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PHYSICAL MORBIDITY AND PSYCHOLOGICAL AND SOCIAL CO-MORBIDITIES AT FIVE STAGES DURING PREGNANCY AND AFTER CHILDBIRTH – A MULTI-COUNTRY CROSS SECTIONAL SURVEY

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PHYSICAL MORBIDITY AND PSYCHOLOGICAL AND SOCIAL CO-MORBIDITIES AT FIVE STAGES DURING PREGNANCY AND AFTER CHILDBIRTH – A MULTI-COUNTRY CROSS SECTIONAL SURVEY

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Abstract

Objective

Maternal morbidity affects millions of women, the burden of which is highest in low resource settings. We sought to explore when this ill-health occurs and is most significant.

Settings

A descriptive observational cross-sectional study at primary and secondary-level healthcare facilities in India, Pakistan, Kenya, and Malawi.

Participants

Women attending for routine antenatal care, childbirth or postnatal care at the study healthcare facilities.

Primary and secondary outcomes

Physical morbidity (infectious, medical, obstetric), psychological and social morbidity co-morbidity were assessed at five stages: first half of pregnancy (≤20 weeks), second half of pregnancy (>20 weeks), at birth (within 24 hours of childbirth), early postnatal (day 1–7) and late postnatal (week 2–12).

Results

11,454 women were assessed: India (2,099) Malawi (2,923) Kenya (3,145) and Pakistan (3,287) with similar numbers assessed at each of the five assessment stages in each country. Infectious morbidity and anaemia are highest in the early postnatal stage (26.1%, 53.6% respectively). For HIV, malaria and syphilis combined, prevalence was highest in the first half of pregnancy (10.0%). Hypertension, pre-eclampsia, and urinary incontinence are most common in the second half of pregnancy (4.6%, 2.1%, 6.6%). Psychological (depression, thoughts of self-harm) and social morbidity (domestic violence, substance misuse) are significant at each stage but most commonly reported in the second half of pregnancy (26.4%, 17.6%, 40.3%, 5.9% respectively). Of all women assessed, maternal morbidity was highest in the second half of pregnancy (81.7%), then the early postnatal stage (80.5%). Across the four countries, maternal morbidity was highest in the second half of pregnancy in Kenya (73.8%) and Malawi (73.8%), and in the early postnatal stage in Pakistan (92.2%) and India (87.5%).

Conclusions

Women have significant maternal multi-morbidity across all stages of the continuum of pregnancy and childbirth, and especially in the second half of pregnancy and after childbirth.

Keywords

Maternal morbidity, co-morbidity, multi-morbidity, antenatal, postnatal, diagnostic screening, psychological health, social health, low- and middle- income countries.

Ethics

The Liverpool School of Tropical Medicine, Liverpool, UK, granted full ethical approval (LSTM14.025). Ethical approval was also obtained from each country-specific research ethics committee: The College of Medicine Research and Ethics Committee, College of Medicine, Blantyre, Malawi (P.07/14/1600); Kenyatta National Hospital and University of Nairobi, Ethics and Research Committee, Nairobi, Kenya (P574/09/214); Research and Ethics Committee, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India (IEC/SJH/VMMC/Project/September-14/19/482); and the National Bioethics Committee, Islamabad, Pakistan (4-87/14/NBC-159/RDC/1850). Written informed consent was obtained from each woman who participated in the study.

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Article summary

Strengths and limitations of this study

- This is one of the first studies to comprehensively describe the burden of maternal multi-morbidity at five assessment stages during pregnancy and after childbirth, using a standardised approach to assess the physical, psychological, and social components of ill-health in combination with objective clinical and laboratory measurements.
- A large sample (11,454) of women across four low-and middle- income countries were surveyed at five assessment stages during pregnancy and after childbirth.
- The study population assessed women who had accessed care at a healthcare facility for routine antenatal care, childbirth and/or postnatal care, and was not able to assess the burden of maternal morbidity in women who did not access care.
- We did not assess women who may have experienced adverse pregnancy outcome (e.g. stillbirth) and such women might have an even higher burden of pregnancy related morbidity.
- The study population we assessed in each country may not be generalizable to different regions of the same country or to other low-and middle-income countries.

Introduction

The global maternal health agenda has undergone a re-focus from preventing maternal deaths to promoting women's health and wellness [1,2]. Addressing the burden of maternal multi-morbidity during and after pregnancy and the need to prevent and treat chronic and non-communicable diseases, is gaining importance as new focus for global initiatives, consistent with the current international strategy that all women have the right to the highest attainable standard of health and well-being, including all dimensions of health i.e. physical, psychological and social health [1,2,3]. An international aim is to ensure that every woman in every setting has an equal chance to 'survive and thrive' during and after pregnancy and that every mother can enjoy a wanted and healthy pregnancy, safe childbirth and full recovery after childbirth [1,2]. However, currently this is not the case with many women living in low- and middle- income countries (LMIC) with recent studies reporting that there is likely to be a significant burden of physical morbidity and co-morbidities during and after pregnancy which may remain un-recognised if care services are not improved [4-7].

Over the past 10 years, the focus of many maternal health intervention programs in LMIC has been centred on care during childbirth and the time immediately after birth with the aim to reduce the global burden of maternal deaths, stillbirths and early neonatal deaths; 'the triple return' [2]. Focusing only on the number of women who die, ignores the women who suffer both severe and non-severe complications related to pregnancy and childbirth [8,9]. Until recently, less emphasis has been placed on ensuring the availability and quality of maternity care during and after pregnancy, and the need to improve maternal health outcomes and experiences.

Maternal morbidity represents a critical interface in the continuum between a healthy pregnancy and childbirth and maternal death [10]. While some mothers will recover from their experienced ill-health with or without treatment, others will not. An increased awareness and understanding of the burden of physical morbidity and associated psychological and/or social co-morbidity, along with prevention, early recognition and appropriate management where required, are important steps that need to be taken to improve maternal health, avert adverse pregnancy outcomes and potentially averting preventable deaths [4-11]. Maternal morbidity is defined as 'any health condition attributed to and/or complicating pregnancy, and childbirth that has a negative impact on the woman's

wellbeing' [12]. Several recent studies have attempted to describe and/or measure the burden of maternal morbidity in line with this new definition in women in low resources settings [4-7,13-15]. However, there is still a lack of information regarding when (during pregnancy or after childbirth) this burden occurs and is most significant. This should inform when the optimal timing is for screening, prevention, and management.

The objective of this study was to assess the prevalence and types of maternal morbidity and co-morbidities for each of five different stages during and after pregnancy and to assess if there are differences in the trends of occurrence and types of physical morbidity, and psychological and social co-morbidity at different stages.

Materials and Methods

Study design and settings

The details of the study design, setting, participants have been described previously [6]. In summary, we conducted a descriptive observational cross-sectional study in India, Pakistan, Kenya, and Malawi, across as representative sample of 12 secondary and 17 primary care level facilities in rural and urban areas.

Participants

All women attending for antenatal care, childbirth or postnatal care at the study healthcare facilities were eligible for inclusion. Women who were too ill to participate (for example altered conscious level, admission to high dependency unit or intensive care unit) were excluded. Each woman was assessed at one of the five stages of pregnancy: first half of pregnancy (≤20 weeks), second half of pregnancy (>20 weeks), birth (within 24 hours of childbirth), early postnatal (days 1-7) and late postnatal (weeks 2-12). For the antenatal assessments, gestation was calculated based on the women's last menstrual period or the results of a dating scan if available. Women were recruited sequentially until the target sample size for each assessment stage was reached in each healthcare facility. All women who consented to take part in the study were interviewed and had a full clinical examination, and basic urine and serological investigations performed by trained healthcare providers (midwives and doctors). Data was collected using a standardised structured questionnaire

formatted onto electronic tablets in India, Pakistan and Kenya. Paper questionnaires were used in Malawi. Demographics including age, marital status, occupation and educational level and socio-economic status were assessed. Current physical symptoms were assessed using 76 questions covering six organ systems - cardiopulmonary, gastrointestinal, musculoskeletal, uro-gynaecology, obstetric, and breast, and miscellaneous (dermatology, endocrine, neurological, immunology, ear-nose-throat). Psychological health was assessed using the Edinburgh Postnatal Depression Scale (EPDS) using a cut-off point of >10 [15]. The 'Hurt, Insulted, Threatened, Screamed at' (HITS) questionnaire was used to assess domestic violence, from the husband or partner and/or other family members (with a score of >10 indicating significant abuse) [16]. Four questions from the 'Alcohol, Smoking and Substance Involvement Screening Test (ASSIST)' questionnaire were included [17].

Clinical parameters including height, weight, pulse rate (PR), respiratory rate (RR), blood pressure (BP), and oral temperature (T) were measured and the conjunctiva, sclera, breast, abdomen (general and obstetric) were examined. Inspection of the perineum and/or speculum examination was only conducted if clinically indicated (for symptoms of vaginal discharge, bleeding, pain).

Urinalysis was performed using Multistix GP©. A simple finger prick test was used to obtain one capillary (<0·5ml) of blood for use in four rapid diagnostic tests: haemoglobin (Hemocue©), malaria (Humasis©), syphilis and Human Immunodeficiency Virus (HIV) (SD BIOLINE HIV/Syphilis Duo©), and C-reaction protein (CRP) (QuickRead©). A reported symptom of cough >two weeks was used to identify chest infection and/or suspected tuberculosis. Anaemia was classified as haemoglobin less than 110 g/l (WHO 2011). Hypertension was classified as BP≥140/90 [18]. Pre-eclampsia was defined as BP≥140/90, and proteinuria (PR >++ on urinalysis) after 20 weeks' gestation [19]. We amended the Systematic Inflammatory Response Syndrome (SIRS) to define possible early infection as the presence of two or more of the following: (1) T>38 °C or <36°C, (2) PR>90 beats per minute; (3) RR>20 breaths per minute or (4) raised CRP (defined as >5mg/dL at each assessment stage, apart from the early postnatal period (first 7 days) where raised CRP was defined as >10mg/dL [20]. Antenatal haemorrhage was defined as women who reported bleeding per vagina during pregnancy and/or who had this confirmed-on examination. Incontinence was defined as all women who reported any leakage of urine and/or had this confirmed-on examination. Summative physical morbidity was categorised as (1) infectious or (2) medical or obstetric. Infectious morbidity

included: HIV, malaria, syphilis, chest infection and/or suspected tuberculosis, and a SIRS score of ≥2. Medical or obstetric morbidity included: anaemia, hypertension, pre-eclampsia, antenatal haemorrhage, and urinary incontinence. Psychological morbidity was defined as an EPDS score of ≥10 and/or thoughts of self-harm. Social morbidity was defined as a woman reporting any domestic violence (HITS score >4) and/or any substance misuse. Maternal morbidity was considered as at least one physical morbidity, or psychological or social co-morbidity.

Sample size calculation and statistical analysis

In Pakistan, Kenya, and Malawi for each of the five assessment stages, data were collected for a minimum of 576 women across two levels of healthcare facility (primary and secondary) selected by stratified cluster sampling [6]. In India, as the study was conducted in one facility (secondary level facility offering primary and secondary care) a cluster sampling approach was not required, giving an amended sample size of 1,900 with a minimum of 380 women per assessment stage [6]. This sample size had 95% power to detect the presence of any morbidity with a prevalence greater than 1%. Data analysis was performed using SPSS version 22 and Stata version 12.1. Unless otherwise stated, all percentages reported use the total sample size for the relevant country. Where a substantial percentage of women have data missing for a variable (>10%) this is stated in the text, but the numbers missing are not tabulated. Percentages are derived using the number of women who responded per assessment stage. Analysis was conducted separately for each stage of pregnancy for each country and then for each stage of pregnancy for women in all countries combined as a cohort.

Ethics

This research was conducted along with the ethics from the Declaration of Helsinki. The Liverpool School of Tropical Medicine, Liverpool, UK, granted full ethical approval (LSTM14.025). Ethical approval was also obtained from each country-specific research ethics committee: The College of Medicine Research and Ethics Committee, College of Medicine, Blantyre, Malawi (P.07/14/1600); Kenyatta National Hospital and University of Nairobi, Ethics and Research Committee, Nairobi, Kenya (P574/09/214); Research and Ethics Committee, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India

(IEC/SJH/VMMC/Project/September-14/19/482); and the National Bioethics Committee, Islamabad, Pakistan (4-87/14/NBC-159/RDC/1850). Written informed consent was obtained from each woman who participated in the study.

Patient and public involvement

No patient nor members of the public were involved in the design, conduct or dissemination of this study.

Results

Study population

A total of 11,454 women across four LMICs were assessed: India (2,099), Pakistan (3,287), Kenya (3,145) and Malawi (2,923) with similar numbers of women assessed at each of the five stages, during and after pregnancy. The socio-demographic and obstetric characteristics of women per stage are displayed in **Supplementary Table 1**. Results are reported for the combined cohort of women and where there are significant differences between the women from each country, these are commented upon in the narrative text. Data obtained for each country for each pregnancy stage are detailed in **Supplementary Tables 2-9.**

Reported symptoms and severity for each stage of pregnancy

Overall, 8,420 women (73.5%) reported at least one symptom of ill-health at any of the assessment points during or after pregnancy with a median (interquartile range) of 2 (0-5) symptoms per woman. The number of symptoms reported by women varied statistically significantly with stage of pregnancy (using categories presented in **Figure 1**, X^2=330, df=12, p<0.001). In the second half of pregnancy the median (IQR) was 3 (1-6), which was significantly higher than for the other stages, and in the late postnatal stage it was 1 (0-3) whereas for the first half of pregnancy it was 2 (0-4), within 24 hours of childbirth it was 2 (1-5) and early postnatal it was 2 (0-5). The percentage of women with reported ill-health (at least one symptom reported) was highest within 24 hours of childbirth (80.9%), with 77.0% in the second half of pregnancy and 74.7% in the early postnatal but not very different to the first half of pregnancy (72.1%) or late postnatal (62.0%) (**Figure 1**). The percentage of women who reported at least four symptoms was highest (43.1%) in the second half of pregnancy. The percentage of women reporting that they had symptoms that were bothering them 'a lot' was similar at each stage of pregnancy (**Figure 1**) and ranged from 11.0% to 16.6%.

Women living in Pakistan reported higher severities of symptoms compared to India, Kenya, and Malawi; and across all five assessment points. At the start of the pregnancy 11.7% of women had ≥3 abnormalities on clinical examination and 22.2% of women had ≥2 abnormalities on urine and/or blood investigation (**Figure 1**). The highest percentage of women with ≥3 abnormalities on clinical examination ≥2 abnormalities on urine and/or blood investigation were in the early postnatal stage (23.5% and 37.1% respectively) (**Figure 1**).

Infectious morbidity

The percentage of women with early signs of infection (SIRS score ≥2) was highest in the early postnatal period (26.1%) and second half of pregnancy (25.1%). Similar percentages of women were detected to be HIV positive across all five assessment stages. The percentage of women with malaria and syphilis was highest in the first half of pregnancy (3.9% and 1.6% respectively) with decreased prevalence at subsequent points (**Table 1**). For the three main diseases combined (malaria, syphilis, and HIV), prevalence was 8.4% overall and highest in the first half of pregnancy (10.0%). This varied per country **(Supplementary Tables 2-5)** and was 0.4% in India, 0.6% in Pakistan with no syphilis and rare cases of malaria), 4.1% in Kenya (mainly HIV) substantially higher in Malawi (27.9% including HIV 14.3%, malaria 10.2% and syphilis 3.4%). The proportion of women with a positive SIRS score was highest in Kenya in the early postnatal period (44.8%) followed by Malawi at 30.1% in the early postnatal period, 16.6% in India and 15.9% in Pakistan, both in the second half of pregnancy.

Medical and Obstetric morbidity

Overall, 1 in 2 women had anaemia during or after pregnancy, the prevalence of was highest in the early postnatal period (53.6% with 2.8% severe anaemia) with 40% of women anaemic in early pregnancy **(Table 1).** The prevalence of anaemia was particularly high in Pakistan in the second half of pregnancy (76.8% with 3.5% severe anaemia), and in India in the early postnatal period (71.5% with 3.9% severe anaemia) (**Supplementary Table 2-5**). With regards to nutritional status, 3.0% of women had a low BMI (<18.5kg/m^2) in the first half of pregnancy and in the early postnatal stage (**Table 1**). Overall, at the start of pregnancy, women with a low BMI (<18.5kg/m2) was between 3.1% and 7.4%. Overall, the highest prevalence of hypertension or pre-eclampsia was in the second half of pregnancy (4.6% and 2.1% respectively) and this was similar across all four countries; except in India, where the highest

percentage of women with pre-eclampsia was in the early postnatal stage (0.2%). Urinary incontinence was consistently most commonly reported in the second half of pregnancy (6.6% overall) dropping to 3.3% in the late postnatal period. Urinary incontinence was comparatively higher in Pakistan with late postnatal urinary incontinence in 10.2% of women in the late postnatal period compared to nil in India, 0.3% in Malawi and 1.4% in Kenya. Overall, antenatal haemorrhage was reported in 6.3% of women in the first half of pregnancy stage and 3.0% in the second half of pregnancy.

Overall, as a combined cohort 50.0% of women had at least one medical or obstetric morbidity; with the highest prevalence in the early postnatal stage, in India (72.0%) and Kenya (34.5%) or the second half of pregnancy in Pakistan (80.6%) and Malawi (44.8%) (**Supplementary Tables 2-5**).

Psychological co-morbidity

Overall, 26.7% of women reported psychological morbidity; 22.9% of women had an EPDS score of ≥10; and 15.2% of women reported thoughts of self-harm [6]. Depression was the commonest form of psychological morbidity at each assessment stage, with the highest percentage of women reporting symptoms of depression or thoughts of self-harm in the second half of pregnancy (26.4% and 17.6% respectively) compared to the early (22.2% and 15.5%) or late postnatal periods (20.3% and 15.7%) (**Table 2**). These trends were similar in India, Pakistan, and Kenya but in Malawi, psychological morbidity was highest within 24 hours of childbirth (18.9%) (**Supplementary Tables 6-9**).

Social co-morbidity

Overall, 3883 (33.9%) women reported domestic violence (HITS >4) and 969 (8.5%) reported higher levels of domestic violence (HITS>10) from their partner/husband and or family members [6]. The highest percentage of women who reported domestic violence (HITS >4), and higher levels of domestic violence (HITS>10) was in the second half of pregnancy stage (40.3% and 28.6% respectively) (**Table 2**). Higher percentages of women reported domestic violence in the second half of pregnancy in Pakistan (60.4%), Kenya (29.4%) and Malawi (24.3%), compared to India, where more women reported domestic violence in the early postnatal period (43.7%) (**Supplementary Tables 6-9).**

Overall, 672 (5.9%) women reported substance misuse, of which 202 (1.8%) required intervention and this was highest in Pakistan and India in the early postnatal period (12.0 and 2.8% respectively) (**Supplementary Tables 6,7**) and in the late postnatal period in Kenya (9.6%) or within 24 hours of childbirth in Malawi (5.3%) (**Supplementary Tables 8,9**).

Multi-morbidity for each pregnancy stage

Overall, 8936 (78.0%) women reported maternal morbidity (infectious, medical, obstetric, psychological, or social) [6]. The percentages of women reporting maternal morbidity were Pakistan: 90.1%, India: 83.9%, Malawi: 71.9%, and Kenya: 67.1%. Of all women assessed, occurrence of maternal morbidity was highest in the second half of pregnancy (81.7%); followed by the early postnatal stage (80.5%), and within 24 hours of childbirth (79.0%). Similar percentages of women had maternal morbidity in the first half of pregnancy (74.8%) and the late postnatal stage (73.9%). The highest occurrence of maternal morbidity was in the second half of pregnancy in Kenya (73.8%) and Malawi (73.8%). In India and Pakistan, the highest percentage of women who had maternal morbidity was in the early postnatal stage (87.5%, 92.2% respectively). As a combined cohort, the different types of maternal morbidity occurred in similar measures across the continuum of pregnancy and childbirth (**Figure 2**). The range of variation in the means was about 5% for infectious and psychological morbidity, and about 10% for medical/obstetric and social morbidities (**Figure 2**).

Discussion

Main findings

Women have significant maternal morbidity at all stages, and especially in the second half of pregnancy and after childbirth. Most women report symptoms after childbirth (80.9%) but the maximum number of different symptoms is experienced in the second half of pregnancy with a median (IQR) of 3 (1-6) symptoms reported per woman. In this population of women attending for 'routine' antenatal or postnatal care, the proportion of women with an abnormal examination was highest in the first half of pregnancy (62.8%) as was the proportion with at least one abnormal investigation (67.3%).

The burden of infectious morbidity was found to be highest in the early postnatal stage with 26.1% of women having possible early signs of infection (SIRS score ≥2) but 1 in 5 women had possible early signs of infection early or late in pregnancy and in the late postnatal period.

The burden of infectious disease varied per country with malaria, syphilis and HIV more common in Malawi and Kenya (27.9% and 4.1% respectively) than in Pakistan or India although up to 1 in 15 women have evidence of infective morbidity most commonly in the second half of pregnancy (14.6% in India and 12.6% in Pakistan). Anaemia including severe anaemia is most commonly seen in the early postnatal stage (53.6%) but up to 64.1% of women in Pakistan are already anaemic in the first half of pregnancy. As expected, hypertension, pre-eclampsia and urinary incontinence were more common in the second half of pregnancy and haemorrhage more common in early pregnancy. Psychological morbidity including thoughts of self-harm (29.7% and 17.6% respectively) was most commonly diagnosed in late pregnancy with still significant but lower prevalence in the late postnatal period (24.9% and 15.7%). Similarly, the social morbidity was found to be highest in the second half of pregnancy with overall 40% of women reporting domestic violence from their husband or family. Substance abuse was comparatively low with up to 2.2% of women overall having an ASSIST score of >4 in the late postnatal period.

Strengths and limitations of the study

To the best of our knowledge, this is the first study to measure the burden of maternal multi-morbidity in a large sample (11,454) of women across four LMICs considering five separate stages during pregnancy and after childbirth. Our study provides measurements of maternal physical morbidity (categorised as infective, medical, or obstetric) as well as co-morbidities (categorised as psychological and/or social) using clear and concise definitions and clinical assessment methodology, enabling comparisons between different settings and countries. We documented very low refusal rate (range 1.1% -2.5%) and working in 'real life 'settings during routine antenatal and postnatal care provision in each setting and conclude that it is acceptable to women and their healthcare providers, and in principle feasible, to screen women for all the different types of morbidity as part of routine healthcare consultations. Further strengths of this study are that both subjective (self-reported symptoms) and objective measures (examination and investigations) are included enabling a 'diagnosis' to be made where needed rather than using a syndromic approach only. Finally, women were assessed as late as up to 12 weeks' post-childbirth.

We note that this study population assessed women who had accessed care at a healthcare facility for routine antenatal or postnatal and was not able to assess the burden of maternal

morbidity in women who did not access care and/or in women who may have experienced adverse pregnancy outcome (e.g. stillbirth) and who do not generally attend for postnatal care. Such women might have an even higher burden of pregnancy related morbidity. However, we note that many women in these settings do access care at least once during pregnancy (77%) and that skilled birth attendance during childbirth is more common (55%) [21,22].

Interpretation (considering other evidence)

There are a small number of studies conducted to date that have assessed maternal morbidity at different stages during and after pregnancy in LMIC settings [4-7,13,23]. We consider the findings for each type of morbidity below.

Infectious morbidity (considering other evidence)

Infectious morbidity is traditionally considered to be a concern after childbirth as 'puerperal sepsis' [24]. However, our study demonstrates that women have early signs of infection (using an adapted SIRS score) from as early as the first half of pregnancy (21.0%), and throughout later pregnancy and childbirth (25.1 - 21.3%) up to 12 weeks postnatal (23.1%); and that the potential causes of infection was not commonly HIV, TB or malaria. Our findings reflect a similar study where 'fever of unknown origin' was noted to be highest in the second half of pregnancy in Malawi (3.5%) and in the first half of pregnancy in Pakistan (3.6%) [7]. In another study, 6% of women reported febrile symptoms at 4-12 weeks; 11% at 12-24 weeks and 13% at 24-26 weeks after childbirth in Kenya [23]. Further studies are needed to explore the significance of possible proxy-measurements of infectious morbidity and to diagnose and manage underlying infection. In our study the prevalence of malaria and syphilis was highest in the first half of pregnancy stage, suggesting that with screening these conditions are detected and treated early; and/or prophylactic measures are successfully implemented (for example malaria nets and anti-malaria prophylaxis). These findings are like those reported in a similar study where the highest percentage of women with malaria was in the early pregnancy stage in Malawi (8.8%) and Pakistan (2.1%) [7]. In our study, detection of HIV was highest in the early postnatal stage (5.4%). This is a similar finding to that of the Zafar et al study where the highest percentage of women diagnosed with HIV was in the postnatal stage in Malawi (16.5%) and Pakistan (7.0%) [7]. A suggested explanation for these findings could be that these women did not attend for and/or receive screening during antenatal care but

did attend for childbirth at the healthcare facility and were screened for HIV as an inpatient. In the Cherish et al study, infectious morbidity was assessed at different stages after childbirth in women in Kenya; with possible markers of urinary tract infection (leucocytes and nitrites in the urine) more frequent at 4-12 weeks and 12-24 weeks after childbirth [23].

Medical and obstetric morbidity (considering other evidence)

In our study, anaemia continues to be a major morbidity at all stages during and after pregnancy, and many women start their pregnancy anaemic. The severity of anaemia increased as the pregnancy continued, and more women had severe anaemia in the early postnatal stage; and this trend was similar in the four LMIC settings. In a study assessing maternal morbidity in Kenya, the highest percentage of women with anaemia (61.0%) was at 12-24 weeks after childbirth [23]. However, this study did not assess women during pregnancy.

In our study, the percentage of women with hypertension/pre-eclampsia was highest in the second half of pregnancy stage; and the highest percentage of women diagnosed with antepartum haemorrhage was in the first half of pregnancy stage. In our study, the highest percentage of women reporting urinary incontinence was in the second half of pregnancy stage 6.6%. In the Zafar et al study, the highest percentage of women reporting incontinence (urine or faeces) was in the postnatal stage in Malawi (0.9%) and Pakistan (4.7%) [7]. In the Cherish et al study, 2% of women had urine incontinence at 12-24 weeks, and 1% of women had urine incontinence at 4-12 weeks and 24-26 weeks after childbirth in Kenya [23]. In our study 3.3% of women continued to report urinary incontinence in the late postnatal stage and this may represent possible early obstetric fistula. However, in our study women who reported persistent urinary incontinence postnatally were referred for specialist input and we did not have capacity to follow these patients up for a confirmed diagnosis of possible obstetric fistula.

Psychological morbidity (considering other evidence)

Psychological morbidity is traditionally considered to be more significant after pregnancy, where it is termed ‘postnatal depression’. The findings of the prevalence of psychological morbidity in our study are higher than previous global estimates of 10% of women during pregnancy and 13% of women after childbirth being affected by psychological ill-health [25].

The findings from our study are more like those of a systematic review of studies from LMIC settings where psychological morbidity was reported to affect 15.6% of women during pregnancy and 19.8% after pregnancy [26]. Another review reported a prevalence of 1 in 4 women in LMIC settings reporting depression during pregnancy and 1 in 5 reported depression after pregnancy [27]. The authors of the review suggest that the figures in LMIC settings are twice the rate of women in high income countries, and suggest that psychological morbidity in general is not reported, not assessed properly, infrequently recognised and under-treated in many LMIC [26].

Social morbidity (considering other evidence)

In our study, high percentages of women reported domestic violence and low percentages of women reported substance misuse. In the Barreix et al study, 12.8% of women self-reported exposure to violence during pregnancy and 11.0% after childbirth [1]. In the study by Cherish et al, only postnatal women were assessed, and more women reported domestic violence - physical (23.3%), sexual (56.9%) - and substance misuse (11%) at 12-24 weeks compared to 4-12 weeks and 24-26 weeks after childbirth in Kenya [23].

Practical and research recommendations

With emerging evidence of the different types of physical multi-morbidity and co-morbidity at specific stages during and after pregnancy, there is a need for comprehensive and detailed longitudinal studies of women from early pregnancy to an extended postpartum period to understand how health and symptoms and signs of ill-health change over time and how current antenatal and postnatal programmes can be improved to address these [28]. Similarly, there is a gap between measuring morbidity for programmatic purposes and assessing its actual impact on a woman's sense of well-being [29]. Recent studies have explored women's lived experiences of ill-health and perceptions of their health needs during and after pregnancy and these findings, in addition to the findings of our study, need to be considered when developing maternal health interventions to improve the quality of maternity care at different stages during pregnancy and after childbirth for women living in LMIC [30, 31].

Conclusion

The overall findings from our study suggest that there is a large burden of physical morbidity, (including infectious, medical, obstetric), psychological and social co-morbidities in women during pregnancy and up to 12 weeks postnatal who access care in different levels of healthcare facilities across the four LMIC in which this study was conducted. Most importantly, the overall burden of disease is not simply at one 'high risk' stage of pregnancy, but women report and/or are diagnosed with significant physical maternal morbidity and psychological and social co-morbidities throughout the continuum of pregnancy and childbirth. At present, available antenatal and especially postnatal care packages across different settings are not adequate to screen for all forms of physical morbidity (including infectious, medical, obstetric) and psychological and social co-morbidities; and do not address the needs of women in a comprehensive holistic way. Anaemia and possible signs of early infection represent a significant burden of ill-health and may be useful clinical proxy markers for maternal physical morbidity. There is a need to increase the focus of high quality comprehensive maternity care (including mental and social healthcare screening and management), from the first half of pregnancy through to the late postnatal stage, to ensure improved health and well-being for women and their babies during and after pregnancy, and not just at the time of childbirth. There is a need for further research to understand how to support healthcare providers to screen for and provide evidence based care all aspects of maternal multi-morbidity (physical, mental and social) at all contacts during pregnancy and after childbirth.

DECLARATIONS

Author's contributions

MMc co-ordinated and supervised the in-country data collection, collected data, conducted data analysis, data interpretation and wrote the manuscript. SW helped design the study, checked all data analysis, and performed further analyses. SBZ supervised the data collection in Malawi, PG in Kenya, PM in India, and SZ in Pakistan. NvdB developed the study design and protocol, oversaw the design, and conduct of the study, data collection and analysis and wrote the manuscript. All authors have read, edited, and approved the final manuscript for submission.

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Ethics

The Liverpool School of Tropical Medicine, Liverpool, UK, granted full ethical approval (LSTM14.025). Ethical approval was also obtained from each country-specific research ethics committee: The College of Medicine Research and Ethics Committee, College of Medicine, Blantyre, Malawi (P.07/14/1600); Kenyatta National Hospital and University of Nairobi, Ethics and Research Committee, Nairobi, Kenya (P574/09/214); Research and Ethics Committee, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India (IEC/SJH/VMMC/Project/September-14/19/482); and the National Bioethics Committee, Islamabad, Pakistan (4-87/14/NBC-159/RDC/1850). Written informed consent was obtained from each woman who participated in the study.

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Patient and Public Involvement

No patient or member of the public were involved in the design, conduct or dissemination of this study.

Competing interests

The authors declare no competing interests.

Availability of data and materials

Extra data is available from the corresponding author on reasonable request.

Abbreviations

ANC	Antenatal care
ASSIST	Alcohol, Smoking and Substance Involvement Screening Test
BP	Blood pressure
CRP	C-reactive protein
EPDS	Edinburgh Postnatal Depression Scale
HITS	Hurt, Insulted, Threatened, Screamed
HIV	Human Immunodeficient Virus
ICT	Islamabad Capital Territory
LMIC	Low- and middle-income countries
MMR	Maternal mortality ratio
PNC	Postnatal care
PR	Pulse rate
QOL	Quality of Life
RR	Respiratory rate
SAMM	Severe acute maternal morbidity
SDI	Socio-demographic Index
T	Temperature
TB	Tuberculosis

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List of tables and figures

Table 1: Physical multi-morbidity (infectious, medical, obstetric) per assessment stage for all countries combined (n=11,454)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women[a]	2204	2425	2250	2264	2311	11,454
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
INFECTIOUS MORBIDITY						
HIV	99 (4.5%)	107 (4.4%)	107 (4.8%)	123 (5.4%)	116 (5.0%)	551 (4.8%)
Malaria	85 (3.9%)	73 (3.0%)	59 (2.6%)	43 (1.9%)	49 (2.1%)	309 (2.7%)
Syphilis	36 (1.6%)	24 (1.0%)	19 (0.8%)	16 (0.7%)	12 (0.5%)	107 (0.9%)
Positive screening for chest infection/ possible tuberculosis	18 (0.8%)	24 (1.0%)	10 (0.4%)	12 (0.5%)	10 (0.4%)	74 (0·6%)
Septic Inflammatory Response Syndrome (SIRS)[b]	480 (21.8%)	609 (25.1%)	472 (21.0%)	590 (26.1%)	492 (21.3%)	2,643 (23.1%)
MEDICAL OR OBSTETRIC MORBIDITY						
Anaemia[c]	900 (40.8%)	1226 (50.6%)	1096 (48.7%)	1213 (53.6%)	985 (42.6%)	5420 (47.3%)
Severe anaemia	28 (1.3%)	47 (1.9%)	41 (1.8%)	63 (2.8%)	23 (1.0%)	202 (1.8%)
Body mass index ≤18.5 kg/m^2	66 (3.0%)	61 (2.5%)	34 (1.5%)	68 (3.0%)	58 (2.5%)	287 (2.5%)
Body mass index > 30kg/m^2	786 (35.6%)	1264 (50.2%)	912 (40.5%)	665 (29.3%)	761 (32.9%)	4867 (42.5%)
Hypertension	33 (1.5%)	111 (4.6%)	82 (3.6%)	66 (2.9%)	48 (2.1%)	340 (3.0%)
Pre-eclampsia	n/a	51 (2.1%)	18 (0.8%)	17 (0.7%)	n/a	86 (1.2%)
Urine incontinence	67 (3.0%)	161 (6.6%)	69 (3.1%)	44 (1.9%)	76 (3.3%)	417 (3·6%)
Antenatal haemorrhage	139 (6.3%)	74 (3.0%)	n/a	n/a	n/a	213(4.6%)
At least 1 medical or obstetric condition	998 (45.3%)	1328 (54.8%)	1135 (50.4%)	1245 (55.0%)	1017 (44.0%)	5723 (50.0%)

[a] Where data were missing for a condition the condition was regarding as being absent for purposes of deriving morbidities; % missing was: HIV 9.7%, malaria 5.3%, syphilis 8.9%, screening for chest infection/TB 2.0%, nutritional status 2.9%, anaemia 1.9%, blood pressure 2.3%, urine incontinence 0.5%.

[b] CRP was not measured at some primary level facilities in Malawi and Pakistan. Only participants for whom a CRP result was obtained are included in these statistics.

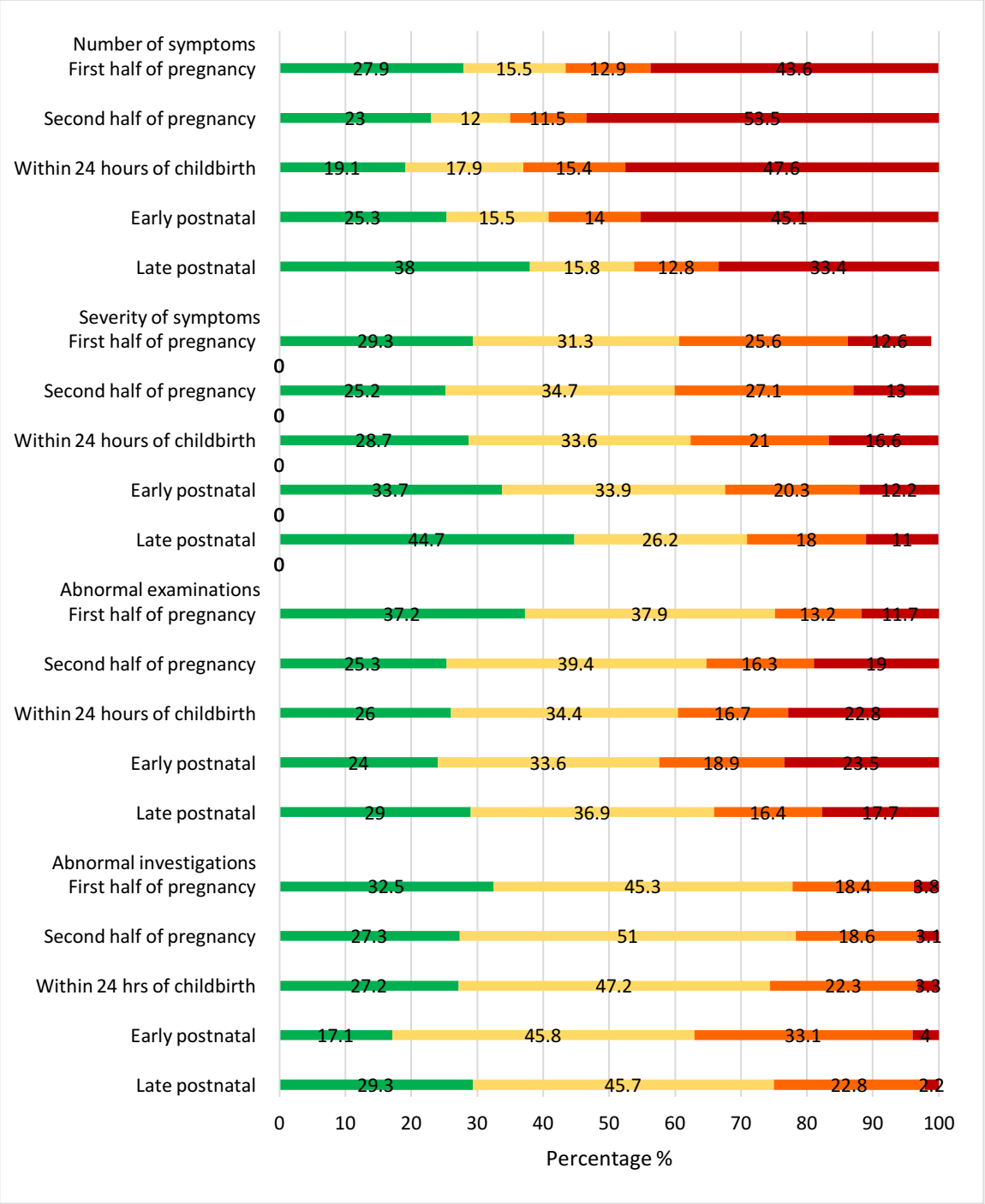
[c] Anaemia is defined as Hb< 11.0g/dL and severe anaemia is defined as Hb<7.0g/dL

Table 2: Psychological and social co-morbidities of women per assessment stage for all countries combined (n= 11,454)

Assessment stage		First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women*		2204	2425	2250	2264	2311	11,454
		n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
PSYCHOLOGICAL MORBIDITY							
EDPS ≥ 10		494 (22.4%)	641 (26.4%)	511 (22.7%)	503 (22.2%)	469 (20.3%)	2618 (22.9%)
Thoughts of self-harm		246 (11.2%)	426 (17.6%)	359 (16.0%)	351 (15.5%)	362 (15.7%)	1744 (15.2%)
EDPS ≥ 10 and/or thoughts of self-harm		542 (24.6%)	721 (29.7%)	630 (28.0%)	591 (26.1%)	575 (24.9%)	3059 (26.7%)
SOCIAL MORBIDITY							
Domestic violence							
HITS score >4	**Husband and/or family**	657 (29.8%)	978 (40.3%)	756 (33.6%)	770 (34.0%)	722 (31.2%)	3883 (33.9%)
	Husband	475 (21.5%)	776 (32.0%)	597 (26.5%)	602 (26.6%)	560 (24.2%)	3010 (26.3%)
	Family	328 (14.9%)	444 (18.3%)	358 (15.9%)	341 (15.1%)	334 (14.4%)	1805 (15.8%)
HITS score >10	**Husband and/or family**	161 (7.3%)	276 (11.4%)	172 (7.6%)	187 (8.3%)	170 (7.4%)	966 (8.4%)
	Husband	101 (4.6%)	223 (9.2%)	109 (4.8%)	127 (5.6%)	121 (5.2%)	681 (6.0%)
	Family	74 (3.4%)	80 (3.3%)	85 (3.8%)	79 (3.5%)	73 (3.2%)	391 (3.4%)
Substance misuse							
Use of alcohol, sedatives, inhalants, tobacco in last 3 months		135 (6.1%)	112 (4.6%)	122 (5.4%)	146 (6.5%)	157 (6.8%)	672 (5.9%)
Intervention required (ASSIST score > 4)		38 (1.7%)	38 (1.6%)	34 (1.5%)	42 (1.9%)	20 (2.2%)	202 (1.8%)

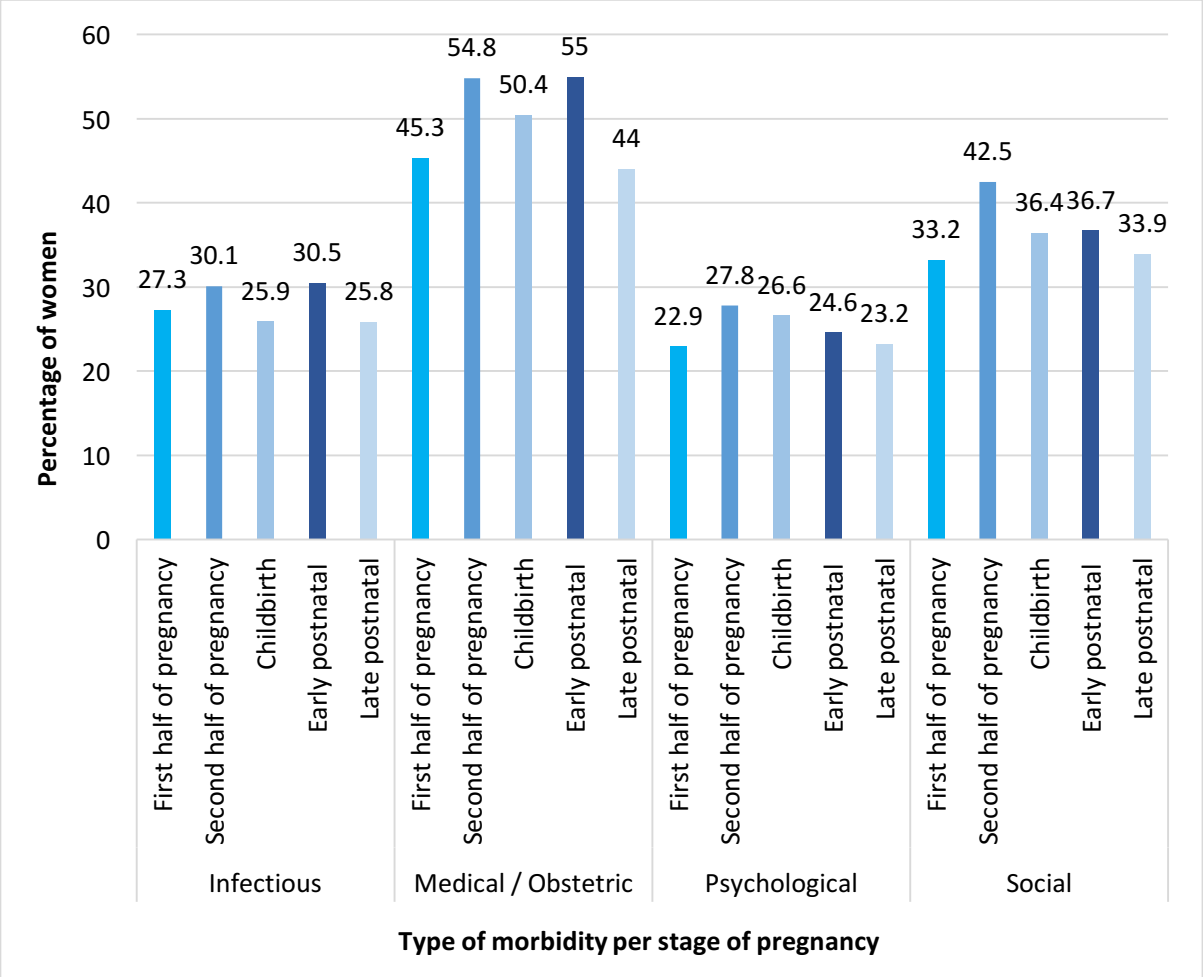
ASSIST: Alcohol, Smoking and Substance Involvement Screening Test; EPDS: Edinburgh Postnatal Depression Scale; HITS: Hurt, Insulted, Threatened, Screamed at.

Figure 1: Histogram of number and severity of symptoms reported, number of abnormal clinical examinations, number of abnormal investigations per stage per combined study population (n=11,454)



	Number of symptoms	Severity of symptoms	Number of abnormal examinations	Number of abnormal investigations
	0	None, Not at all	0	0
	1	Slightly	1	1
	2	Moderately	2	2
	≥3	A lot	≥3	≥3

Figure 2: Percentage of women with infectious, medical/obstetric, psychological and social morbidity per stage per combined study population (n=11,454)



SUPPLEMENTARY TABLES

Supplementary Table 1: Number of women per country, per assessment stage and per healthcare facility level (n=11,454)

Supplementary Table 2: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in India (n=2,099)

Supplementary Table 3: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Pakistan (n=3,287)

Supplementary Table 4: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Kenya (n=3,145)

Supplementary Table 5: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Malawi (n=2,923)

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Supplementary Table 7: Psychological and social morbidity of women per assessment stage for women living in for all countries combined for Pakistan (n= 3,287)

Supplementary Table 8: Psychological and social morbidity per assessment stage for women living in Kenya (n=3,145)

Supplementary Table 9: Psychological and social morbidity per assessment stage for women living in Malawi (n= 2,923)

Supplementary Table 1: Socio-demographic and obstetric characteristics of women by stage and for all stages combined (n=11,454)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total	P value
Number of women	**2,204**	**2,425**	**2,250**	**2,264**	**2,311**	**11,454**	
	%	%	%	%	%	%	
Age category (years)							
<20	11.0	9.4	11.2	11.3	11.3	10.8	0.007
20-24	28.8	26.8	30.6	31.7	28.1	29.2	
25-29	30.7	29.2	29.4	29.8	30.9	30.0	
30-34	15.7	17.8	16.4	15.1	16.4	16.3	
≥35	8.0	8.7	6.6	7.0	7.2	7.5	
Parity							
0 or 1	34.8	30.3	35.7	38.6	35.0	34.8	<0.001
2-4	54.7	56.9	50.8	51.1	55.6	53.8	
≥5	5.9	8.5	6.1	5.7	5.8	6.4	
Marital status							
Single	6.2	6.1	4.9	5.7	4.5	5.5	0.16
Married	92.7	92.5	94.1	93.3	93.7	93.3	
Socioeconomic status (SES)							
1st quintile (upper)	13.7	10.4	10.8	11.2	11.2	11.4	<0.001
2nd quintile	16.5	15.8	15.4	17.4	16.7	16.3	
3rd quintile	31.0	28.8	30.1	28.5	31.8	30.0	
4th quintile	27.5	28.7	29.4	29.3	27.4	28.4	
5th quintile (lower)	8.7	12.1	11.7	10.6	10.3	10.7	
Education level completed							
None	17.2	18.0	20.4	20.9	19.3	19.2	<0.001
Primary	33.1	34.0	35.9	34.1	34.0	34.2	
Secondary	30.0	26.6	25.7	28.1	26.7	27.4	
Post-secondary	15.9	15.6	13.1	13.7	15.5	14.8	

Supplementary Table 2: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in India (n=2,099)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women[a]*	416	397	423	432	431	2099
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
INFECTIOUS MORBIDITY						
Condition						
HIV	2 (0.5%)	2 (0.5%)	1 (0.2%)	1 (0.2%)	0	6 (0.3%)
Malaria	0	0	0	0	2 (0.5%)	2 (0.1%)
Syphilis	0	0	0	0	0	0
Positive screening for chest infection/ possible TB	2 (0.5%)	1 (0.2%)	1 (0.2%)	2 (0.5%)	2 (0.5%)	8 (0.4%)
Septic Inflammatory Response Syndrome (SIRS)[b]	43 (10.3%)	66 (16.6%)	47 (11.1%)	63 (14.6%)	70 (16.2%)	289 (13.8%)
MEDICAL OR OBSTETRIC MORBIDITY						
Condition						
Anaemia[c]	184 (44.2%)	228 (57.4%)	282 (66.7%)	309 (71.5%)	265 (61.5%)	1268 (60.4%)
Severe anaemia	4 (1.0%)	13 (3.3%)	12 (2.8%)	17 (3.9%)	5 (1.2%)	51 (2.4%)
Hypertension	2 (0.5%)	16 (4.0%)	7(1.6%)	7 (1.6%)	1 (0.2%)	33 (1.6%)
Low BMI (<18.5 kg/m^2)	30 (7.4%)	9 (2.3%)	9 (2.1%)	9 (2.1%)	10 (2.3%)	67 (3.2%)
High BMI (> 30kg/m^2)	55 (13.6%)	153 (38.9%)	109 (26.0%)	97 (22.5%)	107 (25%)	521 (25.1)
Pre-eclampsia	n/a	0	0	1 (0.2%)	n/a	1 (0.1%)
Urine incontinence	13 (3.1%)	21 (5.3%)	0	2 (0.5%)	0	36 (1.7%)
Antenatal haemorrhage	0	0	n/a	n/a	n/a	0
At least 1 medical or obstetric condition	202 (48.6%)	254 (64.0%)	285 (67.4%)	311 (72.0%)	266 (61.7%)	1318 (62.8%)

[a] Where data were missing for a condition the condition was regarding as being absent for purposes of deriving morbidities

[b] CRP was not measured at some primary level facilities in Malawi and Pakistan. Only participants for whom a CRP result was obtained are included in these statistics.

[c] Anaemia is defined as Hb< 11.0g/dL and severe anaemia is defined as Hb<7g/dL

Supplementary Table 3: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Pakistan (n=3,287)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women[a]*	607	768	654	618	640	3287
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
INFECTIOUS MORBIDITY						
Condition						
HIV	0	1 (0.1%)	7 (1.1%)	2 (0.3%)	1 (0.2%)	11 (0.3%)
Malaria	0	0	0	1 (0.2%)	0	1 (0.03%)
Syphilis	0	0	0	0	0	0
Positive screening for chest infection/ possible TB	7 (1.1%)	11 (1.4%)	2 (0.3%)	2 (0.3%)	3 (0.5%)	25 (0.8%)
Septic Inflammatory Response Syndrome (SIRS)[b]	67 (11.0%)	122 (15.9%)	54 (8.3%)	70 (11.3%)	55 (8.6%)	368 (11.2%)
MEDICAL OR OBSTETRIC MORBIDITY						
Condition						
Anaemia[c]	389 (64.1%)	590 (76.8%)	435 (66.5%)	437 (70.7%)	375 (58.6%)	2226 (67.7%)
Severe anaemia	9 (1.5%)	27 (3.5%)	18 (2.8%)	22 (3.6%)	5 (0.8%)	81 (2.5%)
Body mass index ≤18.5 kg/m^2	37 (6.2%)	16(2.2%)	7(1.1%)	11 (1.8%)	10 (1.6%)	81 (2.5%)
High BMI (> 30kg/m^2)	289 (48.5%)	470 (63.2%)	306 (48.6%)	325 (53.7%)	307 (49.8%)	1697 (53.2%)
Hypertension	18 (3.0%)	67 (8.7%)	54 (8.3%)	40 (6.5%)	27 (4.2%)	206 (6.3%)
Pre-eclampsia	n/a	26 (3.4%)	8 (1.2%)	6 (1.0%)	n/a	40 (2.0%)
Urine incontinence	40 (6.6%)	106 (13.8%)	64 (9.8%)	39 (6.3%)	65 (10.2%)	314 (9.5%)
Antenatal haemorrhage	80 (13.2%)	60 (7.8%)	n/a	n/a	n/a	140 (10.2%)
At least 1 medical or obstetric condition	422 (69.5%)	619 (80.6%)	455 (69.6%)	455 (73.6%)	388 (60.6%)	2339 (71.2%)

[a] Where data were missing for a condition the condition was regarding as being absent for purposes of deriving morbidities

[b] CRP was not measured at some primary level facilities in Malawi and Pakistan. Only participants for whom a CRP result was obtained are included in these statistics.

[c] Anaemia is defined as Hb< 11.0g/dL and severe anaemia is defined as Hb<7g/dL

Supplementary Table 4: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Kenya (n=3,145)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total

Number of women[a]*	592	684	592	620	657	3145
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
INFECTIOUS MORBIDITY						
Condition						
HIV	24 (4.0%)	19 (2.8%)	24 (4.0%)	25 (4.0%)	25 (3.8%)	117 (3.7%)
Malaria	2 (0.3%)	2 (0.3%)	1 (0.2%)	2 (0.3%)	0	7 (0.2%)
Syphilis	2 (0.3%)	2 (0.3%)	1 (0.2%)	0	3 (0.5%)	8 (0.2%)
Positive screening for chest infection/ possible TB	3 (0.5%)	6 (0.9%)	5 (0.8%)	3 (0.5%)	5 (0.8%)	22 (0.7%)
Septic Inflammatory Response Syndrome (SIRS)[b]	206 (34.8%)	267 (39.0%)	197 (33.3%)	278 (44.8%)	199 (30.3%)	1147 (36.5%)
MEDICAL OR OBSTETRIC MORBIDITY						
Condition						
Anaemia[c]	102 (17.2%)	163 (23.8%)	146 (24.7%)	204 (32.9%)	130 (19.8%)	745 (23.7%)
Severe anaemia	7 (1.2%)	4 (0.6%)	7 (1.2%)	12 (1.9%)	12 (1.8%)	65 (2.1%)
Body mass index ≤18.5 kg/m^2	18 (3.1%)	8 (1.2%)	10 (1.7%)	7 (1.2%)	3 (0.5%)	46 (1.5%)
High BMI (> 30kg/m^2)	278 (47.7%)	404 (59.8%)	328 (56.2%)	350 (57.6%)	325 (50.3%)	1685 (54.4%)
Hypertension	7 (1.2%)	19 (2.8%)	13 (2.2%)	16 (2.6%)	15 (2.3%)	70 (2·2%)
Pre-eclampsia	n/a	8 (1.2%)	0	4 (0.6%)	n/a	12 (0.6%)
Urine incontinence	12 (2.0%)	23 (3.4%)	2 (0.3%)	3 (0.5%)	9 (1.4%)	49 (1.6%)
Antenatal haemorrhage	54 (9.1%)	12 (1.7%)	n/a	n/a	n/a	66 (5.2%)
At least 1 medical or obstetric condition	142 (24.0%)	197 (28.8%)	156 (26.3%)	214 (34.5%)	143 (21.8%)	852 (27.1%)

[a] Where data were missing for a condition the condition was regarding as being absent for purposes of deriving morbidities

[b] CRP was not measured at some primary level facilities in Malawi and Pakistan. Only participants for whom a CRP result was obtained are included in these statistics.

[c] Anaemia is defined as Hb< 11.0g/dL and severe anaemia is defined as Hb<7g/dL

Supplementary Table 5: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Malawi (n=2923)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women [a]	589	576	581	594	583	2923
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
INFECTIOUS MORBIDITY						
HIV	73 (12.4%)	85 (14.8%)	75 (12.9%)	95(16.0%)	90(15.4%)	418 (14.3%)
Malaria	83 (14.1%)	71 (12.3%)	58 (10.0%)	40 (6.7%)	47 (8.1%)	299 (10.2%)
Syphilis	34 (5.8%)	22 (3.8%)	18 (3.1%)	16 (2.7%)	9 (1.5%)	99 (3.4%)
Positive screening for chest infection/ possible TB	6 (1.0%)	6 (1.0%)	2 (0.3%)	5 (0.8%)	0	19 (0.7%)
Septic Inflammatory Response Syndrome (SIRS)[b]	164 (27.8%)	154 26.7(%)	174 (30.0%)	179 (30.1%)	168 (28.8%)	839 (28.7%)
MEDICAL OR OBSTETRIC MORBIDITY						
Anaemia[c]	225 (38.2%)	245 (42.5%)	233 (40.1%)	263 (44.3%)	215 (36.9%)	1181 (40.4%)
Severe anaemia	8 (1.4%)	3 (0.5%)	4 (0.7%)	12 (2.0%)	6 (1.0%)	33 (1.1%)
Body mass index ≤18.5 kg/m^2	18 (3.1%)	7 (1.2%)	19 (3.3%)	22 (3.7%)	22 (3.8%)	88 (3.0%)
High BMI (> 30kg/m^2)	164 (28.3%)	237 (41.6%)	169 (29.2%)	186 (31.5%)	208 (36.1%)	964 (33.3%)
Hypertension	6 (1.0%)	9 (1.6%)	8 (1.4%)	3 (0.5%)	5(0.9%)	31 (1.1%)
Pre-eclampsia	n/a	17 (2.9%)	10 (1.7%)	6 (1.0%)	n/a	49 (2.8%)
Urine incontinence	2 (0.3%)	11 (1.9%)	3 (0.5%)	0	2 (0.3%)	18 (0.6%)
Antenatal haemorrhage	5 (0.9%)	2 (0.4%)	n/a	n/a	n/a	7 (0.6%)
At least one medical or obstetric condition	232 (39.4%)	258 (44.8%)	239 (41.1%)	265 (44.6%)	220 (37.7%)	1214 (41.5%)

[a] Where data were missing for a condition the condition was regarding as being absent for purposes of deriving morbidities

[b] CRP was not measured at some primary level facilities in Malawi and Pakistan. Only participants for whom a CRP result was obtained are included in these statistics.

[c] Anaemia is defined as Hb< 11.0g/dL and severe anaemia is defined as Hb<7g/dL

Supplementary Table 6: Psychological and social morbidity per assessment stage for women living in India (number of women assessed n=2099)

stage		First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women*		416	397	423	432	431	2099
		n %	n %	n %	n %	n %	n %
PSYCHOLOGICAL MORBIDITY							
EDPS ≥ 10		45 (10.8%)	103 (25.9%)	86 (20.3%)	86 (19.9%)	84 (19.5%)	404 (19.2%)
Thoughts of self-harm		40 (9.6%)	79 (19.9%)	72 (17.0%)	71 (16.4%)	66 (15.3%)	328 (15.6%)
EDPS ≥ 10 and/or thoughts of self-harm		60 (14.4%)	116 (29.2%)	102 (24.1%)	99 (22.9%)	95 (22.0%)	472 (22.5%)
SOCIAL MORBIDITY							
Domestic violence							
HITS score >4	Husband and/or family	159 (38.2%)	173 (43.6%)	153 (36.2%)	189 (43.7%)	159 (36.9%)	833 (39.7%)
	Husband	154 (37.0%)	164 (41.3%)	152 (35.9%)	185 (42.8%)	155 (36.0%)	810 (38.6%)
	Family	35 (8.4%)	67 (16.9%)	28 (6.6%)	52 (12.0%)	29 (6.7%)	211 (10.0%)
HITS score >10	Husband and/or family	23 (5.5%)	36 (9.1%)	18 (4.3%)	33 (7.6%)	17 (3.9%)	127 (6.0%)
	Husband	19 (4.6%)	27 (6.8%)	16 (3.8%)	30 (6.9%)	15 (3.5%)	107 (5.1%)
	Family	8 (1.9%)	22 (5.5%)	3 (0.7%)	15 (3.5%)	8 (1.9%)	56 (2.7%)
Substance misuse							
Use of alcohol, sedatives, inhalants, or tobacco in last 3 months		6 (1.4%)	9 (2.3%)	4 (0.9%)	12 (2.8%)	5 (1.2%)	36 (1.7%)
Intervention required		4 (1.0%)	7 (1.8%)	0	5 (1.2%)	1 (0.2%)	17 (0.8%)

ASSIST: Alcohol, Smoking and Substance Involvement Screening Test; EPDS: Edinburgh Postnatal Depression Scale; HITS: Hurt, Insulted, Threatened, Screamed at.

Supplementary Table 7: Psychological and social morbidity of women per assessment stage for women living in for all countries combined for Pakistan (number of women assessed n= 3287)

stage		First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women*		607	768	654	618	640	3287
		n %	n %	n %	n %	n %	n %
PSYCHOLOGICAL MORBIDITY							
EDPS ≥ 10		277 (45.6%)	349 (45.4%)	243 (37.2%)	256 (41.4%)	243 (38.0%)	1368 (41.6%)
Thoughts of self-harm		130 (21.4%)	242 (31.5%)	194 (29.7%)	200 (32.4%)	212 (33.1%)	978 (29.7%)
EDPS ≥ 10 and/or thoughts of self-harm		297 (48.9%)	379 (49.3%)	323 (49.4%)	308 (49.8%)	315 (49.2%)	1622 (49.3%)
SOCIAL MORBIDITY							
Domestic violence							
HITS score >4	Husband and/or family	308 (50.7%)	464 (60.4%)	371 (56.7%)	382 (61.8%)	314 (49.1%)	1839 (55.9%)
	Husband	183 (30.1%)	340 (44.3%)	255 (39.0%)	255 (41.3%)	195 (30.5%)	1228 (37.4%)
	Family	197 (32.4%)	246 (32.0%)	217 (33.2%)	199 (32.2%)	184 (28.7%)	1043 (31.7%)
HITS score >10	Husband and/or family	109 (18.0%)	185 (24.1%)	103 (15.7%)	115 (18.6%)	104 (16.2%)	616 (18.7%)
	Husband	64 (10.5%)	150 (19.5%)	59 (9.0%)	70 (11.3%)	68 (10.6%)	411 (12.5%)
	Family	50 (8.2%)	47 (6.1%)	55 (8.4%)	47 (7.6%)	47 (7.3%)	246 (7.5%)
Substance misuse							
Use of alcohol, sedatives, inhalants, or tobacco in last 3 months		61 (10.0%)	53 (6.9%)	45 (6.9%)	74 (12.0%)	60 (9.4%)	293 (8.9%)
Intervention required		7 (1.1%)	13 (1.7%)	5 (0.8%)	12 (1.9%)	20 (3.1%)	57 (1.7%)

ASSIST: Alcohol, Smoking and Substance Involvement Screening Test; EPDS: Edinburgh Postnatal Depression Scale; HITS: Hurt, Insulted, Threatened, Screamed at.

Supplementary Table 8: Psychological and social morbidity per assessment stage for women living in Kenya (n=3145)

Assessment stage		First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women*		592	684	592	620	657	3145
		n %	**n %**	**n %**	**n %**	**n %**	**n %**
PSYCHOLOGICAL MORBIDITY							
EDPS ≥ 10		86 (14.5%)	101 (14.8%)	81 (13.7%)	72 (11.6%)	49 (7.5%)	389 (12.4%)
Thoughts of self-harm		28 (4.7%)	47 (6.9%)	29 (4.9%)	20 (3.2%)	19 (2.9%)	143 (4.5%)
EDPS ≥ 10 and/or thoughts of self-harm		94 (15.9%)	126 (18.4%)	95 (16.0%)	84 (13.5%)	60 (9.1%)	**459 (14.6%)**
SOCIAL MORBIDITY							
Domestic violence							
HITS score >4	Husband and/or family	99 (16.7%)	201 (29.4%)	130 (22.0%)	105 (17.0%)	144 (21.9%)	679 (21.6%)
	Husband	78 (13.2%)	176 (25.7%)	108 (18.2%)	88 (14.2%)	125 (19.0%)	575 (18.3%)
	Family	29 (4.9%)	51 (7.5%)	35 (5.9%)	24 (3.9%)	47 (7.1%)	186 (5.9%)
HITS score >10	Husband and/or family	9 (1.5%)	26 (3.8%)	22 (3.7%)	12 (1.9%)	17 (2.6%)	86 (2.7%)
	Husband	8 (1.3%)	24 (3.5%)	18 (3.0%)	10 (1.6%)	15 (2.3%)	75 (2.4%)
	Family	2 (0.3%)	2 (0.3%)	6 (1.0%)	2 (0.3%)	2 (0.3%)	14 (0.4%)
Substance misuse							
Use of alcohol, sedatives, inhalants, or tobacco in last 3 months		40 (6.8%)	27 (3.9%)	42 (7.1%)	37 (6.0%)	63 (9.6%)	209 (6.6%)
Intervention required		9 (1.5%)	6 (0.9%)	9 (1.5%)	8 (1.3%)	14 (2.1%)	46 (1.5%)

ASSIST: Alcohol, Smoking and Substance Involvement Screening Test; EPDS: Edinburgh Postnatal Depression Scale; HITS: Hurt, Insulted, Threatened, Screamed at.

Supplementary Table 9: Psychological and social morbidity per assessment stage for women living in Malawi (number of women assessed n= 2923)

Assessment stage		First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women*		589	576	581	594	583	2923
		n %	n %	n %	n %	n %	n %
PSYCHOLOGICAL MORBIDITY							
EDPS ≥ 10		86 (14.6%)	88 (15.3%)	101 (17.4%)	89 (15.0%)	93 (15.9%)	457 (15.6%)
Thoughts of self-harm		48 (8.2%)	58 (10.1%)	64 (11.0%)	60 (10.1%)	65 (11.1%)	295 (10.1%)
EDPS ≥ 10 and/or thoughts of self-harm		91 (15.4%)	100 (17.4%)	110 (18.9%)	100 (16.8%)	105 (18.0%)	506 (17.3%)
SOCIAL MORBIDITY							
Domestic violence							
HITS score >4	Husband and/or family	91 (15.4%)	140 (24.3%)	102 (17.6%)	94 (15.8%)	105 (18.0%)	532 (18.2%)
	Husband	60 (10.2%)	96 (16.7%)	82 (14.1%)	74 (12.5%)	85 (14.6%)	397 (13.6%)
	Family	67 (11.4%)	80 (13.9%)	78 (13.4%)	66 (11.1%)	74 (12.7%)	365 (12.5%)
HITS score >10	Husband and/or family	20 (3.4%)	29 (5.0%)	29 (5.0%)	27 (4.5%)	32 (5.5%)	137 (4.7%)
	Husband	10 (1.7%)	22 (3.8%)	16 (2.7%)	17 (2.9%)	23 (3.9%)	88 (3.0%)
	Family	14 (2.4%)	9 (1.6%)	21 (3.6%)	15 (2.5%)	16 (2.7%)	75 (2.6%)
Substance misuse							
Use of alcohol, sedatives, inhalants, or tobacco in last 3 months		28 (4.7%)	23 (4.0%)	31 (5.3%)	23 (3.9%)	29 (5.0%)	134 (4.6%)
Intervention required		18 (3.1%)	12 (2.1%)	20 (3.4%)	17 (2.9%)	15 (2.6%)	82 (2.8%)

ASSIST: Alcohol, Smoking and Substance Involvement Screening Test; EPDS: Edinburgh Postnatal Depression Scale; HITS: Hurt, Insulted, Threatened, Screamed at.

STROBE Statement for BMJ Open 2021-050287

Checklist of items that should be included in reports of **cross-sectional studies**

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	10
Outcome data	15*	Report numbers of outcome events or summary measures	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11
		(*b*) Report category boundaries when continuous variables were categorized	11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	11
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

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PHYSICAL MORBIDITY AND PSYCHOLOGICAL AND SOCIAL CO-MORBIDITIES AT FIVE STAGES DURING PREGNANCY AND AFTER CHILDBIRTH – A MULTI-COUNTRY CROSS SECTIONAL SURVEY

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PHYSICAL MORBIDITY AND PSYCHOLOGICAL AND SOCIAL CO-MORBIDITIES AT FIVE STAGES DURING PREGNANCY AND AFTER CHILDBIRTH – A MULTI-COUNTRY CROSS SECTIONAL SURVEY

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Abstract

Objective

Maternal morbidity affects millions of women, the burden of which is highest in low resource settings. We sought to explore when this ill-health occurs and is most significant.

Settings

A descriptive observational cross-sectional study at primary and secondary-level healthcare facilities in India, Pakistan, Kenya, and Malawi.

Participants

Women attending for routine antenatal care, childbirth, or postnatal care at the study healthcare facilities.

Primary and secondary outcomes

Physical morbidity (infectious, medical, obstetric), psychological and social morbidity co-morbidity were assessed at five stages: first half of pregnancy (≤20 weeks), second half of pregnancy (>20 weeks), at birth (within 24 hours of childbirth), early postnatal (day 1–7) and late postnatal (week 2–12).

Results

11,454 women were assessed: India (2,099) Malawi (2,923) Kenya (3,145) and Pakistan (3,287) with similar numbers assessed at each of the five assessment stages in each country. Infectious morbidity and anaemia are highest in the early postnatal stage (26.1%, 53.6% respectively). For HIV, malaria and syphilis combined, prevalence was highest in the first half of pregnancy (10.0%). Hypertension, pre-eclampsia, and urinary incontinence are most common in the second half of pregnancy (4.6%, 2.1%, 6.6%). Psychological (depression, thoughts of self-harm) and social morbidity (domestic violence, substance misuse) are significant at each stage but most commonly reported in the second half of pregnancy (26.4%, 17.6%, 40.3%, 5.9% respectively). Of all women assessed, maternal morbidity was highest in the second half of pregnancy (81.7%), then the early postnatal stage (80.5%). Across the four countries, maternal morbidity was highest in the second half of pregnancy in Kenya (73.8%) and Malawi (73.8%), and in the early postnatal stage in Pakistan (92.2%) and India (87.5%).

Conclusions

Women have significant maternal morbidity across all stages of the continuum of pregnancy and childbirth, and especially in the second half of pregnancy and after childbirth.

Keywords

Maternal morbidity, co-morbidity, multi-morbidity, antenatal, postnatal, screening, psychological ill-health, social ill-health, low- and middle- income countries.

Ethics

The Liverpool School of Tropical Medicine, Liverpool, UK, granted full ethical approval (LSTM14.025). Ethical approval was also obtained from each country-specific research ethics committee: The College of Medicine Research and Ethics Committee, College of Medicine, Blantyre, Malawi (P.07/14/1600); Kenyatta National Hospital and University of Nairobi, Ethics and Research Committee, Nairobi, Kenya (P574/09/214); Research and Ethics Committee, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India (IEC/SJH/VMMC/Project/September-14/19/482); and the National Bioethics Committee, Islamabad, Pakistan (4-87/14/NBC-159/RDC/1850). Written informed consent was obtained from each woman who participated in the study.

Funding

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Article summary

Strengths and limitations of this study

- This is one of the first studies to comprehensively describe the burden of maternal multi-morbidity at five assessment stages during pregnancy and after childbirth, using a standardised approach to assess the physical, psychological, and social components of ill-health in combination with objective clinical and laboratory measurements.
- A large sample (11,454) of women across four low-and middle- income countries were surveyed at five assessment stages during pregnancy and after childbirth.
- We describe when different types of maternal morbidity occur most frequently.
- The study population assessed women who had accessed care at a healthcare facility for routine antenatal care, childbirth and/or postnatal care, and did not assess the burden of maternal morbidity in women who did not access care.
- The study population we assessed in each country may not be generalizable to different regions of the same country or to other low-and middle-income countries.

Introduction

The global maternal health agenda has undergone a re-focus from preventing maternal deaths to promoting women's health and wellness [1,2]. Addressing the burden of maternal multi-morbidity during and after pregnancy and the need to prevent and treat chronic and non-communicable diseases, is gaining importance as new focus for global initiatives, consistent with the current international strategy that all women have the right to the highest attainable standard of health and well-being, including all dimensions of health i.e., physical, psychological, and social health [1,2,3]. An international aim is to ensure that every woman in every setting has an equal chance to 'survive and thrive' during and after pregnancy and that every mother can enjoy a wanted and healthy pregnancy, safe childbirth, and full recovery after childbirth [1,2]. However, currently this is not the case for many women in low- and middle- income countries (LMIC) with recent studies reporting that there is likely to be a significant burden of physical morbidity and co-morbidities during and after pregnancy which may remain un-recognised and untreated if routine care services are not improved [4-7]. Over the past 10 years, the focus of many maternal health intervention programs in LMIC has been centred on care during childbirth and the time immediately after birth with the aim to reduce the global burden of maternal deaths, stillbirths, and early neonatal deaths; 'the triple return' [2]. Focusing only on the number of women who die, ignores the women who suffer both severe and non-severe complications related to pregnancy and childbirth [8,9]. Until recently, less emphasis has been placed on ensuring the availability and quality of maternity care during and after pregnancy, and the need to improve maternal health outcomes and experiences. Maternal morbidity represents a critical interface in the continuum between a healthy pregnancy and childbirth and maternal death [10]. While some mothers will recover from their experienced ill-health with or without treatment, others will not. An increased awareness and understanding of the burden of physical morbidity and associated psychological and/or social co-morbidity, along with prevention, early recognition and appropriate management where required, are important steps that need to be taken to improve maternal health, reduce adverse pregnancy outcomes and potentially averting preventable deaths [4-11]. Maternal morbidity is defined as 'any health condition attributed to and/or complicating pregnancy, and childbirth that has a negative impact on the woman's wellbeing' [12]. Several recent

studies have attempted to describe and/or measure the burden of maternal morbidity in line with this new definition in women in low resources settings [4-7,13-15]. However, there is still a lack of information regarding when (during pregnancy or after childbirth) this burden occurs and is most significant. This should inform when the optimal timing is for screening, prevention, and management. The objective of this study was to assess the prevalence and types of maternal morbidity (infectious, medical/obstetric)and psychological and social co-morbidities for each of five different stages during and after pregnancy. Secondly, we explored and compared findings by geographical settings across four LMICs.

Materials and Methods

Study design and settings

The details of the study design, setting, participants have been described previously [6]. In summary, we conducted a descriptive observational cross-sectional study in India, Pakistan, Kenya, and Malawi, across as representative sample of 12 secondary and 17 primary care level facilities in rural and urban areas.

Participants

All women attending for antenatal care, childbirth or postnatal care at the study healthcare facilities were eligible for inclusion. Women who were too ill and unable to speak to participate (for example altered conscious level after an eclamptic seizure) were excluded. Each woman was assessed at one of the five stages of pregnancy: first half of pregnancy (≤20 weeks), second half of pregnancy (>20 weeks), birth (within 24 hours of childbirth), early postnatal (days 1-7) and late postnatal (weeks 2-12). For the antenatal assessments, gestation was calculated based on the women's last menstrual period or the results of a dating scan if available. Women were recruited sequentially until the target sample size for each assessment stage was reached in each healthcare facility. All women who consented to take part in the study were interviewed and had a full clinical examination, and basic urine and serological investigations performed by trained healthcare providers (midwives and doctors). Data was collected using a standardised structured questionnaire formatted onto electronic tablets in India, Pakistan and Kenya. Paper questionnaires were used in Malawi. Demographics including age, marital status, occupation and educational level and socio-

economic status were assessed. Current physical symptoms were assessed using 76 questions covering six organ systems - cardiopulmonary, gastrointestinal, musculoskeletal, uro-gynaecology, obstetric, and breast, and miscellaneous (dermatology, endocrine, neurological, immunology, ear-nose-throat). Psychological health was assessed using the Edinburgh Postnatal Depression Scale (EPDS) using a cut-off point of >10 [15]. The 'Hurt, Insulted, Threatened, Screamed at' (HITS) questionnaire was used to assess domestic violence, from the husband or partner and/or other family members (with a score of >10 indicating significant abuse) [16]. Four questions from the 'Alcohol, Smoking and Substance Involvement Screening Test (ASSIST)' questionnaire were included [17]. Clinical parameters including height, weight, pulse rate (PR), respiratory rate (RR), blood pressure (BP), and oral temperature (T) were measured and the conjunctiva, sclera, breast, abdomen (general and obstetric) were examined. Inspection of the perineum and/or speculum examination was only conducted if clinically indicated (for symptoms of vaginal discharge, bleeding, pain). Urinalysis was performed using Multistix GP©. A simple finger prick test was used to obtain one capillary (<0·5ml) of blood for use in four rapid diagnostic tests: haemoglobin (Hemocue©), malaria (Humasis©), syphilis and Human Immunodeficiency Virus (HIV) (SD BIOLINE HIV/Syphilis Duo©), and C-reaction protein (CRP) (QuickRead©). A reported symptom of cough >two weeks was used to identify chest infection and/or suspected tuberculosis. Anaemia was classified as haemoglobin less than 110 g/l (WHO 2011). Hypertension was classified as BP≥140/90 [18]. Pre-eclampsia was defined as BP≥140/90, and proteinuria (PR >++ on urinalysis) after 20 weeks' gestation [19]. We amended the Systematic Inflammatory Response Syndrome (SIRS) score to define possible early infection as the presence of two or more of the following: (1) T>38 °C or <36°C, (2) PR>90 beats per minute; (3) RR>20 breaths per minute or (4) raised CRP (defined as >5mg/dL at each assessment stage, apart from the early postnatal period (first 7 days) where raised CRP was defined as >10mg/dL [20]. Antenatal haemorrhage was defined as women who reported bleeding per vagina during pregnancy and/or who had this confirmed on examination. Incontinence was defined as all women who reported any leakage of urine and/or had this confirmed-on examination. Summative physical morbidity was categorised as (1) infectious or (2) medical or obstetric. Infectious morbidity included: HIV, malaria, syphilis, chest infection and/or suspected tuberculosis, and a SIRS score of ≥2. Medical or obstetric morbidity included: anaemia, hypertension, pre-eclampsia, antenatal haemorrhage, and

urinary incontinence. Psychological morbidity was defined as an EPDS score of ≥10 and/or thoughts of self-harm. Social morbidity was defined as a woman reporting any domestic violence (HITS score >4) and/or any substance misuse. Maternal morbidity was considered as at least one physical morbidity, or psychological or social co-morbidity.

Sample size calculation and statistical analysis

In Pakistan, Kenya, and Malawi for each of the five assessment stages, data were collected for a minimum of 576 women across two levels of healthcare facility (primary and secondary) selected by stratified cluster sampling [6]. In India, as the study was conducted in one facility (secondary level facility offering primary and secondary care) a cluster sampling approach was not required, giving an amended sample size of 1,900 with a minimum of 380 women per assessment stage [6]. This sample size had 95% power to detect the presence of any morbidity with a prevalence greater than 1%. Data analysis was performed using SPSS version 22 and Stata version 12.1. Unless otherwise stated, all percentages reported use the total sample size for the relevant country. Where a substantial percentage of women have data missing for a variable (>10%) this is stated in the text, but the numbers missing are not tabulated. Percentages are derived using the number of women who responded per assessment stage. Analysis was conducted separately for each stage of pregnancy for each country and then for each stage of pregnancy for women in all countries combined as a cohort.

Ethics

This research was conducted along with the ethics from the Declaration of Helsinki. The Liverpool School of Tropical Medicine, Liverpool, UK, granted full ethical approval (LSTM14.025). Ethical approval was also obtained from each country-specific research ethics committee: The College of Medicine Research and Ethics Committee, College of Medicine, Blantyre, Malawi (P.07/14/1600); Kenyatta National Hospital and University of Nairobi, Ethics and Research Committee, Nairobi, Kenya (P574/09/214); Research and Ethics Committee, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India (IEC/SJH/VMMC/Project/September-14/19/482); and the National Bioethics Committee,

Islamabad, Pakistan (4-87/14/NBC-159/RDC/1850). Written informed consent was obtained from each woman who participated in the study.

Patient and public involvement

No patient nor members of the public were involved in the design, conduct or dissemination of this study.

Results

Study population

A total of 11,454 women across four LMICs were assessed: India (2,099), Pakistan (3,287), Kenya (3,145) and Malawi (2,923) with similar numbers of women assessed at each of the five stages, during and after pregnancy. The socio-demographic and obstetric characteristics of women per stage are displayed in **Supplementary Table 1**. Results are reported for the combined cohort of women and where there are significant differences between the women from each country, these are commented upon in the narrative text. Data obtained for each country for each pregnancy stage are detailed in **Supplementary Tables 2-9.**

Reported symptoms and severity for each stage of pregnancy

Overall, 8,420 women (73.5%) reported at least one physical symptom of ill-health at any of the assessment points during or after pregnancy with a median (interquartile range, IQR) of 2 (0-5) symptoms per woman. The number of symptoms reported by women varied statistically significantly with stage of pregnancy (using categories presented in **Figure 1**, X^2=330, df=12, p<0.001). In the second half of pregnancy the median (IQR) was 3 (1-6), [significantly higher than for the other stages. ; In the late postnatal stage it was 1 (0-3); whereas for the first half of pregnancy it was 2 (0-4), within 24 hours of childbirth it was 2 (1-5) and early postnatal it was 2 (0-5). The percentage of women with reported physical ill-health (at least one symptom reported) was highest within 24 hours of childbirth (80.9%) and the percentage of women who reported at least four symptoms was highest (43.1%) in the second half of pregnancy (**Figure 1**). The percentage of women reporting that they had symptoms that were bothering them 'a lot' was similar at each stage of pregnancy and ranged from 11.0% to 16.6% (**Figure 1**). Women living in Pakistan reported higher severities of symptoms compared to India, Kenya, and Malawi; and across all five assessment points.

At the start of the pregnancy 11.7% of women had ≥3 abnormalities on clinical examination and 22.2% of women had ≥2 abnormalities on urine and/or blood investigation (**Figure 1**). The highest percentage of women with ≥3 abnormalities on clinical examination or ≥2 abnormalities on urine and/or blood investigation were in the early postnatal stage (23.5% and 37.1% respectively) (**Figure 1**).

Infectious morbidity

The percentage of women with early signs of infection (SIRS score ≥2) was highest in the early postnatal period (26.1%) and second half of pregnancy (25.1%). Similar percentages of women were detected to be HIV positive across all five assessment stages. The percentage of women with malaria and syphilis was highest in the first half of pregnancy (3.9% and 1.6% respectively) with decreased prevalence at subsequent points (**Table 1**). For the three main diseases combined (malaria, syphilis, and HIV), prevalence was 8.4% overall and highest in the first half of pregnancy (10.0%). This varied per country **(Supplementary Tables 2-5)** and was 0.4% in India, 0.6% in Pakistan with no syphilis and rare cases of malaria), 4.1% in Kenya (mainly HIV) substantially higher in Malawi (27.9% including HIV 14.3%, malaria 10.2% and syphilis 3.4%). The percentage of women with a positive SIRS score was highest in Kenya in the early postnatal period (44.8%) followed by Malawi at 30.1% in the early postnatal period, 16.6% in India and 15.9% in Pakistan, both in the second half of pregnancy **(Supplementary Tables 2-5)**.

Medical and obstetric morbidity

Overall, 1 in 2 women had anaemia during or after pregnancy, the prevalence of was highest in the early postnatal period (53.6% with 2.8% severe anaemia) with 40% of women anaemic in early pregnancy **(Table 1).** The prevalence of anaemia was particularly high in Pakistan in the second half of pregnancy (76.8% with 3.5% severe anaemia), and in India in the early postnatal period (71.5% with 3.9% severe anaemia) (**Supplementary Table 2-5**). With regards to nutritional status, 3.0% of women had a low BMI (<18.5kg/m^2) in the first half of pregnancy and in the early postnatal stage (**Table 1**). Overall, the highest prevalence of hypertension or pre-eclampsia was in the second half of pregnancy (4.6% and 2.1% respectively), and this was similar across all four countries; except in India, where the highest percentage of women with pre-eclampsia was in the early postnatal stage (0.2%). Urinary incontinence was consistently most commonly reported in the second half of

pregnancy (6.6% overall) dropping to 3.3% in the late postnatal period. Urinary incontinence was comparatively higher in Pakistan with late postnatal urinary incontinence in 10.2% of women in the late postnatal period compared to nil in India, 0.3% in Malawi and 1.4% in Kenya (**Supplementary Table 2-5**). Overall, antenatal haemorrhage was reported in 6.3% of women in the first half of pregnancy stage and 3.0% in the second half of pregnancy. Overall, as a combined cohort 50.0% of women had at least one medical or obstetric morbidity; with the highest prevalence in the early postnatal stage in India (72.0%) and Kenya (34.5%) or the second half of pregnancy in Pakistan (80.6%) and Malawi (44.8%) (**Supplementary Tables 2-5**).

Psychological co-morbidity

Overall, 26.7% of women reported psychological morbidity; 22.9% of women had an EPDS score of ≥10; and 15.2% of women reported thoughts of self-harm [6]. Depression was the commonest form of psychological morbidity at each assessment stage, with the highest percentage of women reporting symptoms of depression or thoughts of self-harm in the second half of pregnancy (26.4% and 17.6% respectively) compared to the early (22.2% and 15.5%) or late postnatal periods (20.3% and 15.7%) (**Table 2**). These trends were similar in India, Pakistan, and Kenya but in Malawi, psychological morbidity was highest within 24 hours of childbirth (18.9%) (**Supplementary Tables 6-9**).

Social co-morbidity

Overall, 3883 (33.9%) women reported domestic violence (HITS >4) and 969 (8.5%) reported higher levels of domestic violence (HITS>10) from their partner/husband and or family members [6]. The highest percentage of women who reported domestic violence (HITS >4), and higher levels of domestic violence (HITS>10) was in the second half of pregnancy stage (40.3% and 28.6% respectively) (**Table 2**). Higher percentages of women reported domestic violence in the second half of pregnancy in Pakistan (60.4%), Kenya (29.4%) and Malawi (24.3%), compared to India, where more women reported domestic violence in the early postnatal period (43.7%) (**Supplementary Tables 6-9).**

Overall, 672 (5.9%) women reported substance misuse, of which 202 (1.8%) required intervention and this was highest in Pakistan and India in the early postnatal period (12.0 and 2.8% respectively) (**Supplementary Tables 6,7**) and in the late postnatal period in Kenya (9.6%) or within 24 hours of childbirth in Malawi (5.3%) (**Supplementary Tables 8,9**).

Multi-morbidity for each pregnancy stage

Overall, 8936 (78.0%) women reported maternal morbidity (infectious, medical, obstetric, psychological, or social) [6]. The percentages of women reporting maternal morbidity were Pakistan: 90.1%, India: 83.9%, Malawi: 71.9%, and Kenya: 67.1%. Of all women assessed, occurrence of maternal morbidity was highest in the second half of pregnancy (81.7%); followed by the early postnatal stage (80.5%), and within 24 hours of childbirth (79.0%). Similar percentages of women had maternal morbidity in the first half of pregnancy (74.8%) and the late postnatal stage (73.9%). The highest occurrence of maternal morbidity was in the second half of pregnancy in Kenya (73.8%) and Malawi (73.8%). In India and Pakistan, the highest percentage of women who had maternal morbidity was in the early postnatal stage (87.5%, 92.2% respectively). As a combined cohort, the different types of maternal morbidity occurred in similar measures across the continuum of pregnancy and childbirth (**Figure 2**). The range of variation in the means was about 5% for infectious and psychological morbidity, and about 10% for medical/obstetric and social morbidities (**Figure 2**).

Discussion

Main findings

Women have significant maternal morbidity during pregnancy and after childbirth. Prevalence of maternal morbidity is highest in the second half of pregnancy and after childbirth. Most women report physical symptoms after childbirth (80.9%), and the maximum number of different symptoms is experienced in the second half of pregnancy with a median (IQR) of 3 (1-6) symptoms reported per woman. In this population of women attending for routine antenatal or postnatal care, the percentage of women with an abnormal examination and/or investigation was highest in the first half of pregnancy (62.8%, 67.3% respectively). The burden of infectious morbidity was highest in the early postnatal stage with 26.1% of women having possible early signs of infection (SIRS score ≥2). However, early signs of infection also occurred in 1 in 5 women early or late in pregnancy and in the late postnatal period. The burden of infectious disease varied per country with malaria, syphilis and HIV more common in Malawi and Kenya (27.9% and 4.1% respectively) than in Pakistan or India although up to 1 in 15 women have evidence of infective morbidity most commonly in the second half of pregnancy (14.6% in India and 12.6% in Pakistan).

Anaemia including severe anaemia is most commonly seen in the early postnatal stage (53.6%) but up to 64.1% of women in Pakistan are already anaemic in the first half of pregnancy. As expected, hypertension, pre-eclampsia and urinary incontinence were more common in the second half of pregnancy and haemorrhage more common in early pregnancy. Psychological morbidity including symptoms of depression and thoughts of self-harm (29.7% and 17.6% respectively) was most commonly diagnosed in late pregnancy with still significant but lower prevalence in the late postnatal period (24.9% and 15.7%). Similarly, social morbidity was found to be highest in the second half of pregnancy with overall 40% of women reporting domestic violence from their husband or family. Substance abuse was comparatively low with up to 2.2% of women overall having an ASSIST score of >4 in the late postnatal period.

Strengths and limitations of the study

To the best of our knowledge, this is the first study to measure the burden of maternal morbidity in a large sample (11,454) of women across four LMICs considering five separate stages during pregnancy and after childbirth. Our study provides measurements of maternal physical morbidity (infective, medical, or obstetric) as well as co-morbidities (psychological and/or social) using clear and concise definitions and clinical assessment methodology, enabling comparisons between different settings and countries. We documented very low refusal rate (range 1.1% -2.5%) and working in 'real life 'settings during routine antenatal and postnatal care provision in each setting and conclude that it is acceptable to women and their healthcare providers, and in principle feasible, to screen women for all the different types of maternal morbidity as part of routine healthcare consultations. Further strengths of this study are that both subjective (self-reported symptoms) and objective measures (examination and investigations) are included enabling a 'diagnosis' to be made where needed rather than using a syndromic approach only. Finally, women were assessed as late as up to 12 weeks' post-childbirth. We note that this study population assessed women who had accessed care at a healthcare facility for routine antenatal or postnatal and was not able to assess the burden of maternal morbidity in women who did not access care and/or in women who may have experienced adverse pregnancy outcome (e.g., stillbirth) and who do not generally attend for postnatal care. Such women might have an even higher burden of pregnancy related morbidity. However, we note that many women in these

settings do access care at least once during pregnancy (77%) and that skilled birth attendance during childbirth is more common (55%) [21,22]. We assessed women in two antenatal contacts only (early and late pregnancy) and future studies could consider assessing women in each trimester. We note that the study population we assessed in each country may not be generalizable to different regions of the same country or to other low- and middle-income countries.

Interpretation (considering other evidence)

This paper describes the burden of maternal morbidity at five different stages during and after pregnancy in four LMIC settings. The overall burden of maternal morbidity and associated factors have been described previously by this research group [6]. At present, it is challenging to interpret measurements of maternal morbidity as there are few studies that have assessed maternal morbidity at different stages during and after pregnancy in LMIC settings [4-7,13,23]; and terms such as "maternal morbidity", "maternal co-morbidity", "maternal multimorbidity" have been used interchangeably. We consider our findings for each type of morbidity to studies that have explored maternal morbidity.

Infectious morbidity (considering other evidence)

Infectious morbidity is traditionally considered to be a concern after childbirth as 'puerperal sepsis' [24]. However, our study demonstrates that women have early signs of infection (using an adapted SIRS score) from the first half of pregnancy (21.0%), and throughout later pregnancy and childbirth (25.1 - 21.3%) and up to 12 weeks postnatal (23.1%); and that the potential causes of infection was not commonly HIV, TB, or malaria. Our findings reflect a similar study that explored non-life threatening maternal morbidity where 'fever of unknown origin' was noted to be highest in the second half of pregnancy in Malawi (3.5%) and in the first half of pregnancy in Pakistan (3.6%) [7]. In another study, 6% of women reported febrile symptoms at 4-12 weeks; 11% at 12-24 weeks and 13% at 24-26 weeks after childbirth in Kenya [23]. Further studies are needed to explore the significance of possible proxy measurements of infectious morbidity and to diagnose and manage underlying infection. In our study the prevalence of malaria and syphilis was highest in the first half of pregnancy stage, suggesting that with screening these conditions are detected and treated early; and/or prophylactic measures are successfully implemented (for example malaria nets and anti-malaria prophylaxis). These findings are like those reported in a similar

study where the highest percentage of women with malaria was in the early pregnancy stage in Malawi (8.8%) and Pakistan (2.1%) [7]. In our study, detection of HIV was highest in the early postnatal stage (5.4%). This is a similar finding to that of the Zafar et al study where the highest percentage of women diagnosed with HIV was in the postnatal stage in Malawi (16.5%) and Pakistan (7.0%) [7]. A suggested explanation for these findings could be that these women did not attend for and/or receive screening during antenatal care but did attend for childbirth at the healthcare facility and were screened for HIV as an inpatient.

Medical and obstetric morbidity (considering other evidence)

In our study, anaemia continues to be a major morbidity at all stages during and after pregnancy, and many women start their pregnancy anaemic. The severity of anaemia increased as the pregnancy continued, and more women had severe anaemia in the early postnatal stage; and this trend was similar in the four LMIC settings. In a study assessing maternal morbidity in Kenya, the highest percentage of women with anaemia (61.0%) was at 12-24 weeks after childbirth [23]. However, this study did not assess women during pregnancy. In our study, the percentage of women with hypertension/pre-eclampsia was highest in the second half of pregnancy stage; and the highest percentage of women diagnosed with antepartum haemorrhage was in the first half of pregnancy stage. In our study, the highest percentage of women reporting urinary incontinence was in the second half of pregnancy stage 6.6%. In a similar study, the highest percentage of women reporting incontinence (urine or faeces) was in the postnatal stage in Malawi (0.9%) and Pakistan (4.7%) [7]. In the Cherish et al study, 2% of women had urine incontinence at 12-24 weeks, and 1% of women had urine incontinence at 4-12 weeks and 24-26 weeks after childbirth in Kenya [23]. In our study 3.3% of women continued to report urinary incontinence in the late postnatal stage and this may represent possible early obstetric fistula. However, in our study women who reported persistent urinary incontinence postnatally were referred for specialist input and we did not have capacity to follow these patients up for a confirmed diagnosis of possible obstetric fistula.

Psychological morbidity (considering other evidence)

Psychological morbidity is traditionally considered to be more significant after pregnancy, often termed ‘postnatal depression’. The findings of the prevalence of psychological

morbidity in our study are higher than previous global estimates of 10% of women during pregnancy and 13% of women after childbirth being affected by psychological ill-health [25]. The findings from our study are more like those of a systematic review of studies from LMIC settings where psychological morbidity was reported to affect 15.6% of women during pregnancy and 19.8% after pregnancy [26]. Another review reported a prevalence of 1 in 4 women in LMIC settings reporting depression during pregnancy and 1 in 5 reported depression after pregnancy [27]. The authors of the review suggest that the figures in LMIC settings are twice the rate of women in high-income countries and suggest that psychological morbidity in general is not reported, not assessed properly, infrequently recognised, and under-treated in many LMIC [26].

Social morbidity (considering other evidence)

In our study, high percentages of women reported domestic violence and low percentages of women reported substance misuse. In a similar study, 12.8% of women self-reported exposure to violence during pregnancy and 11.0% after childbirth [1]. Ina study exploring maternal morbidity in Kenya, only postnatal women were assessed, and more women reported domestic violence -physical (23.3%), sexual (56.9%) - and substance misuse (11%) at 12-24 weeks compared to 4-12 weeks and 24-26 weeks after childbirth in Kenya [23].

Practical and research recommendations

With emerging evidence of the different types of physical multi-morbidity and co-morbidity at specific stages during pregnancy and after childbirth, there is a need for comprehensive and detailed longitudinal studies of women from early pregnancy to an extended postpartum period to understand how health and symptoms and signs of ill-health change over time and how current antenatal and postnatal programmes can be improved to address these [28]. There is ample evidence that psychological and social morbidity are associated with adverse consequences for the mother and the baby, both short and long term [29-33], and there is a need to further explore and document how these types of maternal morbidities are interlinked and associated. There is a need to refine the current definition of maternal morbidity considering the conceptualizations of “maternal multimorbidity” and/or “maternal co-morbidities”, and/or related constructs; and to clarify the timeframe over which maternal morbidity impacts a woman’s health and wellbeing [14]. Similarly, there is a gap between measuring morbidity for programmatic purposes and

assessing its actual impact on a woman's sense of well-being [34]. Recent studies have explored women's lived experiences of ill-health and perceptions of their health needs during and after pregnancy and these findings, in addition to the findings of our study, need to be considered when developing maternal health interventions to improve the quality of maternity care at different stages during pregnancy and after childbirth for women living in LMIC [35, 36].

Conclusion

The overall findings from our study suggest that there is a large burden of physical morbidity, (including infectious, medical, obstetric), psychological and social co-morbidities in women during pregnancy and up to 12 weeks postnatal who access care in different levels of healthcare facilities across the four LMIC in which this study was conducted. Most importantly, the overall burden of ill-health is not simply at one 'high risk' stage of pregnancy, but women report and/or are diagnosed with significant physical morbidity and psychological and social co-morbidities throughout the continuum of pregnancy and childbirth. At present, available antenatal and especially postnatal care packages across different settings are not adequate to screen for all forms of physical morbidity (infectious, medical, obstetric) and psychological and social co-morbidities; and do not address the needs of women in a comprehensive holistic way. Anaemia and possible signs of early infection represent a significant burden of ill-health along the continuum of pregnancy and childbirth and may be useful clinical proxy markers for physical maternal morbidity. There is a need to increase the focus of high quality comprehensive maternity care (including mental and social healthcare screening and management), from the first half of pregnancy through to the late postnatal stage, to ensure improved health and well-being for women and their babies during and after pregnancy, and not just at the time of childbirth. There is a need for further research to understand how to support healthcare providers to screen for and provide evidence based care all aspects of maternal multi-morbidity (physical, psychological, and social) at all contacts during pregnancy and after childbirth.

DECLARATIONS

Author's contributions

MMc co-ordinated and supervised the in-country data collection, collected data, conducted data analysis, data interpretation and wrote the manuscript. SW helped design the study, checked all data analysis, and performed further analyses. SBZ supervised the data collection in Malawi, PG in Kenya, PM in India, and SZ in Pakistan. NvdB developed the study design and protocol, oversaw the design, and conduct of the study, data collection and analysis and wrote the manuscript. All authors have read, edited, and approved the final manuscript for submission.

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Ethics

The Liverpool School of Tropical Medicine, Liverpool, UK, granted full ethical approval (LSTM14.025). Ethical approval was also obtained from each country-specific research ethics committee: The College of Medicine Research and Ethics Committee, College of Medicine, Blantyre, Malawi (P.07/14/1600); Kenyatta National Hospital and University of Nairobi, Ethics and Research Committee, Nairobi, Kenya (P574/09/214); Research and Ethics Committee, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India (IEC/SJH/VMMC/Project/September-14/19/482); and the National Bioethics Committee, Islamabad, Pakistan (4-87/14/NBC-159/RDC/1850). Written informed consent was obtained from each woman who participated in the study.

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Patient and Public Involvement

No patient or member of the public were involved in the design, conduct or dissemination of this study.

Competing interests

The authors declare no competing interests.

Availability of data and materials

Extra data is available from the corresponding author on reasonable request.

Abbreviations

ANC	Antenatal care
ASSIST	Alcohol, Smoking and Substance Involvement Screening Test
BP	Blood pressure
CRP	C-reactive protein
EPDS	Edinburgh Postnatal Depression Scale
HITS	Hurt, Insulted, Threatened, Screamed
HIV	Human Immunodeficient Virus
ICT	Islamabad Capital Territory
LMIC	Low- and middle-income countries
MMR	Maternal mortality ratio
PNC	Postnatal care
PR	Pulse rate
QOL	Quality of Life
RR	Respiratory rate
SAMM	Severe acute maternal morbidity
SDI	Socio-demographic Index
T	Temperature
TB	Tuberculosis

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List of tables and figures

Table 1: Physical multi-morbidity (infectious, medical, obstetric) per assessment stage for all countries combined (n=11,454)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women[a]	2204	2425	2250	2264	2311	11,454
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
INFECTIOUS MORBIDITY						
HIV	99 (4.5%)	107 (4.4%)	107 (4.8%)	123 (5.4%)	116 (5.0%)	551 (4.8%)
Malaria	85 (3.9%)	73 (3.0%)	59 (2.6%)	43 (1.9%)	49 (2.1%)	309 (2.7%)
Syphilis	36 (1.6%)	24 (1.0%)	19 (0.8%)	16 (0.7%)	12 (0.5%)	107 (0.9%)
Positive screening for chest infection/ possible tuberculosis	18 (0.8%)	24 (1.0%)	10 (0.4%)	12 (0.5%)	10 (0.4%)	74 (0·6%)
Septic Inflammatory Response Syndrome (SIRS)[b]	480 (21.8%)	609 (25.1%)	472 (21.0%)	590 (26.1%)	492 (21.3%)	2,643 (23.1%)
MEDICAL OR OBSTETRIC MORBIDITY						
Anaemia[c]	900 (40.8%)	1226 (50.6%)	1096 (48.7%)	1213 (53.6%)	985 (42.6%)	5420 (47.3%)
Severe anaemia	28 (1.3%)	47 (1.9%)	41 (1.8%)	63 (2.8%)	23 (1.0%)	202 (1.8%)
Body mass index ≤18.5 kg/m^2	66 (3.0%)	61 (2.5%)	34 (1.5%)	68 (3.0%)	58 (2.5%)	287 (2.5%)
Body mass index > 30kg/m^2	786 (35.6%)	1264 (50.2%)	912 (40.5%)	665 (29.3%)	761 (32.9%)	4867 (42.5%)
Hypertension	33 (1.5%)	111 (4.6%)	82 (3.6%)	66 (2.9%)	48 (2.1%)	340 (3.0%)
Pre-eclampsia	n/a	51 (2.1%)	18 (0.8%)	17 (0.7%)	n/a	86 (1.2%)
Urine incontinence	67 (3.0%)	161 (6.6%)	69 (3.1%)	44 (1.9%)	76 (3.3%)	417 (3·6%)
Antenatal haemorrhage	139 (6.3%)	74 (3.0%)	n/a	n/a	n/a	213(4.6%)
At least 1 medical or obstetric condition	998 (45.3%)	1328 (54.8%)	1135 (50.4%)	1245 (55.0%)	1017 (44.0%)	5723 (50.0%)

[a] Where data were missing for a condition the condition was regarding as being absent for purposes of deriving morbidities; % missing was: HIV 9.7%, malaria 5.3%, syphilis 8.9%, screening for chest infection/TB 2.0%, nutritional status 2.9%, anaemia 1.9%, blood pressure 2.3%, urine incontinence 0.5%.

[b] CRP was not measured at some primary level facilities in Malawi and Pakistan. Only participants for whom a CRP result was obtained are included in these statistics.

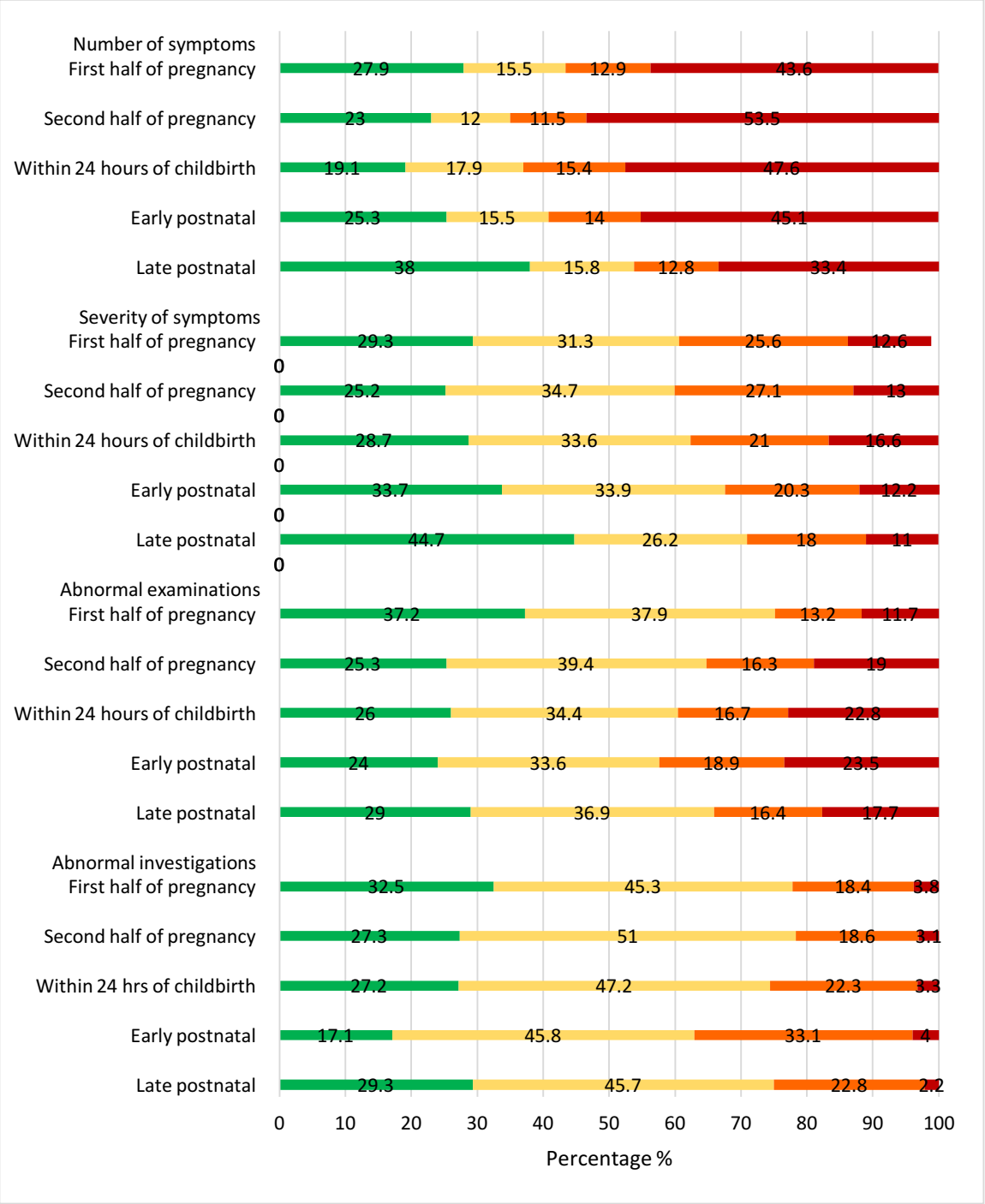
[c] Anaemia is defined as Hb< 11.0g/dL and severe anaemia is defined as Hb<7.0g/dL

Table 2: Psychological and social co-morbidities of women per assessment stage for all countries combined (n= 11,454)

Assessment stage		First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women*		2204	2425	2250	2264	2311	11,454
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
PSYCHOLOGICAL MORBIDITY							
EDPS ≥ 10		494 (22.4%)	641 (26.4%)	511 (22.7%)	503 (22.2%)	469 (20.3%)	2618 (22.9%)
Thoughts of self-harm		246 (11.2%)	426 (17.6%)	359 (16.0%)	351 (15.5%)	362 (15.7%)	1744 (15.2%)
EDPS ≥ 10 and/or thoughts of self-harm		542 (24.6%)	721 (29.7%)	630 (28.0%)	591 (26.1%)	575 (24.9%)	3059 (26.7%)
SOCIAL MORBIDITY							
Domestic violence							
HITS score >4	**Husband and/or family**	657 (29.8%)	978 (40.3%)	756 (33.6%)	770 (34.0%)	722 (31.2%)	3883 (33.9%)
	Husband	475 (21.5%)	776 (32.0%)	597 (26.5%)	602 (26.6%)	560 (24.2%)	3010 (26.3%)
	Family	328 (14.9%)	444 (18.3%)	358 (15.9%)	341 (15.1%)	334 (14.4%)	1805 (15.8%)
HITS score >10	**Husband and/or family**	161 (7.3%)	276 (11.4%)	172 (7.6%)	187 (8.3%)	170 (7.4%)	966 (8.4%)
	Husband	101 (4.6%)	223 (9.2%)	109 (4.8%)	127 (5.6%)	121 (5.2%)	681 (6.0%)
	Family	74 (3.4%)	80 (3.3%)	85 (3.8%)	79 (3.5%)	73 (3.2%)	391 (3.4%)
Substance misuse							
Use of alcohol, sedatives, inhalants, tobacco in last 3 months		135 (6.1%)	112 (4.6%)	122 (5.4%)	146 (6.5%)	157 (6.8%)	672 (5.9%)
Intervention required (ASSIST score > 4)		38 (1.7%)	38 (1.6%)	34 (1.5%)	42 (1.9%)	20 (2.2%)	202 (1.8%)

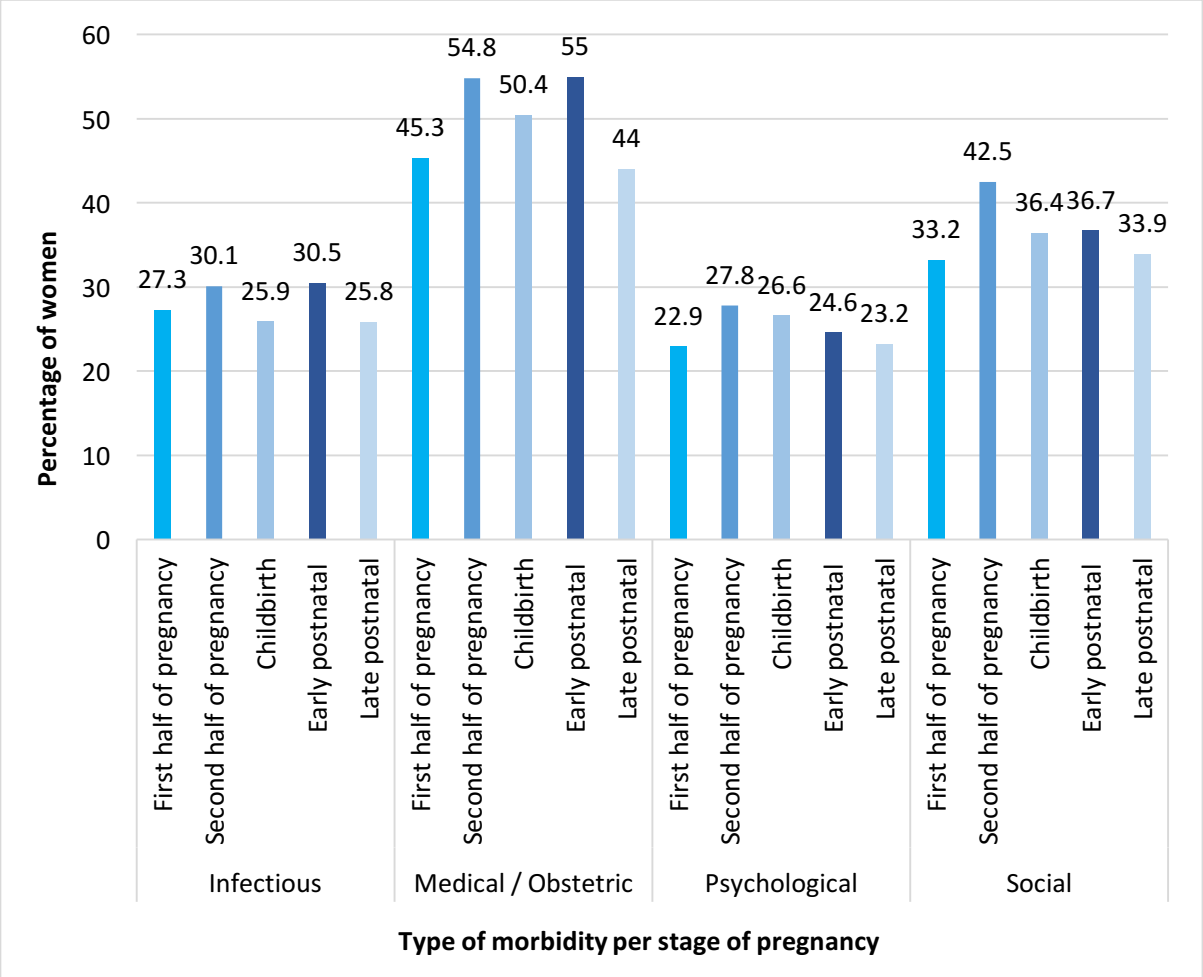
ASSIST: Alcohol, Smoking and Substance Involvement Screening Test; EPDS: Edinburgh Postnatal Depression Scale; HITS: Hurt, Insulted, Threatened, Screamed at.

Figure 1: Histogram of number and severity of symptoms reported, number of abnormal clinical examinations, number of abnormal investigations per stage per combined study population (n=11,454)



	Number of symptoms	Severity of symptoms	Number of abnormal examinations	Number of abnormal investigations
	0	None, Not at all	0	0
	1	Slightly	1	1
	2	Moderately	2	2
	≥3	A lot	≥3	≥3

Figure 2: Percentage of women with infectious, medical/obstetric, psychological and social morbidity per stage per combined study population (n=11,454)



SUPPLEMENTARY TABLES

Supplementary Table 1: Number of women per country, per assessment stage and per healthcare facility level (n=11,454)

Supplementary Table 2: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in India (n=2,099)

Supplementary Table 3: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Pakistan (n=3,287)

Supplementary Table 4: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Kenya (n=3,145)

Supplementary Table 5: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Malawi (n=2,923)

Supplementary Table 6: Psychological and social morbidity per assessment stage for women living in India (n=2,099)

Supplementary Table 7: Psychological and social morbidity of women per assessment stage for women living in for all countries combined for Pakistan (n= 3,287)

Supplementary Table 8: Psychological and social morbidity per assessment stage for women living in Kenya (n=3,145)

Supplementary Table 9: Psychological and social morbidity per assessment stage for women living in Malawi (n= 2,923)

Supplementary Table 1: Socio-demographic and obstetric characteristics of women by stage and for all stages combined (n=11,454)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total	P value
Number of women	**2,204**	**2,425**	**2,250**	**2,264**	**2,311**	**11,454**	
	%	%	%	%	%	%	
Age category (years)							
<20	11.0	9.4	11.2	11.3	11.3	10.8	0.007
20-24	28.8	26.8	30.6	31.7	28.1	29.2	
25-29	30.7	29.2	29.4	29.8	30.9	30.0	
30-34	15.7	17.8	16.4	15.1	16.4	16.3	
≥35	8.0	8.7	6.6	7.0	7.2	7.5	
Parity							
0 or 1	34.8	30.3	35.7	38.6	35.0	34.8	<0.001
2-4	54.7	56.9	50.8	51.1	55.6	53.8	
≥5	5.9	8.5	6.1	5.7	5.8	6.4	
Marital status							
Single	6.2	6.1	4.9	5.7	4.5	5.5	0.16
Married	92.7	92.5	94.1	93.3	93.7	93.3	
Socioeconomic status (SES)							
1st quintile (upper)	13.7	10.4	10.8	11.2	11.2	11.4	<0.001
2nd quintile	16.5	15.8	15.4	17.4	16.7	16.3	
3rd quintile	31.0	28.8	30.1	28.5	31.8	30.0	
4th quintile	27.5	28.7	29.4	29.3	27.4	28.4	
5th quintile (lower)	8.7	12.1	11.7	10.6	10.3	10.7	
Education level completed							
None	17.2	18.0	20.4	20.9	19.3	19.2	<0.001
Primary	33.1	34.0	35.9	34.1	34.0	34.2	
Secondary	30.0	26.6	25.7	28.1	26.7	27.4	
Post-secondary	15.9	15.6	13.1	13.7	15.5	14.8	

Supplementary Table 2: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in India (n=2,099)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women[a]*	416	397	423	432	431	2099
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
INFECTIOUS MORBIDITY						
Condition						
HIV	2 (0.5%)	2 (0.5%)	1 (0.2%)	1 (0.2%)	0	6 (0.3%)
Malaria	0	0	0	0	2 (0.5%)	2 (0.1%)
Syphilis	0	0	0	0	0	0
Positive screening for chest infection/ possible TB	2 (0.5%)	1 (0.2%)	1 (0.2%)	2 (0.5%)	2 (0.5%)	8 (0.4%)
Septic Inflammatory Response Syndrome (SIRS)[b]	43 (10.3%)	66 (16.6%)	47 (11.1%)	63 (14.6%)	70 (16.2%)	289 (13.8%)
MEDICAL OR OBSTETRIC MORBIDITY						
Condition						
Anaemia[c]	184 (44.2%)	228 (57.4%)	282 (66.7%)	309 (71.5%)	265 (61.5%)	1268 (60.4%)
Severe anaemia	4 (1.0%)	13 (3.3%)	12 (2.8%)	17 (3.9%)	5 (1.2%)	51 (2.4%)
Hypertension	2 (0.5%)	16 (4.0%)	7(1.6%)	7 (1.6%)	1 (0.2%)	33 (1.6%)
Low BMI (<18.5 kg/m^2)	30 (7.4%)	9 (2.3%)	9 (2.1%)	9 (2.1%)	10 (2.3%)	67 (3.2%)
High BMI (> 30kg/m^2)	55 (13.6%)	153 (38.9%)	109 (26.0%)	97 (22.5%)	107 (25%)	521 (25.1)
Pre-eclampsia	n/a	0	0	1 (0.2%)	n/a	1 (0.1%)
Urine incontinence	13 (3.1%)	21 (5.3%)	0	2 (0.5%)	0	36 (1.7%)
Antenatal haemorrhage	0	0	n/a	n/a	n/a	0
At least 1 medical or obstetric condition	202 (48.6%)	254 (64.0%)	285 (67.4%)	311 (72.0%)	266 (61.7%)	1318 (62.8%)

[a] Where data were missing for a condition the condition was regarding as being absent for purposes of deriving morbidities

[b] CRP was not measured at some primary level facilities in Malawi and Pakistan. Only participants for whom a CRP result was obtained are included in these statistics.

[c] Anaemia is defined as Hb< 11.0g/dL and severe anaemia is defined as Hb<7g/dL

Supplementary Table 3: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Pakistan (n=3,287)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women[a]*	607	768	654	618	640	3287
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
INFECTIOUS MORBIDITY						
Condition						
HIV	0	1 (0.1%)	7 (1.1%)	2 (0.3%)	1 (0.2%)	11 (0.3%)
Malaria	0	0	0	1 (0.2%)	0	1 (0.03%)
Syphilis	0	0	0	0	0	0
Positive screening for chest infection/ possible TB	7 (1.1%)	11 (1.4%)	2 (0.3%)	2 (0.3%)	3 (0.5%)	25 (0.8%)
Septic Inflammatory Response Syndrome (SIRS)[b]	67 (11.0%)	122 (15.9%)	54 (8.3%)	70 (11.3%)	55 (8.6%)	368 (11.2%)
MEDICAL OR OBSTETRIC MORBIDITY						
Condition						
Anaemia[c]	389 (64.1%)	590 (76.8%)	435 (66.5%)	437 (70.7%)	375 (58.6%)	2226 (67.7%)
Severe anaemia	9 (1.5%)	27 (3.5%)	18 (2.8%)	22 (3.6%)	5 (0.8%)	81 (2.5%)
Body mass index ≤18.5 kg/m^2	37 (6.2%)	16(2.2%)	7(1.1%)	11 (1.8%)	10 (1.6%)	81 (2.5%)
High BMI (> 30kg/m^2)	289 (48.5%)	470 (63.2%)	306 (48.6%)	325 (53.7%)	307 (49.8%)	1697 (53.2%)
Hypertension	18 (3.0%)	67 (8.7%)	54 (8.3%)	40 (6.5%)	27 (4.2%)	206 (6.3%)
Pre-eclampsia	n/a	26 (3.4%)	8 (1.2%)	6 (1.0%)	n/a	40 (2.0%)
Urine incontinence	40 (6.6%)	106 (13.8%)	64 (9.8%)	39 (6.3%)	65 (10.2%)	314 (9.5%)
Antenatal haemorrhage	80 (13.2%)	60 (7.8%)	n/a	n/a	n/a	140 (10.2%)
At least 1 medical or obstetric condition	422 (69.5%)	619 (80.6%)	455 (69.6%)	455 (73.6%)	388 (60.6%)	2339 (71.2%)

[a] Where data were missing for a condition the condition was regarding as being absent for purposes of deriving morbidities

[b] CRP was not measured at some primary level facilities in Malawi and Pakistan. Only participants for whom a CRP result was obtained are included in these statistics.

[c] Anaemia is defined as Hb< 11.0g/dL and severe anaemia is defined as Hb<7g/dL

Supplementary Table 4: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Kenya (n=3,145)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total

Number of women[a]*	592	684	592	620	657	3145
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
INFECTIOUS MORBIDITY						
Condition						
HIV	24 (4.0%)	19 (2.8%)	24 (4.0%)	25 (4.0%)	25 (3.8%)	117 (3.7%)
Malaria	2 (0.3%)	2 (0.3%)	1 (0.2%)	2 (0.3%)	0	7 (0.2%)
Syphilis	2 (0.3%)	2 (0.3%)	1 (0.2%)	0	3 (0.5%)	8 (0.2%)
Positive screening for chest infection/ possible TB	3 (0.5%)	6 (0.9%)	5 (0.8%)	3 (0.5%)	5 (0.8%)	22 (0.7%)
Septic Inflammatory Response Syndrome (SIRS)[b]	206 (34.8%)	267 (39.0%)	197 (33.3%)	278 (44.8%)	199 (30.3%)	1147 (36.5%)
MEDICAL OR OBSTETRIC MORBIDITY						
Condition						
Anaemia[c]	102 (17.2%)	163 (23.8%)	146 (24.7%)	204 (32.9%)	130 (19.8%)	745 (23.7%)
Severe anaemia	7 (1.2%)	4 (0.6%)	7 (1.2%)	12 (1.9%)	12 (1.8%)	65 (2.1%)
Body mass index ≤18.5 kg/m^2	18 (3.1%)	8 (1.2%)	10 (1.7%)	7 (1.2%)	3 (0.5%)	46 (1.5%)
High BMI (> 30kg/m^2)	278 (47.7%)	404 (59.8%)	328 (56.2%)	350 (57.6%)	325 (50.3%)	1685 (54.4%)
Hypertension	7 (1.2%)	19 (2.8%)	13 (2.2%)	16 (2.6%)	15 (2.3%)	70 (2·2%)
Pre-eclampsia	n/a	8 (1.2%)	0	4 (0.6%)	n/a	12 (0.6%)
Urine incontinence	12 (2.0%)	23 (3.4%)	2 (0.3%)	3 (0.5%)	9 (1.4%)	49 (1.6%)
Antenatal haemorrhage	54 (9.1%)	12 (1.7%)	n/a	n/a	n/a	66 (5.2%)
At least 1 medical or obstetric condition	142 (24.0%)	197 (28.8%)	156 (26.3%)	214 (34.5%)	143 (21.8%)	852 (27.1%)

[a] Where data were missing for a condition the condition was regarding as being absent for purposes of deriving morbidities

[b] CRP was not measured at some primary level facilities in Malawi and Pakistan. Only participants for whom a CRP result was obtained are included in these statistics.

[c] Anaemia is defined as Hb< 11.0g/dL and severe anaemia is defined as Hb<7g/dL

Supplementary Table 5: Infectious, medical, and obstetric morbidity identified per assessment stage for women living in Malawi (n=2923)

Assessment stage	First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women [a]	589	576	581	594	583	2923
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
INFECTIOUS MORBIDITY						
HIV	73 (12.4%)	85 (14.8%)	75 (12.9%)	95(16.0%)	90(15.4%)	418 (14.3%)
Malaria	83 (14.1%)	71 (12.3%)	58 (10.0%)	40 (6.7%)	47 (8.1%)	299 (10.2%)
Syphilis	34 (5.8%)	22 (3.8%)	18 (3.1%)	16 (2.7%)	9 (1.5%)	99 (3.4%)
Positive screening for chest infection/ possible TB	6 (1.0%)	6 (1.0%)	2 (0.3%)	5 (0.8%)	0	19 (0.7%)
Septic Inflammatory Response Syndrome (SIRS)[b]	164 (27.8%)	154 26.7(%)	174 (30.0%)	179 (30.1%)	168 (28.8%)	839 (28.7%)
MEDICAL OR OBSTETRIC MORBIDITY						
Anaemia[c]	225 (38.2%)	245 (42.5%)	233 (40.1%)	263 (44.3%)	215 (36.9%)	1181 (40.4%)
Severe anaemia	8 (1.4%)	3 (0.5%)	4 (0.7%)	12 (2.0%)	6 (1.0%)	33 (1.1%)
Body mass index ≤18.5 kg/m^2	18 (3.1%)	7 (1.2%)	19 (3.3%)	22 (3.7%)	22 (3.8%)	88 (3.0%)
High BMI (> 30kg/m^2)	164 (28.3%)	237 (41.6%)	169 (29.2%)	186 (31.5%)	208 (36.1%)	964 (33.3%)
Hypertension	6 (1.0%)	9 (1.6%)	8 (1.4%)	3 (0.5%)	5(0.9%)	31 (1.1%)
Pre-eclampsia	n/a	17 (2.9%)	10 (1.7%)	6 (1.0%)	n/a	49 (2.8%)
Urine incontinence	2 (0.3%)	11 (1.9%)	3 (0.5%)	0	2 (0.3%)	18 (0.6%)
Antenatal haemorrhage	5 (0.9%)	2 (0.4%)	n/a	n/a	n/a	7 (0.6%)
At least one medical or obstetric condition	232 (39.4%)	258 (44.8%)	239 (41.1%)	265 (44.6%)	220 (37.7%)	1214 (41.5%)

[a] Where data were missing for a condition the condition was regarding as being absent for purposes of deriving morbidities

[b] CRP was not measured at some primary level facilities in Malawi and Pakistan. Only participants for whom a CRP result was obtained are included in these statistics.

[c] Anaemia is defined as Hb< 11.0g/dL and severe anaemia is defined as Hb<7g/dL

Supplementary Table 6: Psychological and social morbidity per assessment stage for women living in India (number of women assessed n=2099)

stage		First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women*		416	397	423	432	431	2099
		n %	n %	n %	n %	n %	n %
PSYCHOLOGICAL MORBIDITY							
EDPS ≥ 10		45 (10.8%)	103 (25.9%)	86 (20.3%)	86 (19.9%)	84 (19.5%)	404 (19.2%)
Thoughts of self-harm		40 (9.6%)	79 (19.9%)	72 (17.0%)	71 (16.4%)	66 (15.3%)	328 (15.6%)
EDPS ≥ 10 and/or thoughts of self-harm		60 (14.4%)	116 (29.2%)	102 (24.1%)	99 (22.9%)	95 (22.0%)	472 (22.5%)
SOCIAL MORBIDITY							
Domestic violence							
HITS score >4	Husband and/or family	159 (38.2%)	173 (43.6%)	153 (36.2%)	189 (43.7%)	159 (36.9%)	833 (39.7%)
	Husband	154 (37.0%)	164 (41.3%)	152 (35.9%)	185 (42.8%)	155 (36.0%)	810 (38.6%)
	Family	35 (8.4%)	67 (16.9%)	28 (6.6%)	52 (12.0%)	29 (6.7%)	211 (10.0%)
HITS score >10	Husband and/or family	23 (5.5%)	36 (9.1%)	18 (4.3%)	33 (7.6%)	17 (3.9%)	127 (6.0%)
	Husband	19 (4.6%)	27 (6.8%)	16 (3.8%)	30 (6.9%)	15 (3.5%)	107 (5.1%)
	Family	8 (1.9%)	22 (5.5%)	3 (0.7%)	15 (3.5%)	8 (1.9%)	56 (2.7%)
Substance misuse							
Use of alcohol, sedatives, inhalants, or tobacco in last 3 months		6 (1.4%)	9 (2.3%)	4 (0.9%)	12 (2.8%)	5 (1.2%)	36 (1.7%)
Intervention required		4 (1.0%)	7 (1.8%)	0	5 (1.2%)	1 (0.2%)	17 (0.8%)

ASSIST: Alcohol, Smoking and Substance Involvement Screening Test; EPDS: Edinburgh Postnatal Depression Scale; HITS: Hurt, Insulted, Threatened, Screamed at.

Supplementary Table 7: Psychological and social morbidity of women per assessment stage for women living in for all countries combined for Pakistan (number of women assessed n= 3287)

stage		First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women*		607	768	654	618	640	3287
		n %	n %	n %	n %	n %	n %
PSYCHOLOGICAL MORBIDITY							
EDPS ≥ 10		277 (45.6%)	349 (45.4%)	243 (37.2%)	256 (41.4%)	243 (38.0%)	1368 (41.6%)
Thoughts of self-harm		130 (21.4%)	242 (31.5%)	194 (29.7%)	200 (32.4%)	212 (33.1%)	978 (29.7%)
EDPS ≥ 10 and/or thoughts of self-harm		297 (48.9%)	379 (49.3%)	323 (49.4%)	308 (49.8%)	315 (49.2%)	1622 (49.3%)
SOCIAL MORBIDITY							
Domestic violence							
HITS score >4	Husband and/or family	308 (50.7%)	464 (60.4%)	371 (56.7%)	382 (61.8%)	314 (49.1%)	1839 (55.9%)
	Husband	183 (30.1%)	340 (44.3%)	255 (39.0%)	255 (41.3%)	195 (30.5%)	1228 (37.4%)
	Family	197 (32.4%)	246 (32.0%)	217 (33.2%)	199 (32.2%)	184 (28.7%)	1043 (31.7%)
HITS score >10	Husband and/or family	109 (18.0%)	185 (24.1%)	103 (15.7%)	115 (18.6%)	104 (16.2%)	616 (18.7%)
	Husband	64 (10.5%)	150 (19.5%)	59 (9.0%)	70 (11.3%)	68 (10.6%)	411 (12.5%)
	Family	50 (8.2%)	47 (6.1%)	55 (8.4%)	47 (7.6%)	47 (7.3%)	246 (7.5%)
Substance misuse							
Use of alcohol, sedatives, inhalants, or tobacco in last 3 months		61 (10.0%)	53 (6.9%)	45 (6.9%)	74 (12.0%)	60 (9.4%)	293 (8.9%)
Intervention required		7 (1.1%)	13 (1.7%)	5 (0.8%)	12 (1.9%)	20 (3.1%)	57 (1.7%)

ASSIST: Alcohol, Smoking and Substance Involvement Screening Test; EPDS: Edinburgh Postnatal Depression Scale; HITS: Hurt, Insulted, Threatened, Screamed at.

Supplementary Table 8: Psychological and social morbidity per assessment stage for women living in Kenya (n=3145)

Assessment stage		First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women*		592	684	592	620	657	3145
		n %	**n %**	**n %**	**n %**	**n %**	**n %**
PSYCHOLOGICAL MORBIDITY							
EDPS ≥ 10		86 (14.5%)	101 (14.8%)	81 (13.7%)	72 (11.6%)	49 (7.5%)	389 (12.4%)
Thoughts of self-harm		28 (4.7%)	47 (6.9%)	29 (4.9%)	20 (3.2%)	19 (2.9%)	143 (4.5%)
EDPS ≥ 10 and/or thoughts of self-harm		94 (15.9%)	126 (18.4%)	95 (16.0%)	84 (13.5%)	60 (9.1%)	**459 (14.6%)**
SOCIAL MORBIDITY							
Domestic violence							
HITS score >4	Husband and/or family	99 (16.7%)	201 (29.4%)	130 (22.0%)	105 (17.0%)	144 (21.9%)	679 (21.6%)
	Husband	78 (13.2%)	176 (25.7%)	108 (18.2%)	88 (14.2%)	125 (19.0%)	575 (18.3%)
	Family	29 (4.9%)	51 (7.5%)	35 (5.9%)	24 (3.9%)	47 (7.1%)	186 (5.9%)
HITS score >10	Husband and/or family	9 (1.5%)	26 (3.8%)	22 (3.7%)	12 (1.9%)	17 (2.6%)	86 (2.7%)
	Husband	8 (1.3%)	24 (3.5%)	18 (3.0%)	10 (1.6%)	15 (2.3%)	75 (2.4%)
	Family	2 (0.3%)	2 (0.3%)	6 (1.0%)	2 (0.3%)	2 (0.3%)	14 (0.4%)
Substance misuse							
Use of alcohol, sedatives, inhalants, or tobacco in last 3 months		40 (6.8%)	27 (3.9%)	42 (7.1%)	37 (6.0%)	63 (9.6%)	209 (6.6%)
Intervention required		9 (1.5%)	6 (0.9%)	9 (1.5%)	8 (1.3%)	14 (2.1%)	46 (1.5%)

ASSIST: Alcohol, Smoking and Substance Involvement Screening Test; EPDS: Edinburgh Postnatal Depression Scale; HITS: Hurt, Insulted, Threatened, Screamed at.

Supplementary Table 9: Psychological and social morbidity per assessment stage for women living in Malawi (number of women assessed n= 2923)

Assessment stage		First half of pregnancy	Second half of pregnancy	Within 24 hours of childbirth	Early postnatal	Late postnatal	Total
Number of women*		589	576	581	594	583	2923
		n %	n %	n %	n %	n %	n %
PSYCHOLOGICAL MORBIDITY							
EDPS ≥ 10		86 (14.6%)	88 (15.3%)	101 (17.4%)	89 (15.0%)	93 (15.9%)	457 (15.6%)
Thoughts of self-harm		48 (8.2%)	58 (10.1%)	64 (11.0%)	60 (10.1%)	65 (11.1%)	295 (10.1%)
EDPS ≥ 10 and/or thoughts of self-harm		91 (15.4%)	100 (17.4%)	110 (18.9%)	100 (16.8%)	105 (18.0%)	506 (17.3%)
SOCIAL MORBIDITY							
Domestic violence							
HITS score >4	Husband and/or family	91 (15.4%)	140 (24.3%)	102 (17.6%)	94 (15.8%)	105 (18.0%)	532 (18.2%)
	Husband	60 (10.2%)	96 (16.7%)	82 (14.1%)	74 (12.5%)	85 (14.6%)	397 (13.6%)
	Family	67 (11.4%)	80 (13.9%)	78 (13.4%)	66 (11.1%)	74 (12.7%)	365 (12.5%)
HITS score >10	Husband and/or family	20 (3.4%)	29 (5.0%)	29 (5.0%)	27 (4.5%)	32 (5.5%)	137 (4.7%)
	Husband	10 (1.7%)	22 (3.8%)	16 (2.7%)	17 (2.9%)	23 (3.9%)	88 (3.0%)
	Family	14 (2.4%)	9 (1.6%)	21 (3.6%)	15 (2.5%)	16 (2.7%)	75 (2.6%)
Substance misuse							
Use of alcohol, sedatives, inhalants, or tobacco in last 3 months		28 (4.7%)	23 (4.0%)	31 (5.3%)	23 (3.9%)	29 (5.0%)	134 (4.6%)
Intervention required		18 (3.1%)	12 (2.1%)	20 (3.4%)	17 (2.9%)	15 (2.6%)	82 (2.8%)

ASSIST: Alcohol, Smoking and Substance Involvement Screening Test; EPDS: Edinburgh Postnatal Depression Scale; HITS: Hurt, Insulted, Threatened, Screamed at.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	9
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10

		(c) Consider use of a flow diagram	10
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	10
Outcome data	15*	Report numbers of outcome events or summary measures	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11
		(*b*) Report category boundaries when continuous variables were categorized	11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	11
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.