Postnatal depression and its association with adverse infant health outcomes in low- and middle-income countries: a systematic review and meta-analysis

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Abstract

Background: Postnatal Depression (PND) is a mood disorder that steals motherhood and affects the health and development of a newborn. While the impact of PND on motherhood and newborn in developed countries are well described, its epidemiology and health consequences in infant is not well known in middle-and low-income countries. The objective of this review was to determine the burden and association of PND with adverse infant health outcomes in low-and middle-income countries.

Methods: We searched observational studies written in the English language and conducted in middle-and low-income countries between December 1st, 2007, and December 31st, 2017. The CINHAL, MEDLINE, Emcare, PubMed, Psych Info, and Scopus databases were searched for the following search terms: PND, acute respiratory infection, pneumonia, diarrhea, exclusive breastfeeding, common infant illnesses, and malnutrition. We excluded studies in which the primary outcomes were not measured following a standardized approach. We have meta-analyzed the estimates from primary studies by adjusting for possible publication bias and heterogeneity. The analysis was conducted in Stata 14. The study was registered in PROSPERO protocol number CRD42017082624.

Result: Fifty-eight studies on PND prevalence (among 63,293 women) and 17 studies (among 32,454 infants) on infant health outcomes were included. PND prevalence was higher in the low-income countries (Pooled prevalence (PP) = 25.8%; 95%CI: 17.9–33.8%) than in the middle-income countries (PP = 20.8%; 95%CI: 18.4–23.1%) and reached its peak in five to ten weeks after birth. Poor obstetric history, social support, low economic and educational status, and history of exposure to violence were associated with an increased risk of PND. The risk of having adverse infant health outcomes was 31% higher among depressed compared to non-depressed postnatal mothers (Pooled relative risk (PRR) = 1.31; 95%CI: 1.17–1.48). Malnutrition (1.39; 1.21–1.61), non-exclusive breastfeeding (1.55; 1.39–1.74), and common infant illnesses (2.55; 1.41–4.61) were the main adverse health outcomes identified.

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Conclusions: One in four and one in five postnatal mothers were depressed in low and middle-income countries, respectively. Causes of depression could be explained by social, maternal, and psychological constructs. High risk of adverse infant health outcomes was associated with PND. Timely screening of PND and evidence-based interventions were a pressing need in low and middle-income countries.

Keywords: Postnatal depression, Adverse infant health outcomes, Systematic review, Meta-analysis, Low, And middle-income countries

Background
Worldwide, depression is the most common mental illness and the leading cause of maternal morbidity and disability in the perinatal period [1, 2]. Postnatal depression (PND) is a crippling mood disorder that steals motherhood [3]. It is characterized by signs and symptoms such as low mood, tiredness, insomnia, irritability, and reduced functioning [4]. The symptoms of PND commences four to six weeks after childbirth [4] and get peak two to three months after birth [3, 5, 6]. The causes of PND are explained by genetics and socio-environmental constructs [7].

Postnatal depression is used to be an issue of Western countries [8], and research focus on this problem has been limited until the relationship found between socio-economic status and PND [9, 10]. Recent evidence has shown that the prevalence of PND is higher in low-and middle-income countries (range from 7 to 33%) than high-income countries (range between 13 and 19%) [5, 11, 12]. Postnatal depression found to be heterogeneous in Africa with lower prevalence in Uganda (7.1%) and the highest in Zimbabwe (33%) [13]. Far less is known about PND, although more than 90% of the world’s children are living in low-and middle-income countries [13]. This suggests more concise and updated estimate about PND epidemiology and consequences are pivotal.

Postnatal depression is the second cause of disability next to HIV/AIDS [2], and the most known complication of childbirth [14]. Postnatal depression can increase the cost of the health care system [15], reduce mother’s quality of life and workforce in the economy [16]. Postnatally depressed women are at risk of back pain, insomnia, thought of self-harm, suicidal ideation, and poor parenting behavior [17, 18]. Postnatal depression affects initiation of breastfeeding and effective utilization of available health services [17, 19]. This could lead to malnutrition and weakened immune systems with further predisposition to illnesses including diarrhea, pneumonia, measles, and other childhood illnesses [12, 20–22].

The identification of women potentially at risk of PND is vital to prevent the onset and subsequent consequences. The previous reviews on PND were descriptive, incomprehensive and inconclusive [11, 23–28], skewed to developed countries [4, 17, 23, 24], and lacked detail quantification of risk factors. The previous reviews about PND effects on adverse infant health outcomes were scarce, descriptive, outdated, and mostly included studies from developed countries [12, 13, 17]. We did this comprehensive review to explore the prevalence and thematically quantify and present most notable risk factors of PND, and to investigate its association with risk of adverse infant health outcomes in low- and middle-income countries.

Methods
Search strategy
We searched the CINHAL, MEDLINE, EMCare, PubMed, Psych Info, and Scopus databases for postnatal depression and its effect on adverse infant health outcomes. The following search terms were used: Postnat*, postpart*, depress*, exclusive breastfeeding, pneumonia, common infant illnesses, diarrhea, measles, diarrhea, fever, malnutrition, and infant feeding practices.

Eligibility criteria
We included observational studies conducted in low and middle-income countries, written in the English language, and published between January 1st, 2007, and December 31st, 2017 with an aim of including only updated data on the topic. Furthermore, studies were included if they fulfilled the following main outcome definitions:- (1) malnutrition was measured using standard indices like wasting, stunting, short stature, or underweight/overweight; (2) age-related infant feeding practice that reported exclusive breastfeeding or complementary feeding; (3) common infant illnesses such as ARI (pneumonia, fever, and cough), malaria, measles, and diarrhea were assessed following the WHO Integrated Management of Newborn and Childhood Illnesses (IMNCI) guideline; (4) measurement of depression was done using a standard and validated screening tools. According to the World Bank Atlas, low-income and middle-income countries are those with the Gross National Income (GNI) per capita of ≤ $1025 and between $1026 to 12,375.
Exclusion criteria

Studies that pooled antenatal and PND scores, had fair to poor quality score on the New Castle Ottawa Scale, studies restricted to very high or low-risk populations, conference proceedings, commentaries, abstracts, reports, and unpublished data were excluded.

Data extraction and study quality assessment

This section of methodology has been published previously in recent paper [29].

Data analysis

Estimates from primary studies were reported in prevalence, odds ratios, or relative risks. For the first objective, estimating the overall prevalence of PND, the prevalence extracted from all primary studies were meta-analyzed. For the second objective, identifying prominent risk factors of PND, odds ratios obtained for each risk factor identified from each primary study were meta-analyzed to get a pooled odd ratio for that specific risk factor. For the third objective, investigating the association between PND and adverse infant health outcomes, relative risk estimates obtained from each primary study were collected and meta-analyzed to get a single estimate for each adverse birth outcomes. The meta-analysis for each objective was reported in a separate forest plot, and their main findings were summarized in tables. For studies that lacked adjusted estimates, crude estimates were used. Where a single study reported more than one adverse birth outcomes, pooling was done for each outcome.

Risk of bias and adjustment

Cochran Q ($I^2$), visual inspection of forest plot, Galbraith plot [30], and Higgins test [31] were used to assess the presence of heterogeneity. The DerSimonian and Lairds random-effect model was used to pool odds ratio or relative risk estimates in the presence of heterogeneity. These sub-group analyses investigated differences between and within groups’ effect. Study setting, study design, year of investigation, tools used for measuring depression, sample size, and income of the country were used as base for sub-analysis. Visual inspection of a funnel plot asymmetry and Egger’s regression test were used to check for potential publication bias [32, 33]. The L estimator of Duval and Tweedie was used to find and fill the missed studies through the procedure called the trim-and-fill analysis [34]. A meta-analysis was conducted after log-transforming the estimates from primary studies. As overall adverse infant health outcomes are considered rare in this studies (most of the are close to one), ORs, RRs, and HRs were assumed as a reasonable approximations of each other [35–37]. Sensitivity analysis was also conducted to test for the presence of studies with outlier estimates. All analyses were conducted in Stata 14 [38].

Protocol registration

This review was registered in PROSPERO with protocol number CRD42017082624.

Result

In total, 1291 records were retrieved from databases. After removing duplicates, reviewing titles, and abstracts, 149 records were deemed eligible for full text review. After exclusion of 67 records in full text review, 84 records were assessed for quality. Lastly, 58 articles on PND [39–95] and 17 [56, 58, 83, 85, 86, 89–91, 95–103] articles on adverse infant health outcomes were assessed as good quality and were included in quantitative analysis (Fig. 1).

Postnatal depression

Among 58 studies (with 63,293 population), 47 (81%) studies were conducted in middle-income countries, 38 (66%) were institutional-based studies, and 41 (70%) used EPDS for screening depression. Fourteen studies were conducted in Africa, 13 studies were from countries located in North and South America, and 31 studies were conducted in Asia. A wide range of PND prevalence (3.5% in Ghana to 58.8% in Iran) was observed across the studies. The studies were published from 2007 to 2017 with sample sizes ranging between 87 and 16,560 participants. (Table 1) Because of substantial evidence of heterogeneity among primary studies as evidenced by Cochran Q ($I^2 = 99.0$%), visual inspection of forest plot, and Higgins test ($p = 0.001$), estimate from DerSimonian and Lairds random-effect model was reported in a sub-group analysis. Because of evidence in publication bias, an estimate from trim and fill analysis was reported in each sub-analysis (Egger test, $P < 0.01$). A sensitivity analysis showed a PND prevalence ranging between 18.82 and 25.02%.

Postnatal depression increased during the last seven years, from 18.2% (95%CI: 12.8–23.5%) in 2010–2012 to 25.6% (95%CI: 19.9–27.2%) in 2016–17. The prevalence was higher in low-income countries (Pooled Prevalence (PP) = 25.8%; 95%CI: 17.9–33.8%) and in health institutional-based studies (PP = 22.1%; 95%CI: 18.8–25.3%). Postnatal depression increases from the earliest weeks of birth (PP = 17.6%; 95%CI: 7.7–27.5%) to the end of second year (PP = 25.2%; 95%CI: 19.9–30.5%). Postnatal depression was the highest in studies used Beck Depression Inventory (BDI), Center for Epidemiological Studies Depression scale (CED), the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I), Mini International Neuropsychiatric Interview (MINI).
Poor obstetric history (Pooled Odds Ratio (POR) = 1.98; 95%CI: 1.66–2.36) and social support (POR = 2.44; 95%CI: 1.92–3.09), exposure to history of CMD (POR = 3.30; 95%CI: 1.88–5.80) and violence (POR = 2.61; 95%CI: 2.16–3.15), low economic (POR = 2.05; 95%CI: 1.66–2.54) and educational status (POR = 2.06; 95%CI: 1.56–2.73), and problem with maternal and newborn health (POR = 3.16; 95%CI: 1.96–5.08) were risk factors for PND (Table 3).

The association between postnatal depression on adverse infant health outcomes
Seventeen studies (33 estimates), with a total of 31,454 participants, were included in this analysis. Nine studies from Africa, eight from Asia, and four from countries in North America were found. Fifteen studies represented middle-income countries, and five studies represented low-income countries. Twelve (57%) studies were longitudinal, 12 (57%) were community-based, and their sample size ranged from 166 to 16,560 participants. Center for Epidemiological Studies Depression scale (CED) and EPDS screening tools were used in 7 (33%) and 5 (23.8%) of the studies, respectively (Table 4).

Of 33 estimates, 19 were on malnutrition, 10 were on common infant illness, and 4 were on non-exclusive breastfeeding. The following authors studied more than one outcome in a single study: Adewuya et al. studied two different forms of malnutrition (stunting and underweight); Guo et al. studied febrile illnesses in two countries (Ghana and Côte d'Ivoire); Weobong et al. studied four different types of febrile illnesses (diarrhea, cough, fever, vomiting); Madeghe et al. studied two different
**Table 1** Summary of studies conducted on postnatal depression and associated factors in low and middle-income countries (2007–2017), N = 58

| Author, P. year | Year | Country, income | Study setting | Sample size | Time of assessment | Tool used | Prevalence |
|-----------------|------|-----------------|---------------|-------------|--------------------|-----------|------------|
| Dindar I et al. 2007 | 2007 | Middle HI | birth to 48 weeks | 679 | EPDS | 25.6% |
| Ege E et al. 2008 | 2008 | Middle community | 6 to 48 weeks | 364 | EPDS | 33.2% |
| Flores-Quijano ME et al., 2008 | 2008 | Middle HI | 2 to 12 weeks | 163 | EPDS | 24.5% |
| Hassellmann MH et al., 2008 | 2008 | Middle HI | birth to 8 weeks | 429 | EPDS | 35.8% |
| Tannous L et al., 2008 | 2008 | Middle community | 6 to 8 weeks | 271 | EPDS | 20.7% |
| Durat and Kutlu, 2010 | 2009 | Middle HI | birth to 48 weeks | 126 | EPDS | 23.8% |
| Yagmur Y et al., 2010 | 2010 | Middle community | birth to 48 weeks | 730 | EPDS | 21.0% |
| Botino M et al., 2012 | 2012 | Middle HI | birth to 20 weeks | 811 | EPDS | 24.3% |
| Goker A et al., 2012 | 2012 | Middle HI | 4 to 48 weeks | 318 | EPDS | 31.4% |
| Pocan Ag et al., 2013 | 2013 | Middle HI | 4 to 6 weeks | 187 | EPDS | 28.9% |
| Melo Jr. EF et al., 2012 | 2012 | Middle HI | 4 to 6 weeks | 555 | EPDS | 10.8% |
| Mathisen SE et al., 2013 | 2013 | Middle HI | 4 to 6 weeks | 87 | EPDS | 37.2% |
| Serhan N et al., 2013 | 2012 | Middle community | 8 to 24 weeks | 110 | EPDS | 9.1% |
| de Castro et al. 2015 | 2015 | Middle HI | birth to 36 weeks | 604 | EPDS | 10.6% |
| Lara MA et al., 2015 | 2015 | Middle HI | 24 weeks | 210 | SCID-I | 13.4% |
| Corrêa H et al., 2016 | 2016 | Middle HI | birth to 48 weeks | 3060 | EPDS | 19.5% |
| Robert A et al., 2016 | 2016 | Middle HI | birth to 6 weeks | 194 | EPDS | 40.2% |
| Ho-Yen SD et al. 2007 | 2007 | Low community | 4 to 5 weeks | 426 | EPDS | 4.9% |
| Baghianimoghadam et al., 2009 | 2009 | Middle HI | 1 to 16 weeks | 120 | BDI | 58.8% |
| Gao L et al., 2009 | 2009 | Middle HI | 6 to 8 weeks | 130 | EPDS | 13.8% |
| Kadir AA, et al., 2009 | 2009 | Middle HI | 4 to 6 weeks | 293 | EPDS | 27.3% |
| Wan EY et al., 2009 | 2009 | Middle HI | 6 to 8 weeks | 342 | EPDS | 15.5% |
| Petrosyan D, et al., 2011 | 2011 | Middle HI | 3 months | 437 | EPDS | 14.4% |
| Ahmed HM et al., 2012 | 2012 | Middle HI | 6 to 8 weeks | 1000 | EPDS | 28.4% |
| Hegde S et al., 2012 | 2012 | Middle HI | 6 to 14 weeks | 150 | EPDS | 15.5% |
| Zainal NZ et al., 2012 | 2012 | Middle HI | 6 to 8 weeks | 411 | EPDS | 6.8% |
| Swapan G et al., 2013 | 2013 | Middle HI | 6 weeks | 202 | PRIME MD | 15.8% |
| Panyayong B et al., 2013 | 2013 | Middle community | 6 to 8 weeks | 1731 | EPDS | 8.4% |
| Abdollahi F et al., 2014 | 2014 | Middle HI | 8 to 12 weeks | 1801 | EPDS | 4.5% |
| Deng AW et al., 2014 | 2014 | Middle community | 4 weeks | 1823 | EPDS | 27.4% |
| El-Hachem C et al., 2014 | 2014 | Middle HI | 4 weeks | 228 | EPDS | 12.0% |
| Giri RK et al., 2015 | 2015 | Low HI | 6 to 10 weeks | 346 | EPDS | 30.0% |
| Yusuff ASM et al. 2015 | 2015 | Middle HI | 4 to 24 weeks | 2072 | EPDS | 14.3% |
| Murray L et al., 2015 | 2015 | Middle HI | 4 to 24 weeks | 431 | EPDS | 18.1% |
| Shivalli S et al., 2015 | 2015 | Middle HI | 4 to 6 weeks | 102 | EPDS | 31.4% |
| Abdollahi et al., 2014 | 2014 | Middle HI | 12 weeks | 1910 | EPDS | 19.0% |
| Safadi RR et al., 2016 | 2016 | Low HI | 12 weeks | 315 | PHQ-9 | 25.0% |
| Iranpour S et al., 2017 | 2017 | Middle community | 12 weeks | 360 | EPDS | 34.8% |
| Liu S et al., 2017 | 2017 | Middle community | 4 weeks | 882 | EPDS | 6.7% |
| Ramchandani PG et al., 2009 | 2008 | Middle community | 24 weeks | 1035 | PDQ | 16.4% |
| Stewart RC et al., 2010 | 2009 | Middle HI | 36 weeks | 501 | DSM-IV | 13.9% |
| Hassanein I et al., 2014 | 2014 | Low HI | 12 weeks | 290 | EPDS | 39.0% |
| Mohammed ES et al., 2014 | 2014 | Low community | 56 weeks | 200 | EPDS | 49.5% |
forms of outcome (Non-exclusive breast feeding and underweight); Ndokera et al. studied three different forms of outcomes (serios illnesses, diarrhea, underweight); Benett et al. studied two different forms of malnutrition in four countries (stunting and underweight); Ndokera et al. studied three different forms of outcome (Non-exclusive breast feeding and underweight); and non-exclusive breastfeeding were significant in 12, eight, and three studies, respectively. As a small study effect and high heterogeneity were evidenced, the final estimate corrected for trim and fill analyses from a random effect model was reported (Figs. 3 and 4). Accordingly, PND was associated with 1.31 times increased risk of adverse infant health outcomes (95%CI: 1.17–1.48). The sub-analyses based on the types of outcomes showed the following: a risk of being malnourished, being sick by common infant illnesses, and having non-exclusively breastfeeding was 1.39 times (95%CI: 1.21–1.61), 1.55 times (95%CI: 1.39–1.74), and 2.55 times (95%CI: 1.41–4.61) higher among infants of depressed than non-depressed mothers, respectively (Fig. 2).

A sub-analysis was conducted to explore the consistency of the association across different characteristics of the studies. Accordingly, (1) a pooled estimate from the OR (Pooled Odds Ratio (POR) = 2.62; 95%CI: 2.03–3.38) was larger than the RR (PRR = 1.24; 95%CI: 1.10–1.41) and the HR (PHR = 1.44; 95%CI: 1.21–1.70); (2) the risk was similar for studies used screening (EPDS, PHQ, SRQ) and diagnostic tool (DSM/MINI); (3) the risk of adverse infant health outcomes decreased as age of the infant increased; from 1.75 (95%CI; 1.51–2.03) at the age of 0 to 6 months to 1.28 (95%CI: 1.06–1.54) at the age of 12 months and above; (4) the risk of adverse infant health outcomes was lower in low-income countries (PRR = 1.40; 95%CI:1.37–1.74) compared to middle-income countries (PRR = 1.59; 95%CI: 1.40–1.81); and (5) as sample size increased the association between PND and adverse infant health outcome decreased; from 1.98 (95%CI; 1.63–2.40) for those included a sample size less than 1500 to 1.27 (95%CI; 1.10–1.46) for the studies with larger sample sizes. (Supplementary information)

According to the sensitivity analysis, the pooled relative risks ratio was not affected when individual studies were omitted (Fig. 5).

**Discussion**

The current comprehensive and relatively sizeable review and meta-analyses have dealt with the burden, risk factors, and effects of PND on infant health outcomes in...
### Table 2: Sub-analysis of postnatal depression prevalence in low and middle-income countries (N = 58, 2007–2017), (random effect model, result after a trim and fill analysis)

| Variable of sub-analysis | Number of studies | Sample size | Pooled prevalence; 95%CI |
|--------------------------|-------------------|-------------|-------------------------|
| Year of publication      |                   |             |                         |
| 2007–2009                | 15                | 5752        | 25.1 (18.1–32.2)        |
| 2010–2012                | 10                | 4840        | 18.2 (12.8–23.5)        |
| 2013–2015                | 20                | 14,000      | 19.6 (15.8–23.5)        |
| 2016–2017 (two years)    | 13                | 38,701      | 25.6 (19.9–27.2)        |
| Income of the country    |                   |             |                         |
| Low income               | 11                | 4173        | 25.8 (17.9–33.8)        |
| Middle income            | 47                | 59,120      | 20.7 (18.4–23.1)        |
| Study setting            |                   |             |                         |
| Health institution       | 38                | 21,717      | 22.1 (18.8–25.3)        |
| Community based          | 20                | 41,576      | 20.9 (17.9,23.9)        |
| Time of screening        |                   |             |                         |
| Birth to four weeks      | 5                 | 16,487      | 17.6 (7.8–27.5)         |
| 5 weeks to 10 weeks      | 22                | 26,599      | 21.9 (18.0–25.7)        |
| 11 weeks to 16 weeks     | 12                | 7683        | 17.9 (14.1–21.8)        |
| 17 weeks to 96 weeks     | 19                | 12,524      | 25.2 (19.9–30.5)        |
| A tool used for depression screening |   |             |                         |
| EPDS                     | 41                | 25,013      | 22.6 (19.6,25.7)        |
| PHQ-9 and SRQ-20         | 7                 | 17,479      | 14.4 (6.2–22.6)         |
| DSM-IV                   | 2                 | 17,061      | 8.6 (1.6–18.8)          |
| Other/BDI, CED, SCID-I, MINI/ | 8        | 3740        | 28.3 (16.9–39.8)        |
| Sample size              |                   |             |                         |
| <=1091                   | 49                | 19,143      | 23.4 (20.2–26.5)        |
| >1091                    | 9                 | 44,150      | 14.4 (10.6–18.1)        |

**Note:** EPDS Edinburgh Postnatal Depression Scale, BDI Beck depression inventory, CED Center for Epidemiological Studies Depression scale, SCID-I structured clinical interview for the DSM-IV depression module, MINI Mini International Neuropsychiatric Interview, PHQ-9 patient health questioner, SRQ-20 self-reporting questionnaire.

### Table 3: Summary of risk factors significantly associated with postnatal depression (N = 58, 2007–2017), (random effect model, result after a trim and fill analysis)

| Variable of sub-analysis                                                                 | Number of studies | Sample size | Pooled Odds Ratio (POR), 95%CI | I², p-value |
|------------------------------------------------------------------------------------------|-------------------|-------------|---------------------------------|-------------|
| Poor obstetric history (unplanned pregnancy, GDM, GHP, labor complication, history of emesis, multiparity) | 18                | 28,766      | 1.98 (1.66–2.36)               | 64.5%, p = 0.001 |
| History of CMD (depression during pregnancy, family psychiatric illness, stressful life event) | 13                | 10,074      | 3.30 (1.88–5.80)               | 99.2%, p = 0.001 |
| Poor social support                                                                      | 12                | 11,206      | 2.44 (1.92,3.09)               | 73.8%, p = 0.001 |
| Low economic status                                                                      | 12                | 7671        | 2.05 (1.66–2.54)               | 96.2%, p = 0.001 |
| Problem with maternal and newborn health                                                 | 11                | 5954        | 3.16 (1.96–5.08)               | 91.7%, p = 0.001 |
| Exposure to any forms of violence (physical, emotional, sexual)                          | 7                 | 5730        | 2.61 (2.16–3.15)               | 0%, p = 0.867 |
| Low educational status of the mother                                                     | 7                 | 5549        | 2.06 (1.56–2.73)               | 48.2%, p = 0.007 |

**Note:** CMD common mental disorder, GDM gestational diabetes mellitus, GHP gestational hypertension
Table 4 Summary of studies conducted on the effect of postnatal depression on infant health outcomes in low and middle-income countries, 2007–2017 (N = 14)

| Author, P. year | Country, income | Study setting | Study design | Sample size | Weeks | Screening tool used | Infant adverse health outcomes | Estimate (RR/OR) | LCI | UCI |
|-----------------|-----------------|---------------|--------------|-------------|-------|---------------------|-------------------------------|----------------|-----|-----|
| Hasselmann MH et al. 2008 | Brazil, Middle HI | cohort | 429 | 4 to 8 weeks | EPDS | Non-EB | 1.21 | 1.02 | 1.45 |
| Surkan PJ et al. 2008 | Brazil, Middle HI | cross sectional | 595 | 6 to 12 months | CES-D | Short stature | 1.8 | 1.1 | 2.9 |
| Machado MC et al. 2014 | Brazil, Middle HI | longitudinal | 168 | 1 to 3 months | EPDS | Non-EB | 1.61 | 1.19 | 2.19 |
| Gausia K et al. 2010 | Bangladesh, Low Community | longitudinal | 318 | 6 to 8 weeks | EPDS | Non-EB | 1.74 | 1.25 | 3.42 |
| Rahman A et al. 2016 | Pakistan, Low Community | longitudinal | 279 | 6 months | DSM-IV | Non-EB | 1.42 | 0.98 | 2.06 |
| Upadhyay AK et al. 2016 | India, Middle Community | longitudinal | 1833 | 5 to 21 months | SRQ-20 | Stunting | 1.53 | 1.21 | 1.92 |
| Islam MJ et al. 2017 | Bangladesh, Low Community | cross sectional | 426 | 6 months | EPDS | Stunting | 3.15 | 1.91 | 5.18 |
| Saeed Q et al. 2016 | Pakistan, Low Community | cross sectional | 325 | 2 years | AKUAD | Stunting | 3.26 | 1.99 | 5.34 |
| Adewuya AO et al. 2007 | Nigeria, Middle HI | case control | 242 | 6 to 12 weeks | SCID-NP | Poor weight | 3.41 | 1.3 | 8.52 |
| Guo N et al. 2013 | Ghana, Middle HI | Longitudinal | 654 | 3 months | PHQ | Underweight | 3.28 | 1.03 | 10.47 |
| Guo N et al. 2013 | Côte d’Ivoire | Longitudinal | 654 | 3 months | PHQ | Underweight | 3.28 | 1.03 | 10.47 |
| Ashaba S et al. 2013 | Uganda, Low HI | Case control | 166 | 1–5 yrs | (M.I.N.I.) | Malnutrition | 2.4 | 1.11 | 5.18 |
| Weobong B et al. 2017 | Ghana, Middle | Longitudinal | 16,560 | 4 to 12 weeks | DSM-IV | Diarrhea | 1.8 | 1.45 | 2.14 |
| Madeghe BA et al. 2016 | Kenya, Middle HI | Cross-sectional | 200 | 6 to 14 weeks | EPDS | Underweight | 6.14 | 2.45 | 13.36 |
| Wemakor A et al. 2016 | Ghana, Middle HI | Cross-sectional | 384 | 0–59 months | CED-S | Stunting | 2.48 | 1.29 | 4.77 |
| Ndokera R et al. 2008 | Zambia, Middle community | Cross-sectional | 278 | 2–12 months | CED | Stunting | 1.64 | 0.51 | 5.24 |
| Maureen M Black et al. 2009 | Bangladesh, Low Community | Cross-sectional | 221 | 6–12 months | CED | Stunting | 1.18 | 1.03 | 1.35 |
| Bennett IM et al. 2015 | India, Middle Community | Longitudinal | 1930 | 12 months | CED | Underweight | 1.11 | 0.97 | 1.26 |
| Ethiopia, Low | 1885 | Stunting | 0.91 | 0.81 | 1.02 |
| Peru, Low | 1946 | Stunting | 1.06 | 0.93 | 1.22 |
| Vietnam Low | 1961 | Stunting | 0.85 | 0.6 | 1.19 |
| Underweight | 0.85 | 0.6 | 1.19 |

low and middle-income countries. The review has included 58 primary studies on PND and 17 studies (with 33 estimates) investigating on PND effect on infant health outcomes in the past ten years. The review founds that a significant number of postnatal mothers were depressed, and their infants suffered from malnutrition, common infant illnesses, and non-exclusive breastfeeding.
Postnatal depression and its predictors

The research evidence dealing with PND in low and middle-income countries has been increasing over time. The current meta-analysis showed that one in four and one in five postnatal mothers were living with PND in low- and middle-income countries, respectively. These findings were consistent with a review conducted by Gelaye et al. in low and middle-income countries [12] and slightly higher than a review published by Sawyer et al. [25]. We hypothesized that the rapid decline in reproductive hormones such as estrogen following childbirth might contribute to a dysregulation of the stress hormone, monoamine, and reproductive hormone, which subsequently leads to depression [105]. Postnatal depression prevalence has been increasing from 18 to 25% in the last seven years, which supports the WHO prediction that depression will be the third global leading cause of morbidity by 2030 [106, 107].

The PND prevalence increased in the first 10 weeks, slightly decreased from 11 to 16 weeks, and steadily rose from 17 to 96 weeks after birth. The trend for the first 16 weeks is similar to a study conducted in developed countries [14, 108]. However, the interpretation for these estimates should account for the window of measurement, as a wider window predicts larger estimates. Community-based studies, studies used diagnostic tools (DSM-IV) for identifying depression, and studies with larger samples predicted relatively prevalence. However, the estimates were consistent across all the sub-analysis that showed the high public health importance of PND in low and middle-income countries.
This review identified the following PND predictors: poor obstetric history and social support, history of common mental disorder and violence, low economic and educational status, and maternal and newborn ill health.

Poor obstetric history (unwanted or unplanned pregnancy, multi-parity, history of emesis) strongly predicted PND. These events could be related to household income, mother’s unsatisfactory birth experiences, predisposition to bad parenting experience, and post-traumatic stress [23, 25]. Unwanted or unplanned pregnancies could also affect emotional and instrumental support that the mother could get from her partner and related families [109]. Psychosocial factors such as a history of common mental health disorders, poor social support, and exposure to violence, were identified as significant predictors of PND. These findings are consistent with previously published systematic reviews [12, 14, 25, 110]. Poor social support could aggravate the mother’s stress and depression symptoms as it affects mother’s self-confidence and efficacy [109, 111]. Pregnant mothers who had depression or a history of mental disorders are more likely to develop PND as they are more likely to dampen their positive affect [112], practice rumination and develop a negative cognitive style that could persist throughout the continuum of pregnancy [113, 114]. Moreover, emerging brain neuroimaging explanations of altered neurocognitive functioning have predicted mother’s exposure to childhood abuse or any type of violence as a risk factor for future psychiatric symptomatology [115, 116].

Low economic status and a problem with maternal and newborn health were also predicted PND. Mothers living in low-income countries are less likely to access adequate housing, health service, nutrition, and they experienced
challenges in providing adequate care for their infant situations that would add a further layer of stress [11, 117].

Problem with the mother’s mental health affects mother-infant interactions, hygienic practices during food preparation and storage, and proper care for the newborn, altogether makes the mothers feel guilty and worthless, subsequently leading to depression [91, 118].

Postnatal depression and its effect on adverse infant health outcomes

Postnatal depression in low-and middle-income countries remains mostly untreated, and there is growing evidence that untreated PND results in adverse infant health outcomes [12, 20–22]. The current systematic review and meta-analysis highlighted the effect of PND on infant health and growth. Postnatal depression increased the risk of adverse infant health outcomes by 31%. PND increased the risk of malnutrition (stunting, wasting, short stature), common infant illnesses, and non-exclusive breastfeeding by 39, 55% and by one and a half fold, respectively. We have estimated that 23.66% (7442) of postnatal mothers who had their infants suffered from adverse infant health outcomes in the study population (31,454) were attributed because of their depression status and could be averted if depression during the postnatal period would have been treated.

PND as a risk of adverse infant health outcomes was consistent across all type of association measurement, between use of screening tools (EPDS, PHQ, and SRQ) and clinically diagnosed depression (DSM and MINI), in both institutional and community-based studies, in both high- and low-income countries, and irrespective of study sample. Besides, the association between PND and adverse infant health outcomes was not changed across the age of the infant, even though the risk of adverse infant health outcomes decreased as the age of the infant increased.

The association between malnutrition [20, 95], infant morbidity [119] and PND was supported by a similar systematic review and meta-analysis [120]. Three pathways have been proposed to explain the link between mother’s PND symptoms and adverse infant health outcomes: (1) genetic, (2) hormonal, neuro-regulatory system impairment, and (3) environmental, an indirect

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**Fig. 5** Sensitivity analysis for estimates on postnatal depression and its effect on adverse infant health outcomes in Low-and Middle-income countries (Number of estimates = 33)
effect of PND on the quality of mother’s caregiving [20, 121]. The endocrine dysregulation because of PND would compromise a psychosocial functioning that affects a mother-infant interaction [122]. In middle and low-income countries, mothers are more responsible for caring, feeding, and nurturing their newborns than fathers [123] though they are suffering from lack of adequate income, access to quality water, poor sanitation, and knowledge of illnesses and their prevention [13]. Under these highlighted conditions and exacerbated depression symptoms, postnatal mothers are unable to provide the expected level of care to their infant that would affect their growth and wellbeing.

The current finding related to the effect of PND on non-exclusive breastfeeding is consistent with two systematic reviews [124, 125]. Postnatal depression affects the self-efficacy of the mother and their intention to breastfeed, as explained in the breastfeeding self-efficacy theory [126, 127]. Mothers of better self-efficacy initiate breastfeeding early, stay breastfeeding for a longer time, and produce self-encouraging thoughts to easily overcome challenges of breastfeeding.

**Strength and limitations**

The major strengths of the current review include: (1) it was up-to-date, means included primary studies published up to December 30, 2017; (2) inclusion of 75 studies (22 more studies than the recent systematic review by Gelaye et al. [12]; (3) an in-depth analysis and presentation of PND predictors and; (4) an in-depth and up-to-date estimation and presentation of PND effects on adverse infant health outcomes. However, the estimation would be affected by the type and time of depression measurement, methodological and cultural heterogeneities though we treated this heterogeneity with analytical applications.

Considering the strengths mentioned above and limitations of our systematic review and meta-analysis, we believed in providing the most accurate quantification of PND prevalence, its prominent risk factors and association with infant morbidity, malnutrition, and early breastfeeding cessation in low-and-middle income countries. These findings add one step forward to the consistency of the evidence that PND is a significant public health threat for the birthing mothers and their infants.

**Conclusions**

The findings indicate a quarter and one in five postnatal mothers were depressed in low-and middle-income countries, respectively, an indication that it is highly prevalent in the regions. Postnatal mothers with poor obstetric history and social support, history of common mental disorder and childhood violence, low economic status, a problem with maternal and newborn health were more likely to have depression. Postnatal mothers with depression were also at higher risk of having sick, malnourished, and non-exclusively breastfed infant relative to mothers who did not have depression symptoms. More importantly, this effect was similar between studies that clinically diagnosed depression and used self-reporting scales. Based on the current findings, an early screening of postnatal mothers starting from the first four weeks of birth and taking prompt intervention would save the mother and her infant from morbidity, mortality, disability, and future developmental consequences.

**Supplementary information**

Supplementary information accompanies this paper at https://doi.org/10.1186/s12884-020-03092-7.

**Additional file 1 : Supplementary material 1:** Postnatal supplementary information.
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