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Maternal risk factors associated with term low birth weight in India: A review

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Abstract: Low birth weight is one of the leading factors for infant morbidity and mortality. To a large extent affect, various maternal risk factors are associated with pregnancy outcomes by increasing odds of delivering an infant with low birth weight. Despite this association, understanding the maternal risk factors affecting term low birth weight has been a challenging task. To date, limited studies have been conducted in India that exert independent magnitude of these effects on term low birth weight. The aim of this review is to examine the current knowledge of maternal risk factors that contribute to term low birth weight in the Indian population. In order to identify the potentially relevant articles, an extensive literature search was conducted using PubMed, Goggle Scholar and IndMed databases (1993 – Dec 2020). Our results indicate that maternal age, educational status, socio-economic status, ethnicity, parity, pre-pregnancy weight, maternal stature, maternal body mass index, obstetric history, maternal anaemia, gestational weight gain, short pregnancy outcome, hypertension during pregnancy, infection, antepartum haemorrhage, tobacco consumption, maternal occupation, maternal psychological stress, alcohol consumption, antenatal care and mid-upper arm circumference have all independent effects on term low birth weight in the Indian population. Further, we argue that exploration for various other dimensions of maternal factors and underlying pathways can be useful for a better understanding of how it exerts independent association on term low birth weight in the Indian sub-continent.

Key words: anaemia, gestational weight gain, hypertension, India, Low Birth Weight, maternal age, maternal Body Mass Index, maternal risk factors, obstetric history.

Original article

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Introduction

The birth weight of the newborn is a prime demographic indicator of the health status of a given society. The decrease and the increase in the mean birth weight of the population are directly linked to the quality of maternity care and living condition of the mothers (Barker 2004). Birth weight also plays a pivotal role in infant and childhood mortality (McCormick 1985).

The birth weight of less than 2500 grams is defined as the Low Birth Weight (LBW), regardless of gestational age (WHO 2004). The LBW can be distinguished into three categories. 1) Premature or Pre-Term LBW (born before 37 completed weeks of gestation or with fewer than 259 days of gestation); 2) Term LBW (born between 37 and 42 completed week of gestation, or between 259 and 293 days of gestation); 3) Post-Term LBW (born after 42 week or 294 days of gestation) (WHO 2004).

LBW can be either caused by a short gestation period or retarded intra-uterine growth, as well as by a combination of both these pathophysiologic conditions (Kramer 1987). Importantly, term LBW and intra-uterine growth restriction do not necessarily reflect the same clinical situation. For example, some new-borns, normally formed and perfectly healthy, are born weighing less than the 10^{th} percentile for their gestational age (Resnik 2002), while others whose birth weight is higher than the 10^{th} percentile may show signs of growth restriction if they come from a uterine environment that thwart the foetus from reaching its full potential for growth (Wollmann 1998).

On average, an infant with LBW has 40 times greater mortality risk than normal weight new-borns (Alexander et al. 2007), while Very Low Birth Weight (<1500 gram), might increase mortality risk up to 100 times (Mayor 2016). LBW infants are also more prone to developing iron deficiency anaemia potentially leading to longer and impaired neurodevelopmental disorders (Long et al. 2012). In addition, several research studies have shown that the impaired growth at birth is linked to an increased risk of developing certain types of chronic disorders at an older age (Sallout et al. 2003), such as diabetes, obesity (Kuhle et al. 2017), endothelial dysfunction (Visentin et al. 2014), non-alcoholic fatty liver diseases (Newton et al. 2017), cardiovascular diseases (Kuhle et al. 2017), asthma (Wjst et al. 1998), hypothermia (Erekia Ebrahim 2015) and chronic kidney disease (Hirano et al. 2016).

Globally, LBW was estimated to comprise 12.4–17.1% of all births (WHO 2019). The prevalence of LBW in Low- and Middle-Income Countries (LMIC) was 91% of the world's LBW. There were notable global and regional variations in LBW rates. An estimated 14% of neonates exhibited LBW in Sub-Sahara Africa, 12.2% in North Africa, 5.3% in East Asia, 5.4% in Southeast Asia, 9.9% in Western Asia, 8.7% in Latin America and 26.4% in South Asia. Up to one-fourth of all born LBW infants were born in South Asia (Blencowe et al. 2019). In South Asia itself, India heads the list with 18.2% of the infant with LBW as per the National Family Health survey 4 statistics (IIPS and ICF 2017). Compared to prematurity in developed countries, the observed LBW in developing countries, such as India, can be largely attributed to Intra-uterine growth restriction (Saili 2008).

The major problem in the field of public health is to determine factors influencing LBW and to institute therapeutic measures (Velankar 2009). The aetiology of LBW is complex and mainly influences fetal growth, although these factors can be categorised into several different categories on the basis of the locus of their impact: the placenta, the pregnant woman herself, the fetus and finally, factors produced from the interaction of these factors (Institute of Medicine 1985). Although the progress in obstetrical and neonatal care has improved the prognosis for LBW neonates, the best strategy to reduce it is primary prevention by identifying and avoiding the risk factors that led to LBW. This review aims to update the current knowledge and understanding of the maternal risk factors affecting Term LBW in the Indian population.

Materials and Methods

Search strategy

This comprehensive literature review was conducted using PubMed, Goggle Scholar and IndMed databases from 1993 to December 2021 to identify the relevant articles. The search strategy was developed using combination of medical subject heading (MeSH) terms and words in Title/abstract- ("maternal risk factor" [Title/Abstract] OR "maternal risk factors" [All Fields] OR "risk factor" [All Fields] OR "risk factors" [MeSH Terms]) AND ("infant, low birth weight" [MeSH Terms] OR "infant, low birth weight" [MeSH Terms] OR "low birth weight" [Title/Abstract]). Full text articles that were written in English and relevant to the topic were included in the study. The references of those selected articles were then utilised in a cascade search to obtain more relevant citations.

Selection strategy

Inclusion criteria are followed as:

1) Studies published in English 2) Studies related to human 3) Original research articles 4) Natural conception 5) Singleton pregnancy 6) No history of visceral diseases 7) Studies done on Indian population

Exclusion criteria are followed as:

1) Review studies and 2) Systematic review and meta-analysis

Initial search identified 10900 articles for inclusion. After deleting articles not related to humans, 10329 articles were left for consideration. Assessment based on titles and abstracts were carried out to determine the objectives and relevance of the studies, which resulted in exclusion of 9835 studies. The full texts of remaining 494 papers were included for consideration in the study and those articles that neither met the inclusion nor the exclusion criteria were removed from consideration. At this stage of the search process 46 articles were retained while 9 more articles were identified from the references of searched articles and added for final consideration. In total, 55 studies that met all the inclusion and exclusion criteria. The identifying information (such as research objectives, study design, sample size, risk factor, results, and effect size) of those 55 studies are presented in supplementary table 1.

Results and Discussion

Demographic risk factors

Maternal age

A large number of epidemiological studies in India have shown an increased risk of LBW in extreme reproductive age, i.e., less than 20 years of age (Amin et al.

1993; Fraser et al. 1995; Deshmukh et al. 1998; Agarwal et al. 2005; Joshi et al. 2005; Chen et al. 2007; Dharmalingam et al. 2010; Roy et. al. 2009; Epstein et al. 2013; Raje et al. 2015; Patel et al. 2018; Kumar et al. 2020), and above 30 years of age or both (Cnattingius et al. 1992; Malik et al. 1997; Mondal 2000; Nair et al. 2000; Jha et al. 2009; Ganesh Kumar et al. 2010; Deshpande Jayant et al. 2011; Borah et al. 2016; Patel et al. 2018). The main cause of early conception is a well-established custom of child marriage in India (27% according to NFHS-4 (IIPS and ICF 2017), which is magnified due to the poverty and ignorance (Seth et al. 2018). The devastating effects of early conception also led to an increased risk of stillbirth, abortion, and premature delivery (Rao et al. 2010; Igwegbe et al. 2001). It is generally accepted that women of advanced age (>30 years) exhibit some latent factors that can cause complications in pregnancy, including LBW (Shan et al. 2018; Goisis et al. 2017; Tabcharoen et al. 2009). These latent factors might include an impaired function of the myometrium (Nelson et al. 2013) or a large number of chronic diseases at older ages (Sheen et al. 2018).

Education level

Many research studies have demonstrated a direct association between mother's education level and fetal birth weight. For example, the risk of LBW decreases with an increase in mother's education level. It might suggest that women with higher levels of education were less prone to neglect health care, have high socio-economic status (SES) (Deshpande Jayant et al. 2011; Mathew et al. 2014), and better decision making regarding health care as well as family planning (Mavalankar et al. 1992; Hirve et al. 1994; Biswas et al. 2008; Subramanyam et al. 2010; Sreeramareddy et al. 2011; Chakraborty et al. 2011; Metgud et al. 2012; Epstein et al. 2013; Kader et al. 2014; Patel et al. 2018; Kumar et al. 2020).

Socio-economic status

Studies have shown that low SES was associated with high prevalence (11–50%) of LBW (Deshmukh et al. 1998; Nair et al. 2000; Radhakrishnan et al. 2000; Jha et al. 2009; Roy et al. 2009; Chakraborty et al. 2011; Deshpande Jayant et al. 2011; Khattar et al. 2013; Bellad et al. 2012; Kader et al. 2014; Mathew et al. 2014; Kumar et al. 2020). However, the association between SES and LBW should be interpreted in the light of other factors related to SES, such as maternal age, education level, tobacco consumption, gestational weight gain and maternal height (Deshmukh et al. 1998; Roy et al. 2009). In addition, some studies have also reported that low SES can lead to low health consciousness, lower nutritional status and low antenatal attendance, leading to the increased risk of LBW (Nair et al. 2000; Jha et al. 2009; Deshpande Jayant et al. 2011; Mumbare et al. 2012; Chakraborty et al. 2011; Kumar et al. 2020). Moreover, many studies have also found a significant association between SES and birth weight of neonates (Hirve et al. 1994; Deshmukh et al. 1998).

Ethnicity

India harbours more genetic diversity compared to other comparable global regions (Majumder 1998). Epidemiological studies have reported large disparities in the prevalence rates of LBW in different racial and ethnic groups (James 1993; Branum et al. 2002) as well as regions

(Chakraborty et al. 2011; Epstein et al. 2013). For example, the prevalence of LBW was reported to be the highest in the north India compared to other regions of India (Chakraborty et al. 2011; Epstein et al. 2013). One study reported a significant influence of religion on the prevalence of LBW (i.e. Hindus have more prevalence of LBW compared to Muslims) (Mavalankar et al. 1992). Similarly, the NFHS-4 (National Fertility Health Survey) data also showed that Hindus (18.5%) have more prevalence of LBW than Muslims (17.3%) (IIPS and ICF 2017).

Medical risk before pregnancy

Parity

Maternal Parity is defined as the number of pregnancies reaching viable gestational age (>20 weeks), including live birth and still births. The parity is a well-recognised potential indicator for LBW (Shah 2010). LBW has been reported to be significantly high in nulliparous, decrease significantly in multiparous (parity 2–4) and significantly increase in grand multiparous (parity 5–8) (Amin et al. 1993; Mavalankar et al. 1992; Hirve et al. 1994; Malik et al. 1997; Deshmukh et al. 1998; Anand et al. 2000; Nair et al. 2000; Mondal 2000; Chhabra et al. 2004; Joshi et al. 2005; Negi et al. 2006; Roy et al. 2009; Epstein et al. 2013; Patel et al. 2018). The biological mechanisms regarding how parity influences birth weight has not not clearly understood (Shah 2010). It has been hypothesised that the first pregnancy primes the body and led each subsequent pregnancy to be more efficient (Khong et al. 2003). A lower birth weight in nulliparous may be a direct consequence of multiple health factors, such as the overall health, higher rate of smoking before/during pregnancy, low gestational weight gain, higher age, low pre-pregnancy weight, chronic hypertension, and placental vascular disorder (Ego et al. 2008). In contrast, the increase in the incidence of LBW among grand multiparous (Mesleh 1986; Ozumba et al. 1992; Seidman et al. 1991), could be due to chronic hypertension (Alsibai et al. 1987), loss of elasticity and hyalinisation of blood vessels for uterine rupture (Nelson et al. 2013), uterine atony for post-partum hemorrhage (Israel et al. 1965), atrophy of the endometrium for placenta previa (Evaldson 1990), hyperlordosis, and placenta previa for fetal malpositioning (Tanbo et al. 1987).

Pre-pregnancy weight

Pre-pregnancy weight and BMI are closely linked to pregnancy outcomes. The weight is influenced by both genetic and environmental factors (Kramer 1987). Theoretically, genetic factors determine body weight by controlling adiposity or influencing body mass among infants (O'Rahilly et al. 2006). However, even in the absence of such genetic influences, maternal weight or BMI prior to conception replicates the nutritional reserves that are available for intrauterine growth of the fetus (Kramer 1987). The large meta-analysis of 111,000 births worldwide demonstrated that pre-pregnancy weight has the highest odds ratio for detecting LBW (OR:2.3, 95% CI:2.1–2.5) (Kelly et al. 1996). Young et al. (2015) (Young et al. 2015) showed that one standard deviation increase in pre-pregnancy weight independently associated with 250 grams increase in infant birth weight, which also led to approximately 10% reduction in the risk of delivering LBW infant. Studies conducted in India have shown similar associations in which weight lower than 45 kgs and BMI lower than 20kg/m^2 increases the risk for LBW (Hirve et al. 1994; Ganesh Kumar et al. 2010; Singh et al. 2009; Deshpande Jayant et al. 2011).

Maternal stature

Maternal stature has been argued to predispose the neonate to LBW and preterm birth (Chan et al. 2009). Studies have also reported that short maternal stature is associated with LBW (Britto et al. 2013; Inoue et al. 2016). Studies conducted in India have shown similar associations (Deshmukh et al. 1998; Malik et al. 1997; Jha et al. 2009; Sen et al. 2009; Kumar et al. 2010; Mumbare et al. 2012; Deshpande Jayant et al. 2011; Kader et al. 2014; Mathew et al. 2014; Tellapragada et al. 2016; Shivakumar et al. 2018). A WHO collaborative study (1995) (Kelly et al. 1996) showed that a maternal height cut off range of 146–157 cm (OR:1.7, 95% CI:1.6–1.8) is associated with a higher risk for LBW. Higher risk of LBW among shorter mothers can be related to a narrow pelvis, which results in limited space, consequently led to intrauterine growth restriction (IUGR) (Zhang et al. 2007). On the other hand, a study reported a significant association between taller women with cut off ≥170 cm and LBW (Kheirouri et al. 2017). There can be other factors, such as paternal height or other paternal characteristics, that could play an important role in influencing the neonatal size (Veena et al. 2004).

Maternal BMI

For many decades BMI of mothers has been used as an epidemiological factor predictive of fetal growth (Kramer 1987). A low BMI indicates chronic energy depletion and has been used as an important parameter for assessing nutritional risk in women during the reproductive years (Wynn et al. 1991). It also indicates a wasting of both fat and lean tissue (Allen et al. 1994). Some large epidemiological studies showed that the maternal BMI for gestational age is associated with LBW (Kelly et al. 1996; Brewster et al. 2015). In the same vein, two meta-analyses reported that low BMI among mothers increases the risk of having an LBW infant (Han et al. 2011; Vats et al. 2021) while Indian studies have also shown a similar trend of low maternal BMI (<18.5kg/m2) (Amin et al. 1993; Dharmalingam et al. 2010; Sreeramareddy et al. 2011; Chakraborty et al. 2011; Kader et al. 2014; Raje et al. 2015; Patel et al. 2018). Interestingly, the above-described trend is evenly distributed all over India (i.e., 13 out of 17 states), showing that mothers with low maternal pregnancy BMI are at approximately 30% higher risk of giving birth to a LBW infant with a substantial variation between the states. This variation could be due to the interaction between the proximate factors, such as human development index, antenatal visits, and maternal anaemia (Dharmalingam et al. 2010).

Obstetric history

Antecedences of abortion, both induced abortion and miscarriages, have been associated with LBW (Kramer 1987). Some studies have shown that among women with a history of previous miscarriage and induced abortion the risk of LBW is increased more than fourfold (Anand et al. 2000; Negi et al. 2006). However, most of the Indian studies did not differentiate between induced abortion and miscarriages and the biological mechanisms of these two factors regarding their influence on LBW might be different. In induced abortions, for instance, cervical insufficiency from dilation and curettage and uterine adhesions result from a post-abortion complication (Hooker et al. 2016). On the other hand, the cervical incompetence has been found to be a major predictor of miscarriages, along with genetic, immunological and uterine abnormalities (Jeve et al. 2014).

A history of LBW in previous pregnancy increases the risk of LBW in the current pregnancy, and this risk continues even after controlling for the socio-demographic and obstetric factors (Anand et al. 2000; Idris et al. 2000; Negi et al. 2006; Roy et al. 2009; Singh et al. 2009; Deshpande Jayant et al. 2011; Metgud et al. 2012; Khattar et al. 2013).

Medical risk during the current pregnancy

Maternal anaemia

Anaemia during pregnancy is a major public health concern that affects almost two-third of pregnant women in developing countries and contributes to maternal morbidity and LBW infant (Figueiredo et al. 2018). A large cohort study from China showed that the risk of anaemia increases more than twofold from 13th week to 32nd week of pregnancy (Zhang et al. 2009). According to NFHS-4 statistics (IIPS and ICF 2017), the prevalence of anaemia was estimated to be 50.3% in India. Anaemia during pregnancy is a well-known and established physiological fact. The haemoglobin (Hb) and haematocrit concentration typically decreases during the first 13 weeks and reach the lowest level at the end of 28th week of pregnancy, and increases again during the third trimester (Laflamme 2010). The physiological drop in Hb and haematocrit concentration is attributed to an increase in plasma volume which, in turn, results in a decrease in blood viscosity (Carlin et al. 2008) leading to a better circulation in the placenta (Tan et al. 2013). When the Hb concentration levels were reduced to <11g/dL, changes in placental angiogenesis were observed, limiting the availability of oxygen to the fetus and consequently causing potential restriction of intrauterine growth and LBW (Stangret et al. 2017). Studies conducted in India have suggested a similar pattern showing that maternal Hb levels below 11g/dL were at increased risk of having LBW compared to healthy pregnant women (Mavalankar et al. 1992; Deshmukh et al. 1998; Idris et al. 2000; Anand et al. 2000; Dharmalingam et al. 2010; Ganesh Kumar et al. 2010; Deshpande Jayant et al. 2011; Khattar et al. 2013; Borah et al. 2016; Ahankari et al. 2017; Patel et al. 2018; Shankar et al. 2019).

Gestational weight gain

The weight of women increases during the pregnancy which, in turn, affects the inter-uterine growth (Hector et al. 2013). Weight gain during pregnancy is divided into four components 1) Increase plasma volume 2) growth of breast and uterine tissues 3) laying down the fat stores, and 4) growth of the placenta, amniotic fluid and fetus (Kramer 1987). The first three components serve as an energy source to the growing fetus, and a decline in those will result in a decrease in the overall birth weight (Kramer 1987). Thus, weight gain is a factor that affects the size of the fetus (Hector et al. 2013). In 2009, the Institute of Medicine (IOM), USA, published (Rasmussen and Yaktine 2009) the revised Gestational weight gain (GWG) guidelines that are based on pre-pregnancy ranges for underweight, normal weight, overweight and obese women to gain 12.5–18 kg, 11.5–16 kg, 7–11.5 kg, and 5–9 kg respectively. Although these recommendations have been widely accepted (Davies et al. n.d.), they were based on parameters of American women (Kelly et al. 1996), and Asian women parameters, whose BMI classification differs for the one used in the west (WHO 2000), were not considered. Therefore, the applicability of such guidelines to Asian countries is debated [81]. In addition, there is also no such GWG recommendation available for Asian women. As there are not enough publications based on use of IOM guidelines among the Indians and other Asian women (Arora et al. 2019). However, in the absence of India specific GWG guidelines, it was observed that the weight gain of less than 5 kg increases more than sixfold chance of being LBW (Roy et al. 2009; Metgud et al. 2012; Hanumant Dandekar et al. 2014).

Short pregnancy interval

Birth spacing contributes to adverse birth outcomes (Kramer 1987). The short interval between the pregnancies increased the risk of LBW and other obstetric complications (Gibbs et al. 2012; Kozuki et al. 2013; Allis 1983). Indian studies have found a similar significant association between pregnancy interval of less than 24 months and obstetrical complication (Deshpande Jayant et al. 2011; Metgud et al. 2012). While other studies have mentioned that the increased risk of LBW when the pregnancy interval is shorter than 12 months (Negi et al. 2006; Roy et al. 2009) or 18 months (Borah et al. 2016). The biological mechanism behind this is not yet clearly understood, but it is likely that pregnancies that occur before the restoration of energy balance, maternal hormones and repletion of maternal resources can lead to health complications in subsequent pregnancies (Conde-Agudelo et al. 2012).

Hypertension during pregnancy

Hypertension during pregnancy is classified as gestational hypertension, pre-eclampsia, severe pre-eclampsia, or eclampsia (Mammaro et al. 2009). Gestational hypertension is diagnosed when the blood pressure equals to or is greater than 140/90mmHg without proteinuria after 20 weeks of gestation (Mammaro et al. 2009). Hypertension associated with the symptoms of proteinuria, seizure or both can indicate the presence of pre-eclampsia and eclampsia (Visintin et al. 2010). As per the prevailing hypothesis of the "ischemic model", hypertension decreases uteroplacental perfusion by reducing placental blood flow (van Beek et al. 1997) which, in turn, results in the decreased fetal growth with an increased risk of pre-term birth and LBW (Misra 1996). Studies in India also showed a significant association between increased risks of LBW with pregnancy induced hypertension (Metgud et al. 2012; Deshpande Jayant et al. 2011) or Pre-eclampsia and Eclampsia (Idris et al. 2000; Singh et al. 2009).

Infection

Bacterial, viral and parasite infections experienced during pregnancy can affect placental development and function, which can lead to IUGR (Adams Waldorf et al. 2013). Infections, such as Treponema pallidum (syphilis) (De Santis et al. 2012), HIV (Xiao et al. 2015), Plasmodium falciparum or Plasmodium vivax (Rijken et al. 2012), Trypanosoma cruzi (Chagas') (Cevallos et al. 2014) have been shown to be associated with LBW. In contrast, only two Indian studies that have covered a very broad spectrum for infections have been reported (Tellapragada et al. 2016; Idris et al. 2000) and there has been a paucity of studies related to infections during pregnancy in India to support the above-mentioned associations with various pathogens.

Other widely reported infection in pregnancy, also in India, has been a periodontal infection that also has been regarded as a potential risk factor for LBW (Offenbacher et al. 1996) (Deshpande Jayant et al. 2011; Mathew et al. 2014; Basha et al. 2015; Tellapragada et al. 2016).

Antepartum haemorrhage

Antepartum haemorrhage (APH) is a bleeding from or into the genital tract, usually occurring from 24th week of pregnancy onwards and prior to the birth of the fetus (WHO 2011). It is an important predictor of pregnancy outcomes (Bener et al. 2012). It has been estimated that 70% of women who bleed in the last half of the pregnancy have an equal chance of exhibiting either placenta previa , or abruption placentae while in the remaining 30% five out of six cases is unexplained due to indeterminate site of bleeding and one out of six cases is caused by extra placental factors (Konar 2014). Several worldwide studies showed an increased risk of LBW for bleeding in the late pregnancy (Bener et al. 2012) and studies in India support (OR:3.2, P<0.01) the above-mentioned observation (Idris et al. 2000).

Behaviour and Environmental risks

Tobacco consumption

Tobacco smoking by women of childbearing age has long been suggested to be one of the most critical factors associated with maternal-fetal health. Tobacco consumption affects the intrauterine environment through several mechanisms (Scholl et al. 1986; Kramer 1987) of which the most commonly reported involve mediators, such as carbon monoxide and nicotine. Carbon monoxide decreases the oxygen-carrying capacity and increases carboxy-hemoglobin, which leads to less release of oxygen to the fetal tissues (Longo 1977). Nicotine, on the other hand, works as an appetite suppressant and results in a rapid increase of catecholamines consequent to uterine vasoconstriction (Quigley et al. 1979). Further, the cyanide compound present in smoke leads to mediated inferences with fetal oxidative metabolism (Andrews 1973). Large epidemiological studies have shown a significant association between tobacco consumption and LBW, even after controlling for confounding factors (Coutinho et al. 2009; Dietz et al. 2010). Similar findings have also been also reported from India (Deshmukh et al. 1998; Deshpande Jayant et al. 2011).

Active smoking directly affects maternal-child health, but studies show that passive smoking also affects maternal-child health through inhaled air pathways (Ward et al. 2007; Pogodina et al. 2009). Compered to men, females are more exposed to the ill effects of tobacco smoke due to passive smoking in their homes or outside as environmental conditions, such as overcrowding and poor ventilation at home (Khattar et al. 2013). Studies conducted in developed countries have shown an association between maternal environment tobacco smoke (ETS) exposure and LBW with increased odds from 1.0 to 2.2 (Ward et al. 2007; Pogodina et al. 2009). Most of the Indian studies also shown a stronger association between ETS exposure and LBW neonate (Gupta et al. 2004; Khattar et al. 2013; Metgud et al. 2012).

Maternal occupation

Many studies confirm a significant association between maternal occupation and LBW worldwide (Meyer et al. 2008; Casas et al. 2015). One study showed that a moderate to vigorous activity throughout pregnancy may enhance birth weight while severe activity may lead to lighter offspring (Pivarnik 1998). Choudhary et al. (2013) showed that in India daily calorie, mother occupation, and the daytime rest taken were inter-related and significantly associated with LBW. This study also reported that daily calorie was less than 2000 kcal, daytime rest of less than 1 hour and worked as labourer increases the risk of LBW (Choudhary et al. 2013). Moreover, several studies have also shown that mothers who were unemployed, farm labourers during pregnancy have a higher risk of LBW compared to employed (professional/clerical services et al. 2011; Epstein et al. 2013; Kumar et al. 2020).

Maternal psychological stress

Maternal psychological stress factors include stressful life changing events, anxiety, mental illness, abuse, and unwanted pregnancy. These factors have been shown to be associated with LBW, prematurity and IUGR (Rondó et al. 2003; Chhabra 2007; Sarkar 2008). The reason behind this may be related to the release of catecholamines or corticosteroids, which increases the vulnerability to infectious diseases (like chorioamnionitis) due to a higher degree of neuromuscular reactivity and the secretion of oxytocin. These factors might induce the placental hypotension and consequent restriction of oxygen and nutrient to the fetus, leading to growth impairment or precipitation of pre-term delivery (Omer 1986; Copper et al. 1996). Stressed women have been reported to more often smoke cigarettes or use a substance such as alcohol and caffeine (McAnarney et al. 1990). Rondo et al. (2003), in their study, observed that maternal distress was associated with LBW and prematurity and also reported an interaction between distress and smoking (Rondó et al. 2003). In India, only one study showed an association between local crime involving a harassment of women and girls with LBW (Baker et al. 2018), although no other major study has investigated this association.

Alcohol consumption

A systematic review and meta-analysis revealed that, compared to abstainers (i.e., those who consume less than 19-gram pure alcohol per day) a heavy alcohol consumption during pregnancy increases the risk of LBW, pre-term birth and small for gestational age, whereas light to moderate alcohol consumption showed no effect (although no data from Asia was included in this review (Patra et al. 2011). Another study from Asia revealed that maternal alcohol consumption of more than 1 gram per day during pregnancy was significantly associated with a risk of pre-term birth, but not with LBW and small for gestational age (Miyake et al. 2014). However, the results of this study might not be representative of all Asian countries as the study did not cover the whole of Asia. In India, no study reported the association between alcohol consumption and LBW. One reason can be its low prevalence of 5.8% in India as reported by the Gender, Alcohol, and Culture: An International Study (GENACIS) project (WHO 2005).

Health care risks

Antenatal care

Studies in developing countries have provided evidence that improvement in Antenatal Care (ANC) can significantly reduce the incidence of LBW (Mahumud et al. 2017; Zhou et al. 2019). Quality of ANC, as recommended by WHO, includes at least four standard qualities ANC visits, comprising interventions, such as tetanus toxoid vaccination, screening as well as treatment for infections and identification of warning signs during pregnancy (WHO 2016). These recommendations vary worldwide; in India, for instance, an adequate ANC was considered when the pregnant women were registered at any time during pregnancy, had at least three ANC check-ups, was adequately vaccinated against tetanus, had consumed at least 100 tablets of iron and folic acid, was not involved in hard work and had taken adequate rest during pregnancy (minimum 2 hours sleep during day and 8 hours sleep during the night) (Mumbare et al. 2012). Several studies in India have established a significant relationship between these factors and LBW (Deshpande Jayant et al. 2011; Metgud et al. 2012; Epstein et al. 2013; Choudhary et al. 2013; Negandhi et al. 2014; Mumbare et al. 2012). Other studies have reported a more significant link when registration with ANC was late (Negi et al. 2006; Singh et al. 2009) or a number of ANC visits was lower (Malik et al. 1997; Idris et al. 2000; Agarwal et al. 2005; Dharmalingam et al. 2010; Jha et al. 2009; Khattar et al. 2013; Kader et al. 2014; Mathew et al. 2014). Another study showed a lower incidence of LBW among mothers who received average quality ANC (18.5%), and good quality ANC (13.5%) (OR=1.45, 95% CI: 1.13–1.87, $p < 0.05$) (Nair et al. 2000). To summarise the above studies, adequate ANC care prevents LBW, regardless of the presence of possible confounding factors.

Evolving concepts of risks

Mid-upper arm circumference

Mid-upper arm circumference (MUAC) is a good indicator for identifying chronic energy deficiency in the body (James et al. 1994) and plays an important role in the determinant of LBW. A WHO collaborative study (1995) (Kelly et al. 1996) showed that MUAC cut-off values of <21–23 cm (OR: 1.9, 95% CI: 1.7–2.1) were at higher risk for LBW. In another study, Mohanty et al. (2006) reported MUAC of 395 pregnant women in the first trimester and found that MUAC ≤22.5 cm was the best cut off value to predict LBW (Mohanty et al. 2006). Several other studies conducted in different parts of India showed a significant association between the birth weight of neonates and MUAC. According to those studies, MUAC was the best surrogate measure for LBW (Sen et al. 2009; Shrivastava et al. 2016) as MUAC was insensitive to the changes experienced during the pregnancy (Katz et al. 2010).

Conclusions

Low birth weight has been known to cause numerous adverse effects among neonates and infants. This literature review suggests that maternal age, educational status, socio-economic status, ethnicity, parity, pre-pregnancy weight, maternal stature, maternal body mass index, obstetric history, maternal anaemia, gestational weight gain, short pregnancy outcome, hypertension during

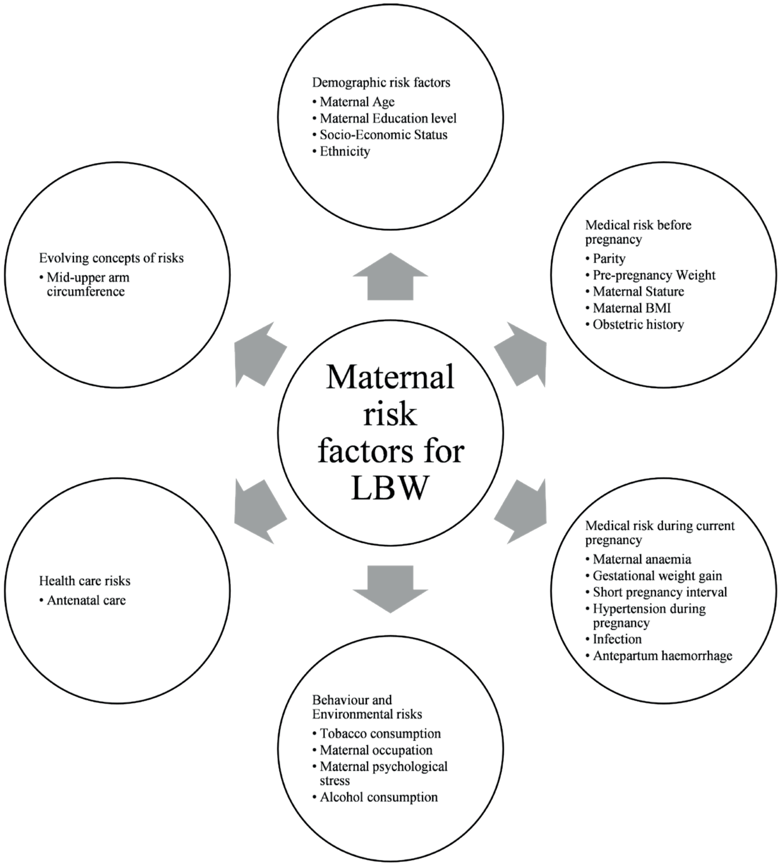

Fig. 1. Summary of Maternal risk factors for LBW in Indian population

pregnancy, infection, antepartum haemorrhage, tobacco consumption, maternal occupation, maternal psychological stress, alcohol consumption, antenatal care and mid-upper arm circumference are independently associated with term LBW in the Indian population. The awareness about the various aspect of maternal risk factors during pregnancy and understanding general pathways underlying Term LBW can be potentially very beneficial for the healthcare providers to apply the preventive measures and the necessary interventions. The prenatal screening should be started so the high-risk pregnant women will be clearly marked and given a plan for pregnancy with regular advice. A suggested summary for maternal risk factors for low birth weight is depicted in figure 1.

Conflict of interest

The authors report no conflict of interest.

Ethical approval

The manuscript is a narrative review paper and did not require any clinical trials registration.

Authors' contributions

The topic was conceived by HV, RS and VG. The literature review was performed by HV and VG who also constructed the project outline and drafted the manuscript. The figure was developed by HV. The critical review of manuscript was done by MPS, GKW, VG.

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