S1).

The estimated pooled prevalence among the studies that used probability sampling was relatively lower (31.8%; 95% CI: 26.4–37.4) compared to those studies used non-probability sampling (38.4%; 95% CI: 22.2–55.9). In the studies with unknown sampling methods, the prevalence was relatively higher (47.7%; 95% CI: 36.1–59.5) (Additional file 3: Figure S2).

We did subgroup analysis as GDS vs. non-GDS (all other than GDS) and found that pooled estimate was higher among studies used GDS tool (37.9%; 31.5–44.5 vs. 25.4%; 17.1–34.6) (Additional file 3: Figure S3).

Pooled prevalence estimates for CES-D, GDS, PHQ, and HDRS were 39.5% (95% CI: 21.7–58.9), 37.9% (95% CI: 31.5–44.5), 19.7% (95% CI: 7.5–35.7), and 10.2% (95% CI: 6.5–14.6), respectively. “Others”, which included MDIPCv2.2, BDI, Goldberg Bridges Scale, and definition based on WHO Technical Report Series 1960 (No. 185) had a pooled prevalence of 32.3% (95% CI: 21.8–43.8) (Additional file 3: Figure S4).

The prevalence in East (including North-East), South, West and North (including Central) zone was 48% (95% CI: 30.1–66.1), 39.8% (95% CI: 34.5–45.3), 32.7% (95% CI: 21.1–45.5), 21.6% (95% CI: 13.3–31.3) respectively (Additional file 3: Figure S5). We divided the states into EAG states, South, and Others (including rest Non-EAG states from East, West, and North India), and found the pooled prevalence of depression as 11.3% (95% CI 7.6–15.8), 39.8% (95% CI 34.5–45.3), and 34.3% (95% CI 25.4–43.8), respectively (Additional file 3: Figure S6).

Pooled prevalence in the individual states is also presented in the map of India (Fig. 5). There was no significant difference between the prevalence from decades 2007–2016 and 1997–2006; the estimated pooled prevalence was 34% (95% CI 28.7–39.5) and 41.7% (95% CI 26.8–57.5), respectively (Additional file 3: Figure S7).

**Quality assessment**

Out of 56 studies (56 datasets are considered as 56 studies in our analysis), 55 studies were assessed for quality. One study cannot be assessed for quality because of lack of full text. The quality score for the studies varied from 2 to 8. The median quality score for the studies was 7, Interquartile range = 5.7. There were 9 high quality studies (score 8), 34 medium quality studies (score varies from 5 to 7) and 12 low quality studies (score < 5). The quality score of each study was provided in Table 1.
| S.No | Author, Year of Publication (study number) | State/ Study Setting | Sampling technique | Age (yrs) | Screening tool | Dementia patients excluded | Combined Prevalence in % | Prevalence in males, % | Prevalence in females,% | Quality Score |
|------|------------------------------------------|----------------------|-------------------|-----------|---------------|--------------------------|--------------------------|---------------------|------------------------|--------------|
| 1    | Abhishekh HA et al., 2013                | Karnataka/ Rural     | US                | ≥ 60      | HDRS          | No                       | 143 (10/70)              | 121 (4/33)          | 162 (6/37)            | 5            |
| 2    | Ahmed MS et al, 2016                    | Karnataka/ Urban     | SyRS              | ≥ 60      | GDS – 15      | No                       | 36.7 (312/850)           | 32.3 (132/409)      | 64.6 (202/310)        | 7            |
| 3    | Arumugam B et al, 2013 (A)              | Tamil Nadu/Rural     | US                | ≥ 60      | GDS – 30      | No                       | 795 (66/83)              | 66.7 (18/27)         | 85.7 (48/56)          | 4            |
| 4    | Arumugam B et al, 2013 (B)              | Tamil Nadu/Urban     | US                | ≥ 60      | GDS – 30      | No                       | 80 (72/90)               | 63.3 (19/30)         | 88.3 (53/60)          | 4            |
| 5    | Arvind P et al, 2004                    | Kerala/ Rural        | SyRS              | ≥ 60      | GDS – 15      | No                       | 24.7 (64/259)            | 18.5 (22/119)        | 30.0 (42/140)         | 8            |
| 6    | Barua A et al, 2010                     | Karnataka/Rural      | SRS               | ≥ 60      | MDIPC v2.2    | Yes                      | 21.7 (132/609)           | 19.9 (43/216)        | 22.6 (89/393)         | 8            |
| 7    | BayapareddyPM et al, 2012               | Tamil Nadu/Rural     | CRS               | ≥ 60      | GDS – 15      | No                       | 47 (376/800)             | 37.5 (150/400)       | 56.5 (226/400)        | 7            |
| 8    | Behera P et al, 2016                    | Haryana/ Rural       | SRS               | ≥ 60      | GDS – 30      | Yes                      | 273 (108/395)            | 233 (40/172)         | 305 (68/223)          | 8            |
| 9    | Bodhare TN et al, 2013                  | Andhra Pradesh/Rural | US                | ≥ 60      | PHQ 9         | No                       | 44.7 (85/190)            | –                   | –                      | 3            |
| 10   | Dasgupta A et al, 2013                   | West Bengal/Rural    | CS                | ≥ 60      | GDS – 15      | No                       | 588 (50/85)              | 484 (15/31)          | 648 (35/54)           | 7            |
| 11   | Dasgupta A et al, 2014                   | West Bengal/Urban    | CS                | ≥ 60      | GDS – 15      | No                       | 469 (61/130)             | 361 (22/61)          | 565 (39/69)           | 7            |
| 12   | Deshpande SS et al, 2011                | Maharashtra/ Rural   | SyRS              | ≥ 65      | GDS – 15      | No                       | 41.1 (74/180)            | 402 (37/92)          | 420 (37/88)           | 6            |
| 13   | Dhar G et al, 2013                      | West Bengal/Urban    | SyRS              | ≥ 60      | GDS – 15      | No                       | 598 (122/204)            | –                   | –                      | 5            |
| 14   | Dhuria M et al, 2014                    | Delhi/ Urban         | Not known         | ≥ 60      | GDS – 15      | No                       | 456 (114/250)            | –                   | –                      | 2            |
| 15   | D’souza L et al, 2015                   | Karnataka/Urban      | Not known         | ≥ 60      | GDS – 15      | No                       | 519 (109/210)            | 33 (35/106)          | 712 (74/104)          | 4            |
| 16   | Dumbray SS et al, 2014                  | Maharashtra/ Urban   | CS                | ≥ 60      | GDS – 15      | No                       | 30 (30/100)              | –                   | –                      | 5            |
| 17   | Ganguli M et al, 1999                   | Haryana/ Rural       | Not known         | > 60      | GDS – 30      | Yes                      | 464 (646/1391)           | 404 (294/727)        | 53 (352/664)          | 7            |
| 18   | Goel PK et al, 2014                     | Uttar Pradesh/ Urban | SyRS              | ≥ 60      | GDS – 30      | No                       | 94 (38/403)              | 97 (20/207)          | 92 (18/196)           | 7            |
| 19   | Goyal A et al, 2014 (A)                 | Punjab/ Rural        | Not known         | ≥ 60      | GDS – 30      | No                       | 746 (44/59)              | –                   | –                      | 5            |
| 20   | Goyal A et al, 2014 (B)                 | Punjab/ Urban        | Not known         | ≥ 60      | GDS – 30      | No                       | 805 (33/41)              | –                   | –                      | 5            |
| 21   | Gupta A et al, 2015                     | Uttar Pradesh/ Urban | MRS               | ≥ 60      | GDS – 30      | Yes                      | 156 (22/141)             | 11 (11/100)          | 268 (11/41)           | 4            |
| 22   | Gupta SK et al, 2012                    | Madhya Pradesh/ Urban| SyRS              | ≥ 60      | GDS – 15      | No                       | 96 (20/208)              | 121 (11/91)          | 7.7 (9/117)           | 4            |
| 23   | Ishikawa M et al, 2016                  | Jammu and Kashmir/ Rural | PS                | ≥ 60      | PHQ-2         | No                       | 7.9 (9/114)              | –                   | –                      | 4            |
| 24   | Jain RK et al, 2007                     | Maharashtra/ Urban   | LQS               | ≥ 60      | GDS – 15      | No                       | 459 (90/196)             | 38 (38/100)          | 542 (52/96)           | 7            |
| 25   | Jariwala V et al, 2010                  | Gujarat/Urban        | CS                | ≥ 60      | BDI (G)       | No                       | 35.7 (25/70)             | –                   | –                      | 5            |
| 26   | Jonas Jost B et al, 2014                 | Maharashtra/         | CS                | ≥ 60      | CES-D         | No                       | 585 (802/1370)           | 48.1 (311/647)       | 67.9 (491/723)        | 8            |
| S.No | Author, Year of Publication (study number) | State/ Study Setting | Sampling technique | Age (yrs) | Screening tool | Dementia patients excluded | Combined Prevalence in % | Prevalence in males,% § | Prevalence in females,% ¶ | Quality Score |
|------|------------------------------------------|----------------------|-------------------|-----------|---------------|---------------------------|--------------------------|---------------------------|---------------------------|--------------|
| 27   | Kamble SV et al, 2009                    | Maharashtra/ Rural   | SyRS              | ≥ 60      | Goldberg & Bridges scale | No                        | 31.4 (155/494)           | 246 (57/232)               | 374 (98/262)               | 8            |
| 28   | Kumar S et al, 2013                     | Andhra Pradesh/ Rural| CRS               | ≥ 60      | GDS – 15       | Yes                       | 47 (188/400)             | 375 (75/200)               | 565 (113/200)               | 7            |
| 29   | Mathias K et al. 2015                   | Uttarakhand/ Unclassified | 2 s CRS         | ≥ 60      | PHQ 9         | No                        | 5.5 (6/100)              | –                          | –                          | 7            |
| 30   | Maulik S et al., 2012                   | West Bengal/Rural    | CRS               | ≥ 60      | GDS- 15 (Bengali) | No                        | 53.7 (44/82)             | 33.3 (9/27)                | 636 (35/55)                | 7            |
| 31   | Nair SS et al, 2013                     | Karnataka/ Urban     | SiRS              | ≥ 60      | GDS – 15       | No                        | 32.4 (59/182)            | 320 (24/75)                | 327 (35/107)               | 3            |
| 32   | Nandi PS et al, 1997                    | West Bengal/Rural    | US                | ≥ 60      | WHO TRS       | Yes                       | 55.2 (101/183)           | 376 (32/85)                | 704 (69/98)                | 4            |
| 33   | Patil SD et al, 2015                    | Karnataka/Rural      | SyRS              | ≥ 60      | GDS – 15       | No                        | 294 (114/388)            | 28 (37/132)                | 301 (77/259)               | 7            |
| 34   | Payghan BS et al, 2013                  | Karnataka/Urban      | StRS              | ≥ 60      | GDS – 15       | No                        | 41.7 (90/216)            | 385 (40/104)               | 446 (50/112)               | 7            |
| 35   | Pillania M et al. 2016                  | Haryana/Rural        | 2 s CRS           | ≥ 60      | GDS – 30       | No                        | 144 (72/500)             | 87 (20/231)                | 193 (52/269)               | 7            |
| 36   | Pongiya UD et al, 2011                  | Tamil Nadu/ Rural    | Not known         | ≥ 60      | CES-D         | No                        | 22 (20/91)               | 283 (13/46)                | 156 (7/45)                | 3            |
| 37   | Poongothai S et al, 2009                | Tamil Nadu/ Urban    | MRS               | ≥ 60      | PHQ 12        | Yes                       | 285 (622/2186)           | 259(296/1142)             | 312 (326/1044)             | 8            |
| 38   | Pracheth R et al, 2013                  | Karnataka/ Urban     | SyRS              | ≥ 60      | GDS – 30       | No                        | 294 (64/218)             | 259 (21/81)                | 314 (43/137)               | 7            |
| 39   | Radhakrishnan S et al, 2013             | Tamil Nadu/ Rural    | SIRS              | ≥ 60      | GDS – 30       | No                        | 588 (235/400)            | 452 (76/168)               | 685 (159/232)             | 7            |
| 40   | Raul A et al, 2013                      | Maharashtra/ Urban    | Not known         | ≥ 60      | MDIPC v2.2    | No                        | 213 (46/216)             | –                          | –                          | –            |
| 41   | Saikia AM et al, 2016                   | Assam/Urban          | CRS               | ≥ 60      | GDS – 15       | Yes                       | 173 (69/400)             | 145 (27/189)               | 196 (42/214)               | 7            |
| 42   | Sandhya G et al, 2010                   | Kerala/ Rural        | SIRS              | ≥ 60      | GDS – 15       | No                        | 254 (65/256)             | 291 (30/103)               | 229 (35/153)               | 7            |
| 43   | Sanjay TV et al, 2014                   | Karnataka/ Urban     | SIRS              | ≥ 60      | GDS – 15 (Kannada) | No                        | 36 (36/100)              | 295 (13/44)               | 41.1 (23/56)               | 7            |
| 44   | Santosh A et al, 2014                   | Karnataka/Urban      | SyRS              | ≥ 60      | GDS            | No                        | 333 (50/150)             | 31.1 (14/45)               | 343 (36/105)               | 7            |
| 45   | Seby K et al, 2011                      | Maharashtra/ Urban    | US                | ≥ 65      | GDS – 15       | Yes                       | 193 (39/202)             | –                          | –                          | 4            |
| 46   | Sengupta P et al, 2015 (A)              | Punjab/ Rural        | US                | ≥ 60      | GDS – 15       | Yes                       | 7.3 (91/1248)            | 5.7 (33/579)               | 8.7 (58/669)               | 8            |
| 47   | Sengupta P et al, 2015 (B)              | Punjab/Urban         | US                | ≥ 60      | GDS – 15       | Yes                       | 101 (180/1790)           | 75 (60/805)                | 122 (120/985)             | 8            |
| 48   | Sharma K et al, 2016 (A)                | Himachal Pradesh/ Rural | 2 s CRS         | ≥ 60      | HDRS           | No                        | 73 (29/400)              | –                          | –                          | 7            |
| 49   | Sharma K et al, 2016 (B)                | Himachal Pradesh/ Urban | 2 s CRS         | ≥ 60      | HDRS           | No                        | 118 (47/400)             | –                          | –                          | 7            |
| S.No | Author, Year of Publication | State/Study Setting | Sampling technique | Age (yrs) | Screening tool | Dementia patients excluded | Combined Prevalence in %  ‡ | Prevalence in males,% § | Prevalence in females,% ¶ | Quality Score |
|------|---------------------------|---------------------|-------------------|-----------|----------------|---------------------------|----------------------------|----------------|----------------|---------------|
| 50   | Sinha SP et al., 2013     | Tamil Nadu/Rural    | US                | ≥ 60      | GDS – 15       | Yes                       | 42.7 (44/103)               | 29.3 (17/58)    | 60 (27/45)     | 5             |
| 51   | Suganathan S et al, 2016  | Tamilnadu/Rural     | CRS               | ≥ 60      | GDS            | No                        | 70.4 (317/450)              | 56.8 (100/176)  | 79.2 (217/274) | 7             |
| 52   | Sundru M et al., 2013 (A) | Andhra Pradesh/Rural| SIRS              | ≥ 60      | GDS – 15       | No                        | 36 (216/600)                | –              | –              | 6             |
| 53   | Sundru M et al., 2013 (B) | Andhra Pradesh/Urban| SIRS              | ≥ 60      | GDS – 15       | No                        | 273 (164/600)               | –              | –              | 6             |
| 54   | Swarnalatha N et al, 2013 | Andhra Pradesh/Rural| SIRS              | ≥ 60      | GDS – 15       | No                        | 47 (188/400)                | 37.5 (75/200)   | 565 (113/200)  | 7             |
| 55   | Thirthahalli C et al, 2014| Karnataka/Urban     | StRS              | ≥ 60      | CES-D          | Yes                       | 378 (179/473)               | 288 (40/139)    | 416 (139/334)  | 8             |
| 56   | Yadav SP et al, 2013      | Maharashtra/Urban    | SyRS              | ≥ 60      | GDS – 15       | No                        | 159 (43/270)                | 14 (18/129)     | 17.7 (25/141)  | 6             |

†US – Universal Sampling (all eligible participants selected); SyRS – Systematic Random Sampling; SIRS – Simple Random Sample; CRS – Cluster Random Sampling; StRS – Stratified Random Sampling; CS – Convenience Sampling; PS – Purposive Sampling; LQS – Lots Quality Sampling; MRS – Multistage Random Sampling; 2 s CRS – Two stage cluster random sampling

‡No. of positive patients/ Total participants; § No. of positive males / Total males; ¶ No. of positive females / Total females
Sensitivity analysis
We did sensitivity analysis using the random effects model to identify the effect of individual studies on the pooled estimate. No significant changes in the pooled prevalence was found on removal of low-quality studies. Prevalence estimate was 33.9% (95% CI 28.3–39.9, I² = 56.4%)

| Study                          | ES (95% CI) | % Weight |
|-------------------------------|-------------|----------|
| Abhishek R et al, 2013        | 14.3 (7.9, 24.3) | 1.70     |
| Ahmed MS et al, 2016          | 36.7 (33.5, 40.0) | 1.83     |
| Arumugam B et al, 2013 (A)    | 79.5 (69.5, 89.8) | 1.72     |
| Arumugam B et al, 2013 (B)    | 80.0 (70.6, 87.9) | 1.73     |
| Arvind P et al, 2014          | 24.7 (19.9, 30.3) | 1.88     |
| Barca A et al, 2010           | 21.7 (18.6, 25.1) | 1.83     |
| Bayyapa reddy PM et al, 2014  | 47.0 (43.6, 50.5) | 1.83     |
| Behera P et al, 2016          | 27.3 (23.2, 31.9) | 1.82     |
| Bhardwaj TN et al, 2013       | 44.7 (37.8, 51.8) | 1.79     |
| Dreszcz I et al, 2015         | 51.9 (45.2, 58.6) | 1.79     |
| Dasgupta A et al, 2013        | 58.8 (48.2, 68.7) | 1.72     |
| Dasgupta A et al, 2014        | 46.9 (38.6, 55.6) | 1.76     |
| Deshpande SS et al, 2011      | 41.1 (34.2, 48.4) | 1.78     |
| Dhar G et al, 2013            | 59.8 (53.0, 66.3) | 1.79     |
| Dhiru H et al, 2016           | 45.6 (39.5, 51.8) | 1.80     |
| D'Nair SS et al, 2014         | 30.0 (21.9, 38.6) | 1.74     |
| Ganguli M et al, 1999         | 46.4 (43.8, 49.1) | 1.84     |
| Goel PK et al, 2014           | 9.4 (9.8, 12.7)  | 1.82     |
| Goyal A et al, 2014 (A)       | 74.6 (62.2, 83.0) | 1.68     |
| Goyal A et al, 2014 (B)       | 80.5 (66.0, 89.8) | 1.61     |
| Gupta A et al, 2015           | 15.6 (10.5, 22.3) | 1.77     |
| Gupta SK et al, 2012          | 9.6 (6.1, 14.4)  | 1.79     |
| Ishikawa M et al, 2016        | 7.9 (4.2, 14.3)  | 1.79     |
| Jain RK et al, 2007           | 45.9 (39.1, 52.9) | 1.79     |
| Jonk Y et al, 2010             | 35.7 (25.5, 47.4) | 1.70     |
| Jonas-Joseph B et al, 2014    | 58.5 (55.5, 61.1) | 1.84     |
| Kasiviswanathan SV et al, 2009| 31.4 (27.4, 35.8) | 1.82     |
| Kumar S et al, 2013           | 47.0 (42.2, 51.9) | 1.82     |
| Mathias K et al               | 5.5 (2.5, 11.6)  | 1.75     |
| Mehta S et al, 2012           | 53.7 (42.9, 64.0) | 1.72     |
| Nair SS et al, 2013           | 32.4 (28.0, 36.9) | 1.79     |
| Nandini PS et al, 1997        | 55.2 (48.3, 62.2) | 1.79     |
| Pandi SD et al, 2015          | 29.4 (20.1, 38.4) | 1.82     |
| Pasyah SS et al, 2013         | 41.7 (35.3, 48.3) | 1.79     |
| Pilania M et al, 2016         | 14.4 (11.6, 17.7) | 1.82     |
| Pongiya UD et al, 2011        | 22.0 (14.7, 31.5) | 1.73     |
| Ponugothai S et al, 2009      | 28.5 (20.6, 36.4) | 1.84     |
| Prasad R et al, 2003          | 29.4 (23.7, 35.7) | 1.79     |
| Prathibha et al, 2013         | 58.7 (53.9, 63.5) | 1.82     |
| Raoul A et al, 2013            | 21.3 (16.4, 27.2) | 1.79     |
| Sajith SC et al, 2016          | 17.3 (13.9, 21.3) | 1.82     |
| Sandhya GI et al, 2010        | 25.4 (20.4, 31.1) | 1.80     |
| Sanjay TV et al, 2014         | 36.0 (27.3, 45.8) | 1.74     |
| Santosh A et al, 2014         | 33.3 (26.3, 41.3) | 1.77     |
| Selby K et al, 2011            | 19.3 (14.5, 25.3) | 1.79     |
| Sen Gupta P et al, 2015 (A)   | 7.3 (6.0, 8.9)   | 1.84     |
| Sen Gupta P et al, 2015 (B)   | 10.1 (8.7, 11.5) | 1.84     |
| Shama K et al, 2016 (A)       | 7.3 (5.1, 10.2)  | 1.82     |
| Shama K et al, 2016 (B)       | 11.8 (9.0, 16.3) | 1.82     |
| Sinha SP et al, 2013          | 42.7 (33.6, 52.4) | 1.74     |
| Suganathan S et al, 2016      | 70.4 (66.1, 74.5) | 1.82     |
| Sundar M et al, 2013 (A)      | 36.0 (32.3, 39.9) | 1.83     |
| Sundar M et al, 2013 (B)      | 27.3 (23.9, 31.0) | 1.83     |
| Swaminathan N et al, 2013     | 47.0 (42.2, 51.9) | 1.82     |
| Thirthahalli C et al, 2014    | 37.8 (33.6, 42.3) | 1.82     |
| Yadav SP et al, 2013          | 15.9 (12.0, 20.6) | 1.80     |
| Overall (I² = 96.5%, p = 0.0) | 34.4 (29.3, 39.6) | 100.00   |

Fig. 2 Estimated prevalence of depression among elderly persons in India pooling included studies, 1997–2016

Sensitivity analysis
We did sensitivity analysis using the random effects model to identify the effect of individual studies on the pooled estimate. No significant changes in the pooled prevalence was found on removal of low-quality studies. Prevalence estimate was 33.9% (95% CI 28.3–39.9, I² = 56.4%).
98.6%, \( p < 0.0001 \)) after omitting the studies with quality score less than 5 (Fig. 6). We found that the pooled prevalence was 34.6% (95% CI 29.3–40, \( I^2 = 98.5\% \)) on the removal of 2 studies (with age group 65 years and above) (Additional file 3: Figure S8). The pooled prevalence was lower (30.7%; 95% CI 25.4–36.3, \( I^2 = 98.6\% \)) when we excluded studies with the sample size less than 100 (Additional file 3: Figure S9). The estimate was also lower (28.9%; 95% CI 20.3–38.4, \( I^2 = 99\% \)) when we omitted the studies which have not screened for dementia (Additional file 3: Figure S10).

### Meta-regression analysis

Mixed effects meta-regression analysis done with study period, residence, geographic region, sampling methods, and screening tool showed that 'geographic region' was

| Study | ES (95% CI) | % Weight |
|-------|-------------|----------|
| Abhishek HA et al, 2013 | 16.2 (7.7, 31.1) | 2.26 |
| Ahmed MS et al, 2016 | 40.8 (36.3, 45.5) | 2.51 |
| Arunugam B et al, 2013 (A) | 85.7 (74.3, 92.6) | 2.35 |
| Arunugam B et al, 2013 (B) | 88.3 (77.8, 94.2) | 2.36 |
| Arvind P et al, 2004 | 30.0 (23.0, 38.0) | 2.45 |
| Barua A et al, 2010 | 22.6 (18.8, 27.0) | 2.51 |
| Bayapa reddy PM et al, 2014 | 56.5 (51.6, 61.3) | 2.51 |
| Behera P et al, 2016 | 30.5 (24.8, 36.8) | 2.48 |
| D’souza L et al, 2015 | 71.2 (61.8, 79.0) | 2.43 |
| Dasgupta A et al, 2013 | 64.8 (51.5, 76.2) | 2.34 |
| Dasgupta A et al, 2014 | 56.5 (44.8, 67.6) | 2.38 |
| Deshpande SS et al, 2011 | 42.0 (32.3, 52.5) | 2.41 |
| Gangwri M et al, 1999 | 53.0 (49.2, 56.8) | 2.52 |
| Goel PK et al, 2014 | 9.2 (5.9, 14.0) | 2.48 |
| Gupta A et al, 2015 | 26.8 (15.7, 41.9) | 2.29 |
| Gupta SK et al, 2012 | 7.7 (4.1, 14.0) | 2.44 |
| Jain RK et al, 2007 | 54.2 (44.2, 63.8) | 2.42 |
| Jonas Jost B et al, 2014 | 67.9 (64.4, 71.2) | 2.52 |
| Kambie SV et al, 2009 | 37.4 (31.8, 43.4) | 2.49 |
| Kumar S et al, 2013 | 56.5 (49.6, 63.2) | 2.48 |
| Maulik S et al, 2012 | 63.6 (50.4, 75.1) | 2.34 |
| Nair SS et al, 2013 | 32.7 (24.6, 42.1) | 2.43 |
| Nandi PS et al, 1997 | 70.4 (60.7, 78.5) | 2.42 |
| Patil SD et al, 2015 | 30.1 (24.8, 36.0) | 2.49 |
| Payghan BS et al, 2013 | 44.6 (35.8, 53.9) | 2.44 |
| Pilania M et al, 2016 | 19.3 (15.1, 24.5) | 2.49 |
| Pongiya UD et al, 2011 | 15.6 (7.7, 28.8) | 2.31 |
| Poongothai S et al, 2009 | 31.2 (28.5, 34.1) | 2.52 |
| Pracheth R et al, 2013 | 31.4 (24.2, 39.6) | 2.45 |
| Radhakrishnan S et al, 2013 | 68.5 (62.3, 74.2) | 2.49 |
| Saikia AM et al, 2016 | 19.6 (14.9, 25.5) | 2.48 |
| Sandhya GI et al, 2010 | 22.9 (16.9, 30.1) | 2.46 |
| Sanjay TV et al, 2014 | 41.1 (29.2, 54.1) | 2.35 |
| Santosh A et al, 2014 | 34.3 (25.9, 43.8) | 2.43 |
| Sengupta P et al, 2015 (A) | 8.7 (6.8, 11.0) | 2.52 |
| Sengupta P et al, 2015 (B) | 12.2 (10.3, 14.4) | 2.52 |
| Sinha SP et al, 2013 | 60.0 (45.5, 73.0) | 2.31 |
| Suganathan S et al, 2016 | 79.2 (74.0, 83.6) | 2.49 |
| Swamalatha N et al, 2013 | 56.5 (49.6, 63.2) | 2.48 |
| Thirthahalli C et al, 2014 | 41.6 (36.5, 47.0) | 2.50 |
| Yadav SP et al, 2013 | 17.7 (12.5, 24.9) | 2.46 |
| Overall (\( I^2 = 98.1\%, \ p = 0.0 \)) | 41.0 (33.8, 48.4) | 100.00 |

![Fig. 3 Estimated prevalence of depression among female elderly persons in India pooling included studies, 1997–2016](image-url)
the only significant covariate that independently and significantly affected the prevalence. The overall model was significant with an $r^2 = 0.50$ and $p$ value $< 0.0001$ (Table 3).

### Publication Bias
The studies had a high degree of heterogeneity ($I^2 = 98.3\%$). Egger test (no small study effects, intercept = 3.22, $t$-value = 1.33, $p$-value = 0.189) did not show any evidence of publication bias. The funnel plot (Fig. 7) is of reasonably symmetrical shape which further supports the findings of Egger's test.

### Discussion
This meta-analysis provided an estimate of the prevalence of depression from 56 community based studies. We found that the pooled prevalence of depression in the elderly population in India was as high as 34.4%. The scope of service provision, improvement is the need of hour specifically designed to equip with the mental
health of elderly persons. Studies from other low and middle income countries also documented high prevalence of depression in the elderly population. The estimated pooled prevalence of depression in China was 22.7% [20] and 23.6% [21] from two recently published meta-analyses. WHO Study on Global Ageing and Adult

| Category          | No. of studies | Pooled prevalence (95% CI) | Cumulative Positives/ cumulative sample size | p-value in between group comparison |
|-------------------|----------------|---------------------------|---------------------------------------------|-----------------------------------|
| All studies       | Overall        | 56                        | 34.4 (29.3–39.6)                             | 7087/22005                       |
| Subgroup          |                |                           |                                             |                                   |
| Year of publication | 2007–2016     | 53                        | 34 (28.7–39.5)                               | 6276/20172 0.3525                |
|                   | 2006 and before| 3                        | 41.7 (26.8–57.5)                             | 811/1833                          |
| Setting           | Rural          | 28                        | 37.8 (29.9–45.9)                             | 4345/11600 0.2778               |
|                   | Urban          | 27                        | 32.1 (26.1–38.5)                             | 2736/10296                       |
| Region            | South          | 26                        | 39.8 (34.5–45.3)                             | 3877/10374 0.0073               |
|                   | North and Central | 15                    | 21.6 (13.3–31.3)                             | 1459/7449                       |
|                   | East including North-east | 6                | 47.9 (30.1–66.1)                             | 447/1084                         |
|                   | West           | 9                         | 32.7 (21.1–45.5)                             | 1304/3098                       |
| State             | Andhra Pradesh | 5                         | 40.1 (32–48.5)                               | 841/2190 < 0.001                |
|                   | Assam          | 1                         | 17.3 (13.9–21.3)                             | 69/400                           |
|                   | Delhi          | 1                         | 45.6 (39.5–51.8)                             | 114/250                          |
|                   | Gujrat         | 1                         | 35.7 (25.5–47.4)                             | 25/70                            |
|                   | Haryana        | 3                         | 28.6 (10.8–50.7)                             | 826/2286                         |
|                   | Himachal Pradesh | 2               | 9.4 (7.4–11.5)                               | 76/800                           |
|                   | Jammu and Kashmir | 1               | 7.9 (4.2–14.3)                               | 9/114                            |
|                   | Karnataka      | 11                        | 33.1 (27.8–38.5)                             | 1155/3466                       |
|                   | Kerala         | 2                         | 25.0 (21.4–28.9)                             | 129/515                          |
|                   | Madhya Pradesh | 1                         | 9.6 (6.3–14.4)                               | 20/208                           |
|                   | Maharashtra    | 8                         | 32.3 (20.4–46.1)                             | 1279/3028                       |
|                   | Punjab         | 4                         | 37.4 (20.1–56.6)                             | 348/3138                         |
|                   | Tamil Nadu     | 8                         | 53.7 (38.9–68.2)                             | 1752/4203                       |
|                   | Uttar Pradesh  | 2                         | 10.9 (8.3–13.6)                              | 60/544                           |
|                   | Uttarakhand    | 1                         | 5.5 (2.5–11.5)                               | 6/109                            |
|                   | West Bengal    | 5                         | 55.1 (50.5–59.7)                             | 378/684                          |
| EAG states        | EAG and Assam  | 5                         | 11.3 (7.6–15.8)                              | 155/1261 < 0.001                |
|                   | Non-EAG states† | 25                    | 34.3 (25.4–43.8)                             | 3055/10370                       |
|                   | South Indian states | 26                | 39.8 (34.5–45.3)                             | 3877/10374                       |
| Sampling methods  | Probability    | 43                        | 31.8 (26.4–37.4)                             | 5069/17812 0.0475               |
|                   | Non-probability | 6                      | 38.4 (22.2–55.9)                             | 1006/1935                       |
|                   | Not known      | 7                         | 47.7 (36.1–59.4)                             | 1012/2258                       |
| Instrument        | CES-D          | 3                         | 39.5 (21.7–58.9)                             | 1001/1934 < 0.001               |
|                   | GDS            | 41                        | 37.9 (31.5–44.5)                             | 4819/15030                       |
|                   | HDRS           | 3                         | 10.2 (6.5–14.6)                              | 86/870                           |
|                   | PHQ            | 4                         | 19.7 (7.5–35.7)                              | 722/2599                         |
|                   | Others†        | 5                         | 32.3 (21.8–43.8)                             | 459/1572                         |
| Type of instrument | GDS            | 41                        | 37.9 (31.5–44.5)                             | 4819/15030 0.0291               |
|                   | Others than GDS | 15                  | 25.4 (17.1–34.6)                             | 2268/6975                       |

†Non-EAG states excluding South Indian states; ‡ “Others” in instruments included MDIPC v2.2, Goldberg and Bridges Scale, and BDI (G)
Health (2007–10) documented higher prevalence of the depression in the Indian elderly population than other low and middle income countries such as China, Ghana, Mexico, Russia, and South Africa [79]. A recently published systematic review of 26 studies among Iranian elderly populations estimated the prevalence of depression (43%) to be higher than India [80]. These differences in the results may be explained by different
culture, genetics, and environmental factors or even methodological/sampling differences. However, taken together, they all support an argument for placing greater importance on the mental health of elderly people, as a part of overall efforts to improve quality of life. In coming years, India will have greater number of elderly people with depression not only due to high prevalence of depression but also increasing share of elderly population. Hence, re-orientation of scarce mental health services and resources including untapped potential of community health workers and new age technology may be useful. In addition, Government of India’s recently launched ambitious scheme Ayushman Bharat also has a great opportunity to address mental health needs through health and wellness centres and national health protection scheme.
This systematic review included studies from 1997 to 2016. This period marked the era of broad access to communication technologies like mobile phone and various applications, Internet, E-health and online access to health information [81]. Also during this time, majority of Indian families moved from joint families to nuclear families, and the younger generation migrated to the towns and cities which further weakened the support structures for elderly population, without any significant improvement in the care and support services for the elderly population [82–84].

Most of the studies on depression among elderly persons published in the last 5 years i.e. from 2012 to 2016. This may be a reflection of increased focus of researchers on problems of elderly persons after adopting aging as an annual theme by WHO in 2012 [85]. In the same year, the World Federation for Mental Health also adopted depression as its theme for World Mental Health day, which further accentuated the awareness for depression in the elderly [86]. The recent increase in publications might also be due to a growth in the

| Covariate                                    | Coefficient | 95% CI         | SE  | Z     | P value |
|----------------------------------------------|-------------|----------------|-----|-------|---------|
| Study period (2007–2016)                     | 0.02        | -0.17, 0.21    | 0.096| 0.23  | 0.82    |
| Urban                                        | -0.08       | -0.16, 0.006   | 0.043| -1.82 | 0.07    |
| Unclassified                                 | -0.11       | -0.47, 0.24    | 0.18 | -0.61 | 0.54    |
| Southern region                              | -0.07       | -0.22, 0.07    | 0.07 | -1.04 | 0.30    |
| North and Central region                     | -0.31       | -0.47, -0.15   | 0.08 | -3.87 | 0.0001  |
| Western region                               | -0.18       | -0.35, -0.01   | 0.086| -2.11 | 0.035   |
| Probability sampling                         | -0.14       | -0.30, 0.02    | 0.08 | -1.71 | 0.087   |
| Unknown sampling methods                     | 0.12        | -0.07, 0.31    | 0.099| 1.23  | 0.22    |
| GDS                                          | 0.11        | -0.07, 0.30    | 0.09 | 1.19  | 0.23    |
| HDRS                                         | -0.09       | -0.35, 0.17    | 0.13 | -0.67 | 0.51    |
| PHQ                                          | -0.026      | -0.27, 0.22    | 0.13 | -0.21 | 0.83    |
| Others                                       | -0.006      | -0.23, 0.22    | 0.12 | -0.05 | 0.96    |

Coefficient is for logit of proportion
Dependent variable: prevalence of depression
Reference categories of independent variables: time period 1997–2006, residence - rural, geographic region - east and north-east, sampling methods- non-probability sampling, screening tool - CES-D

Fig. 7 Funnel plot with pseudo 95% confidence limits
number of online research journals [87]. Our study did not find significant difference in the prevalence by time period. Small sample size in the previous decade (1997–2006) may be possible explanation for it. Similarly, the studies which used probability sampling also reported lower prevalence which may be explained by better representativeness and lesser selection bias.

In this systematic review, we identified studies from 16 states of India. The eastern part of the country had higher prevalence of depression (48%) compared to all other regions. One possible explanation for this finding may be that all the five studies included from the East and North-East zone had used GDS tool which has higher sensitivity [88]. EAG states and Assam lag behind in the demographic transition and have constituted about 46% of India’s population [89]. We found only 5 studies from these states with pooled prevalence of 11.4%. This underscores the need for more research and data on disease burden for effective planning and policymaking in EAG states. Further variable prevalence from different states emphasize on state specific efforts to address this gap, both on the front of research and policy.

In our study, females had higher prevalence of depression which is consistent with global findings and the results of other meta-analyses [90–95]. Diatheses to preponderance of depression in elderly females are vulnerabilities that make them susceptible when stressors occur in their lives. Although, much work was not done on the psychosocial predictors of the gender difference in depression in elderly population, the studies have mostly explored single possible variable such as widowhood/ living alone, poor health, poverty, cognitive decline, caregiving [92, 93, 96].

We found that the prevalence of depression was marginally higher in the rural areas than urban counterparts; however, this was not statistically significant. A systematic review in Chinese rural elderly populations also reported higher prevalence of depression than urban counterparts (29.2% vs. 20.5%) [90]. No specific pattern was observed in other countries [97, 98].

In this meta-analysis, the estimated prevalence of depression in Indian elderly persons varied with different screening criteria. Standardization of the methods and screening tool is essential for assessment of the magnitude of depression among elderly persons in India. The prevalence was higher when CES-D and GDS were used (39.5 and 37.9%, respectively). Since, majority of studies had used the GDS as a screening tool for assessment of depression which is a highly sensitive than others [88]; there is likelihood of over-estimation of the prevalence. There was significant heterogeneity in the prevalence between the screening tools, which might be due to different levels of sensitivity and specificity of the screening tools. Another possible explanation may be that most of these screening tools were not validated in the local settings and languages. However, the level of heterogeneity is used to be high in the prevalence studies by nature; standardization of the methods for a uniform assessment of the magnitude of depression or alternatively large cross-sectional studies with standardized assessment tools may also be employed.

On sensitivity analysis, we found that studies with quality score below 5 (of 8) and studies with age group 65 years and above had not affected the pooled estimate. The studies which excluded dementia before assessment of depression and those with large sample size (above 100) reported lower prevalence rates. Exclusion of dementia may limit the number of false positive cases of depression during the assessment. We therefore suggest that the exclusion of dementia is required before screening of depression. We did not find evidence of small studies effect in this review which may have overestimated the effect size.

Limitations

Most of studies conducted were from South, North and Western region of India and there was no studies from 20 States and Union Territories (UTs) of the total 36 States and UTs in India, although, left out were small States/UTs. Screening tools cannot take the place of a comprehensive clinical interview for confirming a diagnosis of depression; however, it is useful tool for public health programs. Screening provides optimum result when linked with confirmation by psychiatrist, treatment and follow-up. As this meta-analysis included studies using a screening tool, the further meta-analysis on the diagnostic tool will help to estimate the true burden of depression and to determine the need of pharmacological and non-pharmacological interventions.

Conclusion

This meta-analysis reports that in India, the aggregate prevalence of depression among elderly population was 34.4%, though estimates varied widely throughout the country. Given the varied methodological approaches and screening tools used in the studies included in the review, the appropriateness of calculating pooled prevalence estimates could be questioned. Hence, the pooled prevalence estimate should be interpreted with caution. Despite the limitations, the estimates will guide researchers and planners to measure the burden more appropriately in future. It also emphasizes on the need of standardization of the magnitude of depression to further strengthen the public health measures to address the growing problem.
Additional files

Additional file 1: Search strategy. (DOC 28 kb)
Additional file 2: Adapted New Castle Ottawa Scale. (DOC 42 kb)
Additional file 3: Figure S1. Estimated prevalence of depression among elderly persons in India pooling included studies, 1997–2016 (Rural vs. urban – subgroup analysis). Figure S2. Estimated prevalence of depression among elderly persons in India pooling included studies, 1997–2016 (Sampling techniques – subgroup analysis). Figure S3. Estimated prevalence of depression among elderly persons in India pooling included studies, 1997–2016 (Study instruments – subgroup analysis). Figure S4. Estimated prevalence of depression among elderly persons in India pooling included studies, 1997–2016 (Study instrument for geriatric vs. nongeriatric age groups – subgroup analysis). Figure S5. Estimated prevalence of depression among elderly persons in India pooling included studies, 1997–2016 (EAG vs Non-EAG state of India – subgroup analysis).

Figure S6. Estimated prevalence of depression among elderly persons in India pooling included studies, 1997–2015 (Geographical regions of India – subgroup analysis). Figure S7. Estimated prevalence of depression among elderly persons in India pooling included studies, 1997–2016 (Time period – subgroup analysis).

Figure S8. Estimated prevalence of depression among elderly persons in India pooling included studies, 1997–2016 (Studies with inclusion age >60 years only – sensitivity analysis). Figure S9. Estimated prevalence of depression among elderly persons in India pooling included studies, 1997–2016 (Including studies with sample size <100 – sensitivity analysis).

UTs: Union Territories; WHO: World Health Organization

Acknowledgements

We thank Kailash Prajapati (IIHM University, Jaipur) for help in creating the map using ArcGIS software.

Authors’ contributions

Conceived and designed the experiments: MB, VY, MP, GB, and HK. Performed the experiments: MP, VY, MB, and VB. Analyzed the data: VY and MB. Wrote the paper: MB, VY, MP, PMB, VM, and SDG. Data interpretation: VY, MB, PMB, MP, SDG, SP, and VM. Critical revision to the manuscript: MB, VY, PMB, MP, VY, and MB. Analyzed the data: VY and MB. Wrote the paper: VY and MB. Critical revision to the manuscript: MB, VY, MP, PMB, VY, and MB. Data interpretation: VY, MB, PMB, and VY.

References

1. Friedrich MJ. Depression is the leading cause of disability around the world. Jama. 2017;317(15):1517.
2. World Health Organization. Depression and other common mental disorders: Global health estimates. World Health Organization. Geneva; 2017.
3. Agarwal A, Lubet A, Mitglang E, Mohanty S, Bloom DE. Population aging in India : Facts, issues, and options [Internet]. Bonn; 2016. (Discussion Papers). Report No.: 10162. Available from: https://ideas.repec.org/p/gdh/wspaper/13216.html
4. Fiske A, Wetherell JL, Gatz M. Depression in older adults. Annu Rev Clin Psychol. 2009;5:363–89.
5. Mehta A, Grover S, Chakrabarti S, Avasthi A. Symptom profile of depression in elderly: Is assessment with geriatric depression rating scale enough? 2017:18–25.
6. World Health Organization. Mental health of older adults [Internet]. World Health Organization; 2017 [cited 2017 Mar 10]. Available from: http://www.who.int/mental-health/conditions/ageing/en/
7. Sözeri-Yaran G. Depression in the elderly: clinical features and risk factors. Aging Dis (IntNet). 2012;3(6):463–71. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3522513/
8. Pilania M, Bairwa M, Kumar N, Khanna P, Kurana H. Elderly depression in India: an emerging public health challenge. Australas Med J. 2013;6(3):107–11.
9. Aziz R, Steffens DC. What are the causes of late-life depression? Psychiatr Clin North Am. 2013 Dec;36(4):497–516.
10. World Health Organization. Social determinants of mental health. Vol. 978. World Health Organization. Geneva; 2014.
11. Chen Y, Bennett D, Clarke R, Guo Y, Yu C, Bian Z, et al. Patterns and correlates of major depression in Chinese adults: A cross-sectional study of 0.5 million men and women. Psychol Med [Internet]. 2017 Apr;47(5):958–70. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5341494/
12. ICMR PHFI and IHME. India: Health of the Nation’s States. The India State-Level Disease Burden Initiative. [Internet]. New Delhi: ICMR, PHFI, IHME; 2017. Available from: http://www.healthdata.org/policy-report/india-health-nation’s-states
13. Anumgiam B, Nagalingam S, Nivetha R. Geriatric depression among rural and urban slum community in Chennai – a cross sectional study. J Evol Med Dent Sci [Internet]. 2013;2(7):795–801. Available from: http://go.galegroup.com/ps/anonymous?id=GALE%7CA362849640&sid=galegroup.com/ps/anonymous&id=GALE%7CA362849640&ver=4.0&贷=google Scholar&v=2.1&itid=inf&access=abs&isbn=227847488&as=a&ovw=w.
14. Mathias K, Goycoolea I, Kermode M, Singh L, Shidhaye R, San SM. Cross-sectional study of depression and help-seeking in Uttarakhand. North India BMJ Open. 2015;5:e008992.
15. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ. 2009;339:b2535.
16. Pilania M, Bhate P, Yadav V, Baniya G, Bairwa M, Khurana H, et al. A systematic review and meta-analysis of prevalence of depression in elderly population of India (PROSPERO CRD42014014691) [Internet]. PROSPERO. York: National Institute of Health Research (NHS); 2018. Available from: http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42014014691
17. Kramer WM, Rethelsfen ML, Kleijnen J, Franco OH. Optimal database combinations for literature searches in systematic reviews: a prospective exploratory study. Syst Rev [Internet]. 2017 [cited 2019 Apr 13(6):1245. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC5920834/
18. Haddaway NR, Collins AM, Coughlin D, Kirk S. The Role of Google Scholar in Evidence Reviews and Its Applicability to Grey Literature Searching. Wray KB, editor. PLoS One [Internet]. 2015;17 [cited 2019 Apr 13(10):e0138237. Available from: https://doi.org/10.1371/journal.pone.0138237
19. Takashi N, Hashizume M. A systematic review of the influence of occupational organophosphate pesticides exposure on neurological impairment. BMJ Open 2014;4(6):e004798.
