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REVIEW ARTICLE

Gender differences in survival among low birthweight newborns and infants in sub-Saharan Africa: a systematic review

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In sub-Saharan Africa, low birthweight (LBW) accounts for three-quarters of under-five mortality and morbidity. However, gender differences in survival among LBW newborns and infants have not yet been systematically examined. This review examines gender differences in survival among LBW newborns and infants in the region. Ovid Medline, Embase, CINAHL, Scopus and Global Health databases were searched for qualitative, quantitative and mixed methods studies. Studies that presented information on differences in mortality or in morbidity between LBW male and female newborns or infants were eligible for inclusion. The database search yielded 4124 articles, of which 11 were eligible for inclusion. A narrative synthesis method was used to summarize the findings of the included studies. Seven studies reported more LBW male deaths, three studies reported more LBW female deaths and one study did not disaggregate the deaths by gender. Nine of the 11 studies that examined gender differences in mortality did not find significant evidence of gender differences in mortality among LBW newborns and infants. Likewise, no significant differences were found for gender differences in morbidity among this population. The review findings suggest a need for further research on this topic given the potential significance on child health and developmental goals.

Keywords: Africa, gender differences, low birthweight, survival.

Introduction

In 2015, the global prevalence of low birthweight (LBW) was approximately 14.6%, amounting to 20.5 million LBW babies.[1] Approximately 91% of these LBW live births were from low-and-middle income countries (LMICs).[2] Across these regions, the prevalence of LBW was estimated to be 26.4% in Southern Asia, 14.0% in sub-Saharan Africa (SSA), 12.2% in Northern Africa, 12.2% in Southeastern Asia and Oceania, 9.9% in Western Asia, 8.7% in Latin America and the Caribbean, 5.4% in Central Asia and 5.3% in eastern Asia.[2] Accordingly, the WHO identified LBW as an indicator of child health status.[3] Birth weight is the first weight of the fetus or newborn obtained after birth.[3] A birth weight of <2500 g is classed as LBW, regardless of gestational age.[4] LBW is further categorized into very low birth weight (VLBW, <1500 g) and extremely low birth weight (ELBW, <1000 g).[4]

LBW is determined by two major factors, which are the duration of gestation and intrauterine growth rate. Evidence indicates that a baby's low weight at birth is either the result of preterm birth (<37 wk of gestation) or restricted fetal (intrauterine) growth.[5,6] Demographical risk factors include early maternal age, primiparity and low education level, as well as poor maternal nutritional status—both before and during pregnancy—which are well-recognized determinants of birth outcomes.[7]

LBW is a major determinant of infant mortality, morbidity and poor mental and physical development.[8] LBW accounts for approximately 80% of all newborn deaths[2] and it increases the relative risk of morbidity.[9] Indeed, the neonatal and infant periods are vulnerable periods for child survival and quality of life.[10,11] While LBW is amongst the strongest predictors of infant morbidity and mortality in most parts of the developing world, in Africa it is the strongest predictor.[12] SSA in particular, where approximately 14% of neonates are born with LBW, accounts for a quarter of the global burden of LBW live births.[2,13] This region also constitutes the highest neonatal and under-5 mortality rates in the world.[10,11] LBW-related mortality continues to be a significant global and public health challenge. Meeting Sustainable Development Goal (SDG) 3, which aims to ensure health and well-being

for all, is unthinkable without addressing child health.[14] In particular, with SDG 3.2, a target was set to reduce newborn mortality to 12 per 1000 live births, under-five mortality to 25 per 1000 live births and low birth weights to 30% by 2030.[14]

Previous studies have identified various risk factors for mortality among LBW newborns and infants.[15–17] One of the more contested individual level risk factors is gender, which is a key variable for disaggregation of child mortality and morbidity estimates. Unfortunately, gender differences in birth weight have not been extensively explored in the literature.[17,18] Addressing health inequality is reliant on the generation and provision of high-quality data to facilitate evidence-based actions and the monitoring of progress at different levels. SDG 17.18 recommends efforts to increase the availability of data disaggregated by income, gender, age, race, ethnicity, migratory status, disability and geographical location in developing countries to ensure that no one is left behind, with special emphasis given to LMICs.[19] Hence, most United Nations health indicators are gender-disaggregated.[20,21] Organizing gender-disaggregated data is an important component of the analysis of gender differences, in which quantifiable differences are made between males and females.[22] In particular, the analysis of gender differences enables program managers and decision-makers to evaluate the quality of service provision and improve treatment, health-related outcomes and equity among males and females.[23]

Despite the significant influence of LBW on adverse health outcomes, there is a lack of evidence on this key public health concern across SSA. Therefore, this systematic review primarily evaluates gender differences in survival among LBW newborns (aged <28 d) and infants (aged <1 y) in SSA. It synthesizes the existing evidence on gender differences in survival and morbidity outcomes in this population. The availability of gender-disaggregated LBW and mortality data can be crucial in informing interventions to meet SDG 3.2 targets. In addition to identifying the existing evidence, the review will identify evidence gaps in the literature for gender-specific LBW outcomes. Review findings will ultimately inform program implementers, policymakers and researchers addressing LBW-related mortality and morbidity. To our knowledge, there is no existing systematic review on this research aim in SSA.

Materials and Methods

Reporting and protocol registration

This review was designed and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (see Supplementary File 1). The review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO CRD42020163470). The review protocol has also been published.[24]

Eligibility criteria

In terms of population, the review included studies that assessed LBW male and female newborns born in SSA (aged <28 d) and/or LBW male and female infants born in SSA (aged <1 y). The review considered usual standards of care without an intervention for inclusion. In terms of outcome measures, the primary outcome of interest was gender differences in survival or mortality of LBW newborns and/or infants from a health facility. The secondary outcomes of interest included gender differences in morbidity of LBW newborns and infants from a health facility. These morbidities can include non-communicable diseases including cardiovascular and respiratory diseases, cancer and diabetes.[25] The secondary outcomes can also include communicable disease including sepsis, pneumonia, diarrhea, tetanus, measles and other infectious diseases typically accounting for child mortality.[26] The initial review protocol stated that only studies reporting gender differences in survival or morbidity at the time of discharge would be included[24]; however, as several relevant studies assessed these outcomes before discharge, after discharge or did not clearly report the period of assessment, studies reporting these outcomes at any time point were included.

Eligible types of studies were quantitative, qualitative and mixed-method studies on male and female LBW newborns and infants. Moreover, eligible studies included peer-reviewed full-text articles published from January 2000 to August 2020 in English. This period was selected because 2000–2015 was the era of the Millennium Development Goals (MDGs), when significant progress was achieved with regard to infants' health. As a continuation of the increased focus of research on child health, the SDG adopted in 2015 set new targets to reduce child mortality and improve child health by 2030.[14] The period from 2000 to now thereby accounts for the new wave of research related to development goals on reducing child mortality since the turn of the century. Further details on the predefined eligibility criteria for inclusion in the review can be found in the published protocol.[24]

Data sources and search strategy for relevant studies

Ovid Medline, EMBASE, CINAHL, Scopus and Global Health databases were initially searched in February 2020. A second search was conducted in September 2020 to identify studies published during February–August 2020. This was carried out in collaboration with a Health Sciences librarian, who helped in optimizing the retrieval of relevant citations. Search strategies included combinations of keyword and Medical Subject Heading (MeSH) searches with the following terms: low birthweight, preterm, premature, small for gestational age, newborn, infant, gender, male, female and sub-Saharan Africa (see Supplementary File 2).

The search strategies designed to access published materials comprised of three stages: (i) a limited search of Ovid Medline and CINAHL to identify relevant keywords contained in the title, abstract and subject descriptors; (ii) terms identified in this way, and the synonyms used by Ovid Medline, EMBASE, CINAHL, Global Health and Scopus, were used in an extensive search of the literature; and (iii) reference lists of eligible full-text articles were perused to identify additional relevant articles that may have been missed by database searching.

Screening and selection process

Database search records were imported into the Mendeley citation management software, where duplicates were removed. The

articles retrieved were then screened by two reviewers (ATG and AWF) in the Rayyan systematic review management platform (Qatar Computing Research Institute, Qatar)[27] for their eligibility for inclusion in the review. This included title and abstract screening, followed by full-text screening against the eligibility criteria. Disagreements were settled through discussion. In addition, the reference lists of the studies included were manually perused by a third reviewer (PO) to identify additional relevant articles that were not captured through database searching.

Data extraction

ATG and LF adapted a data collection form based on the needs of the review from a standardized data extraction form provided by the Cochrane Library.[28] Following full-text screening, data were independently extracted from the eligible studies by two reviewers (AWF and PO). Disagreements were settled through discussion with ATG. The data extracted included study characteristics and information on outcomes relevant to the review question. These included the following information from each article: (i) author(s) and publication year, study setting and study aim or hypothesis; (ii) sample characteristics, design and data collection methods, outcome measures and statistical analyses; and (iii) study findings. We contacted primary study authors for key information when data were ambiguous or missing from the included studies.

Methodological quality

Two reviewers (ATG and AWF) independently evaluated the quality of each study, with disagreements resolved through discussion. The methodological quality assessments of studies were performed using Joanna Briggs Institute critical appraisal checklists,[29] as these were suitable for the included study designs. Given the designs of the retrieved studies, the reviewers used the checklists for cohort studies (11 items), case series (10 items) and cross-sectional studies (8 items). Each item of the checklist for each article was rated as yes (score of 1), no (score of 0) or unclear (score of 0.5). The overall quality of studies was reported as 'low' (<70%), 'moderate' (70–85%) or 'high' quality (>85%) based on the percentage of criteria met. Studies that met at least 65% of the criteria were included; all the studies scored above this cut-off.

Method of synthesis

A narrative synthesis was conducted, to allow synthesis of evidence from a range of research questions and study designs with quantitative and qualitative approaches.[30] The authors compiled and descriptively summarized the findings of the individual studies regarding gender differences in survival among LBW newborns and infants.[30] A meta-analysis of gender differences in survival was not possible given the heterogeneity in reporting of survival outcomes in the included studies, and limited reporting of survival outcomes separated by gender.

Certainty of review evidence

AWF used the GRADE approach to assess the confidence and certainty of the review evidence for each outcome from the included studies.[31] The certainty of the evidence for primary and secondary outcomes was based on methodological quality, indirectness, imprecision, inconsistency and publication bias. The overall certainty of evidence is graded as either 'high', 'moderate', 'low' or 'very low'.

Results

Selection results

A total of 4124 records were found during the initial (3962 records) and second database searches (162 records) in September 2020. No relevant articles were identified during the second search. After removing duplicates, screening titles, abstracts and full texts, 11 full-text papers remained for inclusion in the systematic review. Figure 1 provides details of the selection process and the reasons for the exclusion of excluded articles.

Description of included studies

In terms of geographical region, four studies were from East African countries,[32–35] three studies were from West African countries[36–38] and four studies were from Southern African countries.[39–42] While all the studies were conducted on LBW newborns or infants, four were specifically conducted on VLBW infants or newborns. All of the included studies were quantitative. In terms of the studies' settings, nine were based in urban hospitals, one in a rural hospital and one in an urban health center. See Table 1 for the specific characteristics of the included studies.

Descriptive findings

The total number of LBW infants and newborns in the included studies was 4952. The numbers of female and male participants were 2529 (51.1%) and 2423 (48.9%), respectively. All of the studies examined mortality, with 10 studies reporting LBW mortality disaggregated by gender. The participants were followed over different times with varying points of measurements for survival or morbidity. The lengths of follow-up ranged from 1 to 108 mo for prospective studies. The periods of measurement of the outcomes were up to discharge, after discharge and both before and after discharge. Of the 2529 female participants in the studies, 533 (21%) had died. Of the 2423 male participants, 578 (23.9%) had died. Of the 1111 participants who died across the studies, 48% were female and 52% were male. Of the total number of deaths, three studies reported more deaths among female infants and newborns,[36,37,40] while seven studies reported more deaths among male infants and newborns.[32–35,38,39,42] One study did not report gender-disaggregated mortality numbers.[41] In terms of the percentage of female and male deaths from the total number of female and male participants, Rylance and Ward[34] reported a higher percentage of LBW female deaths; Kalimba and Ballot[40] reported a higher percentage of LBW male deaths (Table 2).

Quality appraisal

Overall, seven studies were of high quality (>85%), three studies were of moderate quality (75–85%) and one study was of

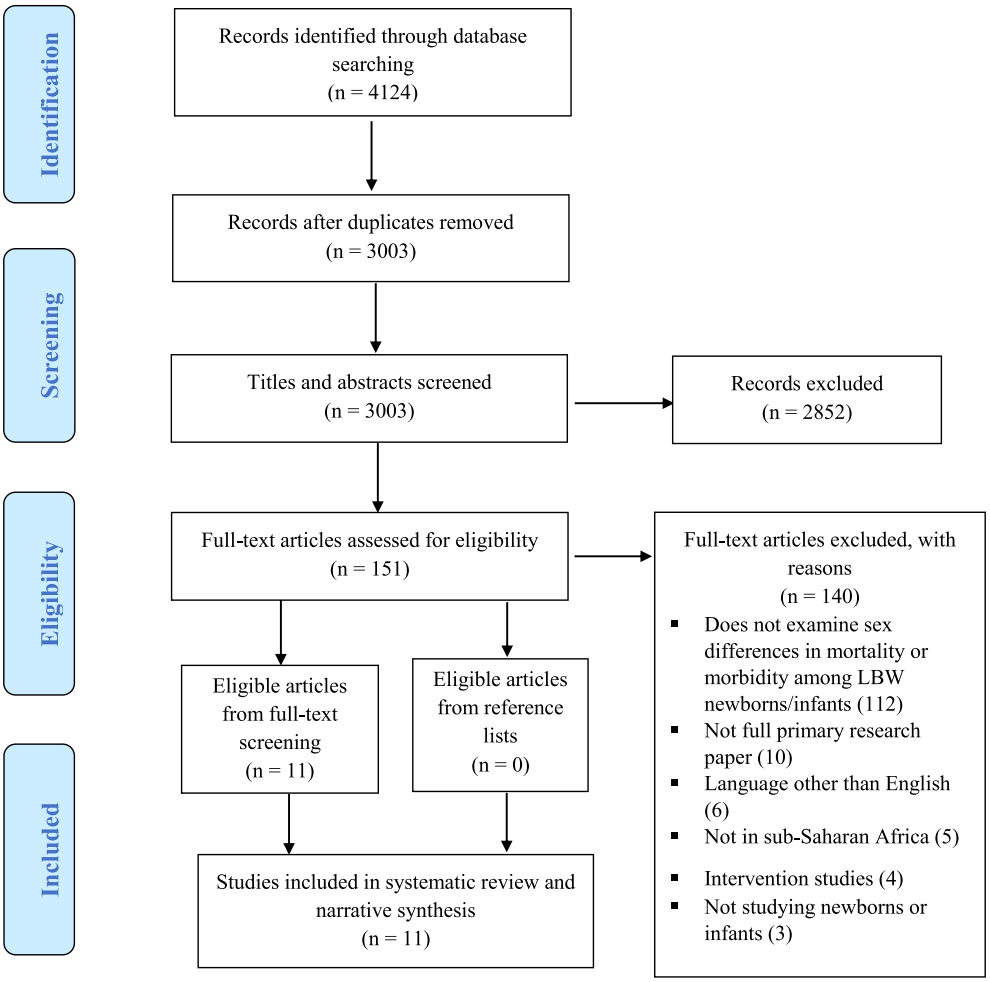

Figure 1. PRISMA flowchart.

low quality (<75%). From the cohort studies, Kuti et al.[38] did not adequately identify or adjust for potential confounding factors, including gestational age, antenatal care received, Agpar score, mode of delivery and underlying conditions. These factors may be associated with survival or death, which could limit the reliability of estimates of true association between gender and survival or death among LBW infants. Also, van der Mei et al.[36] did not clearly articulate strategies to address incomplete follow-up, nor did their study account for participants with missing data. The study did not account for different follow-up times when calculating survival. The unavailability and inaccuracy of hospital records may reduce the validity and reliability of retrospective chart reviews. Lack of clarity about the data abstraction process may also reduce the validity and reliability of retrospective chart reviews. Moreover, in two case studies, unclear reporting of demographical and clinical information, including gender-disaggregated data on birth weight, was a concern regarding the reliability of the findings.[35,40] See Supplementary File 3 for the detailed appraisal scores for each study.

Narrative synthesis

Two studies that assessed survival or death up to discharge from a health facility found a statistically significant relationship between gender and survival or death (Table 3).[41,42] Both of these studies were conducted in the Southern Africa region. Otherwise there are no discernible links between the primary outcome and variables such as period of research, urban/rural or healthcare facility setting. Six studies that assessed survival or death up to discharge did not find a statistically significant relationship between gender and survival or death.[32,34,35,37,39,40] All three studies that assessed survival, death or morbidity after discharge from a health facility found no statistically significant relationship between gender and survival, death or morbidity.[33,36,38] One study that assessed survival or death before and after discharge found no statistically significant relationship between gender and survival or death.[36]

Certainty in the evidence

Given that all the studies were observational, the ratings started as low or moderate quality evidence. There is low certainty in the

Table 1. Characteristics of included studies

First author, year	LBW[a] group (g)	Study design	Participant characteristics	Study country	Region	Healthcare setting (rural/urban)	Healthcare facility
Abdallah, 2018	<1500	Prospective cohort	190 VLBW[b] infants	Uganda	East Africa	Urban	Hospital
Ballot, 2010	<1500	Retrospective record review	470 LBW neonates	South Africa	Southern Africa	Urban	Hospital
Ballot, 2016	<2500	Cross-sectional record review	292 VLBW infants	South Africa	Southern Africa	Urban	Hospital
Coulibaly, 2016	<2500	Prospective cohort	341 LBW infants	Burkina Faso	West Africa	Urban	Primary care facilities
Kalimba, 2013	<900	Retrospective longitudinal record review	382 VLBW infants	South Africa	Southern Africa	Urban	Hospital
Kuti, 2018	<2500	Prospective longitudinal	154 LBW neonates	Nigeria	West Africa	Urban	Hospital
Mei,2000	<2000	Prospective-descriptive	105 LBW infants	Ghana	West Africa	Rural	Hospital
Rylance, 2013	<1500	Retrospective review of case notes	268 VLBW infants	Malawi	Southern Africa	Urban	Hospital
Simiyu, 2004	<2500	Retrospective longitudinal case study	533 LBW infants	Kenya	East Africa	Urban	Hospital
Simiyu, 2005	<2500	Retrospective/ case notes	74 LBW neonates	Kenya	East Africa	Urban	Hospital
Velaphi, 2005	<1499	Retrospective cohort	2143 LBW Infants	South Africa	Southern Africa	Urban	Hospital

[a]LBW refers to low birthweight (<2500 g)
[b]VLBW refers to very low birthweight (<1500 g)

evidence from studies that examined gender differences in mortality or survival due to numerous concerns (see Table 4). There is very low certainty of evidence from the study that examined gender differences in morbidity.[38] The study had some methodological limitations pertaining to confounding factors. There are serious concerns with imprecision and inconsistency due to the low information size, low number of events for the binary outcomes and the fact that only one study contributed to the evidence. The consistency of the direction and/or magnitude of effects across studies could not be established. There were serious publication concerns for both outcomes, particularly due to the exclusion of non-peer-reviewed studies while searching. Within the studies, given the minimal information on gender differences in mortality and morbidity among LBW infants or newborns, there may have been some selective under-reporting of findings.

Discussion

This systematic review was conducted to examine and contribute to the knowledge base on gender differences in survival among LBW newborns and infants in SSA. The review found that 39.6% (1111/2809) of the LBW newborn or infant participants in the included studies that assessed differences in mortality had died, with most studies finding more deaths among male infants or newborns. However, a majority of the studies reported that any gender differences in survival or mortality and morbidity were not statistically significant. The review therefore indicates that gender does not significantly impact mortality or morbidity outcomes among newborns or infants. However, our synthesis of the evidence is limited by the small number of studies investigating this question and the heterogeneity across/between these studies, which prevented the conduct of a meta-analysis.

The literature from developing countries suggests that female newborns or infants are significantly more prone to LBW than males.[6,43–47] Furthermore, the WHO identified female gender as a non-modifiable predictor of LBW.[44] The finding in this review of a higher proportion of death among males is strongly corroborated by the literature. Many studies on LBW over the years have consistently reported higher prevalence and

Table 2. Mortality among LBW infants and newborns in SSA countries

First author, year	Study country	Total no. of participants	No. of females	No. of males	Measurement period of outcome	No. of females dead (%)[a]	No. of males dead (%)[b]	Percentage of LBW deaths from study participants (%)
Abdallah, 2018	Uganda	190	107	83	3 mo after discharge from health facility (14 F and 12 M were lost to follow-up)	14 (13.1)	18 (28.6)	16.8
Ballot, 2010	South Africa	470	251	219	Up to discharge from health facility	59 (23.5)	78 (35.6)	29.1
Ballot, 2016	South Africa	292	128	164	Up to discharge from health facility	50 (39.1)	70 (42.7)	41.1
Coulibaly, 2016	Burkina Faso	341	195	146	29 d after birth	18 (9.2)	0 (0)	5.0
Kalimba, 2013	South Africa	382	204	178	Up to discharge from health facility	142 (69.6)	136 (76.4)	72.8
Kuti, 2018	Nigeria	154	69	85	[*]Following discharge from and facility (10 mo follow-up measurements)	11 (15.9)	17 (20)	18.2
Mei, 2000	Ghana	105	57	48	Up to discharge (4-y period) and after discharge from health facility (ages 4–9 y)	7 (12.3)	2 (4.2)	8.6
Rylance, 2013	Malawi	268	132	136	Up to discharge from health facility	77 (58.3)	79 (58.1)	58.2
Simiyu, 2004	Kenya	533	257	276	Up to discharge from health facility	143 (55.6)	163 (59.1)	57.4
Simiyu, 2005	Kenya	74	37	37	Up to discharge from health facility	12 (32.4)	15 (40.5)	36.5
Velaphi, 2005	South Africa	2143	1092	1051	Up to discharge from health facility	[*]	[*]	27.9

[a]Percentage of LBW female deaths from the total number of female participants
[b]Percentage of LBW male deaths from the total number of male participants
[*]No gender-disaggregated descriptive findings in Velaphi[35]

proportions of death among LBW males compared with females.[16,17,48] However, there are some conflicting findings, with some evidence of no or very slight gender differences in their survival.[49–51] Nevertheless, most of the available evidence supports the argument for a higher mortality risk among LBW males. Scholars have attempted to explain such gender differences in mortality in newborns through the 'male disadvantage hypothesis'.[52,53] The hypothesis states that newborn males are at an inherent biological disadvantage due to their vulnerability to adverse environmental factors during growth. Accordingly, male infants are more prone to neonatal death than female infants.[52]

The findings in this review present insufficient evidence to determine whether or not the 'male disadvantage hypothesis' applies to the review population, with the majority of studies reporting that differences in mortality between LBW males and females are not statistically significant. Studies in India,[16] Jamaica[54] and Iran[55] similarly did not find a statistically significant gender difference in mortality or survival among neonates and infants. However, most studies across other LMICs report statistically significant differences between gender and mortality or survival among LBW infants and neonates.[16,17,56–58] In each of these studies, male gender was a significant predictive factor for increased mortality, while females had a significantly smaller risk for mortality. From the two studies in this review that did find a statistically significant relationship between gender and survival or mortality, both similarly reported significantly lower survival among males.[41,42] These findings are corroborated by a

Table 3. Narrative synthesis findings

First author, year	Analytical method for outcome	Survival outcome	Morbidity outcome	Measurement period
Abdallah, 2018	Survival outcome was computed as a ratio of study participants alive at 3 mo to the total number of study participants who completed study. Study authors also computed p values	p=0.10 for the relationship between gender and mortality	-	Survival after discharge
Ballot, 2010	Binary logistic regression and multiple logistic regression to assess relationship between gender and survival	OR of 1.8 (95% CI 1.24 to 2.69; p=0.004) from binary logistic regression OR of 3.21 (95% CI 1.6 to 6.31; p=0.001) from multiple logistic regression	-	Survival up to discharge
Ballot, 2016	χ^2 to assess relationship between male gender and survival	p=0.638 for the relationship between male gender and survival	-	Survival up to discharge
Coulibaly, 2016	Cox proportional hazards to assess relationship between gender and mortality	Crude HR=1.2 (95% CI 0.5 to 3.1; p=0.718) for the relationship between gender and mortality	-	Survival up to discharge
Kalimba, 2013	χ^2 to assess relationship between male gender and survival	χ^2=4.38 (p=0.357) for relationship between gender and survival	-	Survival up to discharge
Kuti, 2018	χ^2 to assess relationship between gender and respiratory distress	-	χ^2=1.352 (p=0.245) for the relationship between gender and respiratory distress	Respiratory morbidity after discharge
Mei, 2000	Homogeneity of odds test to assess relationship between gender and survival	Homogeneity of odds, p=0.99 for the relationship between gender and survival	-	Survival before and after discharge
Rylance, 2013	Survival outcome was calculated as a ratio of infants surviving to discharge to the total number of male and female infants. Calculated Pearson χ^2 and p value for gender-disaggregated survival	χ^2=0.002 (p=0.97) for the relationship between gender and mortality	-	Survival up to discharge
Simiyu, 2004	χ^2 (homogeneity) and corresponding p value	χ^2=0.65 (p=0.42) for the relationship between gender and survival	-	Survival up to discharge
Simiyu, 2005	χ^2 test used to assess the relationship between gender differences and survival	χ^2=0.52 (p=0.47) for the relationship between gender and survival	-	Survival up to discharge
Velaphi, 2005	Single and multiple logistic regression models (adjusted OR) to assess the relationship between male gender and survival	Adjusted OR=0.76 (95% CI 0.61 to 0.95) for relationship between male gender and survival	-	Survival up to discharge

systematic review of LBW mortality outcomes in predominantly high-income settings.[59] Twenty-six of the 32 included studies in Vu et al. demonstrated poorer male mortality outcomes at discharge, while 6 reported no gender difference (null association) in mortality.[59]

Only one study in this review assessed morbidity as an outcome to LBW exposure,[38] in which it reported a statistically insignificant relationship between gender and respiratory morbidity. In the literature, there are stark gender differences in respiratory morbidity outcomes among LBW newborns and infants. Stevenson et al. extend the male disadvantage hypothesis to morbidity outcomes, reporting that LBW males are at a higher risk of adverse outcomes, including in respiratory morbidity.[60] A contemporary review of gender differences in respiratory morbidity found that male gender also increases the risk of respiratory morbidity.[61] These gender differences were attributed

Table 4. Certainty of evidence

Outcome	Evidence	Number of studies	Certainty in the evidence
Mortality (survival)	Most studies found no statistically significant gender differences in mortality or survival among LBW newborns or infants	10	LOW ⊕⊕OO (due to low quality design, minor concerns with methodological quality and some borderline concerns around publication bias)[a]
Morbidity	The one study on a morbidity outcome found no statistically significant gender differences in respiratory distress among LBW newborns or infants	1	VERY LOW ⊕OOO (due to low quality design, borderline concerns about methodological quality and very serious concerns with imprecision and inconsistency)[b]

[a]Two filled circles correspond with low level of evidence. In this case, the true effect might be markedly different from the estimated effect or outcome.
[b]One filled circle corresponds with very low level of evidence. In this case, the true effect is likely markedly different from the estimated effect or outcome.

to differences in physiology, hormonal regulation and growth factors.

Strengths and limitations

A major strength of this review is that the question it poses has not been addressed previously in this population. The rigorous process of conducting a systematic review is also a strength. The limitations of this review include under-reporting of LBW mortality data by birth weight and gender, possibly resulting in publication bias and methodological quality issues. Second, the inconsistent reporting of information across studies precluded a meta-analysis. For gender differences in morbidity, only one study covered a morbidity outcome among LBW infants or newborns, specifically for respiratory morbidity. Lastly, the sole inclusion of English language studies may have excluded some relevant studies, such as French language studies conducted in Central and West Africa.

Conclusion

This review suggests that although a higher percentage of LBW newborn or infant males succumb to mortality and morbidity, the differences between the genders are not significant. However, the evidence is limited and further research is required to investigate the influence of gender differences on LBW and survival difference. As reflected in the extant review of the literature, this review does not provide sufficient evidence to support or oppose the male disadvantage hypothesis among LBW newborns and infants.

According to UNICEF, birth weight data are not available for nearly 40 million newborns, over half of which reside in SSA.[1] Along with the dearth of studies to adequately represent SSA in this review, this lack of data can explain some of the differences in the literature from SSA and Asia and South America. Therefore, the limited evidence calls for more research studies to examine gender differences in mortality and morbidity among LBW infants and newborns in SSA. Further research should also evaluate biological and social determinants of gender-based disproportions in LBW survival. The studies included mainly reported on gender differences in survival or mortality as a secondary rather than as a primary outcome. Future studies should therefore explore the topic with greater focus on it as a primary outcome. Future prospective and retrospective observational studies should employ regression analysis to estimate the relationships between gender and survival among LBW newborns and infants. Accordingly, studies of the review outcomes should clearly report which confounders were adjusted and the statistical methods used to adjust for confounding. Future observational studies should also calculate interval estimates with point estimates to identify the uncertainties around point estimates. Future reviews should include studies in non-English languages (that are reflective of SSA where LBW infant mortality continues to pose a challenge), as some ostensibly relevant French articles were screened out in this review. Future studies should also conduct such studies in a variety of settings in urban and rural communities to enable comparisons across SSA. Considering that five of the included studies were conducted before 2010, the lack of studies in the last decade could reflect a decline in research interest or lack of funding. More research funding is required to further understand gender-related issues among LBW babies and inform policy and intervention related to SDG 3.2 targets. It is imperative that we aim for optimal health outcomes for all newborns and infants, female and male alike.

Supplementary data

Supplementary data are available at *International Health* online (http://inthealth.oxfordjournals.org).

Author contributions: SY led the design and provided critical comments on the review process. ATG and AWF developed the search strategies in collaboration with a librarian. AWF, ATG and LF developed the extraction form. AWF and PO extracted the data and ATG reviewed the data extraction. ATG and AWF appraised the included studies. AWF and ATG drafted the manuscript and PO checked the descriptive findings. All authors were responsible for critically revising the manuscript for its intellectual content. SY had final responsibility to submit. All authors read and approved the final manuscript. ATG and AWF are joint first authors.

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Competing interests: None declared.

Ethical approval: No consent to publish was needed for this study as we did not use any details, images or videos related to individual participants.

Data availability: The data underlying this review are available in the article and in its online supplementary material.

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