Universidade Federal de Pelotas
Faculdade de Medicina
Programa de Pós-Graduação em Epidemiologia

Tese de Doutorado

Níveis e determinantes do excesso de mortes de meninas menores de cinco anos em países de baixa e média renda

Janaína Calu Costa

Pelotas, 2020

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Tese apresentada ao Programa de Pós-graduação em Epidemiologia da Faculdade de Medicina da Universidade Federal de Pelotas como requisito parcial para obtenção do título de Doutora em Epidemiologia.

Orientador: Prof. Dr. Cesar Gomes Victora

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À minha vó Nenzinha (*in memoriam*)

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A mim mesma, por não desistido.

"*Beti Bachao, Beti Padhao (Save the daughter, educate the daughter). Happiness of a nation lies in the dignity of its daughters."* [1]

Government of India. Ministry of Women and Child Development. Beti Bachao, Beti Padhao.

"*Todo mundo morre, isso é um fato natural, mas a morte, como ela acontece, isso é um fato social.*"

Autor desconhecido

[1] Disponível em: https://wcd.nic.in/bbbp-schemes. "Beti Bachao, Beti Padhao. Salve as filhas, eduque as filhas. A felicidade de uma nação está na dignidade de suas filhas" (Campanha do Governo da Índia para salvar e educar as meninas)

Resumo

COSTA, Janaína Calu. **Níveis e determinantes do excesso de mortes de meninas menores de cinco anos em países de baixa e média renda.** Orientador: Cesar Gomes Victora. 2020. 189 f. Tese (Doutorado em Epidemiologia). Programa de Pós-Graduação em Epidemiologia, Universidade Federal de Pelotas, Pelotas, 2020.

Sexo é uma variável fundamental para análises de mortalidade e, em geral, as taxas são maiores para meninos do que para meninas. No entanto, a discriminação de gênero pode mudar essa relação, por exemplo, através de práticas alimentares inadequadas e menor procura de cuidados de saúde para meninas que podem refletir em sua maior mortalidade. Os objetivos desta tese foram: (I) explorar religião como um dos possíveis determinantes culturais do cuidado diferencial de crianças; (II) analisar quais os fatores associados a viés de gênero na mortalidade de menores de cinco anos; e (III) descrever as metodologias utilizadas por outros estudos para análise das diferenças de sexo na mortalidade de crianças. Foram produzidos dois artigos analíticos baseados em dados de inquéritos populacionais de países de baixa e média renda (*Demographic and Health Surveys* e *Multiple Indicator Cluster Surveys*) e uma revisão de literatura. No primeiro artigo foram utilizados dados de 15 países da África subsaariana (2010-2016). As proporções de crianças que receberam imunização completa com as quatro vacinas básicas (BCG, Polio, DPT e sarampo) e daquelas que não receberam nenhuma dose foram analisadas de acordo com a religião materna e sexo da criança utilizando-se modelos de regressão de Poisson brutos com ajuste para fatores socioeconômicos. Em sete países, a imunização completa foi significativamente menor entre muçulmanos em relação aos cristãos na análise ajustada (razão de prevalência combinada = 0,90 (IC95% 0,87;0,92)]. Em relação às crianças não vacinadas, seis países apresentaram proporções mais altas entre os muçulmanos [RP ajustada = 1,31 (1,14;1,48)]. Sexo não esteve consistentemente associado com vacinação. Para as análises de mortalidade diferencial por sexo foram utilizados dados de 80 países (2010-2018). Os resíduos da associação entre razão de sexo na mortalidade e mortalidade total foram derivados de um modelo de regressão linear, sendo resíduos negativos sugestivos de discriminação contra meninas. Associações entre estes resíduos e indicadores de desenvolvimento nacional, de desigualdade de gênero e de saúde infantil, foram avaliadas através da correlação de Spearman. Foi encontrada mortalidade de meninas acima do esperado em países onde também houve evidência de viés de gênero na procura de cuidados de saúde [rho = -0,24; (-0,45; -0,01)]. A revisão de literatura nos permitiu analisar 154 publicações. Em sua maioria, os estudos focaram em países da Ásia e na mortalidade infantil, e não ajustaram para a mortalidade geral em suas análises. As publicações foram caracterizadas como: *estudos de referência* (n=14) quando estimavam as diferenças esperadas com base na experiência demográfica de populações selecionadas; *estudos comparativos* (n=21) que usaram principalmente tábuas de vida de populações europeias como padrão; e *estudos narrativos* (n=119) que não usaram valores de referência, limitando-se a relatar as estimativas observadas. Estudos com essa perspectiva são importantes para detecção de desigualdades e de práticas discriminatórias e seus determinantes, podendo auxiliar na eliminação das iniquidades de gênero na sobrevivência infantil.

Palavras-chave: Análise de Gênero na Saúde. Mortalidade da Criança. Cobertura vacinal. Epidemiologia. Inquéritos Epidemiológicos.

Abstract

COSTA, Janaína Calu. **Levels and determinants of excess female mortality among children under-five years in low- and middle-income countries.** Advisor: Cesar Gomes Victora. 2020. 189 p. Doctoral Dissertation (Ph.D. in Epidemiology). Postgraduate Program in Epidemiology, Federal University of Pelotas, Pelotas, 2020.

Sex is a fundamental variable for mortality analyses and, in general, rates are higher for boys than for girls. However, gender discrimination can change this relationship, for example, through inappropriate feeding practices and reduced health care-seeking for girls that may reflect their higher mortality. The objectives of this dissertation were: (I) to explore religion as one of the possible cultural determinants of differential care for children; (II) analyze which factors are associated with gender bias in under-five mortality; and (III) describe the methodologies used by other studies to analyze gender differences in early childhood mortality. Two analytical papers were produced based on data from population surveys in low- and middle-income countries (Demographic and Health Surveys and Multiple Indicator Cluster Surveys) and one literature review. The first paper used data from 15 countries in sub-Saharan Africa. The proportions of children who received complete immunization with the four basic vaccines (BCG, Polio, DPT and measles) and those who did not receive any doses were analyzed according to the maternal religion and the child sex using Poisson regression models, crude and adjusted for socioeconomic factors. In seven countries, full immunization was significantly lower among Muslims compared to Christians in the adjusted analysis [combined prevalence ratio = 0.90 (95%CI 0.87; 0.92)]. In relation to unvaccinated children, six countries showed higher proportions among Muslims [adjusted PR = 1.31 (1.14; 1.48)]. Sex was not consistently associated with vaccination. For analysis of differential mortality by sex, data from 80 countries were used (2010-2018) The residuals of the association between sex ratio in mortality and total mortality were derived from a linear regression model, with negative residuals suggestive of discrimination against girls. Associations between these residuals and indicators of national development, gender inequality and child health care, were assessed using Spearman's correlation. Female mortality was higher than expected in countries where there was also evidence of gender bias in health care-seeking and [rho = -0.24; (-0.45; -0.01)]. The literature review allowed us to analyze 154 publications. Most studies focused on Asian countries and child mortality and did not adjust for overall mortality in their analyses. The publications were characterized as: *reference studies* (n = 14) when these estimated the expected differences based on the demographic experience of selected populations; *comparative studies* (n = 21) that used mainly life tables of European populations as the standard; and *narrative studies* (n = 119) that did not use reference values, limited to reporting the observed estimates. Studies with this perspective are important for detecting inequalities, discriminatory practices, and their determinants, and may help to eliminate gender inequities in child survival.

Keywords: Gender Analysis in Health. Child Mortality. Vaccination coverage. Epidemiology. Epidemiological Surveys.

Sumário

Apresentação

Este volume consiste em uma tentativa de mensurar, ou de entender como poderiam ser mensurados, fenômenos sociais que impactam a vida de crianças ao redor do mundo. Este documento é o produto material de uma longa jornada; é fruto de muitos anos de estudo e dedicação, mas também de muitos processos que não saíram como planejado e precisaram passar por adaptações. Através da leitura é possível acompanhar o amadurecimento da pesquisa proposta, desde o projeto original até o produto final, em forma de artigos.

Além das sessões oficiais, a presente tese conta com uma série de “capítulos invisíveis”, que contemplam etapas fundamentais para a materialização desta publicação, e apesar de não ser possível tê-los impressos em seu volume final, certamente se refletem nele. Esses capítulos são frutos de diversas experiências, conquistas, aprendizados, e frustrações, talvez inerentes ao processo, que foram potencializados pelo fato de sua síntese ocorrer em meio a uma pandemia.

Apesar de ser fruto de uma jornada individual, porém moldada pelos coletivos, essa tese só é possível graças a todas aquelas que vieram antes e, infelizmente, por conta da experiência de milhares de mulheres ao redor do mundo que perderam suas filhas e filhos pelas mais diversas causas. Que os estudos que utilizam os dados que contam essas histórias, possam de fato ser úteis para transformar a realidade de tantos que ainda sofrem com as desigualdades. E que nunca esqueçamos que mais do que números, as observações dos nossos bancos de dados representam pessoas, corpos que materializam e são impactados por todas as interações que ocorrem na sociedade.

Oficialmente o volume final da tese foi elaborado segundo as orientações regimentais do Programa de Pós-Graduação em Epidemiologia (PPGEpi) da Universidade Federal de Pelotas e as normas gerais da universidade.

Na primeira seção é apresentado o projeto de pesquisa defendido em julho de 2018, seguido de uma síntese do trabalho de campo, que contempla as atividades realizadas no Centro Internacional de Equidade em Saúde e durante o estágio doutoral na Universidade de Stanford, assim como as modificações realizadas no projeto original que resultaram nos manuscritos apresentados. Nas sessões seguintes encontram-se os três artigos produzidos, em ordem cronológica de redação.

O primeiro artigo, intitulado “*Religious affiliation and immunization coverage in 15 sub-Saharan African countries*” foi publicado em janeiro de 2020 na revista *Vaccine* e descreve desigualdades na cobertura vacinal por grupo religioso.

O segundo manuscrito, “*Levels and possible drivers of excess female mortality in low- and middle-income countries*” foi submetido ao periódico *Paediatric and Perinatal Epidemiology* e apresenta a análise dos resíduos da associação entre a razão de sexo da mortalidade e o nível total de mortalidade de menores de cinco anos em 80 países; a partir dessas estimativas foi possível avaliar, em nível ecológico, os principais índices de desenvolvimento e de desigualdades de gênero associados a maior mortalidade de meninas.

O terceiro manuscrito, intitulado “*A scoping review of methods for assessment of sex differentials in under-five mortality*”, está formatado de acordo com as normas da revista *Journal of Global Health*. Neste trabalho, apresentamos e discutimos as características das metodologias encontradas na literatura cientifica para estimativa das diferenças na mortalidade de meninos e meninas.

Por fim, seguindo ainda as normas internas do PPGEpi, na última sessão deste volume é apresentado um comunicado à imprensa sintetizando os principais achados do estudo.

1 * Projeto de Pesquisa

UNIVERSIDADE FEDERAL DE PELOTAS
FACULDADE DE MEDICINA
PROGRAMA DE PÓS-GRADUAÇÃO EM EPIDEMIOLOGIA

PROJETO DE PESQUISA

Níveis e determinantes da sobremortalidade feminina entre crianças menores de cinco anos em países de baixa e média renda

JANAÍNA CALU COSTA

Pelotas
2018

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Níveis e determinantes da sobremortalidade feminina entre crianças menores de cinco anos em países de baixa e média renda

Projeto de pesquisa apresentado ao Programa de Pós-Graduação em Epidemiologia da Universidade Federal de Pelotas como requisito parcial para a obtenção do título de doutora em Epidemiologia.

Orientador: Prof. Dr. Cesar Gomes Victora

Pelotas

2018

Resumo

Sexo é uma variável importante para a desagregação de taxas de nascimentos e de mortalidade e, em praticamente todos os lugares e épocas, ambas as estimativas são maiores para meninos do que para meninas. Apesar do peso ao nascer mais elevado, os bebês do sexo masculino apresentam maiores prevalências de anomalias congênitas que levam à morte, são mais propensos a nascer prematuramente e a sofrer problemas respiratórios no período neonatal. Meninas recém-nascidas têm menor vulnerabilidade a condições perinatais, incluindo trauma do nascimento, sofrimento fetal e asfixia, devido a seu menor peso; também morrem menos do que meninos devido a prematuridade, tétano neonatal e doenças infecciosas. Desse modo, em condições naturais, espera-se que crianças do sexo masculino morram mais do que as do sexo feminino. No entanto, a discriminação de gênero pode mudar essa relação, por exemplo, através de práticas alimentares inadequadas e menor procura de cuidados básicos de saúde para meninas. Assim, em algumas populações a mortalidade feminina é maior do que a observada para meninos, o que sugere a presença de elementos culturais e comportamentais influenciando esse diferencial. A distinção entre sexo biológico e gênero – a construção social a partir do sexo – estimula a investigação de fatores que possam explicar as variações na saúde e na mortalidade por sexo, em cada contexto. É de fundamental importância identificar populações nas quais o viés de gênero se reflete na mortalidade de menores de cinco anos, através da mensuração do excesso de mortes de meninas (doravante sobremortalidade feminina). Para isso, é necessário obter dados recentes, de alta qualidade, que permitam o ajuste para a maior fragilidade biológica dos meninos e a identificação dos determinantes desse excesso. Os objetivos do projeto incluem: I) propor um indicador que permita identificar a sobremortalidade feminina em países de baixa e média renda; II) analisar características dos países que possam estar associadas à sobremortalidade feminina; e III) explorar a religião como um dos possíveis determinantes culturais do cuidado diferencial. Países onde há viés de gênero precisam de atenção, a fim de assegurar que as meninas recebam cuidados e proteção adequados. Estudos com essa perspectiva são importantes para detecção de iniquidades e de práticas discriminatórias, bem como para auxiliar o enfrentamento de suas causas.

Lista de siglas

ABRASCO – Associação Brasileira de Saúde Coletiva

BCG – Bacille Calmette-Guérin

CAFe – Comunidade Acadêmica Federada

CAPES – Coordenação de Aperfeiçoamento de Pessoal de Nível Superior

DHS – *Demographic and Health Surveys* (Inquéritos de Demografia e Saúde)

DTP – *diphtheria, tetanus, pertussis* (difteria, tétano e coqueluche)

ICEH – *International Center for Equity in Health* (Centro Internacional de Equidade em Saúde)

MICS – *Multiple Indicator Cluster Surveys*

NV – Nascidos vivos

ODM – Objetivos de desenvolvimento do milênio

ODS – Objetivos de desenvolvimento sustentável

OMS – Organização Mundial da Saúde

PIB – Produto Interno Bruto

SWPER – *Survey-based Women's emPowERment index* (Índice de empoderamento feminino baseado em inquéritos)

UNICEF – *United Nations Children's Fund* (Fundo das Nações Unidas para a Infância)

USAID – *United States Agency for International Development* (Agência dos Estados Unidos para o Desenvolvimento Internacional)

WFS – *World Fertility Survey* (Inquérito Mundial de Fecundidade)

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***Demographic and Health Survey* (DHS)** – Inquéritos domiciliares padronizados que coletam dados relativos à população, saúde e nutrição em países de baixa e média renda. Também se refere ao programa internacional que auxilia os países a realizarem tais pesquisas. O programa é implementado pelo *ICF International* e por diversas organizações parceiras através de um contrato com a Agência dos Estados Unidos para o Desenvolvimento Internacional (*United States Agency for International Development* – USAID) (RUTSTEIN; ROJAS, 2006).

Discriminação de gênero – "Toda distinção, exclusão ou restrição baseada no sexo e que tenha por objeto ou como resultado prejudicar ou anular o reconhecimento, gozo ou exercício pela mulher, independentemente de seu estado civil, com base na igualdade do homem e da mulher, dos direitos humanos e liberdades fundamentais nos campos político, econômico, social, cultural e civil ou em qualquer outro campo e concretizada sem qualquer motivo justificável baseada no sexo" (UNITED NATIONS, 1979).

Equidade em saúde – Equidade e imparcialidade em qualquer determinante ou resultado relacionado à saúde, independentemente do status social, étnico e cultural. A iniquidade, ao contrário, se manifesta através de desigualdades sistemáticas de saúde, que são resultado das políticas e práticas sociais e econômicas modificáveis, que criam barreiras à oportunidade (IEA, 2014).

Gênero – Gênero refere-se a um conceito social, culturalmente construído, de papéis e comportamentos distintos para mulheres e homens, meninas e meninos. Os papéis de gênero variam dentro e entre sociedades, normalmente em relação às divisões sociais de poder e autoridade (KRIEGER, 2003).

Indicadores de saúde – Uma variável, suscetível a medição direta, que reflete o estado de saúde de uma população. Exemplos incluem taxas de mortalidade infantil, taxas de incidência baseadas em casos notificados de doença, dias de incapacidade, etc. Estas medidas podem ser utilizadas como componentes no cálculo de um índice de saúde (IEA, 2014).

Método do canivete (*jackknife method*) – Técnica para cálculo da variância de um estimador. Se o tamanho da amostra é n, o estimador é aplicado em cada sub-amostra de tamanho n - 1, obtida pela eliminação de uma medida da análise. A soma os quadrados das diferenças entre cada uma das estimativas obtidas e a sua média, multiplicada por $\frac{(n-1)}{n}$, é a estimativa de da variância (*jackknife estimate of variance*) (PEDERSEN; LIU, 2012).

***Multiple Indicator Cluster Survey* (MICS)** – Conjunto de inquéritos de saúde da mulher e da criança, nacionalmente representativos e internacionalmente comparáveis, criados em 1995 e administrados pelo UNICEF (UNICEF, s/d).

Nascidos vivos – A expulsão ou extração completa de sua mãe de um produto da concepção, independentemente da duração da gravidez, que, após esta separação, respire ou apresente qualquer outro sinal de vida, como batimento do coração, pulsação do cordão umbilical ou movimento definido de músculos voluntários (UNITED NATIONS, 2014).

Países de baixa renda – Países com Produto Interno Bruto (PIB) *per capita*, calculado pelo Banco Mundial a partir do método Atlas, menor ou igual a US$995 em 2017 (WORLD BANK, 2018b). Para períodos anteriores, são utilizados outros pontos de corte e a classificação histórica dos países é disponibilizada pelo Banco Mundial.

Países de média renda – Países com PIB *per capita*, calculado pelo Banco Mundial a partir do método Atlas, maior que US$995, mas menor que US$ 12.056 em 2017. Países de renda média-baixa ou média-alta são separados pelo ponto de corte de US$ 3.895 (WORLD BANK, 2018b).

Razão de sexo – A razão de valores referentes a um sexo por outro; geralmente definida como a razão de homens por mulheres (ou das taxas observadas em homens e mulheres) (IEA, 2014).

Sexo – Conceito biológico baseado nas características que permitem a reprodução sexual. Entre as pessoas, o sexo é atribuído conforme características sexuais como gônadas ou cromossomos sexuais (KRIEGER, 2003).

Sobremortalidade feminina – Taxa de mortalidade entre meninas ou mulheres superior ao que seria esperado (KALABIKHINA, 2001).

Sumário

Artigos planejados

Artigo 1: Proposta de um padrão de referência para mortalidade por sexo, buscando identificar países com evidência de sobremortalidade feminina.

Artigo 2: Análise ecológica de características nacionais associadas com a sobremortalidade feminina.

Artigo 3: Análise em nível individual de viés de gênero na cobertura de intervenções de saúde da criança de acordo com a religião da família em países de baixa e média renda.

1. Introdução

A taxa de mortalidade de crianças menores de cinco anos é um importante indicador das condições de saúde de populações. De maneira geral, esse indicador é expresso em número de mortes por mil crianças nascidas vivas em determinado local e período e representa a probabilidade de óbito antes do quinto aniversário (LAURENTI; SANTOS, 1996; UNICEF, 2017). Como a maioria destas mortes pode ser atribuída a causas preveníveis (pneumonia, diarreia e malária, por exemplo) ou ser influenciadas pelo estado nutricional das crianças e pelo acesso a serviços médicos e saneamento, a mortalidade nesta faixa etária é considerada um indicador de saúde, de bem-estar e de desenvolvimento (UNICEF, 2017).

À luz dos objetivos de desenvolvimento do milênio (ODM), estabelecidos nos anos 2000, e que contemplavam a redução da mortalidade na infância como uma das metas prioritárias, importantes resultados foram obtidos. Entre 1990 e 2015 houve diminuição de 53% na mortalidade de crianças menores de cinco anos, passando de 90 para 43 óbitos por mil nascidos vivos (NV) em todo o mundo; em 2016 esse valor era de 41 por mil NV (UNICEF, 2017).

Apesar do progresso alcançado, permanecem importantes desigualdades no risco de morrer entre os países. A mortalidade entre menores de cinco anos varia de dois óbitos por mil NV nos países de mais baixa mortalidade e alta renda (Eslovênia, Islândia e Finlândia) até mais de 130 por mil, na Somália, um país de baixa renda (UNICEF, 2017). Aproximadamente 80% dos óbitos nesta faixa etária ocorrem em duas regiões do mundo, África subsaariana e sul da Ásia; além disso, apenas seis países contabilizam metade de todas as mortes: Índia, Nigéria, Paquistão, República Democrática do Congo, Etiópia e China, sendo que os dois primeiros somam quase um terço dos óbitos globais (UNICEF, 2017).

As estimativas nacionais revelam grandes discrepâncias entre as regiões e os países, porém, estas podem ainda esconder desigualdades substanciais entre subgrupos populacionais dentro de cada país. Por essa razão é fundamental que as estimativas sejam desagregadas e analisadas em diferentes grupos para que se identifique quais deles apresentam as maiores desvantagens.

Quando a desagregação das taxas de mortalidade é feita pelo sexo da criança, é esperado que a estimativa seja maior entre os meninos em comparação às meninas em praticamente todos os lugares e épocas (SAWYER, 2012). Ao interpretar essas diferenças por sexo, deve-se considerar a maior vulnerabilidade dos meninos, devido a razões fisiológicas e genéticas, que está presente mesmo em sociedades onde não há discriminação de gênero nos cuidados infantis. Quando ambos os sexos apresentam taxas de mortalidade semelhantes, ou se a taxa é maior entre as meninas, é provável que fatores além dos biológicos estejam influenciando a sobrevivência das crianças, incluindo elementos culturais, comportamentais e assistenciais.

A análise destes determinantes demanda a distinção entre sexo biológico e gênero – a construção social a partir do sexo –, que permite então, a investigação de elementos que possam explicar os diferenciais observados em cada contexto.

Nas últimas décadas houve um aumento no número de estudos sobre os diferenciais de sexo na mortalidade, especialmente em crianças, e algumas abordagens para identificação de viés de gênero têm sido propostas (ALKEMA; CHAO; YOU; PEDERSEN *et al.*, 2014; COSTA; DA SILVA; VICTORA, 2017b; GUILMOTO; SAIKIA; TAMRAKAR; BORA, 2018; HILL; UPCHURCH, 1995; UNITED NATIONS, 1998; 2011).

Usualmente atribui-se os problemas relacionados ao gênero a elementos como desenvolvimento, pobreza e educação, e considera-se que os investimentos nestes âmbitos podem resultar em uma boa resposta à discriminação de gênero nos cuidados de saúde infantil (PARK; BRONDI, 2015). No entanto, estudos realizados em regiões específicas têm demonstrado que a discriminação de gênero apresenta profundas raízes sociais e culturais, para além das questões econômicas (BHAN; BHANDARI; TANEJA; MAZUMDER *et al.*, 2005; GUPTA, 2009; MUKHERJEE, 2013).

Ainda persiste, portanto, a necessidade de abordagens abrangentes e atualizadas que ajudem a compreensão dos diferenciais de sexo na mortalidade e inclua os fatores biológicos, sociais, culturais e econômicos (PARK; BRONDI, 2015). Pesquisas que incorporam estes determinantes podem ajudar a combater a discriminação contra meninas em diferentes contextos (PARK; BRONDI, 2015).

O presente projeto inclui uma proposta de referência para as diferenças de sexo na mortalidade, utilizando dados recentes de países de baixa e média renda sem evidências de viés de gênero, e explorar determinantes da sobremortalidade feminina.

2. Marco teórico

2.1. Diferença entre sexo e gênero

Sexo e gênero são dois parâmetros fundamentais para análise e interpretação de indicadores de saúde (OLINTO, 1998). Ambos se inter-relacionam na determinação das condições de saúde dos indivíduos. O primeiro refere-se às características físicas e fisiológicas, biologicamente determinadas, como função e anatomia reprodutivas, composição cromossômica, expressão gênica e níveis hormonais (MIGEON, 2013). O sexo geralmente é categorizado como feminino ou masculino e definido a partir dos órgãos reprodutivos e pares de cromossomos sexuais (de maneira geral, XX para feminino e XY para masculino) (MIGEON, 2013).

Já o gênero refere-se a uma construção social a partir do sexo biológico dos indivíduos, que culmina em papéis, normas e expectativas de comportamento direcionados a cada grupo (OLINTO, 1998). Essa dimensão varia em cada sociedade e não é estática, podendo sofrer alterações ao longo do tempo, e está diretamente relacionada às estruturas de poder e à hierarquia social (SEN; ÖSTLIN, 2007). As normas de gênero decorrentes destes papeis refletem crenças sobre mulheres e homens ou meninas e meninos que são transmitidas através do processo de socialização. Estas normas expressam concepções sobre como mulheres e homens devem ser e agir, estabelecendo assim um ciclo de estereótipos, que são incorporados tanto nas instituições sociais, como nas vidas individuais.

Apesar de muitas vezes serem utilizados como sinônimos, sexo e gênero não são conceitos permutáveis. Na avaliação das condições de saúde é fundamental considerar que estas podem se estabelecer de maneira diferente entre mulheres e homens por variabilidade biológica entre os sexos, resultando em uma maior ou menor susceptibilidade. Outras, porém, são resultado de como as sociedades atribuem valor aos indivíduos, baseados no sexo biológico e sustentados por normas gênero.

Além disso, na interpretação dos indicadores de saúde é importante considerar que estimativas numericamente iguais não necessariamente refletem o que seria esperado para cada sexo. Devido às características biológicas nem sempre igualdade numérica é sinônimo de neutralidade, justiça ou equidade.

Uma medida padrão amplamente utilizada para avaliação da relação quantitativa entre o feminino e o masculino é a razão de sexo, usualmente calculada através da divisão do valor observado para o sexo masculino por aquele relativo ao sexo feminino em determinada população, ano e espaço geográfico (IEA, 2014). Essa medida pode ser representada como M:F ou M/F e ser calculada para comparar homens e mulheres em todos os estágios do ciclo vital e para diversos desfechos de interesse, resultando em diferentes indicadores demográficos e de saúde. Para compreender tais diferenças nas razões de sexo ao longo do curso de vida, é fundamental explorar os determinantes que atuam sobre concepção, nascimento, morbidades e mortalidade.

Em relação à análise das taxas de mortalidade de crianças menores de cinco anos, os conceitos de sexo e de gênero são essenciais, na medida em que atuam sobre o desfecho de maneiras diferentes. Sexo é utilizado para determinar a maior fragilidade biológica dos meninos; já para se avaliar equidade ou investigar o excesso de mortes que decorrem de fatores não biológicos, fala-se de gênero. Assim, as relações de gênero podem influenciar a expressão de características biológicas, através de comportamentos e atitudes diferenciadas, e as normas de gênero decorrentes destas relações podem acarretar em práticas discriminatórias, através de tratamento diferenciando ou injusto, privilegiando um grupo em detrimento de outro (KRIEGER, 2003).

2.2. Razão de sexos na concepção e no nascimento

As variações de desfechos de saúde entre os sexos têm sido objeto de estudo desde o século 17, especialmente a partir da obra de John Graunt, que observou diferenças na mortalidade de homens e mulheres em Londres (AUSTAD, 2015; GRAUNT, 1662). Atualmente, diversas teorias têm sido exploradas em busca de explicações sobre os determinantes das diferenças entre mulheres e homens ao longo do ciclo vital.

A razão de sexo primária, ou seja, aquela estabelecida na concepção dos embriões, tem como maior determinante o acaso, segundo grande parte dos estudos na área (ORZACK; STUBBLEFIELD; AKMAEV; COLLS *et al.*, 2015). Não há evidências de que a produção de espermatozoides contendo cromossomos X e Y apresente proporção diferente de 50% (MIGEON, 2013). Classicamente, a ligeira predominância de bebês do sexo masculino tem sido atribuída à maior mobilidade dos espermatozoides contendo cromossomos Y, mais leve do que aqueles que portam o cromossomo X (MIGEON, 2007). Essa hipótese, no entanto, tem sido questionada e as diferenças nas proporções de nascimentos estão sendo associadas principalmente à sobrevivência dos embriões no útero (BOKLAGE, 2005). Estudo publicado em 2015 utilizando diferentes fontes e um largo conjunto de dados, propôs que a razão de sexo na concepção seria igual a 1 e que a mortalidade fetal seria mais frequente entre o sexo feminino, resultando assim na observada predominância de nascimentos de meninos (ORZACK; STUBBLEFIELD; AKMAEV; COLLS *et al.*, 2015).

Segundo dados da Divisão de Populações das Nações Unidas (PNUD) a população mundial apresentou em 2015 (último dado disponível) uma razão de sexo no nascimento – também chamada de razão de sexo secundária – igual a 1,07, o que corresponde a aproximadamente 7% mais meninos nascendo em comparação às meninas (UNITED NATIONS, 2017). China, Azerbaijão, Armênia e Índia apresentaram as maiores razões de sexo (1,17; 1,16; 1,15 e 1,11 respectivamente), enquanto Guiné, Ruanda, Zimbábue, Serra Leoa e Togo apresentam os menores valores (todos com razão igual a 1,02) (UNITED NATIONS, 2017).

Quando são observadas taxas de nascimentos maiores entre o sexo feminino, ou seja, maior frequência de perdas fetais masculinas, as causas propostas na literatura incluem desastres naturais, maiores níveis de poluição, depressão econômica, dentre outros elementos estressores (CHIAVEGATTO FILHO; LAURENTI, 2012; GARRY; HARKINS; LYUBIMOV; ERICKSON *et al.*, 2002; SONG, 2014). Uma análise detalhada da validade dos estudos que abordam este tema está fora do escopo do presente projeto.

A determinação da razão de sexo secundária depende, portanto, da proporção de embriões concebidos de cada sexo, dos fatores que influenciam a sobrevivência no útero materno, incluindo fatores biológicos e ambientais, e de comportamentos e práticas de seleção pré-natal, como os abortos seletivos, que são discutidos a seguir.

2.3. Razão de sexo na mortalidade

Após o nascimento, indivíduos do sexo masculino apresentam maiores taxas de mortalidade em todas as faixas etárias, fenômeno que pode ser atribuído tanto a diferenças inatas quanto a fatores comportamentais.

Partindo da perspectiva biológica, é sabido que a presença ou ausência do cromossomo Y pode contribuir para diferenças na mortalidade ou na expressão de determinados agravos à saúde (MUENCHHOFF; GOULDER, 2014; WALDRON, 1983; 1987). Diferenças atribuídas ao sexo na determinação de doenças podem ser consequências do processo de inativação do cromossomo X, da expressão de hormônios esteroides e de diferenças anatômicas (FISH, 2008; MIGEON, 2013). O cromossomo X tem tamanho maior que o Y e carrega muitos genes essenciais para o funcionamento do sistema imunológico, coagulação sanguínea, desenvolvimento nervoso, dentre outras funções vitais (WALDRON, 1987). Além disso, durante o processo embrionário feminino ocorre randomicamente a inativação de um dos cromossomos X para uma compensação epigenética das diferenças entre meninas e meninos (MIGEON, 2013). Esse processo, conhecido como mosaicismo, é considerado a uma vantagem feminina e pode influenciar diretamente o mecanismo de doenças causadas por um gene ligado ao X ou indiretamente pelas consequências da inativação do X (MIGEON, 2007).

A sobremortalidade masculina é mais evidente no período neonatal (de zero a 28 dias após no nascimento)[2] do que em períodos posteriores (WALDRON, 1987). Os bebês do sexo masculino, apesar do peso ao nascer mais elevado, apresentam maiores prevalências de anomalias congênitas que levam à morte, bem como de deficiências imunológicas associadas a defeitos genéticos (UNITED NATIONS, 1998; 2011). Adicionalmente, meninos são mais propensos

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[2] A mortalidade de crianças menores de cinco anos pode ser categorizada de acordo com a idade da criança no momento do óbito: neonatal (0-27 dias), pós-neonatal (28-364 dias), infantil (0-364 dias), na infância (1-4 anos). Em inglês o termo '*infant*' é utilizado para crianças de até um ano de idade e o termo '*child*' para crianças de um a quatro anos completos; além disso, a literatura internacional, em muitas situações, utiliza o termo "pós-neonatal" para toda a faixa etária que vai dos 28 dias aos quatro anos e 11 meses.

a nascer prematuramente e a sofrer problemas respiratórios no período neonatal (UNITED NATIONS, 2011). Evidências indicam que os pulmões dos fetos masculinos amadurecem mais lentamente e esse retardo poderia ser atribuído aos níveis de testosterona e outros hormônios (WALDRON, 1983; 1987).

A vantagem das meninas recém-nascidas reside na menor vulnerabilidade a condições perinatais adversas, incluindo trauma do nascimento, sofrimento fetal e asfixia, devido a seu menor peso ao nascer (WALDRON, 1987). Meninas também morrem menos do que meninos devido a síndrome de disfunção respiratória precoce, tétano neonatal e doenças infecciosas, como as intestinais e respiratórias (UNITED NATIONS, 2011).

Com o avançar da idade, observa-se mudanças nas causas de morte e consequentemente na vantagem feminina. Nos países de baixa e média renda, as doenças infecciosas exercem maior contribuição e as diferenças entre os sexos ficam menos evidentes (WALDRON, 1987). A influência dos hormônios na resposta imunológica pode explicar as maiores susceptibilidade e severidade destas doenças entre os meninos. Por outro lado, nas situações em que se observa maior morbimortalidade entre meninas – na ausência de viés de gênero – a hipótese fisiológica por trás é a de maior predisposição a doenças autoimunes e os níveis elevados de imunidade pró-inflamatória (MUENCHHOFF; GOULDER, 2014).

Em países de alta renda com baixas taxas de mortalidade, os óbitos neonatais são responsáveis pela maior parte das mortes de menores de cinco anos, devido ao declínio das causas infecciosas e preponderância de mortes causadas por condições perinatais, com consequente aumento da razão de sexo M:F (DREVENSTEDT; CRIMMINS; VASUNILASHORN; FINCH, 2008).

Desse modo, em condições naturais, espera-se que meninos morram mais do que meninas. Na ausência de discriminação específica contra meninas, as taxas de mortalidade masculina, em todo o mundo, tendem a ser, em média, 20-25% mais altas do que para as meninas. No entanto, estas diferenças variam entre as faixas etárias e conforme o nível de mortalidade total (para ambos os sexos combinados). Como resultado, o fato de que as taxas de mortalidade feminina observadas em uma população sejam iguais ou superiores às taxas masculinas sinaliza a presença de comportamento discriminatório contra as meninas.

2.4. Desigualdades nas razões de sexo

Em algumas sociedades é reconhecida a preferência por filhos de determinado sexo, elemento que pode alterar as proporções de homens e mulheres que seriam esperadas em condições naturais. Esse viés de gênero, geralmente contra meninas e mulheres, se expresso desde antes da concepção e perpassa a infância e a vida adulta, especialmente em sociedades com fortes características patriarcais.

Esse desequilíbrio na distribuição populacional dos sexos passou a ter maior visibilidade nos anos 1990, a partir da obra de Amartya Sen sobre o déficit de mulheres na Ásia, um fenômeno conhecido como “*missing women*”, equivalente a “mulheres desaparecidas” em português (UNFPA, 2012).

A origem deste fato foi observada a partir dos anos 1980, época em que essa lacuna era determinada principalmente pelo excesso de mortes femininas observado em alguns locais, especialmente do sul da Ásia (UNFPA, 2012). O fenômeno foi identificado como consequência da combinação de infanticídio e comportamentos negligentes, como nutrição inadequada em quantidade e qualidade, ou falta de procura de cuidados médicos para doenças em meninas.

A partir de dados históricos baseados nos censos da China e na Índia, ficou evidente que o aumento observado a partir dos anos 1990 na proporção de meninos não poderia ser determinado apenas por diferenças na mortalidade (UNFPA, 2012). Estudos dos anos seguintes demostraram que o desequilíbrio daquela década era causado por outras práticas, como o não registro de meninas e o aborto seletivo a partir do sexo, que se tornou possível devido à disseminação da ultrassonografia obstétrica (UNFPA, 2012).

Esta prática, conhecida como seleção pré-natal, resulta da combinação de três fatores: preferência cultural por filhos homens; crescimento das tecnologias de diagnóstico, combinado com prática de aborto (legal ou não); e a redução no número de filhos por família (diminuição das taxas de fecundidade) (UNFPA, 2012).

Estimativas demográficas da UNFPA para 14 países[3] onde há suspeita de viés de gênero revelaram uma lacuna de 117 milhões de mulheres em 2010, a maioria delas da China e da Índia (UNFPA, 2012). Esta lacuna pode ser explicada por maior mortalidade de meninas devido a negligência, e mais recentemente pela seleção pré-natal.

Por outro lado, evidências de viés contra os meninos são escassas, sendo mais raras as populações em que prevaleça preferência pelas filhas. Isso ocorre, por exemplo, entre do grupo roma na Hungria ("*Hungari Romani*"), que valorizam as mulheres por serem cuidadoras dos pais e dos irmãos, o que inclusive influencia o número de filhos por família e o intervalo interpartal (BERECZKEI; DUNBAR, 2002). Essa preferência se reflete em maior frequência de aborto após o nascimento de filhas e maiores tempo de amamentação e investimento em educação para meninas (BERECZKEI; DUNBAR, 2002). Dados do Banco Mundial mostram que em países da América Latina, há uma aparente preferência por filhas mulheres, apesar de não ter sido encontrada evidência de viés (JONES; HARPER; WATSON; ESPEY *et al.*, 2010).

A preferência por filhos homens pode ser explicada em algumas culturas, por exemplo, pelo valor econômico ou pela utilidade de cada sexo na sociedade. Estudos realizados na Índia na década de 1990 destacam questões como a maior participação de homens nas atividades agrícolas da família e seus maiores ganhos salariais, bem como a possibilidade de manter a descendência e o status familiar, e o recebimento de dotes; no âmbito religioso se destacam as funções exercidas apenas pelos homens (ARNOLD; CHOE; ROY, 1998).

Diversas religiões aparecem na literatura como determinantes do valor social dos homens (JONES; HARPER; WATSON; ESPEY *et al.*, 2010). Um compilado de informações organizadas pelo Centro de Pesquisas sobre Pobreza Crônica, ao avaliar o assunto sobre a perspectiva de gênero identificou as seguintes associações: "no confucionismo a linhagem familiar somente pode ser continuada através de herdeiros do sexo masculino e o fato de não se ter um filho homem é considerado um de três atos infiéis graves; no hinduísmo e na crença sikh, diante da morte de um pai, quem deve realizar os últimos rituais sagrados é um filho, para que o céu seja alcançado; em algumas regiões da

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[3] Afeganistão, Albânia, Azerbaijão, Bangladesh, Armênia, China, Geórgia, Índia, Coréia do Sul, Montenegro, Nepal, Paquistão, Singapura e Vietnam.

África os ritos funerários são realizados apenas por filhos homens; na tradição hindu os filhos são valorizados como portadores de linhagem familiar; em relação ao Islã, de acordo com a lei muçulmana, as heranças destinadas aos filhos são o dobro das filhas" (JONES; HARPER; WATSON; ESPEY *et al.*, 2010).

A ordem de nascimento e o número de descendentes têm sido relatados na literatura como elementos importantes na determinação da discriminação contra meninas em algumas sociedades. De maneira geral, há menor discriminação no momento do nascimento da primeira criança, independente do sexo, mas a tendência é que passe a se manifestar mais com o nascimento das seguintes. Desse modo, a razão de sexo M:F tende a aumentar com incremento na paridade. O sexo dos filhos prévios tem sido considerado um forte preditor da razão de sexo, pois os casais sem filhos homens apresentam maior probabilidade de recorrer à seleção pré-natal ou negligenciar as filhas (BHALOTRA; COCHRANE, 2010).

Em relação às diferenças no cuidado ofertado às meninas e aos meninos, observa-se a presença, em algumas sociedades, de viés no acesso a cuidados pós-natal, vacinas e alimentação, fatores que contribuiriam para a sobremortalidade feminina (CALU COSTA; WEHRMEISTER; BARROS; VICTORA, 2017; PANDIT; PAI, 1991; SACHIDANANDA KAMATH, 2015).

Uma análise de 57 países de baixa e média renda sugere que não há evidências de viés de gênero no uso de serviços de saúde globalmente, porém, foram identificados oito países com viés nas práticas de cuidado, sendo que em seis deles, o viés identificado foi contra meninas (CALU COSTA; WEHRMEISTER; BARROS; VICTORA, 2017). Encontrou-se ainda associação com região geográfica e religião predominante no país, sendo mais provável a presença do viés naqueles com maioria da população muçulmana (CALU COSTA; WEHRMEISTER; BARROS; VICTORA, 2017).

O desbalanço entre os sexos em algumas populações é motivo de alerta e preocupação de agências internacionais. As Nações Unidas recomendam desde 1994 (data da Conferência Internacional sobre População e Desenvolvimento, conhecida como Conferência do Cairo) a eliminação de todas as formas de discriminação contra meninas e das causas que levam à preferência por filhos, incluindo o feminicídio e seleção pré-natal de sexo (UNFPA, 2012). Em 1998 as Nações Unidas publicaram o livro "*Too young to die: genes or gender*", fruto dessas recomendações, em que exploram o conjunto de mecanismos que influenciam as diferenças entre o sexo na mortalidade durante a infância em 82 países entre as décadas de 1970 e 1980 (UNITED NATIONS, 1998).

Em 2011 esse conjunto de análises foi expandido e publicado na forma de um relatório que contemplou dados de 109 países de baixa e média renda e mais 40 países de alta renda[4] e cobriu o período entre as décadas de 1970 e 2000 (UNITED NATIONS, 2011). Encontrou-se maior vantagem feminina na sobrevivência até os cinco anos de idade entre os países mais desenvolvidos e esta tende a aumentar conforme diminui a mortalidade total (UNITED NATIONS, 2011).

2.5. Gênero e religião

As definições de religiosidade têm sido uma fonte de controvérsia há muitos anos; em 1912 foram encontradas 48 definições distintas de religião (MOREIRA-ALMEIDA; LOTUFO NETO; KOENIG, 2006). Uma das definições mais utilizadas atualmente é de religião como "um sistema organizado de crenças, práticas, rituais e símbolos destinados a facilitar a proximidade com o sagrado ou transcendente" (MOREIRA-ALMEIDA; LOTUFO NETO; KOENIG, 2006).

As religiões podem, então, ser consideradas sistemas de crenças e práticas sociais comuns, geralmente resultantes de constructos relativos a seres sobre-humanos, forças sobrenaturais ou outros elementos imateriais, dentro de contextos históricos e culturais específicos (ROSADO NUNES, 2001). Tais sistemas cumprem um papel importante na constituição de valores e na formação de grupos sociais.

Aproximadamente 84% da população mundial é afiliada a alguma tradição religiosa, sendo o cristianismo a que engloba o maior número de seguidores (2,3 bilhões de indivíduos ou 31,2% da população). Na sequência encontra-se a tradição islâmica (1,8 bilhão; 24,1%), os não afiliados (16%), hindus (15%) e budistas (7%) (PEW RESEARCH CENTER, 2017a). Além disso, mais de 80

[4] O documento original, assim como diversas outras referências deste trabalho, utiliza a terminologia "*less developed regions*" (regiões menos desenvolvidas) e "*more developed regions*" (regiões mais desenvolvidas), mas optou-se por utilizar a equivalência de grupos de renda definidos pelo Banco Mundial.

países e territórios, dentre 199, favorecem alguma religião específica, seja como religião oficial, endossada pelo governo ou estado, ou privilegiando uma religião em relação às demais. O islamismo é a religião estatal mais comum no mundo (27 de 43 países com religião oficial) (PEW RESEARCH CENTER, 2017b).

Cada tradição religiosa é geográfica, cultural, socioeconômica e politicamente diversa, sendo a consideração desta diversidade essencial para a discussão de papéis exercidos por cada uma, inclusive para a equidade de gênero (UNFPA, 2016).

As religiões podem cumprir o papel de conectar os indivíduos a uma comunidade e a uma força superior, mas podem também criar e reforçar estereótipos de gênero, ao definir funções e papéis específicos para as mulheres. Trata-se de um campo masculino por excelência, tendo em vista que os homens dominam a produção do que é sagrado nas diversas sociedades. As mulheres, de modo geral, não participam dos espaços definidores das crenças e das políticas organizacionais das instituições religiosas (ROSADO NUNES, 2001). A contribuição da população feminina ocorre no campo da prática e dos rituais, e na transmissão, como guardiãs da memória.

Alguns estudiosos argumentam que as religiões em si não seriam a fonte da opressão, mas sim as interpretações e as práticas em nome das respectivas crenças (ROSADO NUNES, 2001; UNFPA, 2016). Estas interpretações seriam influenciadas por outras dinâmicas socioculturais que também refletem a opressão ou a discriminação. Em décadas recentes, a luta histórica das mulheres tem criticado exclusão feminina da formulação de conhecimento religioso e de suas práticas, sem necessariamente abandonar a religião. Além disso, para algumas linhas teóricas das ciências sociais, as formas de organização religiosa agem como instrumentos que controlam as vidas e os corpos das mulheres.

A análise de gênero nos possibilita explorar o significado das práticas culturais e religiosas, e especificamente aquelas que são discriminatórias e prejudiciais para meninas e mulheres, na medida em que as mesmas são justificadas com base na religião (UNFPA, 2016).

Os estudos na área da saúde sobre a relação das religiões com questões de gênero, em grande parte focam na saúde sexual e reprodutiva das mulheres adultas, e mais recentemente de adolescentes (UNFPA, 2016). As evidências apontam que os grupos religiosos diferem em seu apoio às práticas de saúde, incluindo planejamento familiar, saúde sexual e reprodutiva, atenção ao HIV e redução de danos (TOMKINS; DUFF; FITZGIBBON; KARAM *et al.*, 2015). Ainda que essa abordagem seja fundamental para que alcance a equidade de gênero, poucos estudos têm abordado a associação das normas de gênero estabelecidas ou refletidas por diferentes crenças e práticas religiosas com a saúde infantil.

2.6. Modelo teórico

A elaboração do modelo teórico passa pela organização dos determinantes que podem vir a influenciar o desfecho, bem como do estabelecimento dos diferentes níveis em que se encontram, como os contextos global, nacional, domiciliar e individual, conforme apresentado na **Figura 1**. O modelo foi construído a partir dos estudos de determinantes sociais e biológicos da mortalidade fetal e de crianças menores de cinco anos (MOSLEY; CHEN, 2003). Acrescenta-se ainda a separação daqueles relacionados ao sexo e ao gênero das crianças, que podem levar de maneiras distintas à sobremortalidade masculina ou feminina.

Os determinantes sociais estruturais apresentados incluem fatores de contexto global e nacional, como aqueles ligados à renda, educação e desigualdades, e são considerados os principais responsáveis pelas iniquidades regionais e de mais difícil resolução em curto prazo (CALDEIRA; FRANÇA; GOULART, 2001). Os intermediários, por sua vez, determinam diferenças na exposição e vulnerabilidade a agravos de saúde e compreendem as condições de vida e de trabalho, a disponibilidade de alimentos, os comportamentos, e o estilo de vida. Já os determinantes proximais constituem as causas imediatas de doença e/ou morte (CALDEIRA; FRANÇA; GOULART, 2001). A articulação destes diferentes níveis poder levar às desigualdades na saúde e sobrevivência das crianças, especialmente em populações de baixa e média renda. Essas desigualdades podem ser atribuídas à falta de recursos ou à sua distribuição, quando realizada de forma injusta (VICTORA; HUTTLY; FUCHS; OLINTO, 1997).

A redução nas taxas de mortalidade de menores de cinco anos observada desde a década de 1990 pode ser atribuída à implementação de intervenções preventivas e curativas, de efetividade conhecida, especialmente no que diz respeito às doenças infecciosas e a melhorias na atenção pré- e pós-natal (UNICEF, 2017). Essas ações podem amenizar desvantagens biológicas enfrentadas pelos meninos e potencializar a vantagem das meninas.

O sexo, determinante biológico, é inserido no modelo como uma variável que origina as características individuais da criança, bem como sua condição de saúde, vulnerabilidade a certas patologias e complicações. Por sua vez, os elementos relacionados ao gênero das crianças acompanham a cultura da comunidade, com maior ou menor intensidade, a depender do valor atribuído às crianças a partir do sexo, e se insere como elemento que leva a práticas diferenciadas. No modelo, influencia diretamente nas práticas de cuidado, prevenção e tratamento.

Figura 1 – Modelo conceitual da mortalidade de crianças menores de cinco anos e da sobremortalidade feminina

3. Revisão de literatura

O viés de gênero pode afetar a saúde da criança quando diferentes valores são atribuídos a meninas e meninos dentro da comunidade em que vivem, fazendo com que tenham acesso a tratamentos, cuidados e recursos diferentes de acordo com o sexo. Existe um volume substancial de produções científicas que abordam variados aspectos do viés de gênero, desde a seleção de sexo antes do nascimento até práticas diferenciais de cuidado, incluindo alimentação, imunização e busca de serviço, dentre outros.

As consequências do viés de gênero podem ser observadas em diferentes populações, por exemplo, através das taxas de mortalidade quando analisadas separadamente por sexo. Não obstante, além de práticas e comportamentos discriminatórios, é preciso considerar as características biológicas de cada sexo, que levam a diferenças na mortalidade mesmo em situações em que não exista discriminação.

O objetivo da revisão de literatura foi identificar estudos da área da saúde que abordassem as diferenças de sexo na sobrevivência de crianças menores de cinco anos, explorar os métodos e procedimentos analíticos existentes, e descrever os principais determinantes associados às diferenças entre meninos e meninas.

Nesse processo, utilizando-se a base de dados *Pubmed* (http://www.ncbi.nlm.nih.gov/pubmed/), conforme estratégia apresentada no **Quadro 1**, foram buscados artigos científicos disponíveis na literatura científica. O procedimento de busca foi definido a partir da combinação dos termos *sexo* e *gênero* com expressões que pudessem identificar a relação entre o masculino e o feminino. Acrescentou-se em seguida os desfechos (*mortalidade* ou *sobrevivência*) e termos que indicassem a faixa etária de interesse. Não foi utilizado nenhum filtro que restringisse população, período de estudo ou data de publicação, idioma ou disponibilidade do texto. A busca foi realizada em 05 de setembro de 2017. As 12.484 referências captadas foram transferidas para o programa EndNote X7®.

A fim de se identificar publicações em outros formatos e acessar a “literatura cinzenta” realizou-se uma busca complementar no Google em junho de 2018. Nesta etapa, a estratégia foi utilizar os termos (*gender* AND *mortality*) e (*gender discrimination* AND *mortality*) e navegar pelas cinco primeiras páginas de resultados de cada um deles. Neste primeiro momento foram considerados elegíveis aquelas publicações em formato de livro e relatório. Esta busca está sendo complementada com outras bases de dados que incluam publicações nestes formatos e que permitam identificação de outros trabalhos que não estão indexados na *Pubmed*. No **Apêndice 1**, apresentamos uma listagem incluindo documentos já identificados até o momento.

Neste primeiro momento são descritos os estudos realizados com dados de múltiplos países e daqueles com maior número de ocorrências. No decorrer da execução do projeto, serão avaliados estudos com outros desfechos de saúde, comportamento ou nutrição da criança, que possam ser afetados por viés de gênero, como diferenças na amamentação, oferta de alimentos, estado nutricional, busca de cuidados, etc.

Quadro 1 – Estratégias de busca sistematizada da literatura para localização de referências sobre a relação entre viés de gênero e mortalidade na infância.

Número da busca	Estratégia de busca	Número de referências recuperadas
1	("son bias" OR "son preference" OR "missing girls" OR "excess female mortality" OR "sex imbalance" OR "sex ratio" OR "sex preference" OR "sex factors" OR sexism OR "sex differentials" OR "sex-specific" OR "sex differences" OR "sex distribution" OR "sex bias" OR "sex inequality" OR "sex discrimination" OR "sex selection" OR "sex difference" OR "gender selection" OR "gender discrimination" OR "gender inequality" OR "gender bias" OR "gender distribution" OR "gender differences" OR "gender-specific" OR "gender differentials" OR "gender factors" OR "gender preference" OR "gender ratio" OR "gender imbalance" OR "gender difference" OR "excess male mortality" OR "sex ratios" OR "excess male" OR "excess female" OR "female disadvantage" OR "male advantage" OR "gender disparity" OR "sex disparity")	353.209
2	#1 AND (child OR children OR infant OR childhood)	92.553
3	#2 AND (mortality OR survival)	12.484

A **Figura 2** ilustra o processo de seleção das publicações identificadas através da busca na *Pubmed* e o quantitativo resultante de cada uma das etapas, que consistiram em remoção de duplicatas, seleção de títulos, leitura de resumos (quando disponíveis) e leitura dos artigos na íntegra.

Para obtenção dos artigos selecionados que não ofereciam acesso aberto utilizou-se tanto o acesso remoto via Comunidade Acadêmica Federada (CAFe) através do Portal de Periódicos da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) quanto o acesso pela rede da Universidade de São Paulo.

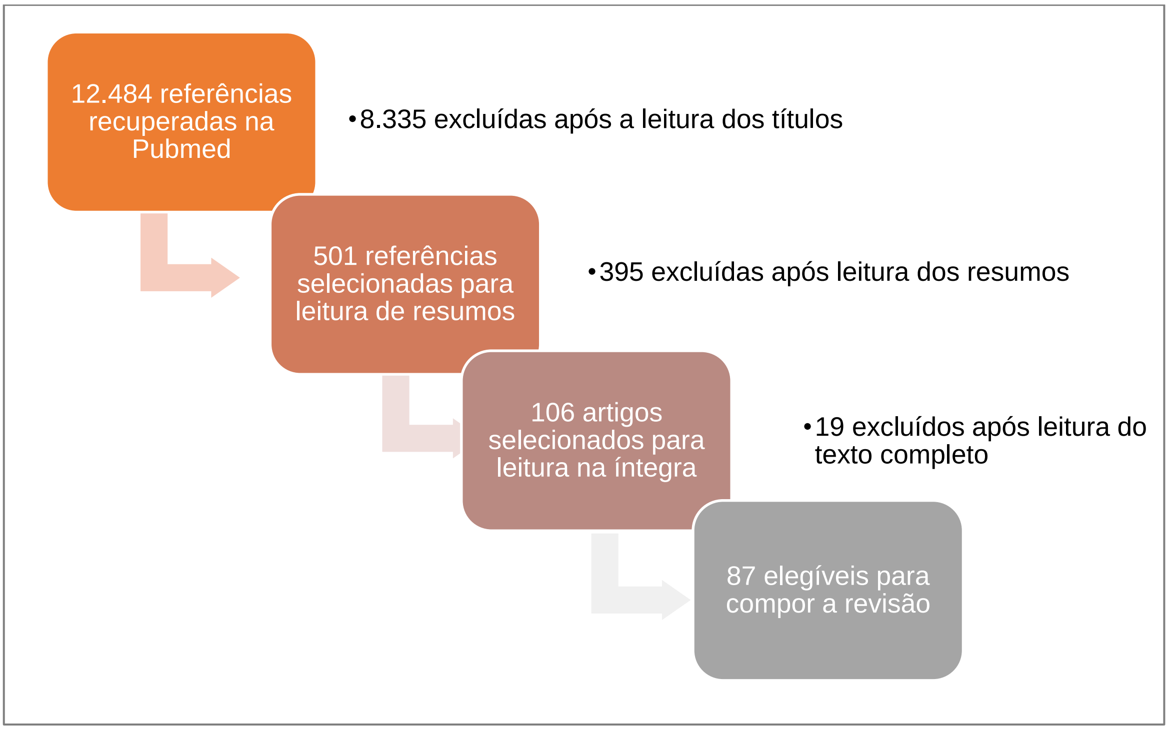

Figura 2 – Fluxograma de seleção das referências avaliadas sobre sexo e gênero e saúde da criança

Inicialmente, foram excluídos estudos que tivessem como população-alvo idosos, adultos, adolescentes ou crianças maiores de cinco anos. Neste primeiro momento da revisão, o foco residiu em estudos com desfechos relacionados à mortalidade fetal ou de menores de cinco anos, que explorassem a possibilidade de viés de gênero. Não foram incluídos estudos que abordaram o sexo da criança como uma covariável nas análises, mas sem explorar o viés de gênero. Tampouco foram incluídos estudos sobre diferenças biológicas entre os sexos.

Quadro 2 – Características agregadas das publicações selecionadas para avaliação de viés de gênero na mortalidade na infância.

Características	Número de estudos
Período de publicação	
1960 – 1969	1
1970 – 1979	3
1980 – 1989	12
1990 – 1999	39
2000 – 2009	17
2010 – 2017	15
Locais de realização do estudo	
Índia	33
China	10
Bangladesh	8
Estados Unidos	3
Outros países (por região)	
- Europa	6
- América	1
- África	1
- Ásia	14
Múltiplos países	11
Total	**87**

Foram identificadas 87 publicações relevantes durante a revisão de literatura. Observa-se que houve um expressivo aumento no número de estudos sobre o assunto a partir da década de 1980, tendo seu pico nos anos 1990 e diminuindo a partir dos anos 2000 (**Quadro 2**). A maior parte dos estudos foi realizada em países de baixa e média renda localizados na Ásia, especialmente Índia, China e Bangladesh.

As fontes de dados mais utilizadas foram inquéritos de demografia e saúde (como DHS, MICS ou similares), exceto nos estudos sobre a China, em que são utilizados majoritariamente dados dos censos nacionais. No caso de países de alta renda, que apresentam melhor cobertura de sistemas de saúde, foram utilizados registros de nascimentos e mortalidade, muitas vezes vinculados entre si. A maioria das publicações aborda apenas um país ou regiões subnacionais/estados dentro de um país.

Onze publicações apresentam abrangência global ou contemplam um grupo de países com características semelhantes (como mesmo grupo de renda ou região geográfica). No **Quadro 3** são apresentadas características específicas de cada uma dessas publicações e descritas no decorrer do texto. Em seguida, sínteses das referências que abordaram dados e informações da Índia e da China são apresentadas.

3.1. Estudos em múltiplos países

Os 11 estudos que utilizaram dados de mais de um país na mesma publicação empregaram diferentes abordagens metodológicas para identificar a sobremortalidade feminina entre menores de cinco anos. Essas metodologias tanto comparam as estimativas observadas a uma referência de valores esperados, quanto descrevem os valores sem necessariamente estabelecer referências.

Waldron (1987) apresenta uma revisão das principais hipóteses sobre as causas de sobremortalidade feminina na infância e analisa características contrastantes das situações em que meninas ou meninos apresentam maior mortalidade. Além disso, avalia as estimativas de razão de sexo para 17 países ‘em desenvolvimento’ a partir de dados das Nações Unidas e de inquéritos globais de fecundidade (WALDRON, 1987). A comparação das estimativas das duas fontes de informação é apresentada através de análise de correlação, mas não há nenhum parâmetro de referência, apenas a magnitude das razões de sexo.

Utilizando dados de inquéritos de demografia (*Demographic and Health Survey*) e de fecundidade (*World Fertility Survey*) de 62 países de baixa e média renda, Tabutin (1995) descreveu a relação entre as razões de mortalidade M:F nos anos 1970 e 1980, período em que houve importante redução da mortalidade total. Os valores de sobremortalidade feminina, considerada como razão abaixo de 1, foram expressivos na faixa etária de um a quatro anos e, por região, variaram de 16% na Ásia centro-ocidental a 5% na África subsaariana em 1970; e de 13% na Ásia centro-ocidental a 10% no norte da África em 1980 (TABUTIN, 1995). Dentre os 26 países com dados comparáveis para os dois períodos, foi possível observar a evidência da sobremortalidade feminina nos anos 1980 em três países (Gana, Indonésia e Paraguai); houve aumento significativo em três (Camarões, México e Paquistão) e discreto em outros três (República Dominicana, Marrocos e Peru); observou-se redução em cinco (Argélia, Colômbia, Egito, Maurício e Tunísia) (TABUTIN, 1995). Três países não apresentaram evidência de sobremortalidade feminina: Chile, Cuba e Quênia.

Em 1995 Hill e Upchurch propuseram um método de cálculo da razão de mortalidade por sexo, levando em conta a desvantagem biológica a que os meninos estão sujeitos, com o objetivo de identificar a sobremortalidade feminina. Suas equações têm como referência a experiência de mortalidade entre menores de cinco anos em países de alta renda nos séculos 19 e 20, nos quais se esperaria que a discriminação de gênero no tratamento dado às crianças fosse baixa ou inexistente (HILL; UPCHURCH, 1995). Os autores sugerem que as razões esperadas de mortes entre meninas e meninos podem variar de 0,899 em locais com altos níveis de mortalidade entre meninos até 0,774 onde a mortalidade masculina era baixa (HILL; UPCHURCH, 1995). Ao aplicar o método para países de baixa e média renda, utilizando dados de 38 inquéritos do tipo DHS, os autores identificaram sobremortalidade feminina, sendo mais acentuada a diferença para faixa etária entre um e quatro anos. Esta foi identificada em 21 dos inquéritos (HILL; UPCHURCH, 1995).

Já Garenne (2003), ao analisar 60 países da África subsaariana (1977-1998) não identificou nenhum país com a estimativa da razão de sexo M:F abaixo de 1, porém, apenas nove deles apresentaram estimativa significativamente maior que 1 e em Níger a razão de sexo foi menor do que 1, o que segundo os autores seria esperado devido a flutuação amostral (GARENNE, 2003).

Para descrever a relação da mortalidade entre os sexos em países de alta renda Drevenstedt e colaboradores (2008) analisaram dados históricos de 15 países e observaram que o excesso de mortes está consistentemente concentrado nas crianças do sexo masculino no período entre 1751 e 1970. A sobremortalidade masculina aumentou de 10% para mais de 30%. Os autores levantam a hipótese de que todos eles passaram por mudanças similares nas causas de mortalidade infantil, com declínio das causas infecciosas e deslocamento para mortes relacionadas às condições perinatais, o que teria levado à maior expressão da vulnerabilidade dos meninos e, consequentemente, da razão de mortalidade meninos/meninas (DREVENSTEDT; CRIMMINS; VASUNILASHORN; FINCH, 2008).

Também apresentando uma abordagem descritiva, Sawyer (2012) apresentou tendências para a mortalidade infantil, 1-4 anos, e menores de cinco anos. Os dados mostram que na maioria dos países de renda média e baixa a razão de sexo na mortalidade tem crescido desde 1970. Esse fato é atribuído principalmente ao aumento na faixa de 1-4 anos de idade, particularmente em países da África subsaariana, norte da África, sul da Ásia e Ásia ocidental. Na Índia e na China, há evidências de sobremortalidade feminina em menores de um ano. Na China, entre 1970 e 2000, a razão de sexo de mortalidade infantil caiu de 112 (por 100) para 76 (SAWYER, 2012).

Uma outra abordagem, a partir de modelos bayesianos hierárquicos de séries temporais, Alkema e colaboradores (2014), utilizando dados de 195 países, encontraram razões de sexo globais em 2012 de 1,13 para menores de um ano; 0,95 para crianças de um a quatro anos e 1,08 para mortalidade de menores de cinco anos. Foram identificados 15 países com valores aberrantes, sendo que em 10 deles encontrou-se maior mortalidade de meninas do que o esperado (Afeganistão, Bahrein, Bangladesh, China, Egito, Índia, Irã, Jordânia, Nepal e Paquistão) (ALKEMA; CHAO; YOU; PEDERSEN *et al.*, 2014).

Estas duas abordagens foram aplicadas a um conjunto de 60 países de média e baixa renda e comparadas em estudo de Costa e colaboradores (2017). Encontrou-se forte correlação entre os dois resultados, porém a magnitude do excesso de mortes femininas foi superior quando utilizado o método prescritivo (COSTA; DA SILVA; VICTORA, 2017b). Os 13 países com os maiores e os dez com os menores valores de excesso de mortalidade feminina foram os mesmos de acordo com ambas as abordagens. A sobremortalidade das meninas não variou entre os grupos de renda dos países, mas sim por região. No sul da Ásia e no Oriente Médio e norte da África, todos os países apresentaram valores excessivos de mortalidade feminina (COSTA; DA SILVA; VICTORA, 2017b).

No campo das diferenças biológicas, Stephenson e colaboradores (2017) utilizaram dados de 38 DHS realizadas em diferentes regiões do mundo para avaliar desfechos de saúde e sobrevivência em pares de gêmeos. Os autores encontraram menor chance de mortalidade infantil entre os pares compostos por uma ou duas meninas (STEPHENSON; THARP; WIGINTON; METHENY, 2018). Eles levantam a hipótese de que, mesmo em países com conhecida preferência por filhos homens, a vantagem biológica das meninas se sobrepõe a possíveis práticas discriminatórias (STEPHENSON; THARP; WIGINTON; METHENY, 2018).

Em relação aos elementos sociais que poderiam estar associados à sobremortalidade feminina, em estudo de Monden e Smits (2013) a escolaridade materna apareceu como importante determinante das diferenças na sobrevivência entre meninos e meninas menores de cinco anos. Os autores utilizaram DHS de 31 países localizados na África subsaariana e quatro do sul da Ásia e encontraram as menores razões de sexo (M:F) entre mulheres sem educação em ambas as regiões. Os menores valores foram referentes à mortalidade de menores de cinco anos (0,88; $IC_{95\%}$ 0,82 – 0,95) e de um a quatro anos (0,54; $IC_{95\%}$ 0,41 – 0,72) na região Asiática, indicando maior sobremortalidade feminina (MONDEN; SMITS, 2013). Fuse (2006) identificou níveis de desenvolvimento baixos, taxa de fecundidade alta, dominância da indústria na economia, desemprego das mulheres, dentre outros, estão associados à desvantagem feminina na sobrevivência (FUSE; CRENSHAW, 2006).

Quadro 3 – Características individuais das publicações realizadas com dados de múltiplos países incluídas na revisão de literatura.

Autor (ano)	Objetivo	Locais	Fonte de dados	Período	Medida	Principais resultados
Waldron, I (1987)	Apresentar razões de sexo na mortalidade de duas fontes diferentes e revisar as principais hipóteses sobre as causas de maior mortalidade feminina na infância	17 países "em desenvolvimento"	Nações Unidas e WFS	A partir de 1945	Razão de sexo M:F	A sobremortalidade feminina é observada apenas se houver discriminação na nutrição e/ou nos cuidados de saúde e se a mortalidade total não for dominada por certas causas de morte que, de forma consistente, levem à sobremortalidade masculina
Hill, K e Upchurch, D (1995)	Utilizar dados das DHS para mensurar a extensão das diferenças na mortalidade na infância e explorar as razões para estas diferenças.	38 países de baixa e média renda	DHS	1987-1993	Índice de desvantagem feminina	Presença de sobremortalidade feminina em 21 dos inquéritos, sendo mais acentuada a diferença para faixa etária entre um e quatro anos.
Tabutin, D (1995)	Explorar como os diferenciais de sexo na mortalidade evoluíram durante as décadas de 1970 e 1980 e avaliar a relação entre o excesso de mortalidade feminina e alguns indicadores de desenvolvimento	62 países de baixa e média renda	DHS e WFS	Décadas de 1970 e 1980	Razão de sexo M:F	Sobremortalidade feminina expressiva de um a quatro anos e, por região, variaram de 16% na Ásia centro-ocidental a 5% na África subsaariana em 1970; e de 13% na Ásia centro-ocidental a 10% no norte da África em 1980.
Garenne, M (2003)	Fornecer uma síntese sobre as diferenças entre os sexos na mortalidade e nos indicadores de saúde a partir dos dados disponíveis em pesquisas demográficas.	60 países da África subsaariana	WFS e DHS	1977-1998	Razão de sexo M:F	Em nenhum dos países foi encontrada razão menor que 1 e nove tiveram razão significativamente maior que 1.
Fuse K e Crenshaw EM (2006)	Abordar razões para os diferenciais de sexo na mortalidade infantil variarem entre países	93 países	Nações Unidas	2000	Razão M:F da taxa de mortalidade infantil	Níveis de desenvolvimento baixos, taxa de fecundidade alta, dominância da indústria na economia, desemprego das mulheres, dentre outros, estão associados à desvantagem feminina na sobrevivência.

Autor (ano)	Objetivo	Locais	Fonte de dados	Período	Medida	Principais resultados
Drevenstedt, GL *et al* (2008)	Examinar as razões de sexo da probabilidade de morte na infância	15 países de alta renda	*Human Mortality Database*	1751-2004	Razão de sexo M:F	Redução na mortalidade infantil por infecções e aumento de mortes por condições perinatais favoreceram as meninas. A redução sobremortalidade masculina após 1970 pode ser atribuída a melhores práticas obstétricas e cuidados neonatais.
Sawyer, CS (2012)	Estimar as tendências na razão de sexo da mortalidade de crianças para avaliar as mudanças ao longo do tempo na mortalidade relativa de meninos e meninas para países individuais e regiões do mundo.	153 países	Sistemas de registros vitais, censos e inquéritos	1970-2000	Razão de sexo M:F	Regiões menos desenvolvidas: mortalidade <5 dos meninos nos anos 2000 foi 2% maior; alguns países ainda apresentam maior mortalidade de meninas de 1 a 4 anos; Regiões mais desenvolvidas: pico nos anos 70 e 80, com declínio posterior.
Monden, CWS e Smits, J (2013)	Estender o conhecimento sobre o papel da educação materna na determinação de diferenças de gênero na mortalidade de menores de cinco anos.	31 países da África subsaariana e quatro do sul da Ásia	DHS	Anos 2000	Razão de sexo M:F	Escolaridade materna está positivamente associada à M:F; na África Subsaariana, as meninas têm melhores chances de sobrevivência especialmente se suas mães são mais bem educadas; no sul da Ásia, as meninas de mães não-educadas têm taxas de mortalidade mais altas que os meninos
Alkema, L *et al* (2014)	Avaliar a relação global entre as razões de sexo e as taxas de mortalidade total e identificar países com valores aberrantes	195 países com dados disponíveis	Registros vitais, censos e inquéritos	1990-2012	Razão de sexo M:F	Razões de sexo mais altas foram observadas em regiões desenvolvidas; a diminuição da mortalidade foi associada ao aumento das razões, exceto com mortalidade infantil muito baixa; foram identificados 15 países com valores extremos, dos quais dez apresentaram sobremortalidade feminina.
Costa, JC *et al* (2017)	Comparar duas abordagens propostas para avaliar a sobremortalidade feminina entre menores de cinco anos	60 países de baixa e média renda	DHS	A partir de 2005	Excesso de mortes de meninas	A abordagem prescritiva identificou sobremortalidade feminina em 20 países, e a abordagem descritiva, apenas um. Ambas apresentaram rankings semelhantes. Sobremortalidade feminina entre as regiões do mundo foram significativas, mas não entre os grupos de renda.
Stephenson, R *et al* (2017)	Examinar se existe viés de gênero nos desfechos de saúde para gêmeos	38 países de baixa e média renda	DHS	Inquéritos a partir de 2010	Razão de odds	Pares de gêmeos contendo pelo menos uma menina têm menor chance de mortalidade no primeiro ano de vida do que pares de meninos, sugerindo que fatores biológicos que contribuem para a vantagem feminina podem estar atuando e contrabalanceando a preferência por filhos homens.

3.2. Estudos realizados na Índia

A Índia é um país conhecido pela preferência por filhos homens, pela prática de abortos seletivos baseados no sexo do feto, e por melhores condições de atenção médica e de nutrição dispendidas aos meninos, que geram disparidade de gênero na população.(KHOSLA, T, 1980; KUNTLA; GOLI; JAIN, 2014; OSTER, 2009) Essas práticas têm como consequências a razão de sexo no nascimento acima da média mundial devido à seleção pré-natal, e a sobremortalidade feminina, causada por infanticídio e negligência das meninas. Trata-se do país com maior número de estudos realizados sobre o assunto, identificados na presente revisão.

Na Índia, a preferência por filhos homens e a maior sobrevivência de meninos em relação às meninas é relatada em diversos estados e ao longo dos anos, sendo mais comumente descrita nos Estados do norte, como Punjab e Haryana (CHOWDHURY; TANEJA; MAZUMDER; BHANDARI *et al.*, 2017; KHOSLA, T., 1980; KRISHNAN; DWIVEDI; GUPTA; BYASS *et al.*, 2013). A desvantagem feminina aparece mesmo entre famílias de melhor posição socioeconômica no norte da Índia (KRISHNAN; DWIVEDI; GUPTA; BYASS *et al.*, 2013). Essa informação revela a heterogeneidade cultural do país, pois a discriminação contra mulheres é menor nos estados do sul (GHOSH, 1990; GUILMOTO; SAIKIA; TAMRAKAR; BORA, 2018; HARRISS, 1989).

Jha e colaboradores (2011) encontraram que, após o ajuste para o excesso de mortalidade nas meninas, as estimativas do número de abortos seletivos de meninas aumentaram de 0 a 2 milhões na década de 1980, para 1,2 a 4,1 milhões na década de 1990 e para 3,1 a 6,0 milhões na década de 2000 (JHA; KESLER; KUMAR; RAM *et al.*, 2011). Trata-se de uma prática amplamente difundida em todo o país, em áreas urbanas e rurais, em diferentes posições socioeconômicas e níveis de escolaridade (MADAN; BREUNING, 2014). A prática de seleção de sexo pré-natal aparece ainda mais expressiva em domicílios mais ricos para segundos e terceiros nascimentos quando os primogênitos eram do sexo feminino (GELLATLY; PETRIE, 2017).

Em relação à mortalidade, a existência de irmãs mais velhas aparece como fator de risco significativo para a meninas, mas não correlacionado com a riqueza familiar, o que pode refletir que domicílios mais ricos têm acesso às medidas de interrupção da gestação, levando a uma menor taxa de nascimentos de meninas 'indesejadas', mas ainda não é totalmente inexistente o viés de gênero contra as meninas deste grupo social. Nacionalmente, a partir de dados da DHS de 2005, encontrou-se evidente sobremortalidade feminina para a faixa etária de dois a cinco anos (OR = 1,33; IC95% = 1,13; 1,58) (SUBRAMANIAN; NANDY; IRVING; GORDON *et al.*, 2006).

Guilmoto e colaboradores (2018) utilizaram dados do Censo populacional de 2011 em uma análise espacial para descrever a sobremortalidade feminina (<5 anos) e a encontraram em mais de 90% dos distritos, especialmente nos maiores estados do Norte (Uttar Pradesh, Bihar, Rajasthan, e Madhya Pradesh correspondem a 66,7% das mortes excessivas) (GUILMOTO; SAIKIA; TAMRAKAR; BORA, 2018). O nível médio de excesso de mortes de meninas estimado é de 18,5 ($IC_{95\%}$ 13,1 – 22,6) por 1000 nascimentos, o que corresponderia a 239 000 ($IC_{95\%}$ 169 000 – 293 000) mortes por ano. Como principais preditores dessa mortalidade excessiva estão o baixo desenvolvimento econômico, as desigualdade de gênero e as altas taxas de fecundidade (GUILMOTO; SAIKIA; TAMRAKAR; BORA, 2018).

3.3. A situação da China

A China é o país que apresenta o segundo maior número de publicações identificadas. De maneira geral, um dos principais temas contemplados pelos estudos é a desproporção de número de mulheres e homens na população chinesa. Na China, a escassez de mulheres na população é observada há muitas décadas e considerada por diversos autores como fruto da política de filho único somada ao rápido aumento da prática de aborto seletivo (REN, 1995).

A mortalidade infantil de ambos os sexos diminuiu consideravelmente a partir da década de 1970; a razão de sexos para mortalidade infantil passou de 1,15 em 1973-75, 1,06 em 1981 para 0,86 em 1990 (XU; RIMPELA; JARVELIN; NIEMINEN, 1994). Já a mortalidade de menores de cinco anos, apesar do declínio no período, permaneceu com uma razão constante e próxima da unidade (XU; RIMPELA; JARVELIN; NIEMINEN, 1994), o que também poderia indicar uma mortalidade feminina acima do esperado.

A partir de dados de um inquérito de fertilidade e controle de nascimentos realizado em 1988, observou-se que entre os primogênitos menores de um ano a diferença entre meninos e meninas não foi estatisticamente significativa, mas entre as crianças do sexo feminino com idade entre um e cinco anos a mortalidade foi maior do que para as crianças do sexo masculino (CHOE; HAO; WANG, 1995). Esse resultado é corroborado por um estudo de tendência que compara a mortalidade de crianças nascidas nas décadas de 1960 e 1970 A sobrevivência feminina é maior se a criança for filha única e para aquelas com uma irmã mais velha (HAO; MINJA; WANG, 1994). A probabilidade de um segundo nascimento e um curto intervalo de interpartal foi maior para mães com um primeiro filho do sexo feminino (HAO; MINJA; WANG, 1994).

O Censo realizado na China em 1982 indicou menor mortalidade infantil de meninas em relação aos meninos (LI; FELDMAN, 1996); essas estimativas, porém, são consideradas consequências de subnotificação de nascimentos de meninas.

Os resultados de estudos sub-regionais na China, apresentam resultados variados em relação à presença de viés de gênero. Estudo realizado em três municípios pobres da China, não foi identificado viés de gênero nas razões de sexo, mas identificou que a preferência por meninos era manifestada tanto pelos pais quanto pelas mães, que também reconhecem que as meninas são mais propensas a cuidar de pais idosos (RILEY, 1996). Em algumas outras províncias, porém, encontra-se uma proporção de 114 homens para cada 100 mulheres, evidenciando o desequilíbrio na razão de sexo (RILEY, 1996). Além da identificação da subnotificação de nascimentos e da prática de aborto seletivo, também se observou maiores taxas de mortalidade entre as meninas em algumas regiões, especialmente nas idades de um a quatro anos (REN, 1995).

4. Justificativa

No campo da saúde das crianças, diversos são os exemplos de práticas discriminatórias às quais as meninas estão sujeitas em diversos países, como a preferência por filhos homens, alimentação inadequada e piores cuidados, mesmo em países onde ocorreram importantes avanços na cobertura de intervenções de saúde (CALU COSTA; WEHRMEISTER; BARROS; VICTORA, 2017; JONES; HARPER; WATSON; ESPEY *et al.*, 2010; UNICEF, 2015). Exemplos incluem diferenciais prejudiciais às meninas na amamentação, distribuição de alimentos em quantidade e qualidade, vigilância parental, recurso aos serviços de saúde, e imunização (CHAKRAVARTY, 2015; CORSI; BASSANI; KUMAR; AWASTHI *et al.*, 2009; UNFPA, 2012; UNICEF, 2015). Os resultados destas práticas podem ser identificados a partir da análise de gênero, ou seja, um exame crítico de como as diferenças nos papéis, atividades, necessidades, oportunidades e direitos afetam mulheres, homens, meninas e meninos em determinado contexto (UNITED NATIONS, 2015a).

Muitas vezes as estimativas de saúde desagregadas por sexo refletem as diferenças decorrentes das normas de gênero, mas quando isso ocorre é necessário descartar a possibilidade de que estas diferenças sejam devidas a fatores puramente biológicos. No caso das diferenças de sexo na mortalidade de menores de cinco anos, por exemplo, é fundamental que seja considerada a maior vulnerabilidade biológica dos meninos.

O reflexo destas discriminatórias contra as meninas pode levar à ocorrência de mortalidade em uma frequência maior do que seria esperado e, consequentemente a uma distorção na relação entre os sexos, avaliada pela razão das taxas de mortalidade. Porém, as metodologias utilizadas para avaliação da presença de sobremortalidade feminina são bastante heterogêneas e não há padronização de abordagens para a identificação do fenômeno.

As duas principais referências utilizadas na literatura para estimar as diferenças nas taxas de mortalidade entre meninos e meninas usam abordagens distintas. Estas apresentaram fortes correlação e concordância, porém, se propõem a medir dimensões diferentes do fenômeno e até o presente momento não existe um padrão prescritivo atual, que utilize dados recentes e que permita identificar evidências da sobremortalidade feminina, uma vez que o padrão proposto por Hill e Upchurch se baseia na experiencia de populações europeias entre 1820 e 1964 (ALKEMA; CHAO; YOU; PEDERSEN *et al.*, 2014; COSTA; DA SILVA; VICTORA, 2017b; HILL; UPCHURCH, 1995). Para melhor compreensão do comportamento da mortalidade por sexo, é essencial entender como meninos e meninas são afetados, na atualidade, por distintas causas de morte.

Tendo como base os objetivos de desenvolvimento do milênio (ODM), encerrados em 2015, os objetivos de desenvolvimento sustentável (ODS) foram propostos pelas Nações Unidas e adotados por 193 países em 2015 (UNITED NATIONS, 2015b). Em especial, o objetivo 17 dos ODS contempla a necessidade de análises estratificadas por indicadores que favoreçam a identificação de desigualdades: sexo, renda, idade, etnia, status migratório, deficiência, dentre outras características (UNITED NATIONS, 2015b). As metas estabelecidas neste acordo refletem convicções de que o progresso relativo à igualdade de gênero é central para o desenvolvimento sustentável. As estimativas desagregadas por sexo devem, portanto, ser sistematicamente utilizadas para fins de monitoramento, levando em conta quais diferenças são esperadas em termos puramente biológicos, e identificando situações onde isso as diferenças indicam desvantagem para um ou outro sexo ao longo do tempo (SAWYER, 2012).

A partir de um embasamento teórico sólido e da existência de um padrão atualizado, torna-se viável aprofundar a compreensão de como o gênero pode influenciar o comportamento e os desfechos de saúde, utilizando-se dados disponíveis de inquéritos nacionais representativos de múltiplos países. A literatura sugere, por exemplo, que a religião pode ser um dos determinantes do viés de gênero para saúde, mas não existem estudos sistemáticos cobrindo vários países e avaliando sua influência na saúde de crianças (CALU COSTA; WEHRMEISTER; BARROS; VICTORA, 2017; JONES; HARPER; WATSON; ESPEY *et al.*, 2010). Por outro lado, as evidências apontam que o comportamento em relação ao cuidado das crianças, como busca de serviços e vacinação, podem influenciar na mortalidade diferencial por sexo, mais até mesmo do que seria esperado em relação ao estado nutricional, por exemplo

(BASU, 1989; COSTA; DA SILVA; VICTORA, 2017a; TIMAUS, 1998; UNICEF, 2015).

Em síntese, a proposta do projeto é apresentar um indicador de sobremortalidade feminina, baseado em informações de cuidado infantil e condições de saúde, que seja uma referência baseadas nas causas de morte atuais entre menores de cinco anos em países de baixa e média renda e que seja de fácil aplicação a partir de dados de inquéritos nacionais também atualizados.

5. Objetivos

5.1. Objetivo geral

Utilizando dados de inquéritos populacionais do tipo DHS e MICS de 92 países de baixa e média renda (lista disponível no **Apêndice 2**), este estudo irá investigar a presença e a magnitude do excesso de mortes de meninas entre crianças menores de cinco anos a partir de uma nova proposta de indicador de sobremortalidade feminina, baseado em estimativas de saúde infantil, e explorar alguns possíveis determinantes.

5.2. Objetivos específicos

- Desenvolver um indicador de referência para mortalidade de meninas menores de cinco anos baseado nos níveis de mortalidade de países de baixa e média renda onde não exista evidência de viés de gênero em indicadores preventivos, curativos e nutricionais;

- A partir da estimativa dos países de referência proposta no objetivo anterior, identificar países com evidência de sobremortalidade feminina;

- Através de um estudo ecológico, analisar características dos países que possam estar associadas com a sobremortalidade feminina, como riqueza nacional e sua distribuição, índices de desigualdade de gênero, escolaridade feminina e religiões às quais a população é afiliada;

- Analisar a associação entre a religião da família e a razão de sexo na taxa de mortalidade, na cobertura de intervenções preventivas e curativas, e em indicadores nutricionais de crianças menores de cinco anos.

6. Hipóteses

- Será possível identificar países sem evidência de viés de gênero na saúde e nutrição de crianças, com base nos quais poderá ser construída uma referência internacional mortalidade por sexo, conforme o nível de mortalidade total de menores de cinco anos;

- A presença da sobremortalidade feminina estará associada com os níveis mais elevados de mortalidade total e com práticas de cuidado em que seja evidenciada a discriminação contra as meninas;

- O indicador evidenciará a presença de sobremortalidade feminina nos países mais pobres e naqueles localizados no sul da Ásia e no Norte da África;

- Países com maioria da população muçulmana apresentarão maior mortalidade e menor cobertura de intervenções de saúde para as meninas.

7. Material e Métodos

7.1. Fonte de dados

Serão utilizados dados de inquéritos populacionais, do tipo *Demographic and Health Surveys* (DHS) e *Multiple Indicator Cluster Surveys* (MICS), realizados em países de baixa e média renda. São elegíveis para serem incluídos aqueles disponibilizados no formato padrão e com acesso público através das páginas correspondentes (https://dhsprogram.com/ e http://mics.unicef.org/surveys). A abordagem básica destes inquéritos é a coleta de dados nacionalmente representativos e comparáveis entre países, através de modelos padronizados de questionários (RUTSTEIN; ROJAS, 2006).

A representatividade das populações é garantida através de um processo de amostragem probabilística em dois estágios. Na primeira etapa, um subconjunto de agregados geográficos delimitados, geralmente setores censitários, com tamanho populacional conhecido, é selecionado. Na segunda etapa, uma amostra de domicílios é selecionada (RUTSTEIN; ROJAS, 2006).

Estes inquéritos são planejados para listar todos os membros e visitantes habituais das residências selecionadas e coletar informações sobre as características e estrutura domiciliares. Nos domicílios selecionados, todas as mulheres em idade reprodutiva (de 15 a 49 anos) são elegíveis para uma entrevista individual que inclui questões sobre a própria saúde, saúde e nutrição das crianças, e história reprodutiva. Em muitos países uma amostra de homens é entrevistada (RUTSTEIN; ROJAS, 2006).

Após a publicação do relatório do inquérito de cada país, geralmente após 12 meses do término da coleta de dados, os bancos de dados padronizados (nomes e categorização das variáveis, por exemplo) são disponibilizados publicamente e liberados através de um processo de registro eletrônico (RUTSTEIN; ROJAS, 2006).

7.1. Processamento dos dados

Os bancos de dados e indicadores a serem utilizados são processados de maneira contínua pelo Centro Internacional de Equidade em Saúde (*International Center for Equity in Health* – ICEH)[5], concebido para fornecer dados ao Observatório de Saúde Global da Organização Mundial da Saúde (OMS) e à Iniciativa *Countdown to 2030*[6], para monitoramento da equidade em saúde e nutrição em países de baixa e média renda.

As principais atividades do ICEH envolvem análise de dados, particularmente oriundos de DHS e MICS, para avaliar a equidade em saúde e gerar um conjunto padrão de indicadores de desigualdades em saúde e nutrição, que são atualizados periodicamente à medida que novos inquéritos são disponibilizados.

7.2. Análise dos dados

As principais variáveis a serem utilizados nas análises são provenientes de quatro dos bancos de dados disponibilizados para cada país em que foi realizado o inquérito: do domicílio, da mulher, da criança e de nascimentos (história reprodutiva).

Os desfechos de interesse contemplam a cobertura de intervenções, práticas e comportamentos de saúde e taxas de mortalidade de crianças menores de cinco anos. Diferenças entre os sexos em relação às práticas de busca por cuidado e imunização aparecem como indicadores associados ao diferencial na mortalidade e por isso serão incluídos como critério para definição do padrão.(BASU, 1989; COSTA; DA SILVA; VICTORA, 2017a; TIMAUS, 1998)

Todas as estimativas serão estratificadas por sexo (principal exposição). Com exceção das taxas de mortalidade, em que é esperado que sejam maiores entre os meninos, para os demais indicadores e na ausência de discriminação de gênero seriam esperadas estimativas semelhantes para ambos os sexos. A definição destes indicadores é apresentada a seguir:

[5] International Center for Equity in Health: http://equidade.org/
[6] Countdown 2030: http://countdown2030.org/

a) **Taxa de mortalidade de menores de cinco anos**: número de óbitos ocorridos antes do quinto aniversário (ou inferior a 60 meses de idade) por 1.000 crianças nascidas vivas, a partir das informações de história reprodutiva completa das mulheres entrevistadas (15-49 anos).

   i. **Erro padrão da mortalidade**: calculado através do método *jackknife* de reamostragem, também conhecido como técnica do canivete, em português. É utilizado para estimar a variância de uma estimativa através de repetidos cálculos, sendo que para cada um deles é retirada uma medida da análise. No caso dos inquéritos populacionais, a cada repetição elimina-se um cluster (agregado domiciliar) do processo. A soma os quadrados das diferenças entre cada uma das estimativas obtidas e a sua média, multiplicada por $\frac{(n-1)}{n}$, é a estimativa de da variância (*jackknife estimate of variance*) (PEDERSEN; LIU, 2012).

b) **Sobremortalidade feminina**: na literatura, também chamada de "excesso de mortalidade feminina", é a razão de sexo de mortalidade inferior (quando calculada pela razão meninos:meninas) ou superior (quando calculada meninas:meninos) ao que seria esperado em função da taxa de mortalidade total para ambos os sexos ou para níveis determinados de mortalidade masculina (ALKEMA; CHAO; YOU; PEDERSEN *et al.*, 2014; HILL; UPCHURCH, 1995). O padrão de mortalidade a ser criado no primeiro artigo desta tese será utilizado como referência.

c) **Cobertura vacinal completa**: proporção de crianças[7] que tenham recebido três doses de vacina contra DTP (sigla para *diphtheria, tetanus, pertussis* – difteria, tétano e coqueluche), três doses de vacina contra pólio, uma dose de vacina contra sarampo e uma dose de vacina BCG (Bacille Calmette-Guérin, imunização contra tuberculose).

d) **Práticas de busca por cuidado**: proporção de crianças menores de cinco anos para as quais se buscou cuidado adequado ao apresentarem

[7] A cobertura vacinal é usualmente calculada para crianças de 12-23 meses. Esta faixa etária será utilizada no primeiro artigo, que utiliza dados de todo o inquérito (ver abaixo). Para as análises por religião dentro de cada país, usaremos a faixa etária de 12-59 meses para aumentar o tamanho da amostra.

diarreia, febre ou sintomas de pneumonia nas duas semanas anteriores à entrevista (CALU COSTA; WEHRMEISTER; BARROS; VICTORA, 2017).

As variáveis independentes utilizadas em cada estudo, quando pertinentes, serão especificadas no tópico referente a cada um dos artigos.

Artigo 1

O padrão de mortalidade para menores de cinco anos por sexo será construído com dados de mortalidade de meninas e meninos residentes em países onde não há evidência de viés de gênero na cobertura de intervenções de saúde infantil. O padrão resultante será utilizado para identificar locais onde a razão de sexo encontra-se acima do que seria esperado para o nível global de mortalidade observado.

Inicialmente, os dois indicadores selecionados para identificar países sem viés de gênero serão a cobertura vacinal completa e as práticas de busca por cuidado. A partir da razão de sexo para estes indicadores, serão estabelecidos dois critérios para considerar presença ou não do viés de gênero: i) magnitude da razão, considerando-se ausência de viés as razões que apresentem valores dentro do intervalo de 10%, para mais ou para menos, da unidade (entre 1,1 e 0,9), e ii) significância estatística através do intervalo de confiança, utilizando o erro padrão da razão, calculado pelo método *jackknife*.

Durante o doutoramento, a candidata fará um estágio na Universidade de Stanford, onde obterá o treinamento nas técnicas estatísticas necessárias para a construção das referidas curvas.

Usando dados dos países sem evidência de viés de gênero no cuidado das crianças, as razões de sexo esperadas para cada nível de mortalidade geral (para ambos os sexos) serão calculadas, sendo produzidas curvas mostrando as faixas aceitáveis da razão de sexos. Inicialmente, métodos bayesianos serão utilizados para criar estes padrões, similares aos usados por Alkema e colaboradores (ALKEMA; CHAO; YOU; PEDERSEN *et al.*, 2014).

Artigo 2

Para o segundo artigo proposto, será conduzido um estudo ecológico, em que cada unidade analítica será um país de baixa ou média renda. O desfecho será a razão de sexo observada dividida pela esperada, determinada através dos resultados do inquérito mais recente em cada país a partir de 2010 (conforme a metodologia a ser criada na análise do primeiro artigo). A partir deste cálculo será possível estimar os possíveis excessos ou déficits percentuais de mortes de meninas menores de cinco anos. A variável resultante (razão entre a razão de sexo esperada e observada) será o desfecho das análises ecológicas. As variáveis explanatórias são apresentadas no **Quadro 4,** abaixo:

Quadro 4 – Definição, fonte e classificação das variáveis explanatórias a serem utilizadas no segundo artigo proposto para compor a tese.

Variável	Definição	Fonte	Tipo
Região	Conjuntos geográficos de países de acordo com a classificação estabelecida pelo UNICEF	UNICEF	Categórica
Religião	Pode ser definida como crença na existência de um poder ou princípio superior que se reflete em posturas morais (Pew Research Center 2017b); as principais fontes de dados sobre religião serão os próprios inquéritos e os estudos realizados pelo Pew Forum sobre Religião e Vida Pública (*Pew Forum on Religion and Public Life*) (PEW RESEARCH CENTER, 2017a)	Pew Forum; CIA; inquéritos	Contínua (percentual da população) ou categórica
Produto Interno Bruto (PIB) nacional e PIB *per capita*	Representam a soma (em valores monetários) de todos os bens e serviços produzidos por um país, durante um período determinado, geralmente um ano. O PIB é um dos indicadores mais utilizados na macroeconomia com o objetivo de quantificar a atividade econômica de uma região; tem como fonte principal o Banco Mundial. O PIB per capita é obtido pela divisão do PIB total pelo número de habitantes do país (WORLD BANK, 2017)	Banco Mundial	Contínua
Coeficiente de Gini	Mede a extensão em que a distribuição de renda entre indivíduos ou agregados familiares dentro de uma economia desvia de uma distribuição perfeitamente igual (WORLD BANK, 2018a). Consiste em um número entre 0 e 100, onde 0 corresponde à completa igualdade de renda (onde todos têm a mesma renda) e 100 corresponde à completa desigualdade.	Banco Mundial	Contínua

Variável	Definição	Fonte	Tipo
Classificação de renda	Agrupamento realizado pelo Banco Mundial de acordo com o PIB per capita de cada país no ano fiscal de interesse (WORLD BANK, 2018b).	Banco Mundial	Contínua
Gender Inequality Index (Índice de desigualdade de gênero)	Fornece informações compostas sobre as disparidades de gênero na saúde reprodutiva, empoderamento e mercado de trabalho para 152 países. Varia entre 0, em que mulheres e homens se saem iguais, e 1, em que um gênero se sai o pior possível nas três dimensões (UNITED NATIONS DEVELOPMENT PROGRAMME, 2016)	PNUD	Contínua
Gender Development Index (Índice de desenvolvimento de gênero)	Mede as desigualdades de gênero no desempenho em três dimensões básicas do desenvolvimento humano: saúde (expectativa de vida ao nascer); educação (anos de escolaridade esperados para crianças e média de anos de escolaridade para adultos com idade igual ou superior a 25 anos); e comando sobre os recursos económicos (estimativa do rendimento alcançado). O valor final do índice é obtido através da razão entre os Índices de Desenvolvimento Humano das mulheres pelo dos homens (UNITED NATIONS DEVELOPMENT PROGRAMME, 2016)	PNUD	Contínua
Global Gender Gap Index (Índice global de lacuna de gênero)	Estima a lacuna entre homens e mulheres em quatro categorias fundamentais: oportunidades e participação econômica, nível educacional, saúde e sobrevivência, e empoderamento político. O valor final varia entre 0 (desigualdade) e 1 (igualdade) (WORLD ECONOMIC FORUM, 2017)	Fórum Econômico Mundial	Contínua
Empoderamento feminino	Estimado através do índice SWPER (*Survey-based Women's emPowERment index*) que engloba três domínios de empoderamento (atitude para violência, independência social e tomada de decisão) e permite comparação intra e entre países (EWERLING; LYNCH; VICTORA; VAN EERDEWIJK *et al.*, 2017)	Inquéritos	Contínua
Escolaridade feminina	Pode ser estimada a partir de diferentes indicadores, como anos de escolaridade esperados e taxa de alfabetização das mulheres	Banco Mundial; PNUD; inquéritos	Contínua ou categórica ordinal

Como é de praxe em estudos ecológicos, os métodos de análise incluirão o cálculo de coeficientes de correlação (r de Pearson) e de determinação (R^2). Será testada ainda a possibilidade de associações não lineares através do uso de modelos polinomiais. Para a exposição “região geográfica”, que é uma variável categórica, será utilizada análise de variância. Para a análise multivariável, será utilizada regressão múltipla, com termos lineares e polinomiais.

Artigo 3

O objetivo deste trabalho será analisar se as religiões das famílias estão associadas com viés de gênero nos indicadores de saúde da criança. Além disso, procurará responder se a associação, caso exista, poderia ser explicada por características socioeconômicas e demográficas das famílias e dos domicílios.

Serão analisados três desfechos, separadamente para meninos e meninas: (a) cobertura vacinal completa (em crianças de 12-59 meses), (b) práticas de busca por cuidado em crianças menores de cinco anos que apresentaram sintomas nos últimos 15 dias, e (c) taxa de mortalidade de menores de cinco anos.

A informação sobre religião, principal variável independente, será obtida do questionário individual ou do domicílio, em inquéritos realizados a partir de 2010. No caso das DHS, a pergunta direta feita para a mulher entrevistada que aparece no questionário individual é “Qual é a sua religião?”, seguida de alternativas determinadas em cada país, contemplando a possibilidade de responder “outra” e informá-la ou se identificar como sem religião. Nos inquéritos do tipo MICS a pergunta “Qual é a religião do chefe do domicílio?” encontra-se no questionário do domicílio e as possibilidades de resposta seguem o padrão da DHS. Ambas as informações serão utilizadas assumindo-se como a religião predominante no domicílio.

A forma de coletar a informação sobre religião varia de inquérito para inquérito, sendo utilizados termos locais relevantes para definir esta variável. As variáveis originais serão recodificadas em oito grupos de acordo com a classificação do Pew Fórum sobre Religião e Vida Pública (*Pew Forum on*

Religion and Public Life): 1. Cristã, 2. Muçulmana, 3. Hindu, 4. Budista, 5. Judaica, 6. Religiões tradicionais e populares (incluindo religiões tradicionais africanas, religiões populares chinesas, religiões nativas americanas e religiões aborígenes australianas), 7. Grupo de indivíduos sem religião, e 8. Outras (sem identificação) (PEW RESEARCH CENTER, 2017a).

Por ser a religião mais frequente na maioria dos inquéritos, optou-se por usar os cristãos como grupo de referência nas análises, com o qual os demais serão comparados. Em cada país, o número de comparações possíveis será determinado pelo número de religiões com pelo menos 10% da amostra.

As análises incluirão as seguintes etapas:

1. Cálculo das estimativas estratificadas por sexo e por religião;
2. Cálculo da razão de sexo da cobertura e seu intervalo de confiança, por religião;
3. Meta-análise comparando as razões em cada país (após teste para heterogeneidade);
4. Dentro de cada país, ajuste para os covariáveis (ver abaixo) e cálculo da razão de sexo ajustada;
5. Nova meta-análise utilizando as razões ajustadas, conforme descrito acima no item 3.

As seguintes covariáveis socioeconômicas e demográficas coletadas serão utilizadas para o ajuste (**Quadro 5**):

Quadro 5 – Definição e classificação das variáveis explanatórias a serem utilizadas no terceiro artigo proposto para compor a tese.

Variável	Definição	Tipo
Riqueza do domicílio	O índice de riqueza é calculado a partir de dados sobre a propriedade de um domicílio, posse de bens, materiais para a construção da habitação, e acesso à água e instalações sanitárias. Utiliza-se análise de componentes principais para sua construção e os escores resultantes são divididos em quintis e atribuídos aos domicílios da amostra (RUTSTEIN; JOHNSON, 2004). O quintil 1 representa os 20% mais pobres e o quintil 5, os 20% mais ricos.	categórica ordinal
Escolaridade materna	Anos completos de estudo ou categorias de escolaridade	contínua ou categórica ordinal
Idade materna	Anos completos	contínua ou categórica ordinal
Área de residência	Urbana ou rural	categórica nominal

7.3. Pontos fortes e limitações

O principal ponto forte deste estudo é a utilização de dados de grande número de inquéritos domiciliares com metodologias similares e representatividade nacional. Os grandes tamanhos amostrais dos inquéritos (número mediano de 15.000 mulheres) permitem a desagregação das estimativas, ou seja, é possível explorar diversas variáveis que podem estar associados à desvantagem de determinados grupos, através da estratificação das estimativas. Além disso, o processamento de dados brutos possibilita a criação de novos indicadores compostos, que aumentam o poder estatístico das análises, como é o caso da imunização completa e da busca de cuidados para doenças comuns na infância.

Uma limitação é a não inclusão de alguns países, tanto pela inexistência de inquéritos populacionais de acesso livre, como é o caso da China, quanto pela disponibilidade de dados de períodos anteriores àquele determinado com critério de inclusão, como por exemplo o Brasil (último inquérito disponível é de 2006). De maneira geral os dados disponíveis apresentam maior cobertura de informações para países de baixa renda do que para países de média renda.

Cabe notar ainda que os inquéritos, de forma geral, não têm como foco as análises de gênero, apesar de nos últimos anos terem sido inseridos módulos específicos para esse tipo de abordagem (por exemplo, empoderamento feminino) e blocos de questões referentes a tópicos como mutilação genital, violência doméstica, uso de contraceptivos, etc. Não obstante, as análises aqui propostas podem ser realizadas com indicadores que já estão presentes nos bancos de dados.

Outra limitação é que alguns questionários utilizados coletam dados sobre a religião da pessoa entrevistada, enquanto outros se referem ao chefe do domicílio. A análise conjunta de todos os inquéritos pressupõe que a religião do respondente é a mesma que a do chefe do domicílio. Além disso, é necessário se considerar os contextos nacionais e características de cada cultura ao se analisar desigualdades por grupo religioso. Esses pontos serão abordados e aprofundados na sessão de discussão dos artigos propostos.

Em relação aos desfechos, algumas limitações também precisam ser reconhecidas. As diferenças na busca por cuidado podem ser devidas à maior severidade das infecções experimentadas pelos meninos, em função de sua maior fragilidade biológica, e o indicador proposto não será capaz de detectar essa diferença. Outro ponto a ser ressaltado é que a informação sobre incidência da doença é baseada no recordatório da pessoa responsável pela criança, sem validação externa. Apesar desta limitação, os indicadores de busca por cuidado provenientes de inquéritos são amplamente utilizados na literatura.

O mesmo problema referente ao recordatório e uso de dados retrospectivos ocorre no cálculo da taxa de mortalidade, pois as informações são coletadas a partir da história reprodutiva reportada pela mulher entrevistada. Segundo alguns autores, pode haver ainda viés de gênero desde a coleta da informação, através da omissão de mortes de crianças de determinado sexo (HILL; UPCHURCH, 1995). Como a mortalidade pode ser um desfecho raro em alguns locais, o tamanho amostral pode influenciar a identificação de diferenças entre os grupos.

7.4. Aspectos éticos

Os inquéritos a serem utilizados nas análises foram submetidos aos comitês de ética dos países onde foram realizados e o processo de aprovação é descrito em cada relatório nacional. Os bancos de dados são anônimos, garantindo a confidencialidade da informação. Uma vez que esta será uma análise de dados disponíveis publicamente, não há necessidade de submissão do projeto ao comitê de ética local.

8. Financiamento

Os dados a serem utilizados foram pré-processados pelo Centro Internacional de Equidade em Saúde com financiamento da Fundação Bill e Melinda Gates, da Fundação Wellcome Trust e da Associação Brasileira de Saúde Coletiva (ABRASCO).

9. Cronograma

O cronograma elaborado para a conclusão projeto, apresentado no **Quadro 6**, inclui as etapas de constante atualização da revisão de literatura; trabalho de campo no ICEH, considerado como realização do processamento e análise dos dados; estágio doutoral na Universidade de Stanford, EUA, durante parte do segundo e do terceiro ano do doutorado; redação dos três artigos científicos propostos conforme exigência do Programa de Pós-Graduação em Epidemiologia da UFPel; e defesa da tese ao fim do quarto ano de doutorado.

Quadro 6 – Cronograma previsto para realização e conclusão do projeto de pesquisa.

Atividade	**2017**				**2018**				**2019**				**2020**			
	Trimestre				**Trimestre**				**Trimestre**				**Trimestre**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Revisão de literatura	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Elaboração do projeto	■	■	■	■	■											
Defesa do projeto						■										
Trabalho de campo	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Estágio sanduíche							■	■	■	■						
Análise dos dados							■	■	■	■	■	■	■			
Redação dos artigos							■	■	■	■	■	■	■	■	■	■
Defesa da tese																■

10. Divulgação dos resultados

Os resultados desse estudo serão publicados na forma de artigos científicos em periódicos reconhecidos na área e serão divulgados nos meios de comunicação local.

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Apêndices

Apêndice 1 – Lista de referências da literatura cinzenta identificadas e não incluídas na revisão de literatura atual

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Apêndice 2 – Lista de países com inquéritos do tipo DHS ou MICS disponíveis a partir do ano 2010

País	Ano	Fonte
Afghanistan	2015	DHS
Algeria	2012	MICS
Angola	2015	DHS
Armenia	2015	DHS
Bangladesh	2014	DHS
Barbados	2012	MICS
Belarus	2012	MICS
Belize	2011	MICS
Benin	2014	MICS
Bhutan	2010	MICS
Bosnia and Herzegovina	2011	MICS
Burkina Faso	2010	DHS
Burundi	2016	DHS
Cambodia	2014	DHS
Cameroon	2014	MICS
Central African Rep.	2010	MICS
Chad	2014	DHS
Colombia	2015	DHS
Comoros	2012	DHS
Congo, Dem. Rep.	2013	DHS
Congo, Rep.	2011	DHS
Costa Rica	2011	MICS
Cuba	2014	MICS
Cote dIvoire	2011	DHS
Dominican Republic	2014	MICS
Egypt	2014	DHS
El Salvador	2014	MICS
Ethiopia	2016	DHS
Gabon	2012	DHS
Gambia	2013	DHS
Ghana	2014	DHS
Guatemala	2014	DHS
Guinea	2012	DHS
Guinea-Bissau	2014	MICS
Guyana	2014	MICS
Haiti	2012	DHS
Honduras	2011	DHS
India	2015	DHS
Indonesia	2012	DHS
Iraq	2011	MICS
Jamaica	2011	MICS
Jordan	2012	DHS
Kazakhstan	2015	MICS

País	Ano	Fonte
Kenya	2014	DHS
Kosovo	2013	MICS
Kyrgyzstan	2014	MICS
Lao PDR	2011	MICS
Lesotho	2014	DHS
Liberia	2013	DHS
Macedonia	2011	MICS
Malawi	2015	DHS
Mali	2015	MICS
Mauritania	2011	MICS
Mexico	2015	MICS
Moldova	2012	MICS
Mongolia	2013	MICS
Montenegro	2013	MICS
Mozambique	2011	DHS
Myanmar	2015	DHS
Namibia	2013	DHS
Nepal	2016	DHS
Niger	2012	DHS
Nigeria	2016	MICS
Pakistan	2012	DHS
Panama	2013	MICS
Paraguay	2016	MICS
Philippines	2013	DHS
Rwanda	2014	DHS
Saint Lucia	2012	MICS
Sao Tome and Principe	2014	MICS
Senegal	2016	DHS
Serbia	2014	MICS
Sierra Leone	2013	DHS
South Sudan	2010	MICS
State of Palestine	2014	MICS
Sudan	2014	MICS
Suriname	2010	MICS
Swaziland	2014	MICS
Tajikistan	2012	DHS
Tanzania	2015	DHS
Thailand	2012	MICS
Timor-Leste	2016	DHS
Togo	2013	DHS
Tunisia	2011	MICS
Turkmenistan	2015	MICS

País	Ano	Fonte
Uganda	2016	DHS
Ukraine	2012	MICS
Uruguay	2012	MICS
Vietnam	2013	MICS
Yemen	2013	DHS
Zambia	2013	DHS
Zimbabwe	2015	DHS

2 * Relatório de trabalho de campo e alterações no projeto original

Relatório de trabalho de campo

O trabalho de campo foi realizado no Centro Internacional de Equidade em Saúde (*International Center for Equity in Health – ICEH),* um centro de pesquisa desenvolvido por uma equipe de professores da Universidade Federal de Pelotas (UFPel) com ampla experiência em pesquisa de equidade e que estão ativamente envolvidos no Programa de Pós-Graduação em Epidemiologia (PPGEpi), conhecido por seu foco na área de epidemiologia do ciclo vital. O ICEH tem, como um de seus objetivos, monitorar a situação de equidade em saúde e nutrição em diferentes países, com ênfase naqueles de renda baixa e média.

Através da identificação e análise de inquéritos populacionais, o Centro conta com uma base de dados ampla e atualizada que permite o estudo de desigualdades, com foco em saúde sexual e reprodutiva de mulheres de 15 a 49 anos, e saúde, nutrição e mortalidade de crianças menores de cinco anos. As principais fontes de dados são inquéritos nacionais padronizados do tipo *Demographic and Health Surveys*, *Multiple Indicator Cluster Surveys* e *Reproductive Health Surveys*. A disponibilização dos indicadores em sistemas internacionais, como o Observatório Global de Saúde da Organização Mundial da Saúde e a Iniciativa *Countdown to 2030 – Maternal, Newborn & Child Survival,* estão entre as principais atividades realizadas.

Os estudantes que compõem a equipe são vinculados ao PPGEpi e desenvolvem seus planos de pesquisa de dissertação e tese com dados processados e analisados pelo grupo. Este projeto, desenvolvido sob supervisão do diretor científico do ICEH, Professor Cesar Victora, utilizou estimativas de mortalidade e de saúde da criança padronizadas, analisadas, e conferidas pelas equipes de trabalho que atuam nas atividades de rotina.

A rotina de trabalho envolve identificação de novos inquéritos para análise, verificação das informações disponíveis nos bancos de dados de cada inquérito, padronização das variáveis quando necessário, atualização dos códigos para cálculo das estimativas, criação dos indicadores em nível nacional, comparação dos valores calculados com os publicados no relatório, correção das estimativas quando necessário, cálculo das estimativas estratificadas por diversas dimensões de desigualdades (como área de residência, idade, escolaridade, quintis e decis de riqueza, sexo, região subnacional), avaliação da consistência das estimativas em relação à temporalidade e aos demais inquéritos do mesmo país já analisados, documentação do processo.

Além das atividades de rotina, o desenvolvimento desta tese se beneficiou de um período de estágio no Departamento de Pediatria da Universidade de Stanford, onde parte das análises dos dois artigos originais foram desenvolvidas sob orientação do Professor Gary Darmstadt. O grupo liderado pelo Dr. Darmstadt conduz uma série de estudos sobre a temática de gênero, avaliando desigualdades e seus impactos na saúde e desenvolvimento de meninas e mulheres.

Alterações no projeto original

Após a banca de qualificação, realizada em julho de 2018, procedemos com a tentativa de aprimorar o projeto de acordo com as recomendações dos avaliadores. Muitas das sugestões foram contempladas nos artigos produzidos, especialmente no que diz respeito ao aprofundamento de uma revisão crítica da literatura e maior discussão sobre as análises de religião. Buscou-se acrescentar exemplos de práticas discriminatórias que poderiam levar a distorções nas razões de sexo na mortalidade de crianças.

Um dos maiores desafios na análise e interpretação das diferenças de sexo na mortalidade de crianças é a inexistência de um padrão que informe o quanto as taxas para meninos e meninas deveriam diferir na ausência da discriminação de gênero, ou seja, em uma situação em que todos recebessem o mesmo cuidado e sobrevivência fosse predominantemente determinada por diferenças biológicas.

Durante o desenvolvimento das análises, diversas possibilidades de padrões e referências foram exploradas, incluindo aquelas propostas no projeto original, dados de outras fontes, para o mesmo conjunto de países de baixa e média renda, e dados demográficos históricos de populações de países de alta renda. Optamos por manter uma análise descritiva da relação entre as razões de sexo e a taxa de mortalidade total explorando diferentes métodos de ajuste, como modelos paramétricos e não paramétricos, e os fatores contextuais possivelmente associados às diferenças observadas foram analisados no mesmo estudo.

Adicionalmente, diante dos desafios para estabelecimento dos padrões, optamos por realizar uma revisão de literatura sobre as abordagens metodológicas utilizadas para análise das diferenças na mortalidade de meninos e meninas. O foco dessa revisão foram os métodos, mais do que os resultados encontrados, como o objetivo de identificar limitações e pontos fortes dos estudos, em relação aos dados utilizados, parâmetros de comparação (quando pertinentes).

O estudo sobre intersecção entre religião e gênero apresentou uma limitação importante na seleção dos países a serem incluídos, tendo em vista que a distribuição dos grupos religiosos é bastante heterogênea nas regiões do mundo. Optamos por restringir as análises à África subsaariana, uma região para a qual já existiam evidências disponíveis que sugeriam a associação entre afiliação religiosa e comportamentos relacionados à saúde e onde haveria a possibilidade de avaliar mais de um grupo religioso em múltiplos países. As evidências crescentes referentes à baixa prevalência de vacinação de crianças também foi um fator motivador para a restrição dos desfechos a este campo.

3 * Artigos

3.1. Artigo original 1: *Religious affiliation and immunization coverage in 15 countries in Sub-Saharan Africa*

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Religious affiliation and immunization coverage in 15 countries in Sub-Saharan Africa

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ABSTRACT

Background: Although religious affiliation has been identified as a potential barrier to immunization in some African countries, there are no systematic multi-country analyses, including within-country variability, on this issue. We investigated whether immunization varied according to religious affiliation and sex of the child in sub-Saharan African (SSA) countries.

Methods: We used data from 15 nationally representative surveys from 2010 to 2016. The major religious groups were described by country in terms of wealth, residence, and education. Proportions of fully immunized and unvaccinated children were stratified by country, maternal religion, and sex of the child. Poisson regression with robust variance was used to assess whether the outcomes varied according to religion, with and without adjustment for the above cited sociodemographic confounders. Interactions between child sex and religion were investigated.

Results: Fifteen countries had >10% of families affiliated with Christianity and >10% affiliated with Islam, and four also had >10% practicing folk religions. In general, Christians were wealthier, more educated and more urban. Nine countries had significantly lower full immunization coverage among Muslims than Christians (pooled prevalence ratio = 0.81; 95%CI: 0.79–0.83), of which seven remained significant after adjustment for confounders (pooled ratio = 0.90; 0.87–0.92). Four countries had higher coverage among Muslims, of which two remained significant after adjustment. Regarding unvaccinated children, six countries showed higher proportions among Muslims, all of which remained significant after adjustment [crude pooled ratio = 1.83 (1.59–2.07); adjusted = 1.31 (1.14–1.48)]. Children from families practicing folk religions did not show any consistent patterns in immunization. Child sex was not consistently associated with vaccination.

Conclusion: Muslim religion was associated with lower vaccine coverage in several SSA countries, both for boys and girls. The involvement of religious leaders is essential for increasing immunization coverage and supporting the *leave no one behind* agenda of the Sustainable Development Goals.

1. Background

Although important progress has been made in child health and survival worldwide, significant disparities within regions and countries persist [1]. The Sustainable Development Goals (SDGs), proposed by the United Nations and formally adopted by all member states in 2015, include target 3.8 of achieving universal health coverage, and leaving no one behind [2]. Yet, over 5 million children under the age of five still die every year, many from vaccine-preventable illnesses [3]. Universal coverage of preventive interventions such as immunizations would make a major contribution to reducing the mortality of children [1]. For instance, it has been estimated that more than 17 million deaths would be avoided in 73 priority countries from 2011 to 2020 by providing vaccines to children under-five years of age [4].

In order to identify children and families who are being left behind, SDG 17.18 recommends that national statistics should be "disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts" [5]. Whereas the global child survival literature is plentiful with analyses of inequalities according to wealth, gender, and geographic location, there are fewer studies on other axes of inequalities. In particular, we identified very few

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multi-country studies addressing within-country disparities in child health according to religious affiliation.

Some evidence suggests that religious affiliation may affect child health. Akseer and colleagues [6] showed that Muslim-majority countries (MMCs) presented higher maternal and child mortality and lower coverage regarding several reproductive, maternal, newborn and child health interventions than countries with less than 50% of the population reporting to be Muslims. The authors attributed this finding to political instability and conflicts in MMCs, as well to low empowerment of women and girls [6]. An earlier study by Razzak and colleagues [7] found that both maternal and infant mortality rates were about twice as high in MMCs than in non-MMCs and the predictors that seemed to explain most of the differences were gross national income, literacy rate, access to clean water, and level of corruption. However, neither study evaluated within-country differences across religious groups. Moreover, some countries such as Nigeria were categorized as non-MMCs, even though Islam was practiced by a substantial proportion of the population, albeit not a clear majority, thus potentially underestimating the role of religion.

Sub-Saharan Africa (SSA) is an ideal setting for studying the association between religious affiliation and child health. First, it is the region of the world with the highest mortality rates for children, with an overall under-five mortality rate of 79 per 1000 live births in 2018 [3]. Second, it is known for high proportions of the population having religious affiliation and engagement in religious practices [8]. Third, in many African countries, the majority of the population are affiliated with one or the other of the world's two largest religions, Christianity and Islam [9]. Also, folk religious practices are reported by about 3% of the population in SSA countries [10]. This group, however, is often omitted in surveys and in several countries respondents may have more than one affiliation and fail to report folk practices. [11].

In the present analyses, we investigated whether immunization coverage varied according to religious affiliation in SSA countries with recent survey data. We also investigated whether religion might be associated with differential coverage for boys and girls.

2. Methods

2.1. Data sources

We used publicly available datasets from Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS) (https://www.dhsprogram.com/, http://mics.unicef.org). Both initiatives collect nationally representative data from probability multi-stage samples of households in low- and middle-income countries (LMICs). Within selected households, all women of reproductive age (15–49 years) provided information about their households, themselves and their children. The surveys use comparable methodologies for data collection and similar questionnaires that allow comparisons across countries. [12,13] We used the most recent data from each country carried out from 2010 onwards. Ethical clearance was the responsibility of the institutions that administered the surveys and all analyses relied on anonymized datasets.

2.2. Outcomes

The two outcomes under study were full immunization coverage and the proportion of unvaccinated children. Full immunization coverage was defined as the proportion of children aged 12–23 months who had received at any age the following vaccines: one dose of Bacille Calmette-Guérin (BCG), three doses of vaccine against diphtheria, pertussis, and tetanus (DPT) or tetravalent/pentavalent vaccine, three doses of polio vaccine, and one dose of measles vaccine (either as monovalent vaccine or as measles-containing vaccine combinations with other immunogens) [14]. Unvaccinated children were those in the same age range who had not received any of the four vaccines listed above. Children with missing data were treated as not having received the intervention (a conservative assumption) and we did not use imputation for missing values.

2.3. Main exposure

Information on religious affiliation was obtained from country-specific questions in the individual or household questionnaire, depending on the type of survey. The original variable on a woman's religion (from DHS datasets) or religion of the head of household (from MICS) was recoded into eight groups according to Pew Forum on Religion and Public Life classification: Buddhist, Christian, Folk and traditional religions, Hindu, Jewish, Muslim, Unaffiliated, and Other [10]. The categories from the original variables allocated to each group are shown in the Supplementary Material. For the MICS databases, the affiliation was defined for the household and attributed to each woman in the household at the individual level. In the analysis, we included countries with at least 10% of the women's sample in each group of Christians and Muslims; when a third religion accounted for 10% or more of the sample, it was also included in the analyses.

2.4. Explanatory variables

Multivariable analyses considered the differences between religious groups in terms of wealth, urban-rural residence and women's education. Wealth quintiles were derived using principal component analyses of household assets and building characteristics in each country; the first quintile represents the poorest 20% of households, and the fifth quintile the wealthiest 20% in the survey sample [15,16]. Urban and rural residence was defined by each country at the time of the survey. Women's education was classified as none, primary, and secondary or higher.

2.5. Analysis

The major religious groups were described in terms of their distribution of wealth, residence, and women's education at the country-level. We calculated point estimates, standard errors and confidence intervals for the outcomes by religious group and child sex in each country. The results are presented as ratios and Pearson's chi-squared test was used to test differences across religious groups and sex. A series of country-specific Poisson regression models with robust variance were used to assess whether each of the two outcomes varied according to religion, with and without adjustment for wealth, residence and education [17]. Interactions between sex and religion were investigated in the regression models. Using Pearson's coefficient of correlation, we also tested the linear association between adjusted ratios (Muslim-to-Christian prevalence) for both outcomes and the proportion of Muslim women in the national samples. All analyses accounted for the multi-stage survey design, including sampling weights and clustering, using complex survey analysis functions of Stata® SE version 15 (StataCorp LP, College Station, Texas, United States), which allow robust variance estimates [18].

3. Results

Of the 50 SSA countries, 24 have had a DHS or MICS since 2010. Of these, 15 (10 DHS and 5 MICS) had information on vaccine coverage and included at least 10% of the sample respondents affiliated with Christian religion, and another 10% or more with Muslim religion. The median survey year was 2014. Table 1 describes the distribution of religions by country. Christians were the largest group in nine of the 15 countries. The proportions of survey respondents who were Christian ranged from 21.2% in Sierra Leone to 86.9% in Malawi, whereas Muslims ranged from 10.9% in Liberia to 78.5% in Sierra Leone. Folk and traditional religions were included in the analysis for four countries, namely Benin (16.3%), Guinea Bissau (17.7%), Mozambique (12.2%), and Togo (14.3%).

The Supplementary Material (Table S2 and Figures S1) show the distributions of wealth, urban/rural residence, and educational attainment by religious group in each country. In general, Christian women and their families were wealthier, more educated and more urban. For all countries but Uganda, higher proportions of women with at least secondary education were Christians. In Chad and Liberia, Muslim women were richer, and in Uganda, Muslims were richer, more educated, and more urban. In the four countries where Folk religion is common, this group was disadvantaged compared to the other two, except for Mozambique where the least advantaged group was Muslim.

The average proportion of fully immunized children in all countries studied was 58.9%, ranging from 24.2% in Nigeria to 81.3% in Burkina Faso. Table 2 and Fig. 1a show that coverage among Christians was higher than for Muslims in 11 countries, in nine of which the differences were statistically significant. In four countries Muslims had higher coverage than Christians, of which two were significant (Liberia and Mozambique). Considering Folk religions, we found lower vaccination rates in Guinea-Bissau and Togo among this group in comparison to both Christian and Muslim categories, however, the rate was statistically significant only for Togo.

The average proportion of unvaccinated children in all countries studied was 8.1%, ranging from 1.3% in Uganda to 40.0% in Nigeria (Table 2 and Fig. 1b). In six of the 15 countries, there were significant differences according to religion. In all of these six countries, Muslim children were at higher risk of not receiving any vaccines, with ratios of unvaccinated children (Muslim/Christian) ranging from 1.87 in Ethiopia to 9.78 in Guinea-Bissau. In the six countries with the highest proportions of unvaccinated children, this was largely due to lack of immunizations among Muslims (Fig. 1b). Folk groups had significantly higher proportions of unvaccinated children than Christians in three countries, namely Benin, Guinea-Bissau, and Togo (Table 2 and Fig. 1b). In Benin, the Muslim group had a higher prevalence, compared to both Christians and Folk. In contrast, the estimates were significantly higher for Folk affiliates in Togo compared to the other two groups. No significant differences between Folk and Muslim groups were found in Guinea-Bissau. Mozambique, the fourth country with expressive proportion of Folk affiliates, did not presented any differences among the religious groups.

We also analyzed how coverage of the four separate vaccines varied according to religion (Supplementary Table S3). These patterns were very similar to those for full immunization coverage, suggesting that any differences between religious groups were not due to a particular vaccine. Coverage for BCG vaccine was not statistically associated with religion in three countries (Liberia, Mozambique, and Uganda) for which there was an association with full coverage, possibly because this vaccine is given soon after birth and does not require visiting a facility.

The results of Poisson regression models are presented in Fig. 2 and in Supplementary Table S4. Full adjustment for women's education, wealth, and urban/rural residence did not modify the results for most countries. Of the nine countries with significantly higher immunization coverage among Christians compared to Muslims in the crude analyses, seven remained significant. In Cameroon and Guinea-Bissau, the adjustment removed the effect of religion on vaccination coverage. Burkina Faso was the only country in which higher coverage among Christians became significant after adjustment. The difference was still significant for the two countries where Muslims had significantly higher unadjusted coverage. In Togo, Muslims had significantly higher coverages than both Christians and Folks. We performed a test of heterogeneity for the pooled prevalence ratios and found an I^2 statistic of 92.5% (p value < 0.001) for the Muslim-Christian comparison and 14.8% ($p = 0.318$) for the Folk-Christian, suggesting greater heterogeneity across countries for the first paired comparison, but more homogeneity for the second.

Controlling for socio-demographic variables had some influence on the estimated associations between religious group and unvaccinated children. For the six countries with crude differences between Muslim and Christians, the association remained significant after full adjustment, but in four (Benin, Chad, Ethiopia, and Nigeria), there was substantial attenuation of the ratio, reducing the magnitude of the inequality. In Uganda, the difference became significant after adjustment, with a higher risk for Muslim children. Again, we found heterogeneity across countries for the Muslim-Christian comparison, but not for Folk-Christian ratios, with I^2 statistics of 76.7% ($p < 0.001$) and 8.5% ($p = 0.351$), respectively.

In a set of ecological analyses, countries with higher proportions of Muslim women showed lower adjusted ratios for full vaccine coverage (Pearson's $r = -0.466$, $p = 0.080$), indicating that the higher the Muslim population in a given country, lower the immunization coverage of Muslim children compared to Christians, and higher ratios for unvaccinated children ($r = 0.358$; $p = 0.189$). National

Table 1
Distribution of religious groups, by country.

Country	Year	Source	Christian	Muslim	Folk	Other	Unaffiliated	Largest group
Benin	2014	MICS	**50.7%**	**26.9%**	**16.3%**	0.7%	5.4%	Christian
Burkina Faso	2010	DHS	**30.0%**	**61.8%**	7.4%	0.0%	0.9%	Muslim
Cameroon	2014	MICS	**69.8%**	**21.7%**	3.6%	1.4%	3.5%	Christian
Chad	2014	DHS	**44.4%**	**52.5%**	0.3%	0.0%	2.9%	Muslim
Côte d'Ivoire	2016	MICS	**41.0%**	**44.6%**	6.0%	0.7%	7.7%	Muslim
Ethiopia	2016	DHS	**67.5%**	**31.2%**	0.8%	0.6%	–	Christian
Ghana	2014	DHS	**80.2%**	**15.2%**	2.0%	0.0%	2.7%	Christian
Guinea-Bissau	2014	MICS	**31.5%**	**46.8%**	**17.7%**	0.6%	3.4%	Muslim
Liberia	2013	DHS	**86.2%**	**10.9%**	0.5%	0.0%	2.5%	Christian
Malawi	2015	DHS	**86.9%**	**12.5%**	–	0.1%	0.5%	Christian
Mozambique	2015	DHS	**60.4%**	**18.9%**	**12.2%**	2.0%	6.5%	Christian
Nigeria	2016	MICS	**40.4%**	**58.6%**	0.8%	0.1%	0.0%	Muslim
Sierra Leone	2013	DHS	**21.2%**	**78.5%**	0.0%	0.2%	0.1%	Muslim
Togo	2013	DHS	**60.7%**	**17.0%**	**14.3%**	0.1%	7.9%	Christian
Uganda	2016	DHS	**86.2%**	**12.9%**	0.0%	0.8%	0.1%	Christian

Note: in bold groups larger than 10%.

Table 2
Percentage of children fully immunized and unvaccinated at national level and by religious group.

Country	National			Christian			Muslim			Folk			Ratio Muslim/Christian	Ratio Folk/Christian	Ratio Folk/Muslim
	Percentage	95%CI	N	Percentage	95%CI	N	Percentage	95%CI	N	Percentage	95%CI	N			
							Full immunization								
Benin	58.1%	(55.2%;61.0%)	2.439	62.9%	(59.3%;66.5%)	1.229	51.0%	(45.4%;56.5%)	735	55.4%	(48.2%;62.5%)	329	0.81 a	0.88	1.09
Burkina Faso	81.3%	(79.3%;83.4%)	2.791	85.0%	(81.8%;88.2%)	757	81.1%	(78.5%;83.7%)	1.741				0.95		
Cameroon	77.5%	(74.5%;80.6%)	1.389	82.5%	(79.4%;85.6%)	961	70.9%	(62.9%;79.0%)	318				0.86 a		
Chad	25.7%	(22.7%;28.6%)	2.880	37.6%	(32.5%;42.7%)	1.011	13.6%	(11.3%;16.0%)	1.770				0.36 a		
Côte d'Ivoire	44.9%	(41.1%;48.7%)	1.750	56.2%	(49.9%;62.4%)	540	40.3%	(35.9%;44.7%)	851				0.72 a		
Ethiopia	38.6%	(34.5%;42.8%)	1.929	48.2%	(43.0%;53.4%)	968	26.5%	(20.4%;32.5%)	921				0.55 a		
Ghana	78.2%	(74.6%;81.8%)	1.128	78.6%	(74.3%;82.8%)	806	80.3%	(73.5%;87.1%)	233				1.02		
Guinea-Bissau	69.6%	(65.6%;73.6%)	1.581	75.3%	(68.9%;81.7%)	322	68.2%	(62.9%;73.4%)	786	67.3%	(59.5%;75.0%)	390	0.91 a	0.89	0.99
Liberia	54.8%	(50.9%;58.8%)	1.433	53.9%	(49.8%;58.1%)	1.216	70.7%	(59.7%;81.8%)	163				1.31b		
Malawi	76.5%	(74.4%;78.6%)	3.248	77.2%	(74.9%;79.5%)	2.736	72.5%	(68.0%;77.1%)	488				0.94		
Mozambique	66.5%	(62.3%;70.8%)	1.029	63.9%	(58.3%;69.5%)	581	76.9%	(68.9%;84.9%)	182	67.9%	(60.0%;75.8%)	159	1.20b	1.06	0.88
Nigeria	24.2%	(22.3%;26.0%)	5.377	41.6%	(38.6%;44.7%)	2.152	15.9%	(13.8%;18.1%)	3.178				0.38 a		
Sierra Leone	68.4%	(65.2%;71.6%)	2.090	74.1%	(68.4%;79.8%)	387	67.4%	(63.9%;70.9%)	1.694				0.91 a		
Togo	61.5%	(57.5%;65.4%)	1.404	64.0%	(59.6%;68.4%)	688	70.2%	(64.2%;76.1%)	299	49.1%	(39.8%;58.3%)	293	1.10	0.77 a	0.70b
Uganda	57.3%	(55.0%;59.7%)	2.922	59.0%	(56.7%;61.3%)	2.492	48.3%	(41.8%;54.9%)	397				0.82 a		
							Unvaccinated children								
Benin	8.8%	(7.0%;10.6%)	2.439	4.4%	(3.0%;5.9%)	1.229	16.4%	(11.4%;21.3%)	735	9.1%	(5.2%;12.9%)	329	3.69b	2.05c	0.55b
Burkina Faso	1.8%	(1.1%;2.5%)	2.791	1.7%	(0.4%;2.9%)	757	1.2%	(0.5%;1.9%)	1.741				0.75		
Cameroon	2.5%	(1.4%;3.5%)	1.389	2.0%	(0.8%;3.1%)	961	1.6%	(0.4%;2.8%)	318				0.81		
Chad	18.6%	(16.5%;20.7%)	2.880	5.2%	(3.6%;6.7%)	1.011	32.5%	(29.2%;35.8%)	1.770				6.29b		
Côte d'Ivoire	12.0%	(9.9%;14.2%)	1.750	6.1%	(3.8%;8.5%)	540	13.4%	(10.0%;16.7%)	851				2.18b		
Ethiopia	16.5%	(13.5%;19.4%)	1.929	12.4%	(8.9%;15.9%)	968	23.2%	(18.1%;28.2%)	921				1.87b		
Ghana	1.6%	(0.7%;2.5%)	1.128	1.5%	(0.5%;2.6%)	806	1.6%	(0.0%;3.8%)	233				1.03		
Guinea-Bissau	2.9%	(1.9%;3.9%)	1.581	0.4%	(0.0%;1.3%)	322	4.3%	(2.6%;6.1%)	786	2.4%	(0.7%;4.2%)	390	9.78b	5.54c	0.57
Liberia	1.5%	(0.8%;2.3%)	1.433	1.6%	(0.7%;2.6%)	1.216	0.4%	(0.0%;1.1%)	163				0.22		
Malawi	1.6%	(1.0%;2.2%)	3.248	1.6%	(1.0%;2.3%)	2.736	1.5%	(0.2%;2.8%)	488				0.93		
Mozambique	5.0%	(2.6%;7.4%)	1.029	4.7%	(1.9%;7.5%)	581	3.7%	(0.0%;7.7%)	182	8.1%	(2.1%;14.1%)	159	0.80	1.73	2.17
Nigeria	40.0%	(37.6%;42.3%)	5.416	17.0%	(14.8%;19.3%)	2.169	50.9%	(47.7%;54.2%)	3.196				3.00b		
Sierra Leone	3.5%	(2.3%;4.6%)	2.090	2.0%	(0.5%;3.6%)	387	3.5%	(2.4%;4.7%)	1.694				1.74		
Togo	3.6%	(2.3%;5.0%)	1.404	1.8%	(0.7%;2.9%)	688	2.5%	(0.7%;4.3%)	299	8.9%	(4.2%;13.7%)	293	1.41	5.04c	3.58c
Uganda	1.3%	(0.8%;1.8%)	2.922	1.2%	(0.7%;1.7%)	2.492	2.2%	(0.7%;3.8%)	397				1.92		

[a]Higher percentage among Christians (p value < 0.05 based on crude Poisson regression models).
[b]Higher percentage among Muslims (p < 0.05).
[c]Higher percentage among Folk practitioners (p < 0.05).

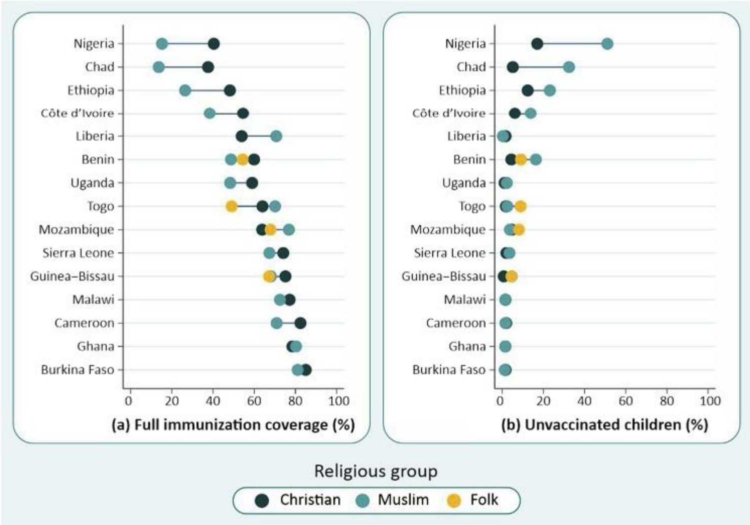

Fig. 1. (a) Full immunization coverage and (b) unvaccinated children, by religious group. Countries are ranked by national full immunization coverage.

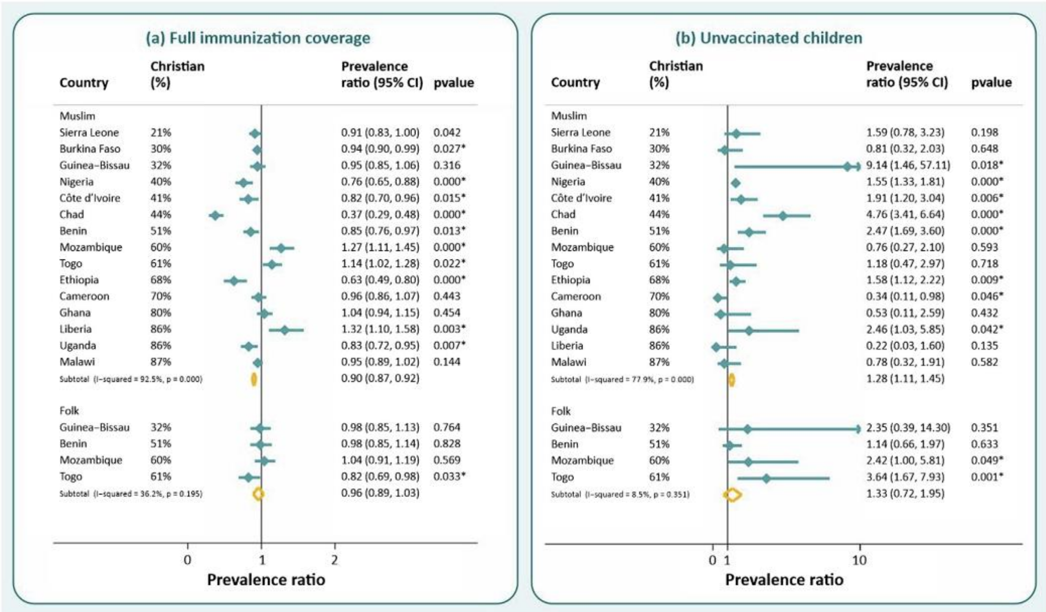

Fig. 2. Coverage ratios adjusted for wealth, area of residence and education, and correspondent 95% confidence intervals for (a) full immunization coverage and (b) unvaccinated children from Muslim and Folk (when available) families compared to Christian, by country. Countries are ranked by proportion of Christian population.

immunization coverage was also directly associated with the adjusted ratios ($r = 0.609$; $p = 0.016$). In contrast, there was no such association between national coverage and the adjusted ratio for unvaccinated children ($r = 0.079$; $p = 0.779$).

Sex of the child was not found to consistently affect the likelihood of being vaccinated or not receiving any vaccine when the full national samples were studied (Table 3). In seven of the 15 countries, immunization coverage appeared to be higher among boys,

Table 3
Percentage of children fully immunized and unvaccinated, by sex.

Country	Boys			Girls			Sex ratio boys/girls	p value#
	Percentage	95%CI	N	Percentage	95%CI	N		
Full immunization								
Benin	59.6%	(55.9%;63.3%)	1.208	56.7%	(53.2%;60.2%)	1.231	1.05	0.201
Burkina Faso	82.1%	(79.5%;84.7%)	1.394	80.6%	(78.0%;83.3%)	1.397	1.02	0.388
Cameroon	76.1%	(72.3%;79.9%)	729	79.2%	(74.9%;83.5%)	660	0.96	0.241
Chad	25.4%	(22.0%;28.9%)	1.461	25.9%	(22.1%;29.7%)	1.419	0.98	0.823
Côte d'Ivoire	45.4%	(40.5%;50.3%)	896	44.4%	(39.8%;49.1%)	854	1.02	0.757
Ethiopia	36.5%	(31.0%;42.0%)	946	40.5%	(35.3%;45.7%)	983	0.90	0.250
Ghana	79.3%	(75.1%;83.5%)	577	77.1%	(72.5%;81.7%)	551	1.03	0.416
Guinea-Bissau	69.4%	(65.3%;73.6%)	816	69.7%	(63.8%;75.6%)	766	1.00	0.927
Liberia	52.9%	(47.9%;58.0%)	736	56.9%	(51.0%;62.8%)	697	0.93	0.320
Malawi	75.9%	(73.1%;78.7%)	1.622	77.1%	(74.4%;79.8%)	1.626	0.98	0.522
Mozambique	68.8%	(63.1%;74.5%)	491	64.3%	(58.4%;70.2%)	538	1.07	0.257
Nigeria	23.9%	(21.7%;26.2%)	2.653	24.4%	(21.7%;27.0%)	2.724	0.98	0.795
Sierra Leone	68.4%	(64.7%;72.1%)	1.016	68.4%	(64.0%;72.8%)	1.074	1.00	0.998
Togo	63.9%	(59.1%;68.7%)	720	59.0%	(54.2%;63.8%)	684	1.08	0.082
Uganda	58.4%	(55.6%;61.2%)	1.496	56.2%	(53.0%;59.5%)	1.426	1.04	0.278
Unvaccinated children								
Benin	8.4%	(6.1%;10.6%)	1.208	9.1%	(6.9%;11.4%)	1.231	0.92	0.578
Burkina Faso	1.6%	(0.8%;2.3%)	1.394	2.1%	(1.0%;3.1%)	1.397	0.74	0.338
Cameroon	2.6%	(1.0%;4.3%)	729	2.3%	(0.9%;3.6%)	660	1.16	0.739
Chad	17.4%	(14.9%;20.0%)	1.461	19.8%	(17.1%;22.5%)	1.419	0.88	0.143
Côte d'Ivoire	11.9%	(9.2%;14.6%)	896	12.2%	(9.2%;15.1%)	854	0.98	0.883
Ethiopia	16.8%	(13.2%;20.4%)	946	16.1%	(12%;20.2%)	983	1.04	0.790
Ghana	2.0%	(0.4%;3.6%)	577	1.2%	(0.4%;2.1%)	551	1.63	0.361
Guinea-Bissau	2.6%	(1.2%;4.0%)	816	3.2%	(1.8%;4.7%)	766	0.81	0.540
Liberia	2.2%	(0.8%;3.7%)	736	0.8%	(0.3%;1.2%)	697	2.87 a	0.016 *
Malawi	1.4%	(0.8%;2.1%)	1.622	1.7%	(0.9%;2.6%)	1.626	0.82	0.534
Mozambique	5.1%	(1.7%;8.5%)	491	4.9%	(2.6%;7.3%)	538	1.03	0.926
Nigeria	39.8%	(36.8%;42.7%)	2.668	40.2%	(37.1%;43.4%)	2.748	0.99	0.815
Sierra Leone	3.8%	(2.3%;5.3%)	1.016	3.2%	(1.9%;4.5%)	1.074	1.17	0.483
Togo	4.6%	(2.6%;6.6%)	720	2.7%	(1.1%;4.2%)	684	1.71	0.123
Uganda	1.1%	(0.6%;1.7%)	1.496	1.5%	(0.7%;2.3%)	1.426	0.75	0.450

[a]Percentage of boys significantly higher than girls.
\# p value for Pearson's chi-squared test.
* p value < 0.05.

but none of the differences were statistically significant. No country had significantly higher coverage for girls than for boys. For unvaccinated children, a significant sex difference was found only in Liberia where this was more common among boys than girls.

When examining sex differences within religious groups, a few significant differences were found (Table 4). Christian boys were less likely to be vaccinated than Christian girls in Cameroon. Regarding unvaccinated children, Christian girls were more likely not to be vaccinated than Christian boys in Burkina Faso, while in Liberia the proportion was higher among Christians boys. In total, eight significant differences were found in 68 independent comparisons by sex within religious group.

Formal tests of interaction between child sex and religion were carried out for all crude and adjusted comparisons. With a p-level of 0.10 we found four statistically significant results out of 39 independent comparisons (Table 4 and Supplementary Table S5).

The widest religious-group disparities were found in countries with low overall immunization coverage, namely Chad, Ethiopia and Nigeria, suggesting that the Muslim disadvantage was more evident in low-coverage countries (figures and coefficients of correlation are presented in the Supplementary Figure S3 and Table S6). Also, countries with higher proportions of Muslim population tended to show lower Muslim-Christian vaccination coverage ratios (Supplementary Table S6).

4. Discussion

The global health literature is remarkably scant on the role of religion in explaining social inequalities in health. Even SDG 17.18, which calls for disaggregated analyses of national performance, does not include religion as one of the suggested variables for monitoring inequalities. Yet, religion may affect health outcomes through direct influences on beliefs and values, or due to differential access to resources [8,19]. Religion may also contribute to improved mental health and health-related behaviors [20]. It is noteworthy, however, that epidemiological studies often treat religion solely as a confounding variable, without detailed examination of potential effects and their pathways [19,21]. In light of the importance of religion for health, it is rather surprising that data from national surveys have not been subjected to multi-country analyses of health inequalities. We have contributed to the lack of systematic, multi-country studies on religion and health-related behaviors by analyzing immunization coverage among African children from 15 countries in SSA where both Muslims and Christians comprised 10% or more of the survey sample.

Eighty four percent of the world's population is estimated to be affiliated to a religion, and Christian and Muslim faiths are the most common [11]. Sub-Saharan Africa is home to about 24% of all the Christians and 15% of all Muslims in the world [11]. The 15 countries included in the analyses account for 50% of the population in Sub-Saharan Africa, and have median values of 53% for Christian, 24% for Muslim and 3% for Folk affiliation, compared to 63%, 30% and 3% for the whole continent. Among the 19 countries with a survey that were not included, one (Guinea) did not provide information on vaccines, and the remaining had fewer than 10% of the sample in one of the two main groups (Christian and Muslim) [11].

Religious diversity leads to differences in life conditions. In our analyses, Muslim and Folk women were less urbanized, had lower formal education and were more likely to live in poverty than Christian women.

Table 4
Percentage of children full immunized and unvaccinated, by sex and religion.

Country	Religion	Boys			Girls			Sex ratio boys/girls	chi^2 p value	Interaction p value[#]	
		Percentage	95%CI	N	Percentage	95%CI	N			Unadjusted	Adjusted
					Full immunization						
Benin	Christian	63.8%	(59.0%;68.6%)	631	62.0%	(57.1%;66.8%)	598	1.03	0.559	..	..
	Muslim	52.8%	(45.6%;60.0%)	358	49.2%	(42.7%;55.8%)	377	1.07	0.385	0.674	0.908
	Folk	54.7%	(44.9%;64.5%)	145	55.9%	(47.1%;64.7%)	184	0.98	0.844	0.668	0.661
Burkina Faso	Christian	87.9%	(83.6%;92.2%)	366	82.3%	(78.0%;86.6%)	391	1.07	0.060	..	..
	Muslim	81.6%	(78.3%;85.0%)	876	80.6%	(77.1%;84.1%)	865	1.01	0.660	0.224	0.205
Cameroon	Christian	78.4%	(73.7%;83.0%)	497	87.1%	(83.4%;90.8%)	464	0.90b	0.003 [*]	..	..
	Muslim	74.9%	(66.3%;83.6%)	177	66.5%	(55.4%;77.6%)	141	1.13	0.152	0.020 [**]	0.015 [**]
Chad	Christian	37.8%	(32.1%;43.5%)	512	37.4%	(30.5%;44.3%)	499	1.01	0.920	..	..
	Muslim	12.5%	(9.6%;15.5%)	902	14.8%	(11.6%;17.9%)	868	0.85	0.261	0.339	0.517
Côte d'Ivoire	Christian	56.4%	(48.6%;64.2%)	273	55.9%	(48.2%;63.7%)	267	1.01	0.919	..	..
	Muslim	38.0%	(32.3%;43.8%)	438	42.6%	(36.4%;48.8%)	413	0.89	0.266	0.350	0.339
Ethiopia	Christian	46.2%	(39.1%;53.3%)	448	49.8%	(43.8%;55.8%)	520	0.93	0.364	..	..
	Muslim	25.1%	(17.0%;33.3%)	474	27.8%	(19.5%;36.0%)	447	0.91	0.639	0.913	0.953
Ghana	Christian	79.4%	(74.5%;84.2%)	413	77.7%	(72.4%;83.0%)	393	1.02	0.580	..	..
	Muslim	85.1%	(78.0%;92.2%)	120	75.5%	(64.6%;86.4%)	113	1.13	0.114	0.261	0.251
Guinea-Bissau	Christian	77.9%	(71.6%;84.2%)	174	72.0%	(60.8%;83.3%)	148	1.08	0.338	..	..
	Muslim	68.3%	(62.6%;73.9%)	411	68.1%	(60.6%;75.6%)	376	1.00	0.969	0.388	0.514
	Folk	64.2%	(53.8%;74.6%)	195	70.4%	(61.7%;79.2%)	195	0.91	0.277	0.154	0.285
Liberia	Christian	51.0%	(45.6%;56.4%)	624	57.0%	(50.6%;63.4%)	592	0.90	0.173	..	..
	Muslim	72.9%	(58.0%;87.9%)	84	68.1%	(52.0%;84.2%)	79	1.07	0.661	0.310	0.460
Malawi	Christian	76.6%	(73.6%;79.7%)	1.377	77.8%	(74.8%;80.9%)	1.359	0.98	0.556	..	..
	Muslim	71.2%	(64.2%;78.2%)	235	73.7%	(67.8%;79.6%)	253	0.97	0.595	0.793	0.863
Mozambique	Christian	67.8%	(60.1%;75.5%)	288	60.0%	(52.2%;67.7%)	293	1.13	0.146	..	..
	Muslim	75.9%	(64.4%;87.4%)	81	77.9%	(68.7%;87.0%)	101	0.97	0.769	0.244	0.379
	Folk	68.5%	(55.8%;81.2%)	70	67.4%	(55.9%;79.0%)	89	1.02	0.910	0.507	0.395
Nigeria	Christian	41.6%	(37.6%;45.6%)	1.063	41.7%	(37.8%;45.5%)	1.089	1.00	0.984	..	..
	Muslim	15.5%	(12.8%;18.2%)	1.561	16.3%	(13.0%;19.6%)	1.617	0.95	0.697	0.715	0.928
Sierra Leone	Christian	73.0%	(65.3%;80.6%)	189	75.2%	(67.3%;83.2%)	198	0.97	0.673	..	..
	Muslim	67.5%	(63.4%;71.7%)	824	67.3%	(62.6%;72.0%)	870	1.00	0.943	0.688	0.616
Togo	Christian	66.8%	(60.8%;72.8%)	341	61.4%	(55.6%;67.3%)	347	1.09	0.179	..	..
	Muslim	72.0%	(64.6%;79.4%)	168	67.7%	(58.0%;77.3%)	131	1.06	0.477	0.840	0.966
	Folk	48.5%	(38.1%;59.0%)	156	49.6%	(38.6%;60.7%)	137	0.98	0.844	0.407	0.563
Uganda	Christian	60.1%	(57.2%;62.9%)	1.264	57.9%	(54.5%;61.3%)	1.228	1.04	0.300	..	..
	Muslim	49.7%	(41.1%;58.3%)	214	46.7%	(37.7%;55.7%)	183	1.06	0.613	0.842	0.828
					Unvaccinated children						
Benin	Christian	3.7%	(2.0%;5.5%)	631	5.1%	(3.0%;7.3%)	598	0.73	0.281	..	..
	Muslim	17.0%	(10.8%;23.3%)	358	15.8%	(10.1%;21.4%)	377	1.08	0.713	0.261	0.140
	Folk	8.4%	(3.6%;13.2%)	145	9.6%	(3.8%;15.4%)	184	0.88	0.760	0.741	0.709
Burkina Faso	Christian	0.0%	(0.0%;0.0%)	366	3.3%	(0.8%;5.7%)	391	0.00b	0.012 [*]	..	..
	Muslim	1.4%	(0.5%;2.2%)	876	1.1%	(0.0%;2.3%)	865	1.20	0.765	0.000 [**]	–
Cameroon	Christian	2.0%	(0.3%;3.7%)	497	2.0%	(0.4%;3.6%)	464	0.99	0.990	..	..
	Muslim	1.4%	(0.1%;2.7%)	177	1.8%	(0.0%;3.8%)	141	0.79	0.748	0.809	0.794
Chad	Christian	4.6%	(2.9%;6.2%)	512	5.8%	(3.4%;8.2%)	499	0.79	0.368	..	..
	Muslim	31.1%	(26.8%;35.4%)	902	33.9%	(29.7%;38.1%)	868	0.92	0.296	0.592	0.735
Côte d'Ivoire	Christian	8.2%	(4.3%;12.0%)	273	4.1%	(1.7%;6.5%)	267	2.01	0.067	..	..
	Muslim	12.5%	(8.3%;16.6%)	438	14.3%	(9.7%;18.9%)	413	0.87	0.531	0.062 [**]	0.065 [**]
Ethiopia	Christian	11.5%	(7.1%;15.8%)	448	13.1%	(8.8%;17.5%)	520	0.87	0.525	..	..
	Muslim	24.4%	(18.4%;30.3%)	474	22.0%	(14.1%;30.0%)	447	1.11	0.643	0.439	0.446
Ghana	Christian	1.6%	(0.0%;3.4%)	413	1.5%	(0.4%;2.6%)	393	1.02	0.978	..	..
	Muslim	2.8%	(0.0%;7.1%)	120	0.4%	(0.0%;1.1%)	113	7.31	0.073	0.177	0.154
Guinea-Bissau	Christian	0.8%	(0.0%;2.4%)	174	0.0%	(0.0%;0.0%)	148	0.00	0.371	..	..
	Muslim	3.9%	(1.5%;6.3%)	411	4.8%	(2.4%;7.2%)	376	0.82	0.605	–	0.000 [**]
	Folk	1.6%	(0.0%;3.3%)	195	3.3%	(0.8%;5.8%)	195	0.49	0.208	–	0.000 [**]
Liberia	Christian	2.7%	(0.9%;4.4%)	624	0.6%	(0.1%;1.0%)	592	4.71 a	0.002 [*]	..	..
	Muslim	0.0%	(0.0%;0.0%)	84	0.8%	(0.0%;2.3%)	79	0.00	0.286	0.000 [**]	0.000 [**]
Malawi	Christian	1.2%	(0.6%;1.9%)	1.377	2.0%	(0.9%;3.0%)	1.359	0.62	0.179	..	..
	Muslim	2.5%	(0.2%;4.9%)	235	0.6%	(0.0%;1.8%)	253	4.14	0.170	0.109	0.110
Mozambique	Christian	3.8%	(0.3%;7.4%)	288	5.6%	(2.2%;8.9%)	293	0.69	0.428	..	..
	Muslim	6.1%	(0.0%;13.8%)	81	1.4%	(0.0%;3.4%)	101	4.32	0.101	0.069 [**]	0.112
	Folk	8.0%	(1.0%;14.9%)	70	8.3%	(0.6%;15.9%)	89	0.97	0.947	0.629	0.485
Nigeria	Christian	17.9%	(15.0%;20.9%)	1.063	16.1%	(13.1%;19.1%)	1.098	1.12	0.357	..	..
	Muslim	50.4%	(46.3%;54.5%)	1.561	51.5%	(47.1%;55.8%)	1.630	0.98	0.692	0.301	0.344
Sierra Leone	Christian	2.1%	(0.0%;4.5%)	189	2.0%	(0.0%;3.9%)	198	1.07	0.933	..	..
	Muslim	3.9%	(2.2%;5.5%)	824	3.2%	(1.8%;4.6%)	870	1.21	0.513	0.887	0.991

Table 4 (*continued*)

Country	Religion	Boys			Girls			Sex ratio boys/girls	chi^2 p value	Interaction p value#	
		Percentage	95%CI	N	Percentage	95%CI	N			Unadjusted	Adjusted
Togo	Christian	2.7%	(0.9%;4.4%)	341	0.9%	(0.0%;2.1%)	347	2.80	0.096	..	..
	Muslim	2.0%	(0.0%;4.1%)	168	3.1%	(0.1%;6.1%)	131	0.65	0.545	0.129	0.091**
	Folk	11.1%	(4.1%;18%)	156	6.7%	(0.3%;13.0%)	137	1.66	0.367	0.539	0.447
Uganda	Christian	0.9%	(0.3%;1.4%)	1.264	1.5%	(0.6%;2.3%)	1.228	0.60	0.239	..	..
	Muslim	2.5%	(0.4%;4.7%)	214	1.9%	(0.0%;4.3%)	183	1.34	0.711	0.374	0.324

[a]Percentage among boys significantly higher than among girls.
[b]Percentage among girls significantly higher than among boys.
* p value < 0.05 for chi-squared test.
** p value < 0.10 for interaction coefficient of Poisson regression model.
\# p value based on interaction test using Poisson regression models; references: Male and Christian categories.

Overall, the average proportion of fully vaccinated children in the 15 countries was only 58%, and unvaccinated children accounted for 8%. Yet, national averages often mask inequalities, and disaggregated analyses are essential. Most countries presented higher immunization coverage among children of Christian families compared to Muslim families, and a few showed higher coverage among Muslims. The widest religious-group disparities were found in countries with low overall immunization coverage, namely Chad, Ethiopia and Nigeria, suggesting that when coverage is high, both Christian and Muslim children are reached.

We tested the hypothesis that countries where Muslims constituted most of the population would show more favorable results for children from Muslim families than would be the case for countries where Muslims are a minority. Yet, our results were in the opposite direction (Supplementary Table S6), although the correlation was not significant (p value = 0.08 in the adjusted analyses). Further studies are needed to understand this apparent contradiction.

Our results on unvaccinated children were quite striking. Although significant differences were observed for fewer countries, Muslim children represented a substantial proportion of those who were not vaccinated in Chad, Ethiopia and Nigeria. Religious-group gaps were attenuated in several countries after adjustment for wealth, women's education and residence, but associations remained significant in most countries, and in a few cases (Burkina Faso and Togo for full immunization and Uganda for unvaccinated children) differences became significant only after adjustment.

The largest difference between crude and adjusted coefficients for immunization coverage was observed in Nigeria, where the Muslim-Christian prevalence ratio changed from 0.38 to 0.73, suggesting that much of the religious disparity in immunization in this country is associated with socioeconomic factors. The same patterns were observed for unvaccinated children in this country. Earlier studies found that 80% of non-immunized children in Nigeria were born to Muslim mothers, who are concentrated in the North of the country, the poorest region [22] known for being historically resistant to vaccination and other "Western" health interventions [23,24]. In early 2000s, polio vaccine was held by Muslim leaders as being used to sterilize young girls, which led to vaccine hesitancy and low coverage, with a resulting polio epidemic that spread to polio-free countries in Africa, Asia and the Middle- East [25].

Our analyses showed similar patterns for all vaccines, except possibly for BCG which is given soon after birth and may be less prone to parental hesitancy than vaccines given at later ages, which require contact with a health facility or worker.

Both unadjusted and adjusted analyses are of value. The former is useful for targeting interventions at specific population subgroups (in this case, Muslim children) who are being left behind, whatever the reasons for these disparities. Adjusted analyses are helpful to answer the question of the extent by which poverty, lack of parental education, and place of residence may account for gaps in coverage.

Lower immunization rates among certain religious groups has been found to be associated with factors such as limited access to social programs, marginalization, limited knowledge and perceptions of illness, and influence of religious leaders [26,27]. Further studies are needed to elucidate these mechanisms.

In addition to Nigeria, our literature review found that Muslim religion has been identified as a potential barrier to immunization coverage in Ethiopia [29] and in Chad [30], which along with Nigeria are the countries we identified with high proportions of unvaccinated Muslim children. Nevertheless, it has been argued that skepticism towards immunization by religious leaders are rooted less in faith-based beliefs than in health-related concerns that spread across social networks within religious communities [28,31]. Islamic groups in other countries also have concerns that some vaccines are not *halal*, and therefore could not be administered [32]. On the other hand, a multi-country study on vaccine confidence showed that Muslim faith itself is not always linked to low coverage, citing Saudi Arabia as an example, where 100% of the respondents were Muslim and there were few objections to vaccines [28]. It is worth noting, however, that Saudi Arabia is a very wealthy country where economic conditions may offset any potential resistance to vaccination [33]. In fact, involvement of Islamic and Christian leaders in the promotion of child survival interventions in Sierra Leone was linked to a marked increase in coverage in the 1980s [31]. Similar successful experiences also took place in Angola and India [31].

Our analyses of gender bias within the different religious groups, and of interactions between sex of the child and religious groups, failed to show any clear patterns. Thus, our analyses did not provide evidence of preferential treatment of boys, either overall or within each religious group. However, even in the absence of sex differences in the two outcomes, gender issues remain as important determinants of access to preventive and curative interventions for children. Gender equality, expressed in women's empowerment and decision-making power, is associated with better health outcomes for both their male and their female children [34,35]. Again, national averages may mask variations at geographic and other sociodemographic sublevels even within religious groups; thus, the results might be interpreted taking this limitation into account [36].

The strengths of the present analyses include the comparability of DHS and MICS in terms of nationally-representative sampling and health indicator definitions [13]. With 15 countries where the comparison between Christians and Muslims was possible, our analyses provide the largest set of results on within-country religious inequalities in child health.

Several limitations must be acknowledged. Using surveys to assess the impact of religious affiliation on health is challenging. Although both MICS and DHS collect information on religion, different questions are used, and we had to assume that religion of the woman being interviewed (DHS) and that of the head of the household (MICS) was the same. Also, as expected, the numbers and labels of religious affiliations vary markedly from country to country. Differences in the geographic distribution of religious groups within a country were not studied, and access to vaccines and providers vary according to geography [37]. We opted not to adjust P levels for multiple comparisons given that separate samples were studied in each country, and that appropriate meta-analytic techniques were used to pool results.

Heterogeneity within the main religious denominations – for example between mainstream Christians and evangelical churches – was not considered in our analyses, yet major differences may occur. However, given our objective of presenting a multi-country comparison, we needed to rely on broad, consistent denominations; our results may be interpreted as a weighted average of the different affiliations in each broad category [8]. Further disaggregation into various categories would reduce the number of observations in each, and except for very large surveys this would not be advisable due to loss of analytic power. Lastly, available data do not allow differentiation between affiliation and individual beliefs and practices, as the questionnaires do not include information on religious attendance or subjective views of the religion. In SSA, individuals who report Christian and Islamic affiliation may also incorporate elements of African traditional religions into their daily lives [9].

In spite of the limitations, this multi-country study provided new insights into understanding the role of religion in child health, answering the SDG 17.18 demand for disaggregated data analyses. Taking together the results from the 15 countries, we found lower immunization coverage among Muslims than Christians, a finding that persisted after adjustment for wealth, education and residence in nearly all countries. Only four countries had a substantial proportion of folk practitioners, and there were no consistent patterns for this group compared to the other two.

Religion cannot be understood as separate from the cultural, economic, and political spheres of life that determine gender bias and access to life-saving interventions. Nevertheless, our analyses suggest that religious-group disparities are only partly due to measurable sociodemographic differences, suggesting that discrimination or parental hesitancy, possibly magnified through social networks, may play an important role. Greater involvement of Muslim leaders in vaccine promotion has proven to be effective in earlier studies and may constitute an important strategy for reaching children who are not vaccinated in selected countries.

Further qualitative and quantitative research is needed to explore the inequalities across religious groups that were identified in the present analyses, by using more granular definitions of religious affiliation and collecting information on practices and beliefs. Incorporation of religion in stratified analyses of child health indicators is essential for supporting the *leave no one behind* agenda of the Sustainable Development Goals.

Ethics approval

Data used are from public sources of information and ethical approval has already been obtained by the institutions responsible in each country.

Author's contributions

JCC and CGV conceptualized the paper. JCC conducted the analyses, interpreted the results, and wrote the manuscript. CGV, GLD, SA, and AMW supervised the analysis, interpretation, and writing. All authors read and approved the final manuscript.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2019.11.024.

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Supplementary Material

Supplementary table S1 – Categories of the original variables recoded into eight religious groups, Demographic and Health Surveys and Multiple Indicator Cluster Surveys.

Country (Year) Source	Christian	Muslim	Folk	Other	Unaffiliated
Benin (2014) MICS	Catholique Protestant méthodist Autres protestants Céleste Autres chrétiens	Islam	Vodoun Autres traditionnelles	Autre religion	Pas de religion
Burkina Faso (2010) DHS	Catholic Protestant	Muslim	Traditional/animist	Other	No religion
Cameroon (2014) MICS	Catholique Protestant Autre chétien	Musulman	Animiste	Autre religion (non chrétien)	Pas de religion
Chad (2014) DHS	Catholic Protestant Other Christians	Muslim	Animist	Other	No religion
Côte d'Ivoire (2016) MICS	Catholique Evangélique Méthodiste Céleste Harriste Autre religion chrétienne	Musulman	Animiste	Autre religion	Pas de religion
Ethiopia (2016) DHS	Orthodox Catholic Protestant	Muslin	Traditional	Other	NA
Ghana (2014) DHS	Catholic Anglican Methodist Presbyterian Pentecostal/Charismatic Other Christian	Islam	Traditional/spiritualist	Other	No religion
Guinea-Bissau (2014) MICS	Católica Evangélico	Muçulmano	Anemista	Outra religião	Sem religião
Liberia (2013) DHS	Christian	Muslim	Traditional religion	Other	No religion
Malawi (2015) DHS	Christian CCAP Anglican Seventh Day Adventist / Baptist Other Christian	Muslim	NA	Other	No religion
Mozambique (2015) DHS	Catholic Protestant Evangelical/ Pentecostal Anglican	Islamic	Zion	Other	No religion
Nigeria (2016) MICS	Christianity	Islam	Traditional	Other religion	No religion
Sierra Leone (2013) DHS	Christian	Islam	Traditional	Bahai	None
Togo (2013) DHS	Catholic Evangelical Presbyterian Methodist Assembly of God Baptist Pentecotist Jeovah Witness Adventist Other Christian	Muslim	Traditional/ animist	Other	No religion
Uganda (2016) DHS	Anglican Catholic Seventh Day Adventist Orthodox Pentecostal/Born Again/ Evangelical Baptist Presbyterian Mammon Jeovah's Witness Salvation Army	Muslim	Traditional	Other	No religion

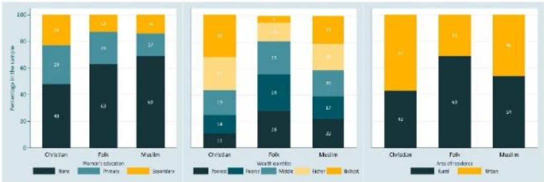
Supplementary table S2 – Distribution of education, wealth and residence according to religious groups, by country.

Country	Religion	Women's education				Wealth quintiles						Area of residence		
		None	Primary	Secondary+	p value#	Poorest	Poorer	Middle	Richer	Richest	p value#	Urban	Rural	p value#
Benin	Muslim	68.8%	16.9%	14.3%	<0.001*	21.9%	17.3%	19.7%	19.7%	21.4%	<0.001*	46.4%	53.7%	<0.001*
	Christian	48.1%	29.3%	22.6%		10.8%	14.1%	18.6%	24.7%	31.8%		56.7%	43.4%	
	Folk	63.3%	23.9%	12.8%		28.1%	27.6%	25.2%	14.2%	4.9%		31.4%	68.6%	
Burkina Faso	Muslim	78.9%	11.6%	9.4%	<0.001*	15.3%	18.0%	20.4%	21.8%	24.5%	<0.001*	26.0%	74.0%	<0.001*
	Christian	58.6%	19.7%	21.7%		15.8%	18.2%	16.1%	18.1%	32.0%		35.4%	64.6%	
Cameroon	Muslim	48.4%	31.4%	20.3%	<0.001*	21.1%	21.5%	22.5%	20.7%	14.2%	<0.001*	47.7%	52.3%	0.066
	Christian	9.7%	31.0%	59.3%		12.5%	15.8%	19.2%	23.1%	29.4%		57.4%	42.6%	
Chad	Muslim	83.7%	10.0%	6.4%	<0.001*	14.8%	17.2%	21.2%	23.3%	23.5%	<0.001*	25.8%	74.2%	0.392
	Christian	36.6%	37.9%	25.5%		23.4%	21.7%	17.9%	16.3%	20.7%		22.6%	77.4%	
Côte d'Ivoire	Muslim	20.0%	55.9%	24.1%	0.011*	13.7%	17.5%	22.3%	25.5%	21.0%	<0.001*	58.4%	41.6%	0.757
	Christian	20.4%	52.3%	27.3%		13.3%	14.7%	14.6%	21.7%	35.7%		59.5%	40.5%	
Ethiopia	Muslim	57.0%	35.3%	7.7%	<0.001*	23.0%	22.7%	20.9%	17.0%	16.4%	<0.001*	13.8%	86.2%	<0.001*
	Christian	42.9%	35.3%	21.8%		13.0%	15.8%	18.3%	21.3%	31.6%		26.4%	73.6%	
Ghana	Muslim	41.5%	18.3%	40.2%	<0.001*	27.0%	19.6%	17.1%	21.1%	15.3%	<0.001*	55.6%	44.5%	0.907
	Christian	13.0%	17.1%	69.9%		12.1%	16.7%	21.6%	23.6%	26.0%		54.9%	45.1%	
Guinea-Bissau	Muslim	54.6%	28.6%	16.8%	<0.001*	6.8%	22.5%	27.1%	22.5%	21.2%	<0.001*	45.6%	54.4%	<0.001*
	Christian	17.4%	29.8%	52.8%		11.5%	10.3%	10.1%	28.2%	39.9%		74.2%	25.8%	
	Folk	47.2%	38.1%	14.8%		53.1%	19.5%	12.6%	8.4%	6.4%		21.6%	78.4%	
Liberia	Muslim	52.8%	25.4%	21.8%	<0.001*	14.5%	19.0%	16.8%	19.4%	30.4%	0.379	53.8%	46.2%	0.219
	Christian	30.3%	31.5%	38.3%		16.8%	17.2%	19.2%	23.1%	23.8%		62.3%	37.7%	
Malawi	Muslim	23.7%	62.5%	13.8%	<0.001*	24.6%	21.6%	19.6%	17.9%	16.3%	<0.001*	13.0%	87.0%	0.005*
	Christian	10.2%	62.1%	27.6%		18.4%	18.7%	18.8%	19.3%	24.8%		19.1%	80.9%	
Mozambique	Muslim	32.0%	52.0%	16.0%	<0.001*	25.7%	23.1%	17.9%	19.4%	13.9%	<0.001*	40.3%	59.7%	0.134
	Christian	24.4%	50.0%	25.6%		19.4%	17.6%	16.6%	18.9%	27.6%		37.1%	62.9%	
	Folk	29.1%	58.4%	12.6%		10.5%	15.7%	24.8%	29.5%	19.6%		26.0%	74.0%	
Nigeria	Muslim	46.8%	19.0%	34.3%	<0.001*	24.8%	22.8%	20.3%	17.3%	14.8%	<0.001*	32.9%	67.1%	0.001*
	Christian	11.4%	20.3%	68.2%		7.1%	13.2%	18.4%	25.3%	36.1%		40.9%	59.1%	
Sierra Leone	Muslim	60.4%	14.4%	25.2%	<0.001*	19.6%	19.0%	20.3%	21.1%	20.1%	<0.001*	31.9%	68.1%	<0.001*
	Christian	38.5%	12.5%	49.0%		15.0%	15.7%	13.1%	17.7%	38.5%		49.5%	50.5%	
Togo	Muslim	39.7%	28.9%	31.4%	<0.001*	14.2%	13.2%	15.6%	27.4%	29.7%	<0.001*	54.4%	45.6%	<0.001*
	Christian	18.7%	36.4%	44.8%		9.4%	13.6%	18.1%	26.5%	32.5%		54.8%	45.2%	
	Folk	66.7%	26.3%	7.1%		43.9%	31.4%	18.8%	4.7%	1.3%		6.9%	93.1%	
Uganda	Muslim	7.5%	50.1%	42.4%	<0.001*	10.1%	15.0%	14.2%	22.0%	38.8%	<0.001*	36.0%	64.0%	<0.001*
	Christian	9.8%	58.5%	31.7%		18.7%	18.8%	19.2%	19.7%	23.7%		25.5%	74.5%	

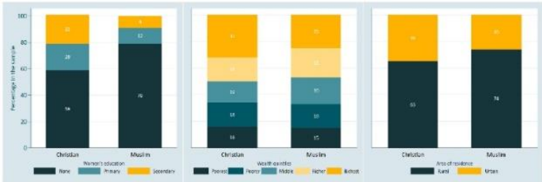
p values based on Pearson's chi-squared test, * p value < 0.05

Supplementary figures S1 – Distribution of educational attainment, wealth quintiles and urban/rural residence according to religious group, by country.

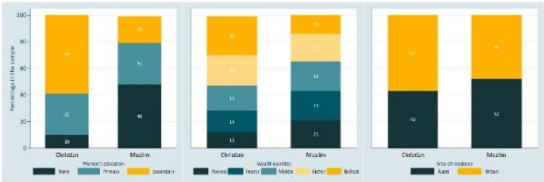
Benin



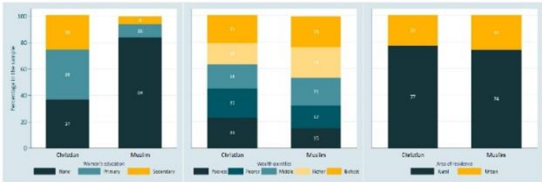
Burkina Faso



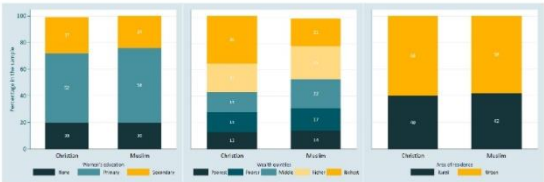
Cameroon



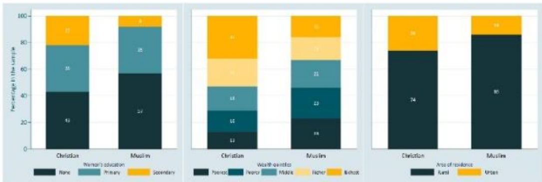
Chad



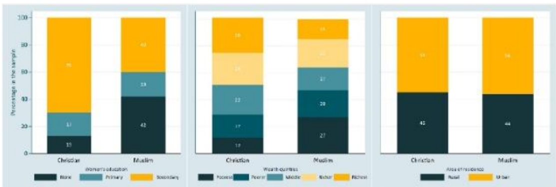
Côte d'Ivoire



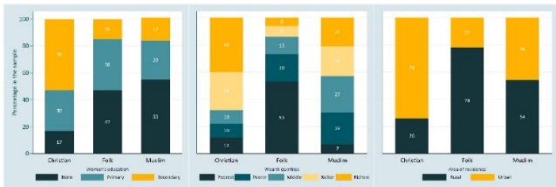
Ethiopia



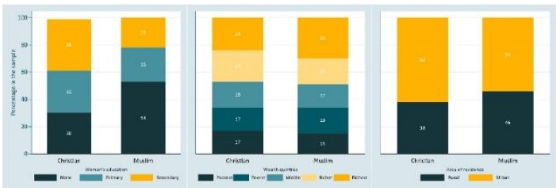
Ghana



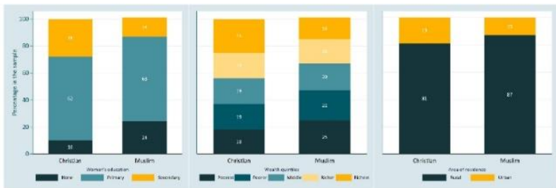
Guinea-Bissau



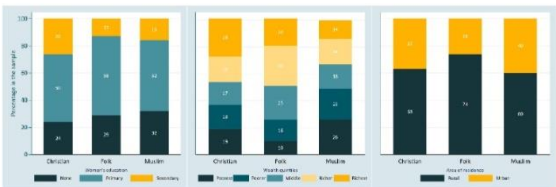
Liberia



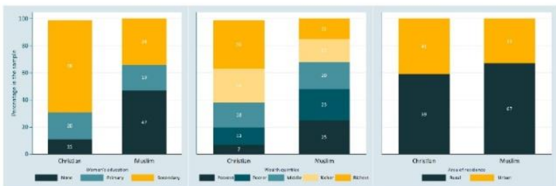
Malawi



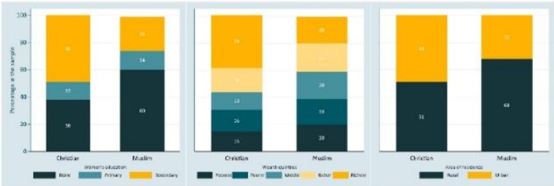
Mozambique



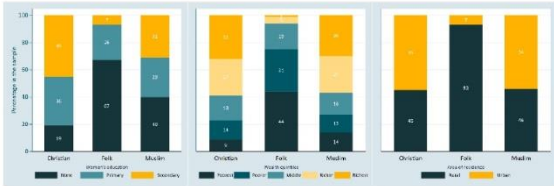
Nigeria



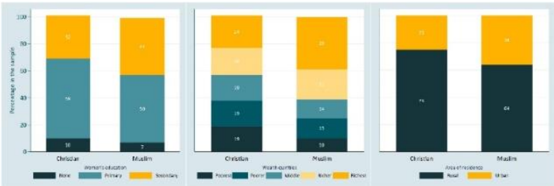
Sierra Leone



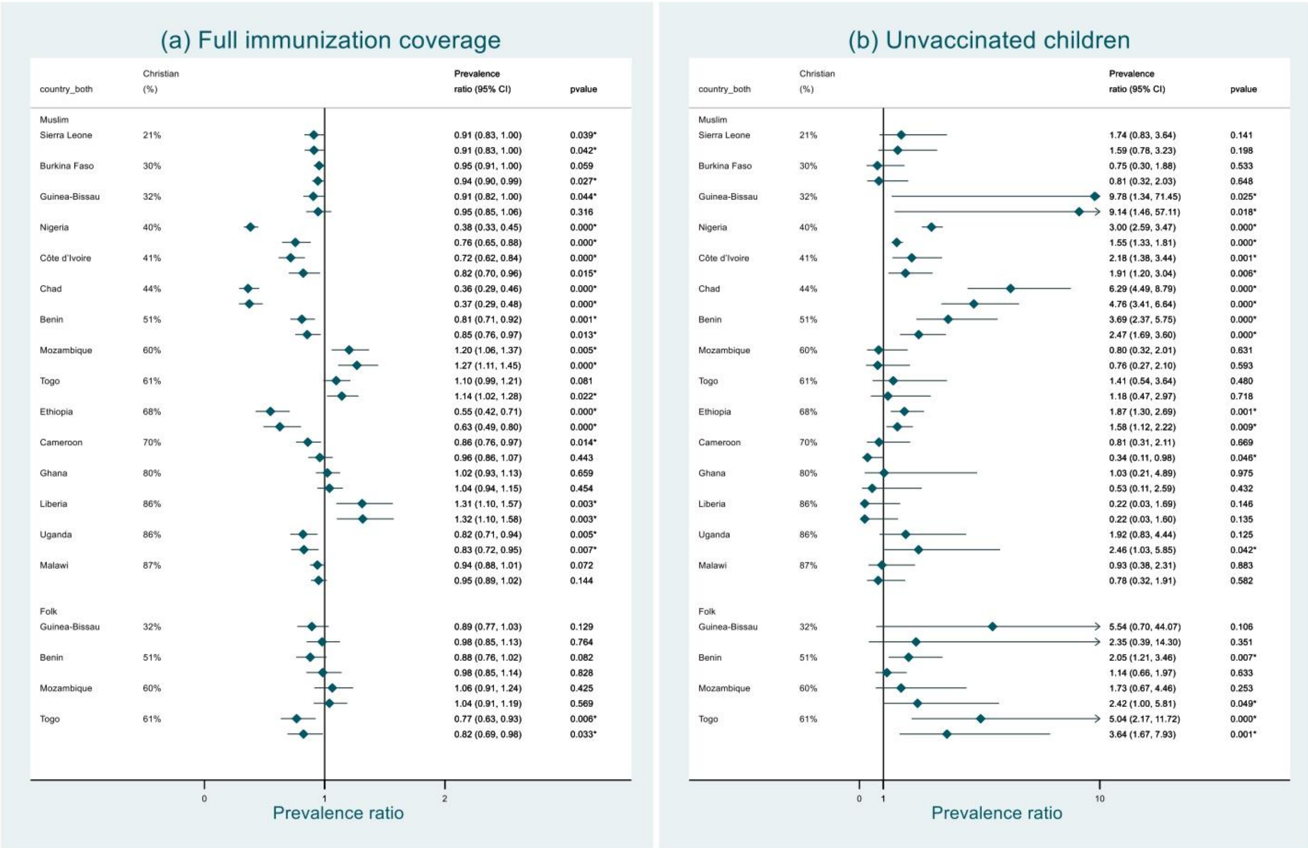
Togo



Uganda



Supplementary figure S2 – Crude and adjusted prevalence ratios (Muslim/Christian) for (a) full immunization coverage and (b) unvaccinated children by religious group, sorted by proportion of Christians in the population.



Supplementary table S3 – Crude and adjusted prevalence ratios from Poisson regression models for full immunization coverage, BCG, Polio, Measles, DPT, and percentage of unvaccinated children, by country.

Country	Full immunization		BCG		Polio		Measles		DPT		Unvaccinated	
	Crude	Adjusted #	Crude	Adjusted #	Crude	Adjusted #	Crude	Adjusted #	Crude	Adjusted #	Crude	Adjusted #
Benin	0.81 a	0.85 a	0.87 a	0.90 a	0.85 a	0.88 a	0.85 a	0.90 a	0.84 a	0.88 a	3.69 b	2.46 b
Burkina Faso	0.95	0.94 a	0.99	0.98	1.00	0.99	0.96 a	0.95 a	0.96	0.95 a	0.75	0.81
Cameroon	0.86 a	0.94	0.93 a	0.98	0.99	1.03	0.85 a	0.91	0.83 a	0.91	0.81	0.35 b
Chad	0.36 a	0.37 a	0.62 a	0.65 a	0.45 a	0.46 a	0.60 a	0.64 a	0.44 a	0.43 a	6.29 b	4.76 b
Côte d'Ivoire	0.72 a	0.79 a	0.89 a	0.89 a	0.88 a	0.89 a	0.78 a	0.84 a	0.79 a	0.84 a	2.18 b	2.02 b
Ethiopia	0.55 a	0.63 a	0.79 a	0.84 a	0.71 a	0.77 a	0.70 a	0.76 a	0.67 a	0.75 a	1.87 b	1.56 b
Ghana	1.02	1.04	0.99	1.01	1.06	1.08 b	0.96	0.99	1.04	1.07 b	1.03	0.54
Guinea-Bissau	0.91 a	0.94	0.97	0.98	0.94	0.94	0.93	0.95	0.93 a	0.95	9.78 b	9.16 b
Liberia	1.31 b	1.31 b	1.04	1.04 b	1.16	1.17 b	1.19 b	1.21 b	1.28 b	1.28 b	0.22b	0.23
Malawi	0.94	0.95	0.99	1.00	0.96	0.96	0.96 a	0.97	1.00	1.01	0.93	0.77
Mozambique	1.20 b	1.27 b	1.03	1.03	1.18 b	1.23 b	1.06	1.08 b	1.16 b	1.20 b	0.80	0.77
Nigeria	0.38 a	0.76 a	0.53 a	0.79 a	0.58 a	0.84 a	0.47 a	0.75 a	0.38 a	0.69 a	3.00 b	1.56 b
Sierra Leone	0.91 a	0.91 a	0.99	0.99	0.95	0.95	0.94	0.95	0.96	0.96	1.74	1.57
Togo	1.10	1.15 b	0.99	1.00	1.02	1.02	1.07	1.11 b	0.99	1.01	1.41	1.20
Uganda	0.82 a	0.83 a	0.98	0.98	0.84 a	0.86 a	0.89 a	0.87 a	0.93 a	0.93	1.92	2.46 b

[#] Full model adjusted for women's education, wealth quintiles, and urban/rural residence
[a] Higher prevalence among Christians (p value <0.05 based on crude Poisson regression models)
[b] Higher prevalence among Muslims (p <0.05)

Supplementary table S4 – Crude and adjusted ratios from Poisson regression models for full immunization coverage and percentage of unvaccinated children according to religious affiliation.

Country	Religion	Unadjusted				Women's education				Wealth quintiles				Urban/rural residence				Full adjustment[#]			
		Reference: Christian		Reference: Muslim		Reference: Christian		Reference: Muslim		Reference: Christian		Reference: Muslim		Reference: Christian		Reference: Muslim		Reference: Christian		Reference: Muslim	
		PR	p value	PR	p value	PR	p value	PR	p value	PR	p value	PR	p value	PR	p value	PR	p value	PR	p value	PR	p value
Full immunization coverage																					
Benin	Muslim	0.82[a]	0.00	××	××	0.84[a]	0.014	××	××	0.86[a]	0.02	××	××	0.82[a]	0.00	××	××	0.86[a]	0.02	××	××
	Folk	0.91	0.21	1.11	0.231	0.96	0.55	1.13	0.175	1.02	0.75	1.18	0.052	0.92	0.25	1.11	0.215	1.03	0.72	1.19[c]	0.046
Burkina Faso	Muslim	0.95	0.06	××	××	0.96	0.07	××	××	0.95	0.06	××	××	0.95[a]	0.03	××	××	0.94[a]	0.03	××	××
Cameroon	Muslim	0.86[a]	0.01	××	××	0.97	0.57	××	××	0.87[a]	0.02	××	××	0.9	0.06	××	××	0.95	0.32	××	××
Chad	Muslim	0.36[a]	<0.0001	××	××	0.41[a]	<0.0001	××	××	0.35[a]	<0.0001	××	××	0.34[a]	<0.0001	××	××	0.37[a]	<0.0001	××	××
Côte d'Ivoire	Muslim	0.70[a]	<0.0001	××	××	0.79[a]	0.01	××	××	0.69[a]	<0.0001	××	××	0.72[a]	<0.0001	××	××	0.80[a]	0.01	××	××
Ethiopia	Muslim	0.55[a]	<0.0001	××	××	0.60[a]	<0.0001	××	××	0.57[a]	<0.0001	××	××	0.61[a]	<0.0001	××	××	0.63[a]	<0.0001	××	××
Ghana	Muslim	1.02	0.66	××	××	1.04	0.51	××	××	1.02	0.66	××	××	1.02	0.74	××	××	1.04	0.49	××	××
Guinea Bissau	Muslim	0.90[a]	0.03	××	××	0.98	0.73	××	××	0.88[a]	0.01	××	××	0.91[a]	0.05	××	××	0.94	0.31	××	××
	Folk	0.89	0.12	0.99	0.882	0.96	0.59	0.98	0.759	0.96	0.52	1.09	0.253	0.91	0.15	0.99	0.969	0.98	0.83	1.04	0.56
Liberia	Muslim	1.31[b]	0.00	××	××	1.34[b]	0.00	××	××	1.32[b]	0.00	××	××	1.26[b]	0.01	××	××	1.31[b]	0.00	××	××
Malawi	Muslim	0.94	0.07	××	××	0.95	0.14	××	××	0.94	0.06	××	××	0.94	0.09	××	××	0.95	0.15	××	××
Mozambique	Muslim	1.20[b]	0.01	××	××	1.25[b]	0.00	××	××	1.23[b]	0.00	××	××	0.95	0.44	××	××	1.27[b]	<0.0001	××	××
	Folk	1.06	0.43	0.88	0.133	1.1	0.21	0.88	0.111	1.03	0.67	0.83[b]	0.042	1.17[c]	0.01	0.91	0.262	1.03	0.63	0.81[b]	0.015
Nigeria	Muslim	0.37[a]	<0.0001	××	××	0.75[a]	0.00	××	××	0.41[a]	<0.0001	××	××	0.57[a]	<0.0001	××	××	0.73[a]	<0.0001	××	××
Sierra Leone	Muslim	0.91[a]	0.04	××	××	0.92	0.09	××	××	0.90[a]	0.03	××	××	0.89[a]	0.02	××	××	0.91[a]	0.04	××	××
Togo	Muslim	1.1	0.08	××	××	1.16[b]	0.01	××	××	1.09	0.12	××	××	1.09	0.09	××	××	1.15[b]	0.02	××	××
	Folk	0.77[a]	0.01	0.70[b]	0.001	0.86	0.10	0.74[b]	0.003	0.78[a]	0.01	0.72[b]	0.001	0.79[a]	0.01	0.72[b]	0.002	0.85	0.06	0.73[b]	0.002
Uganda	Muslim	0.82[a]	0.01	××	××	0.82[a]	0.00	××	××	0.82[a]	0.01	××	××	0.82[a]	0.01	××	××	0.83[a]	0.01	××	××
Unvaccinated children																					
Benin	Muslim	3.69	0.00	××	××	2.95	0.00	××	××	2.68	0.00	××	××	3.58	0.00	××	××	2.46	0.00	××	××
	Folk	2.05	0.01	0.55	0.00	1.63	0.07	0.55	0.02	1.20	0.50	0.45	0.00	1.95	0.02	0.54	0.02	1.14	0.64	0.46	0.00
Burkina Faso	Muslim	0.75	0.53	××	××	0.66	0.37	××	××	0.89	0.80	××	××	0.74	0.53	××	××	0.81	0.66	××	××

Country	Religion	Unadjusted				Women's education				Wealth quintiles				Urban/rural residence				Full adjustment[#]			
		Reference: Christian		Reference: Muslim		Reference: Christian		Reference: Muslim		Reference: Christian		Reference: Muslim		Reference: Christian		Reference: Muslim		Reference: Christian		Reference: Muslim	
		PR	p value	PR	p value	PR	p value	PR	p value	PR	p value	PR	p value	PR	p value	PR	p value	PR	p value	PR	p value
Cameroon	Muslim	0.81	0.67	××	××	0.33	0.05	××	××	0.59	0.31	××	××	0.75	0.57	××	××	0.35	0.06	××	××
Chad	Muslim	6.29	0.00	××	××	4.14	0.00	××	××	6.83	0.00	××	××	6.74	0.00	××	××	4.76	0.00	××	××
Côte d'Ivoire	Muslim	2.18	0.00	××	××	1.75	0.02	××	××	2.16	0.00	××	××	2.33	0.00	××	××	2.02	0.00	××	××
Ethiopia	Muslim	1.87	0.00	××	××	1.74	0.00	××	××	1.61	0.01	××	××	1.76	0.00	××	××	1.56	0.01	××	××
Ghana	Muslim	1.03	0.98	××	××	0.57	0.51	××	××	0.84	0.84	××	××	1.03	0.98	××	××	0.54	0.45	××	××
Guinea Bissau	Muslim	9.78	0.03	××	××	6.24	0.03	××	××	11.08	0.02	××	××	7.16	0.05	××	××	9.16	0.02	××	××
	Folk	5.54	0.11	0.57	0.03	3.80	0.14	0.61	0.22	2.64	0.33	0.24	0.00	3.30	0.24	0.46	0.05	2.37	0.35	0.26	0.00
Liberia	Muslim	0.22	0.15	××	××	0.17	0.10	××	××	0.26	0.20	××	××	0.21	0.13	××	××	0.23	0.14	××	××
Malawi	Muslim	0.93	0.88	××	××	0.77	0.58	××	××	0.92	0.85	××	××	0.93	0.88	××	××	0.77	0.58	××	××
Mozambique	Muslim	0.80	0.63	××	××	0.76	0.59	××	××	0.74	0.54	××	××	0.82	0.69	××	××	0.77	0.61	××	××
	Folk	1.73	0.25	2.17	0.23	1.66	0.29	2.18	0.23	2.27	0.06	3.08	0.11	1.60	0.33	1.94	0.31	2.47	0.05	3.22	0.08
Nigeria	Muslim	3.00	0.00	××	××	1.55	0.00	××	××	2.10	0.00	××	××	2.78	0.00	××	××	1.56	0.00	××	××
Sierra Leone	Muslim	1.74	0.14	××	××	1.49	0.27	××	××	1.86	0.10	××	××	1.79	0.13	××	××	1.57	0.21	××	××
Togo	Muslim	1.41	0.48	××	××	1.17	0.73	××	××	1.47	0.43	××	××	1.42	0.47	××	××	1.20	0.70	××	××
	Folk	5.04	0.00	3.58	0.00	3.60	0.00	3.09	0.01	4.88	0.00	3.31	0.01	4.50	0.00	3.17	0.02	3.84	0.00	3.20	0.02
Uganda	Muslim	1.92	0.13	××	××	2.16	0.07	××	××	2.30	0.06	××	××	2.21	0.07	××	××	2.46	0.04	××	××

[#] Full model adjusted for women's education, wealth quintiles, and urban/rural residence

Supplementary table S5 – Poisson regression coefficients for interactions between sex of the child and religion for full immunization coverage and non-vaccinated children.

Country	Unadjusted								Full adjustment#							
	PR sex	p value		PR religion	p value	PR interaction	p value	model p value	PR sex	p value		PR religion	p value	PR interaction	p value	model p value
Full immunization																
Benin	0.97	0.583	Muslim	0.82	0.023**	0.98	0.816	0.052	0.98	0.68	Muslim	0.86	0.088	0.99	0.949	<0.001
			Folk	0.88	0.191	1.07	0.565				Folk	0.99	0.924	1.07	0.594	
Burkina Faso	0.94	0.053	Muslim	0.93	0.023**	1.06	0.224	0.047	0.94	0.06	Muslim	0.92	0.009	1.06	0.205	0.031
Cameroon	1.13	0.001**	Muslim	0.95	0.494	0.8	0.02**	0.000	1.14	<0.0001	Muslim	1.05	0.378	0.79	0.022	<0.001
Chad	0.99	0.920	Muslim	0.33	<0.001**	1.19	0.339	<0.001**	1.02	0.84	Muslim	0.35	<0.0001	1.12	0.517	<0.001
Côte d'Ivoire	0.95	0.571	Muslim	0.66	<0.001**	1.12	0.400	<0.001**	0.98	0.87	Muslim	0.75	0.010	1.13	0.375	<0.001
Ethiopia	1.08	0.368	Muslim	0.54	0.001**	1.02	0.913	0.001**	1.06	0.51	Muslim	0.62	0.008	1.01	0.953	<0.001
Ghana	0.98	0.581	Muslim	1.07	0.187	0.91	0.261	0.314	0.98	0.56	Muslim	1.09	0.133	0.90	0.251	0.785
Guinea-Bissau	0.93	0.371	Muslim	0.87	0.020**	1.08	0.375	0.151	0.95	0.55	Muslim	0.92	0.220	1.06	0.508	<0.001
			Folk	0.83	0.039**	1.17	0.186				Folk	0.93	0.448	1.12	0.339	
Liberia	1.12	0.169	Muslim	1.43	0.003**	0.84	0.310	0.014	1.11	0.20	Muslim	1.39	0.002	0.88	0.460	<0.001
Malawi	1.02	0.555	Muslim	0.93	0.177	1.02	0.793	0.297	1.01	0.57	Muslim	0.94	0.278	1.01	0.863	<0.001
Mozambique	0.88	0.149	Muslim	1.12	0.221	1.16	0.244	0.097	0.89	0.15	Muslim	1.21	0.041	1.11	0.379	<0.001
			Folk	1.01	0.925	1.11	0.507				Folk	0.97	0.781	1.13	0.395	
Nigeria	1.00	0.956	Muslim	0.37	<0.001**	1.03	0.840	<0.001	1.06	0.39	Muslim	0.72	0.001	1.02	0.912	<0.001
Sierra Leone	1.03	0.671	Muslim	0.93	0.218	0.97	0.688	0.213	1.04	0.60	Muslim	0.93	0.260	0.96	0.616	0.007
Togo	0.92	0.177	Muslim	1.08	0.254	1.02	0.840	0.023	0.93	0.22	Muslim	1.14	0.067	1.00	0.966	0.003
			Folk	0.73	0.006**	1.11	0.407				Folk	0.81	0.060	1.07	0.563	
Uganda	0.96	0.303	Muslim	0.83	0.037**	0.97	0.842	0.020	0.97	0.34	Muslim	0.84	0.047	0.97	0.828	0.078
Unvaccinated children																
Benin	1.38	0.283	Muslim	4.55	0.000	0.67	0.261	0.000	1.40	0.25	Muslim	3.18	0.000	0.61	0.140	0.000
			Folk	2.25	0.036	0.83	0.741				Folk	1.26	0.546	0.81	0.709	
Burkina Faso ±			Muslim								Muslim					
Cameroon	1.01	0.990	Muslim	0.72	0.622	1.26	0.809	0.954	0.97	0.10	Muslim	0.31	0.102	1.28	0.794	0.000
Chad	1.26	0.367	Muslim	6.78	0.000	0.87	0.592	0.000	1.23	0.41	Muslim	5.00	0.000	0.91	0.735	0.000

Country	Unadjusted								Full adjustment#							
	PR sex	p value		PR religion	p value	PR interaction	p value	model p value	PR sex	p value		PR religion	p value	PR interaction	p value	model p value
Côte d'Ivoire	0.50	0.072	Muslim	1.53	0.158	2.30	0.062	0.002	0.47	0.06	Muslim	1.42	0.276	2.30	0.065	0.000
Ethiopia	1.15	0.526	Muslim	2.13	0.001	0.79	0.439	0.005	1.15	0.51	Muslim	1.77	0.012	0.79	0.509	0.000
Ghana	0.98	0.977	Muslim	1.79	0.559	0.14	0.177	0.486	0.96	0.95	Muslim	0.97	0.980	0.13	0.154	0.004
Guinea-Bissau ±			Muslim								Muslim					
			Folk								Folk					
Liberia ±			Muslim								Muslim					
Malawi	1.62	0.192	Muslim	2.04	0.192	0.15	0.109	0.331	1.63	0.18	Muslim	1.70	0.332	0.15	0.110	0.322
Mozambique	1.45	0.432	Muslim	1.59	0.418	0.16	0.069	0.403	1.42	0.45	Muslim	1.38	0.609	0.20	0.112	0.000
			Folk	2.08	0.263	0.71	0.629				Folk	3.15	0.057	0.64	0.485	
Nigeria	0.90	0.358	Muslim	2.81	0.000	1.14	0.301	0.000	0.86	0.18	Muslim	1.47	0.000	1.12	0.344	0.000
Sierra Leone	0.94	0.933	Muslim	1.85	0.311	0.88	0.887	0.501	0.87	0.86	Muslim	1.58	0.441	0.99	0.991	0.009
Togo	0.36	0.111	Muslim	0.76	0.668	4.31	0.129	0.006	0.34	0.09	Muslim	0.61	0.410	4.92	0.091	0.002
			Folk	4.19	0.003	1.69	0.539				Folk	2.89	0.018	1.93	0.447	
Uganda	1.67	0.244	Muslim	2.88	0.052	0.45	0.374	0.245	1.69	0.23	Muslim	3.83	0.015	0.41	0.324	0.000

PR = Prevalence ratio tested using Poisson regression models
NA = Not available
References: Male and Christian categories
Full model adjusted for women's education, wealth quintiles, and urban/rural residence
* p value < 0.10; ** p value < 0.05
± Prevalence equal to zero for one of the categories

Supplementary table S6 – Pearson's coefficients of correlation between crude and adjusted ratios (Muslim/Christian) of full immunization coverage and proportion of unvaccinated children.

	Full immunization coverage				Unvaccinated children			
	Crude ratio		Fully adjusted ratio#		Crude ratio		Fully adjusted ratio#	
	Pearson's r	p value	Pearson's r	p value	Pearson's r	p value	Pearson's r	p value
National coverage	0.726	<0.01*	0.610	0.016*	-0.018	0.948	-0.142	0.614
Muslim (%)	-0.485	0.067	-0.467	0.079	0.358	0.189	0.313	0.257
Christian (%)	0.339	0.217	0.316	0.251	-0.471	0.077	-0.432	0.108

Full adjustment for women's education, wealth quintiles, and urban/rural residence

3.2. Artigo original 2: *Levels and potential drivers of under-five mortality sex ratios in low- and middle-income countries*

Artigo submetido para a revista *Paediatric and Perinatal Epidemiology*

Levels and potential drivers of under-five mortality sex ratios in low- and middle-income countries

Short running title**: Under-five mortality sex ratios**

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Social media quote

"We explored potential drivers of male/female differences in childhood mortality in 80 countries. Countries where boys are more likely than girls to be brought to health services for common illnesses also show evidence of excess mortality of girls." (Figure 2)

Synopsis

Study question

Which national characteristics – including indicators of levels of development, gender inequality, or gender bias in childcare – can predict male to female sex ratios in under-five mortality, after adjusting for total mortality level?

What's already known

Sex ratios in U5MR vary around the world, according to overall levels and causes of mortality, and to the presence of gender bias. Contextual factors associated with sex differentials in mortality have been explored, but so far studies failed to take overall mortality levels into account.

What this study adds

After adjustment for total mortality, higher-than-expected female mortality was found in countries where there was also evidence of gender bias in care-seeking for common illnesses.

Abstract

Background

Non-biological childhood mortality sex ratios may reflect community sex preferences and gender discrimination in health care.

Objective

We assessed the association between contextual factors and gender bias in under-five mortality rates (U5MR) in low- and middle-income countries.

Methods

Full birth histories available from Demographic and Health Surveys and Multiple Indicator Cluster Surveys (2010–2018) in 80 countries were used to estimate U5MR male-to-female sex ratios. Expected sex ratios and their residuals (difference of observed and expected) were derived from a linear regression model, adjusted for overall mortality. Negative residuals indicate more likelihood of discrimination against girls, and we refer to this as a measure of potential gender bias. Associations between residuals and national development and gender inequality indices, and with survey-derived child health care indicators were tested using Spearman's correlation.

Results

Mortality residuals for under-five mortality were not associated with national development, education, religion, or gender inequality indices. Negative residuals were more common in countries where boys were more likely to be taken to health services than girls (rho = -0.24, 95% CI -0.45, -0.01).

Conclusions

Countries where girls were more likely to die than boys, accounting for overall mortality levels, were also countries where boys were more likely to receive health care than girls. Further research is needed to understand which national characteristics explain the presence of gender bias, given that the analyses of development levels and gender equality did not discriminate between countries with or without excess mortality of girls. Reporting on child mortality separately by sex is required to enable such advances.

Keywords: Child Mortality; Sex Ratio; Child Health; Developing Countries; Models, Statistical; Surveys and Questionnaires

Word count: 3,069

Background

Sex differences in mortality are observed along the life cycle in association with various biological and social factors.[1, 2] Overall mortality of children under five years of age is an important indicator of population development, whereas the unexpected differences in mortality sex ratios may reflect community sex preference and gender discrimination in child health care.[3, 4]

Under circumstances where boys and girls are equally valued and health care is evenly available to both sexes, boys have higher mortality rates than girls due to biological differences.[2] The expected sex ratio in under-five mortality rates (U5MR), however, varies geographically according to the causes and overall levels of mortality.[5, 6]

In low- and middle-income countries (LMICs) the survival advantage of girls becomes more evident as overall mortality falls because perinatal causes and malformations, which represent the leading causes of death when mortality is low, predominate among male infants.[6-8] Nonetheless, in some countries and regions girls are dying more often than expected and present similar or even higher mortality rates as their male counterparts, thus lowering the observed sex ratios. Where sex ratios in mortality deviate from the expected due to higher female mortality, gender bias must be considered as an underlying cause.

Documentation of sex ratios according to mortality levels can be used to identify where potential gender bias in childhood mortality exists. Over the past decades, different approaches and methods have been used for assessing the presence of excess female deaths based on overall or male mortality rates.[5, 9-12] Some studies have used descriptive approaches to identify LMICs with sex ratios greater or lower than 1.0,[12] or used mathematical models to identify outliers using data from all high, middle, and low-income countries with available information.[9] We refer to these as descriptive, because all countries with information were included in the models, without excluding those with likely gender bias in child health care or other societal aspects. In contrast, prescriptive approaches have been proposed, starting with the selection of countries where gender discrimination or preference is assumed to be absent, and using these data to derive expected mortality levels by sex or sex ratios according to male mortality.[5, 10] Prescriptive models, as would be expected, tend to identify more countries presenting gender bias than purely descriptive approaches, although both methods result in similar rankings of countries in terms of excess mortality among girls.[13]

Some authors explored multiple contextual factors associated with sex differentials in mortality, including socioeconomic development level and measures of gender discrimination, but failed to take the overall level of mortality into account in their analyses. [12, 14]

In this article, we address an issue that has not been previously investigated in the literature in multiple countries. After adjusting sex ratios by overall under-five mortality rates, we assessed whether differences between observed and expected sex ratios may be predicted by national indices of development and gender inequalities, or by survey-based measures of gender bias in child health care.

Methods

The rationale for the present analyses was to model the relationship between under-five mortality rate – for both males and females – and mortality sex ratio. Then we investigated covariates associated with residuals from the model. The residuals allow the identification of geographical units where the mortality sex ratio is above or below what would be expected based on overall mortality.

Data sources

We analysed data from nationally representative Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS) carried out in LMICs from 2010 onwards. For countries with more than one survey, we selected the most recent. These surveys collect comparable data across countries based on standard questionnaires. We aimed to include all surveys with public-domain datasets available on the DHS and MICS websites (http://dhsprogram.com and http://mics.unicef.org, respectively), which had information on full birth histories for women of reproductive age. Ethical clearance was obtained by the national agencies responsible for each survey and all identifying data are omitted guaranteeing participants' anonymity.

Outcome

The probability of a child dying between birth and the fifth birthday, known as U5MR, was estimated from full retrospective birth history using standard DHS methods.[15] Women aged 15 to 49 years were asked about pregnancies and deliveries in the years preceding the survey, including characteristics such as birth date, sex of the child, and survival status. If a child was not alive, the age at death was recorded. From these questions, it was possible to calculate U5MR using a synthetic cohort life table approach in which probabilities of survival for small age segments were combined to calculate the probability of surviving up to age five (the mortality rate being calculated as 1 minus the probability of survival).[15, 16] Estimates were based on the ten years preceding the survey to ensure a reasonable sample size after stratification. Mortality rates are presented as the number of deaths per 1,000 live births. From the rates disaggregated by sex, male-to-female ratios were estimated. In order to facilitate the interpretation, sex ratios are presented multiplied by 100.

Statistical analyses

Linear regression was used to model the association between U5MR sex ratio and total U5MR (for both sexes combined). The analyses included all countries for which mortality data were available. Sex ratio residuals were estimated for each country as the difference between observed and predicted values from the regression model. We refer to residuals as a measure of potential gender bias, as positive values indicate higher mortality than expected among boys than girls, which we interpret as a lower likelihood of discrimination against girls. Negative residuals signal higher than expected female mortality and thus indicate the presence of potential gender bias disadvantaging girls.

Next, we tested the association of covariates with the above-mentioned residuals, using Spearman's correlation coefficient due to the non-normal distribution of the variables. For contextual factors that could reflect on mortality differentials by sex, we used indices of development and gender inequality at the national level, available from external databases.

Based on studies from Tabutin and Willems (1995) and Fuse and Crenshaw (2006), we selected similar development indices to assess associations with sex ratio residuals.[12, 14] From the World Bank repository, we included gross domestic product (GDP) per capita, based on purchasing power parity (constant international dollar), annual rate of growth of GDP, total health expenditure per capita as a percentage of GDP, percentage of the total economically active population employed in industry and services, adult literacy rate of men and women aged 15 and above (those who can read and write with understanding a short statement about everyday life), the difference between boys and girls in primary school enrolment, mean years of schooling for women as a percentage of those for men, women's secondary education enrolment rate, life expectancy at birth, and total fertility rate for women aged 15 to 49 years.

We obtained information from the Pew Forum on Religion and Public Life repository on percentages of Christian and Muslim population by country. Also, we acquired data from the United Nations Development Programme (UNDP) on women's average age at first marriage as well as the Human Development Index, a summary measure of average achievements in life expectancy, education, and standard of living. The study by Fuse and Crenshaw (2006) also included the percentage of Buddhists in each country, but in our analyses, there were only six countries where this proportion was above 1%, and we opted to leave out this variable.

Gender inequality indices are composite measures that combine data on factors such as health, economics, politics, empowerment, and labour participation. Four gender indices were chosen: Gender Development Index (GDI) and Gender Inequality Index (GII), from UNDP; Social Institutions and Gender Index (SIGI), from the Organization for Economic Co-operation and Development; and Women, Peace and Security Index (WPS), from the Georgetown Institute for Women, Peace, and Security. For GDI, GII, and SIGI, higher absolute values represent greater gender inequalities in each country, whereas for WPS the reverse is true. Definitions and data sources are detailed in Supplementary eTable 1.

Because information on contextual variables is not available for all calendar years, we used data for the closest year to the mid-point of the 10-year interval over which births were studied in each survey, that is, five years before the survey date.

The assessment of factors potentially associated with gender bias in U5MR was complemented by analyses using child health care indicators available from the same surveys used for mortality estimates, in order to investigate whether the sex ratio in mortality could be related to the sex ratio in health care utilization. The following indicators were analysed: i) Care-seeking for common childhood symptoms: proportion of children under five years of age who presented with symptoms of pneumonia (short, rapid breathing which was chest-related and/or difficult breathing), fever, or diarrhoea in the two weeks prior to the interview and were taken to an appropriate health care provider (the definitions of appropriate providers are country-specific, but neither pharmacists, drug sellers, or traditional practitioners were included); ii) Full immunization coverage: proportion of children aged 12 to 23 months who received at any age all the following vaccines: one dose of BCG (Bacille Calmette-Guérin), three doses of DPT (diphtheria, pertussis, and tetanus) or tetravalent/pentavalent vaccine, three doses of polio, and at least one dose of measles (either as monovalent vaccine or as measles-containing vaccine combinations with other immunogens); and iii) Post-natal care for babies: proportion of last-born children under two years of age who received any health check-up within two days after birth.

Sensitivity analyses

Sensitivity analyses are presented in the supplementary materials and include estimates of sex ratio residuals for countries according to the methods proposed by Alkema *et al* (2014) and Guilmoto *et al* (2018). The former is a descriptive model and defines sex ratio higher or lower than expected based on the modeled global relations between mortality levels and sex ratios.[9] The latter used expected female U5MR on the basis of the relation between male and female U5MRs observed in 46 countries without known gender discrimination in different periods.[10]

Clustering and sampling weights were taken into account in all analyses using Stata® version 15.0 (StataCorp, College Station, TX, USA) and Microsoft Excel® (Microsoft Corp, WA, USA).

Results

A total of 82 countries had information on mortality rates by sex. We removed two countries identified as outliers from the analyses for U5MR (Albania and Armenia); the results for the complete dataset including these two countries are presented in Supplementary Materials (eFigure1). Table 1 shows that the mean U5MR in the 80 countries was 58 per thousand live births [standard deviation (SD) = 33], ranging from 16 in Moldova to 153 in Niger. Summary statistics for the sex ratios are also presented in Table 1.

-- Table 1 --

Figure 1 shows the scatter of the observations – sex ratios and total mortality level – as well as the fitted line correspondent to the model. We observe higher male-to-female sex ratios when overall mortality rates are low, which decreases as total U5MR increases, reaching values close to 100.

-- Figure 1 --

Potential gender bias against girls is observed when residuals are negative, reflecting lower-than-expected sex ratios after adjustment for total U5MR, that is, fewer deaths of boys and more deaths of girls than would be expected. Residuals of U5MR sex ratios ranged from -43.7 to 34.5 (mean = 0, SD = 13.3, and median = 0.11). Skewness and kurtosis test for normality showed a p-value of 0.124, presenting no evidence that residuals were not normally distributed. Supplementary eFigure 2 shows the distribution of the residuals.

The rank correlation coefficients between the residuals with explanatory variables at national level are presented in Table 2. We found no statistical evidence of the association between sex ratio residuals for U5MR and any of national indicators including GDP, Human Development Index, religion, age at first marriage, fertility, employment, education, or gender inequality indices.

-- Table 2 --

Next, we tested associations between the residuals and sex ratios for three child health care indicators derived from the same surveys. There was no statistical evidence of associations with sex ratios in postnatal care or full immunisation coverage. However, the male-to-female ratio in care-seeking for common diseases (rho = -0.24, 95% CI -0.45, -0.01) was associated with mortality residuals in the expected direction (Figure 2).

-- Figure 2 --

Comment

Our findings confirm prior research showing that the male-to-female sex ratio in mortality tends to be higher when overall U5MR is lower.[5, 6, 9] We presented a novel approach, quantifying potential gender bias through residuals of the sex ratio for mortality, adjusted for overall mortality level. Where residuals are positive, there is higher mortality of boys relative to girls than expected, and lower likelihood of gender bias against girls.

We then sought evidence that mortality residuals would be associated with national characteristics, based on the ecological analyses of 80 countries after removing two outliers with very low mortality and unusual sex ratios. These analyses failed to show statistical evidence of associations with national wealth, income, women's characteristics, or gender inequality indices. Despite not presenting statistical evidence, the correlation coefficients for the association between the residuals and female mean years of schooling (as a percentage of male schooling) and female mean age at first marriage presented the highest values, in the expected direction.

Previous research also failed to find evidence of associations. Using data from LMICs in the 1980s, Tabutin and Willems (1995) addresses the sex ratio of mortality at ages 1-4 years (child mortality rates, CMR) and found no relationship with the level of social and educational development attained by countries and regions. In these analyses, GDP and Human Development Index were correlated with sex ratios, but non-significantly associated with the sex ratios of CMR when analysing a set of 43 countries.[12] A weak association was found in the bivariate analyses performed by Fuse and Crenshaw (2006) of sex differentials in infant mortality rate (IMR, 0-1 year of age) for all countries with available information, including high-income geographies. In this latter study, national income was not associated with the IMR sex ratios in the crude analyses, but the association became statistically significant after adjustment for several covariates.[14]

Regarding the education indicator, the direction of the association agrees with the literature. Results from Sub-Saharan Africa and South Asia indicate, that as maternal education increases, so does the male-to-female mortality ratio.[17] In another set of LMICs, indicators of inequality in education between men and women were associated with excess female deaths in the expected direction.[12] The above-mentioned study by Fuse and Crenshaw (2006) found that female secondary education enrolment was associated with sex ratios for IMR in the expected direction.[14] Education levels reflect the social position of women, which is supported by other research showing the positive impact of female education in decreasing overall child mortality.[18]

Another indicator that might reflect women's position in society is the mean age at first marriage. In our analyses, we found that countries with older average age at marriage may show less evidence of gender bias against girls in mortality. Tabutin (1995) had reported an association in the same direction, although their finding was not significant.[12]

Next, we explored associations between mortality sex ratios and the sex ratios for coverage of postnatal care, immunisations, and care-seeking for common childhood illnesses, calculated from the same surveys. There was statistical evidence of an association with the latter indicator, in the expected direction, that is countries where boys were more likely to receive care were also those with evidence of mortality bias against girls. These findings are also corroborated by previous analysis from 60 DHS.[19] Gender-based discrimination in child health care has been reported in specific settings, mostly in South Asia and China.[20] It has been argued that excess female mortality has a multidimensional nature and is more likely to happen if there is sex discrimination in nutrition or health care, but that this also depends on the cause-of-death pattern observed in each population.[7]

In our sensitivity analyses, we calculated residuals using the equations proposed by Alkema et al (2014) and Guilmoto et al (2018). [9, 10] These approaches produced similar direction of associations with most of the explanatory variables (Supplementary eTable 2).

Some limitations ought to be recognized. Estimation of mortality rates for children is based upon maternal recall obtained in household sample surveys and may be affected by recall bias, misdating errors, and omission.[15] These biases, however, are assumed to affect all countries and both sexes in the same way.[15] Also, some degree of survival bias may exist when assessing coverage with child health interventions, because these questions are asked for children who are still alive, and gender bias in mortality may have already happened. Childhood mortality sex ratios may also be affected by sex-selective abortions, which would restrict the number of unwanted births of girls, and ensure higher survival among those girls who are born.[14, 21] It is important to point out that some within-country variations in mortality levels as well as in gender bias in mortality exist, as already reported for some countries, such as India (where mortality is higher and gender bias against girl is more likely to happen in the Northern regions).[10] In addition, single surveys can be subject to random error to a greater extent than in the case for mortality estimates based upon multiple surveys over time from the same country.[22] Lastly, we found statistical evidence in one pairwise association out of 22 comparisons, so that chance cannot be ruled out; nevertheless we note that the association between possible gender bias in mortality and health care was in the expected direction.

Despite these limitations, some important take-home messages are drawn from our analyses. Sex ratio analyses of death rates must be adjusted for total mortality levels in order to incorporate the variability due to causes of death and the female biological advantage in survival. Instead of using a fixed value for the expected sex ratio, we were able to model such ratios according to the overall mortality level, leading to estimates of expected sex ratios and allowing us to calculate residuals.

Conclusion

In conclusion, our results confirm the importance of reporting on child mortality separately by sex and contributes to the existing literature by updating previous research on the association of mortality sex ratios and contextual factors. Contrary to our original set of hypotheses, national characteristics were not correlated with mortality residuals, except for higher care-seeking for boys than for girls.

Further research is needed to refine the analyses of explanatory factors for gender-specific mortality.

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Table 1 - Descriptive statistics of under-five mortality rates from 80 low- and middle-income countries.

	N	Mean	Std. Dev.	Median	P25	P75	Minimum	Maximum
Total	80	58	33	54	30	78	16	153
Male	80	63	36	57	30	85	16	160
Female	80	53	32	51	27	68	14	146
Sex ratio	80	119	13	119	110	125	78	156

Table 2 – Spearman's correlation coefficient between U5MR sex ratio residuals and explanatory variables.

Group	Development and gender indices	N[a]	rho	95%CI	
Economics	GDP per capita	80	0.05	-0.17	0.27
	GDP annual growth	79	0.09	-0.14	0.30
	Health expenditure (% of GDP)	77	-0.02	-0.24	0.21
Employment	Labour force in industry	78	0.14	-0.08	0.35
	Labour force in services	78	0.11	-0.12	0.32
Education	Adult literacy rate	74	0.12	-0.11	0.34
	Primary education (difference between boys and girls)	75	-0.02	-0.25	0.21
	Female secondary enrolment	72	0.04	-0.19	0.27
	Female mean years of schooling (% of male)	74	0.17	-0.06	0.38
Demographics	Life expectancy	80	-0.05	-0.27	0.17
	Female average age at first marriage	53	0.26	-0.01	0.50
	Total fertility rate	80	-0.01	-0.23	0.21
	Human Development Index	77	0.04	-0.19	0.26
Religion	Christian	79	-0.07	-0.29	0.15
	Muslim	79	-0.01	-0.23	0.21
Gender	Gender Development Index	73	0.04	-0.19	0.27
	Gender Inequality Index	67	-0.13	-0.36	0.12
	Social Institutions and Gender Index	67	0.07	-0.17	0.31
	Women, Peace and Security index	70	0.07	-0.16	0.30
Child health (sex ratios)	Postnatal care for babies	56	0.01	-0.25	0.27
	Full immunization coverage	76	0.11	-0.12	0.32
	Care-seeking for common illnesses	71	-0.24[b]	-0.45	-0.01

Note: Negative values for residuals indicate more likelihood of gender bias against girls
[a] Sample sizes vary according to data availability
[b] 95% Confidence Interval does not include the null value

Figure 1 – Distribution of U5MR sex ratios (times 100) by total U5MR and respective fitted line. Horizontal dashed lines represent equal mortality rates for boys and girls.

Figure 2 – Rankings of U5MR sex ratio residuals and sex ratio of care-seeking for common childhood symptoms.

Supplementary Materials

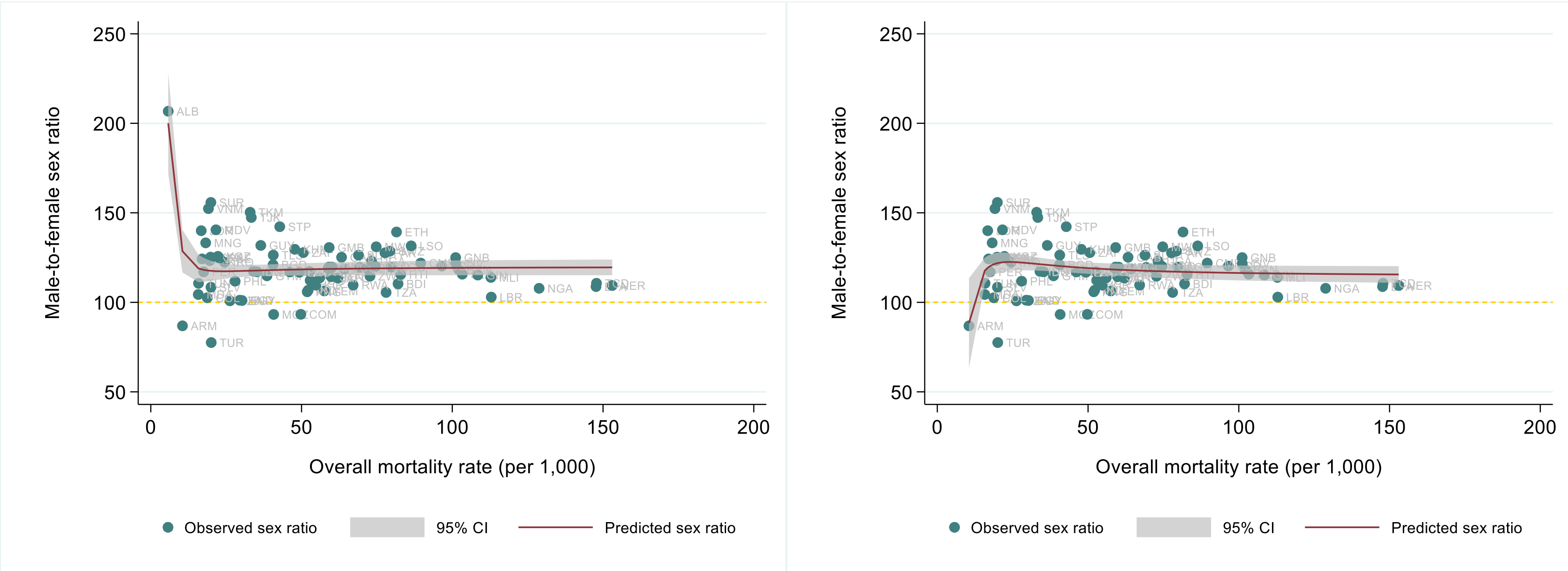
eTable 1 – Definition and data source of potential drivers of sex differentials in U5MR.

Variable	Description	Source
Gross Domestic Product (GDP) *per capita*	“GDP is gross domestic product converted to international dollars using purchasing power parity rates (PPP). GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. Data are in current international dollars based on the 2011 International Comparison Program (ICP) round.”	World Bank
Rate of growth of GDP (annual %)	“Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars.”	World Bank
Current health expenditure (% of GDP)	“Level of current health expenditure expressed as a percentage of GDP. Estimates of current health expenditures include healthcare goods and services consumed during each year. This indicator does not include capital health expenditures such as buildings, machinery, IT and stocks of vaccines for emergency or outbreaks.”	World Bank
Labour force structure	Percentage of the total economically active population employed in industry. “Employment is defined as persons of working age who were engaged in any activity to produce goods or provide services for pay or profit, whether at work during the reference period or not at work due to temporary absence from a job, or to working-time arrangement. The industry sector consists of mining and quarrying, manufacturing, construction, and public utilities (electricity, gas, and water)”	World Bank
Labour force structure	Percentage of the total economically active population employed in services. “The services sector consists of wholesale and retail trade and restaurants and hotels; transport, storage, and communications; financing, insurance, real estate, and business services; and community, social, and personal services”	World Bank
Adult literacy rate	“Adult literacy rate is the percentage of people ages 15 and above who can both read and write with understanding a short simple statement about their everyday life.”	World Bank
Primary school enrolment among girls	Difference between boys and girls in primary enrolment. “Primary education provides children with basic reading, writing, and mathematics skills along with an elementary understanding of such subjects as history, geography, natural science, social science, art, and music.”	World Bank
Women’s educational status	Percentage of all women enrolled in secondary education. “Secondary education completes the provision of basic education that began at the primary level and aims at laying the foundations for lifelong learning and human development, by offering more subject- or skill-oriented instruction using more specialized teachers.”	World Bank
Mean years of schooling for women	“Average number of years of education received by people ages 25 and older, converted from educational attainment levels using official durations of each level”. We used the indicator as female mean years of schooling, as percentage that for men.	UNDP
Life expectancy at birth	“Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.”	World Bank
Women's average age at first marriage	“Mean age at marriage shows the average length of single life expressed in years among those females who marry before age 50. It is a synthetic indicator calculated from marital status categories of men and women aged 15 to 54 at the census or survey date.”	World Bank

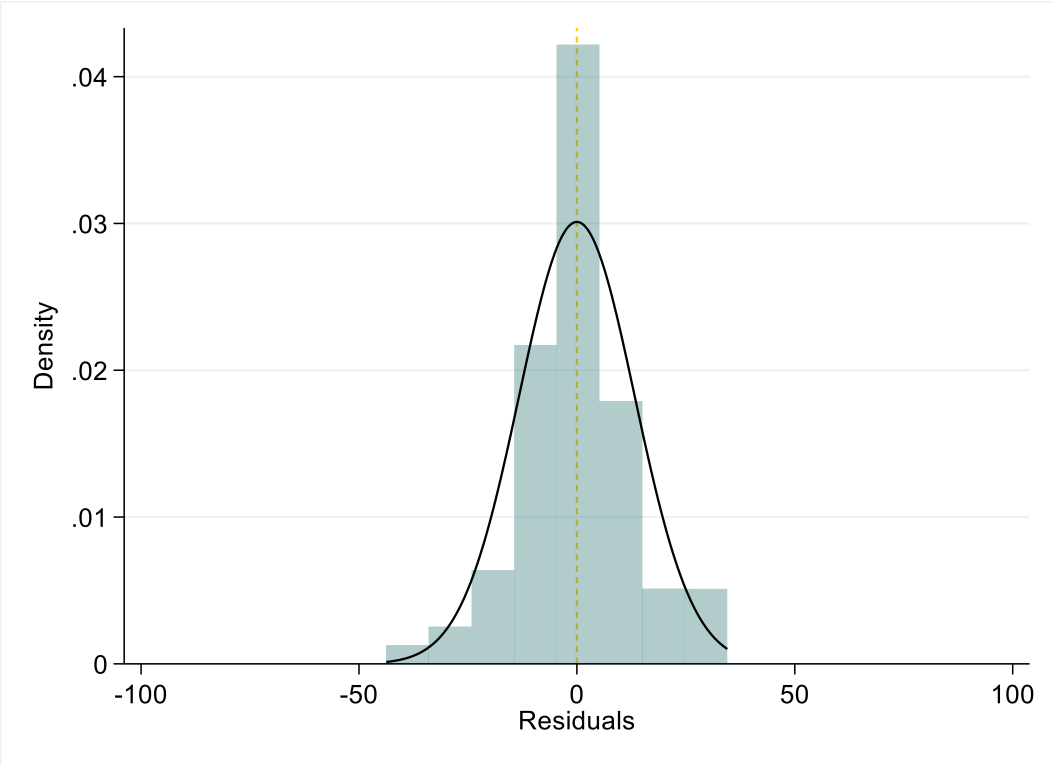
Variable	Description	Source
Total fertility rate	"Represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year."	World Bank
Human Development Index	The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. The health dimension is assessed by life expectancy at birth, the education dimension is measured by mean of years of schooling for adults aged 25 years and more and expected years of schooling for children of school entering age. The standard of living dimension is measured by gross national income per capita. The HDI uses the logarithm of income, to reflect the diminishing importance of income with increasing GNI. The scores for the three HDI dimension indices are then aggregated into a composite index using geometric mean.	UNDP
Christian	Percentage of Christian population	Pew Research Center
Muslim	Percentage of Muslim population	Pew Research Center
Gender Development Index	"GDI measures gender gaps in human development achievements by accounting for disparities in three basic dimensions: health, knowledge and living standards using the same component indicators as in the Human Development Index (HDI). The GDI is the ratio of the HDIs calculated separately for females and males using the same methodology as in the HDI. It is a direct measure of gender gap showing the female HDI as a percentage of the male HDI. Higher values of GDI represent greater deviation from parity in each country and takes equally into consideration gender gaps favouring males, as well as those favouring females."	United Nations Development Programme
Gender Inequality Index	"A composite measure reflecting inequality in achievements between women and men in three dimensions: reproductive health, empowerment and the labour market." GII with higher values represents greater gender inequality in each country.	United Nations Development Programme
Social Institutions and Gender Index	"The SIGI covers four dimensions of discriminatory social institutions, spanning major socio-economic areas that affect women's lives: discrimination in the family, restricted physical integrity, restricted access to productive and financial resources and restricted civil liberties. The SIGI's variables quantify discriminatory social institutions such as unequal inheritance rights, child marriage, violence against women, and unequal land and property rights. Higher SIGI values indicate higher inequality: from 0% for no discrimination to 100% for very high discrimination."	Organization for Economic Co-operation and Development
Women, Peace and Security Index	"The Women, Peace, and Security Index is a comprehensive measure of women's wellbeing spanning three dimensions: inclusion (economic, social, political); justice (formal laws and informal discrimination); and security (at the family, community, and societal levels)"	Georgetown Institute for Women, Peace and Security

eTable 2 – Sensitivity analysis of the association between mortality sex ratios and selected predictors using Spearman's correlation.

Group	Country development and gender indices	Alkema et al (2014)				Guilmoto et al (2018)			
		N	rho	LL	UL	N	rho	LL	UL
Economics	GDP per capita	80	-0.08	-0.29	0.15	80	-0.04	-0.26	0.18
	GDP annual growth	79	0.08	-0.15	0.29	79	0.09	-0.13	0.31
	Health expenditure (% of GDP)	77	0.01	-0.21	0.23	77	-0.01	-0.23	0.21
Employment	Labour force in industry	78	0.03	-0.19	0.25	78	0.07	-0.15	0.29
	Labour force in services	78	0.00	-0.23	0.22	78	0.03	-0.19	0.25
Education	Adult literacy rate	74	0.01	-0.22	0.24	74	0.04	-0.19	0.27
	Primary education (difference between boys and girls)	75	-0.08	-0.30	0.15	75	-0.06	-0.29	0.16
	Female secondary enrolment	72	-0.09	-0.32	0.14	72	-0.06	-0.28	0.18
	Female mean years of schooling (% of male)	74	0.06	-0.17	0.28	74	0.09	-0.14	0.31
Demographics	Life expectancy	80	-0.21	-0.41	0.01	80	-0.17	-0.38	0.05
	Female average age at first marriage	53	0.17	-0.11	0.42	53	0.18	-0.09	0.43
	Total fertility rate	80	0.12	-0.11	0.33	80	0.08	-0.14	0.30
	Human Development Index	77	-0.12	-0.33	0.11	77	-0.08	-0.30	0.15
Religion	Christian (%)	79	-0.05	-0.27	0.17	79	-0.07	-0.28	0.16
	Muslim (%)	79	-0.01	-0.23	0.21	79	0.01	-0.21	0.23
Gender	Gender Development Index	73	-0.04	-0.27	0.19	73	-0.03	-0.26	0.20
	Gender Inequality Index	67	0.00	-0.24	0.24	67	-0.03	-0.27	0.21
	Social Institutions and Gender Index	67	0.17	-0.08	0.39	67	0.15	-0.10	0.38
	Women, Peace and Security index	70	-0.03	-0.26	0.21	70	-0.01	-0.24	0.23
Child health (sex ratios)	Postnatal care for babies	56	0.01	-0.25	0.27	56	0.01	-0.25	0.27
	Full immunisation coverage	76	0.13	-0.10	0.34	76	0.13	-0.10	0.34
	Care-seeking for common illnesses	71	-0.20	-0.41	0.04	71	-0.21	-0.42	0.03



eFigure 1 – Distribution of U5MR sex ratios (times 100) by total U5MR and respective fractional polynomials fitted line for the full sample of countries (n = 82) and excluding Albania (the top-left point). Horizontal dashed lines represent equal mortality rates for boys and girls.



eFigure 2 – Distribution of sex ratio residuals of under-five mortality

3.3. Artigo de revisão: *A scoping review of methods for assessment of sex differentials in early childhood mortality*

Artigo submetido para a revista *Journal of Global Health*

A scoping review of methods for assessment of sex differentials in early childhood mortality

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ABSTRACT

Background: While assessment of sex differentials in child mortality is straightforward, their interpretation must consider that, in the absence of gender bias, boys are more likely to die than girls. The expected differences are also influenced by levels and causes of death. However, there is no standard approach for determining expected sex differences.

Methods: We performed a scoping review of studies on sex differentials in under-five mortality, using PubMed, Web of Science, and Scopus databases. Publication characteristics were described, and studies were grouped according to their methodology.

Results: From the 17,693 references initially retrieved we included 154 studies published since 1929. Indian, Bangladeshi, and Chinese populations were the focus of 44% of the works, and most studies addressed infant mortality. Fourteen publications were classified as *reference* studies, as these aimed to estimate expected sex differentials based upon the demographic experience of selected populations, either considered as gender-neutral or not. These studies used a variety of methods – from simple averages to sophisticated modeling – to define values against which observed estimates could be compared. The 21 *comparative* studies mostly used life tables from European populations as standard for expected values, but also relied on groups without assuming those values as expected, otherwise, just as comparison parameters. The remaining 119 studies were categorized as *narrative* and did not use reference values, being limited to reporting observed sex-specific estimates or used a variety of statistical models, and in general, did not account for mortality levels.

Conclusion: Studies aimed at identifying sex differentials in child mortality should consider overall mortality levels, and report on more than one age group. A comparison of results with one or more reference values, and the use of statistical testing, are strongly recommended. Time trends analyses will help understand changes in population characteristics and interpret findings from a historical perspective.

BACKGROUND

Mortality is a result of the interaction between several complex factors such as genetics, environment, health care, and behaviors, and there is overwhelming evidence that at every age, males have higher risk of death than do females.(1-3) Nevertheless, there are many historical examples of excess female mortality at specific periods of the life course.(4-6)

Especially during the first five years of life, equality in male and female death rates may be evidence of inequity, as even in circumstances in which boys and girls receive the same care, higher mortality among male children is observed.(7)

Due to biological advantages, females enjoy lesser vulnerability to infant mortality due to perinatal conditions, congenital anomalies, and infectious diseases.(8) Although this advantage tends to decline with age, still for deaths from 1-4 years of age, it can be eroded if girls are deprived of access to health care or proper nutrition, suggesting discriminatory gender norms and bias in child care due to community male preference.(1) Therefore, excess female mortality may be indicator of influences that outweigh the survival advantages of girls.(1)

Although sex differentials in early childhood mortality are recognized as important issues globally, there is no consensus about what would be expected in the absence of discrimination. A further challenge is that the magnitude of differences will vary according to total mortality levels and to the distribution of causes of death.(7-9)

Many studies have assessed differences in mortality between boys and girls, and sets of reference values have been proposed, however, there is not a standard method for such analyses. In particular, the literature still lacks a proper description of how the estimates for such variations had been defined. By bringing together the approaches used so far and using a scoping review methodology, we described how studies addressed sex differentials in early childhood mortality with a special focus on the methods used to measure such discrepancies.

METHODS

We conducted searches on PubMed, Web of Science, and Scopus electronic databases for potentially relevant publications on sex differentials in mortality among children, with no date limits or language restrictions. The searches included combinations of the key terms “gender” and “sex” with words that reflect differences between the groups, such as “bias”, “differential”, “selection”, “discrimination”, and so on, plus the words “mortality” and “child*”. Additionally, we undertook searches using commonly used terms for excessive deaths, such as “excess male”, “excess female”, etc., combined with “mortality” and “child*”, as well as “missing girls” and “missing women”. The list of terms and the full search strategy are presented in **Figure 1**.

After removing the duplicates, we reviewed titles and abstracts for inclusion and if any doubts persisted, the full publication was read and included if it met the eligibility criteria. Finally, the reference lists of selected studies were searched for further relevant works. The search ended in July 2020.

Studies were eligible for inclusion if they quantitatively explored and discussed differentials in early child mortality by sex, including any indicator of deaths of children under the age of five, namely neonatal (NMR, 0-28 days of life), post-neonatal (PNMR, 28 days to 11 months and 29 days), infant (IMR, 0-11 months), child (CMR, 1-4 years), and under-five mortality rate (U5MR, 0-4 years), or any publication-specific age range. We excluded studies focusing on specific diseases, conditions (e.g. preterm) or behaviors (e.g. accidents and injuries), and those that only reported differences in causes of death but not on overall mortality levels. Also, we did not include works that addressed fetal mortality or population sex ratios as a measure of differential survival.

For each reference, we extracted publication characteristics, methodology, and results of interest. Detailed information is described in the **Supplementary Table S1**.

We defined three categories of publications based on similarities in the methodological approach used in each of them: i) *Reference*, when specific reference populations were defined and well-defined methods to estimate expected values or standards for sex differentials in childhood mortality were employed; ii) *Comparative*, when used a previously defined expected estimate to compare the data being analyzed; and iii) *Narrative*, when the authors did not use any reference or comparison standard, otherwise describing the sex differentials in mortality based only on the study's data.

Studies included in the *reference* group were also identified as either *descriptive* or *prescriptive*, based on a previous classification.(10) The former group includes studies that show how sex ratios in mortality vary according to mortality levels, regardless of whether gender bias is assumed to exist, that is, without an *a priori* judgment. The latter group consists of publications in which mortality rates by sex are compared to values that would be expected in societies where gender discrimination is believed to be low or absent. Also, the number of citations for each study were collected from Google Scholar metrics.

Based on the titles we generated a word cloud, a visual representation of text data in which the items are weighted according to their frequency. It helps us to visualize how the terms have been used in the field.

Ethics approval

This review was exempted from ethics review as the data used have already been published.

Patient and public involvement

No patients or members of the public were involved in the design, analysis, or reporting of this study.

RESULTS

The initial searches yielded 17,693 publications. After removing the 4,525 duplicates, 13,168 titles and abstracts were screened, and afterward 147 articles were assessed in detail. Of these, 103 met all the inclusion criteria. From the lists of references, we found and could get access to more 51 works, resulting in 154 studies included in this review. The flow diagram displays the search strategy and study selection process (**Figure 2**).

The word cloud based on titles revealed a diversity of terminologies used in the publications, especially the possible interchangeable use of “sex” and “gender” and the high frequency of studies from India (**Supplementary Figure S1**).

The period of mortality estimates ranged from 1700 to 2016, which may refer to the survey year, the period before the survey for which the rates were estimated, or the actual years when the deaths occurred. Many studies assessed changes over time, either by comparing two points in time or by analyzing time series with several points.(1-3, 5-7, 9, 11-61)

The studies were published in a period between 1929 and 2020. Up to the 1980s, there were only thirteen publications,(11, 23, 48, 51, 53, 54, 58, 60-65) and the number increased to 21 in the 1980s,(8, 19, 24, 30, 55, 56, 66-80) 46 in the 1990s,(3, 4, 6, 18, 20, 29, 36, 40, 41, 43, 46, 49, 50, 81-113) decreased to 30 in the 2000s,(7, 12, 13, 17, 21, 22, 32, 33, 38, 44, 47, 57, 59, 114-130) and reached 44 in the period between 2010 and 2020.(1, 2, 5, 9, 10, 14-16, 25-28, 31, 34, 35, 37, 39, 42, 45, 52, 131-154)

One hundred and eight studies used data from single countries, mostly from India (n=50, 32%), followed by Bangladesh (n=11, 7%, and all of them carried out in the Matlab region) and China (n=7, 5%). Fourteen explored data from more than one country and other 27 used data from a set of countries grouped according to income level classification or geographic region, mostly sub-Saharan Africa (n=9) and low- and middle-income countries (LMICs, n=12). In **Figure 3** the area of each rectangle is proportional to the number of studies from each place.

Estimates of mortality were derived from several sources, including civil registration systems and other official demographic statistics (29%), censuses (18%), and surveys (47%). Registration data from the Human Mortality Database, the United Nations Demographic Yearbook, and other sources of life tables and national estimates from international agencies have also been used (8%). The remaining relied on published estimates from other authors, specific studies, and experiments (16%).

Information on child age allows more than one group to be attributed to each study. Most of the publications addressed IMR, as this was the primary measure of child survival in the past. More recently, because gender discrimination seems to be more evident in the age range of 1-4 years, the focus was moved to CMR and all under-five children. In some studies, the authors defined specific age groups for the analysis, reporting on non-standard age groups.(5, 20, 32-34, 36, 43, 51, 69-71, 75, 77, 78, 80, 82, 83, 85-87, 91, 96, 99, 106, 108, 109, 112, 113, 115, 116, 124, 126, 137, 144, 147, 154)

Some authors reported on female-to-male sex ratios for mortality, but most presented results as male-to-female ratios, either as a simple ratio or multiplied by 100, with values of 1 and 100, respectively, indicating equality between boys and girls. Also, in some of them, the excess mortality of girls was estimated.(2, 10, 14-16, 39, 90, 100, 107, 130, 151, 152)

Reference studies

Fourteen publications defined expected values for sex ratios or for sex-specific mortality based on the experience of particular populations, being categorized as *reference* studies. This heterogeneous set of studies relied upon a variety of data sources and analytical methods to define the expected differentials in male and female deaths. The first study was published in the late 1980s,(74) five dated from the early 1990s,(90, 92, 97, 98, 103) and the other eight from the 2010s.(2, 14-16, 39, 134, 136, 151) A summary of the characteristics is presented in **Table 1**. For consistency, we recalculated the outcomes and present the actual ratios of male-to-female death rates, even when the authors' presentations were in other formats.

Regarding the age groups under assessment, six studies reported on more than one category, usually IMR, CMR, and U5MR,(2, 92, 97, 98, 103, 136) five studies only on IMR,(14-16, 39, 90) and three solely on U5MR.(74, 134, 151)

Several reference populations were used as the standard against which authors assessed results from one or more countries. The reference populations include: life table models from multiple high-income geographies(92, 98, 103, 136); survey data from LMICs,(14, 74, 134) official statistics gathered by the United Nations,(90, 151) estimates published by other authors(39), and multiple sources including census, surveys, vital registration and surveillance systems.(2) Three studies from India used internal comparison parameters, as the authors chose the Kerala state or a set of countries as standards of low gender bias.(14-16) The studies were labeled as *prescriptive* or *descriptive*, depending on the judgment of presence or absence of gender bias in the reference populations and this information is presented in **Table 1**.

In five studies, after the reference population was selected, the average observed sex ratios were calculated and the resulting means were considered as the expected value for a given age group, regardless of the overall mortality level.(74, 90, 97, 134, 136) For example, Johansson and Nygren

(1991) proposed an IMR sex ratio of 130 and Jamison et al (2013) defined a reference of 118 for U5MR sex ratio.(90, 134) Another two studies proposed a range of expected sex ratio values based on overall or male mortality levels.(2, 98) For example, Hill and Upchurch (1995) suggested that for male mortality rates of 25 and 300 per thousand the expected IMR sex ratio should be, respectively 130 and 118.(98) Lastly, five works presented equations for calculating expected values, usually for female death rates according to levels of male mortality (14, 39, 151) or for the estimation of sex ratios greater than expected.(92, 103) Two studies relied upon regression coefficients for comparison.(15, 16)

While the simpler studies were restricted to calculating average sex ratios as mentioned above, more sophisticated approaches included the use of locally weighted least squares (LOWESS) procedure for the association between sex ratios and male mortality,(98) linear, logistic and quadratic regression models,(14-16, 151) ratio of observed and expected sex ratios,(103) and Bayesian models for the association of sex ratios and overall mortality.(2)

Most studies compared the reference with observed sex ratios in single Asian countries: seven in India,(14-16, 39, 74, 134, 151) two in China(90, 134), and one in Vietnam(97). The remaining studies used data from multiple countries from Sub-Saharan Africa,(103, 136) South Asia,(136) low- and middle-income countries(98). Lastly, a global study used data from 195 countries, areas, and territories with available information(2).

To evaluate whether an observed value differed from the reference population, the most frequent procedure was the simple comparison of the magnitudes of the estimates, with only a few studies reporting confidence intervals or other forms of statistical testing.(2, 74, 90, 136)

Comparative studies

The group of 21 *comparative* studies includes works comparing sex ratios in specific populations to reference values without proposing new methodologies for the definition of expected values. The reference values are either those reflecting the experience of populations in which gender discrimination is supposed to be absent or those from areas, single country, or set of countries for comparison, with no judgment about expected values. Detailed information for each study is presented in **Table 2**.

The works were published since 1977, mostly from 2000 onwards. The publications reported on sets of countries (Middle East region,(44) Arab countries,(65) North Africa,(94) sub-Saharan Africa,(92) low- and middle-income countries,(10) or global analyses(125)). The remaining covered one specific country (India,(33, 36, 66, 75, 76, 130) China,(96, 122) Bangladesh,(17, 85, 106) Korea,(73), Japan,(102), North Korea,(111) and Egypt(77)), all from Asia.

The most frequently used references were the Coale and Demeny (1966 and 1983) life tables, which are widely used for estimation and projections.(155, 156) These authors examined a large number of life tables from countries with reliable data, mostly in Europe, and used regression methods to build four families of model life tables, labeled as "West", "North", "East" and "South", corresponding roughly to European regions. The models are based on the observed relationships between mortality in different age ranges and mortality levels. Each model has variants for males and females, which allows the definition of expected levels of mortality by sex or sex ratios, and which may thus be compared to values derived from a given study. Assessments of gender bias were made by comparing observed sex ratios or actual sex-specific mortality levels with expected values according to the model life tables.(17, 73, 77, 96, 122, 130)

The Hill and Upchurch (1995) and the Alkema et al (2014) references, described above, were also used in some studies, alone or combined with other methods.(10, 44) Both provide parameters that allow estimating expected sex ratios for a given level of male or overall mortality.

Intervention studies often compare their results with a control area.(36, 75, 106) Other parameters included mortality by sex in high-income countries such as Sweden(92, 102, 103) and Japan,(96) sets of countries,(33, 65, 66, 76) previously published expected values from other works,(111, 122, 125) and singleton births as reference for sex-discordant pairs of twins.(85)

Narrative studies

The remaining 119 publications were categorized as *narrative* as they assessed sex differentials in childhood mortality, but do not rely on any reference or expected value to corroborate the presence of bias. The assessed outcomes include absolute differences in male and female rates, sex ratios calculated either by dividing the observed sex-specific rates or derived from statistical models (as odds ratio, hazard ratio, relative risk, etc.). This group includes studies that either did not perform statistical tests to compare rates by sex or, if these tests were included, did not account for the greater biological weakness of male children. Nonetheless, studies with higher mortality among girls are useful because this should not occur unless there is a bias against girls. Also, in this group are the studies that used multivariable analyses, including sex as one of the predictors, or sex-specific models.

Up to the late 1970s, all publications used *narrative* approaches, mostly reporting on time series, with a historical perspective on mortality sex ratios.(11, 23, 48, 51, 53, 54, 58, 60-64) Almost all studies conducted with populations from high-income geographies, e.g. Belgium,(4, 18) Canada,(61) England,(26, 32, 53) Japan,(63, 112) The Netherlands,(5) Sweden,(116, 142) Taiwan,(31) and United States(13, 48, 54, 62, 81, 133, 150) are in this group, as well as sets of high-income countries.(11, 58, 120) The approaches used in each study can be found in the **Supplementary Table S1**.

DISCUSSION

In this review, we described 154 studies since 1929 that employed quantitative methods to address sex differentials in early childhood mortality. The main challenge in these analyses is how to separate biologically determined sex differences from gender inequity that may affect mortality rates. Usually, gender bias is suspected when the mortality of girls is higher than expected. Infanticide and neglect of girls, for instance, are likely to affect the sex ratios, leading to either similar mortality rates for both sexes or higher mortality for girls than for boys.(40, 157, 158) Specifically, the complexities in the analyses include the specification of expected values for sex ratios for a given mortality level, the definition of what constitutes excess mortality of girls or boys, and the availability and quality of the data. In light of these conundrums, selected publications were grouped according to the methodological approach.

Fourteen studies (about 9%) aimed at presenting reference parameters, as well as analytical methods to define the expected relationship between male and female mortality. These publications are quite heterogeneous and rely either on the comparison of populations with similar mortality levels or on historical data from currently high-income populations. The most influential articles in this group include the standard developed by Hill and Upchurch (1995) based on the historical experience of high-income populations and the reference by Alkema et al (2014) based on recent data from 195 countries.(2, 98) In addition, no statistical testing was performed in some studies, and any magnitude of differences between observed and expected values were considered. For these publications, the comparison with populations with different demographic characteristics arises as an additional limitation.

We have classified reference studies as either *descriptive* or *prescriptive*. A previous analysis employed two of the reference methods included in this review in a set of surveys from LMICs to compare their potential for identifying countries with evidence of gender bias in U5MR.(10) The authors found higher values of excess female mortality when using the expected values from Hill and Upchurch (1995), a prescriptive approach, than when using Alkema et al (2014) estimates, a descriptive method.(71)

Twenty-one publications (14%) were *comparative* studies that used either external or internal comparison parameters. The comparisons used in analyses included parameters defined by reference studies mentioned above, for example, the Hill and Upchurch standards. Other studies relied on Coale and Demeny's life table models (1966 and 1983).(155, 156) Even though these tables were not originally proposed for comparing mortality sex ratios – and therefore were not included in the group of reference studies summarized above – they have been widely used to define expected values. The limitation that arises in these situations is that model life tables incorporate estimates of typical sex differences in mortality for different levels of life expectancy for European populations, rather than for levels of child mortality.(98) Additionally, the estimates differ both according to the model and according to the level within each model.(74) It should be noted that present-day LMICs – the principal focus of the analyses – may have epidemiological and demographic profiles that differ from the settings upon which the models used as the reference were based. Additionally, the definition of the comparison group is often based on an *a priori,* arbitrary judgment of absence of gender discrimination. Even so, these comparisons are useful for monitoring sex ratios and identifying outliers. Some studies combined values from published sex ratios in different populations in order to define expected values, which is questionable.

Most studies classified in the *narrative* group were restricted to describing sex ratios within a population, without comparisons to a reference or standard to interpret these results. Typically, sex ratios above or below the unity are assumed to be indicative of excess mortality for boys or girls. These studies are useful for providing an overview of the relationship between male and female mortality, especially in time series. Their main limitations include failing to account for the biological frailty of boys, lack of adjustment for overall mortality level, and absence of statistical assessment of the sex differences. Even so, more than identifying statistical differences between male and female mortality, it would be necessary to analyze if the relationship between the estimates is different from that that would be expected in a given context. Unless a study shows significantly higher mortality of girls than boys, which is never observed in the absence of gender bias, in general, these studies are not robust enough to provide evidence of discrimination.

Other characteristics of the publications identified in the review are discussed below. Different age ranges for mortality were used in the studies. It is important to highlight that neonatal mortality is heavily influenced by biological factors, being less sensitive to familial behavior. Post-neonatal mortality is more likely to be independent of preexisting medical complications and to happen at home, and more dependent on nurturing care provided by the family. Beyond the age of one year, the female mortality advantage is not marked as is the case for infants, and the effects of discrimination become more evident.(1) Nonetheless, there are many biomedical interventions, such as antibiotics or vaccines, that may prevent infant deaths, and for which access may be affected by gender bias in care-seeking behaviors. (159)

In terms of the populations under study, most analyses came out of India, a country known for gender discrimination against females and where various interventions have been used to prevent what has been described as “daughter elimination”.(40) India, Bangladesh, and China were explored in almost a half of all studies. In these three countries, there is vast evidence of female disadvantage in survival, regardless of the method used to assess it. Interestingly, few standalone studies were based on other South Asian or Middle Eastern countries, which multi-country studies often single out as presenting gender bias. Works that used data from high-income countries were mainly published up to 1980, all of them were included in the *narrative* group of studies. Most of these studies were focused on the magnitude of male disadvantage in survival. In the few studies reporting higher mortality among girls, this was only observed beyond the childhood period, particularly during adolescence or adulthood, being related to maternal deaths or those associated with the occupation.

Regarding data sources, civil or vital registration systems are the gold standard, as these record births and deaths on a continuous real-time basis and cover a whole defined population. However, few LMICs have such systems in place with sufficient coverage and quality. Therefore, household surveys collecting information on reproductive histories of women, including births and deaths of their children, constitute the main source of nationally representative child mortality estimates for LMICs. However, they may present some limitations. Since they are based on retrospective self-reports, there is always a chance that the number and sex of children have been misreported. Also, there may be errors in the dating of events and age heaping, the omission of events, and sampling errors. The same limitations apply to census data, which are also frequently used for mortality estimation using indirect methods. Waldron (1987) compared mortality sex ratios estimated from the United Nations life tables (based on vital registration) and from the World Fertility Surveys for 17 countries and found a weak correlation between these estimates, with girls presenting 12% higher mortality than boys in the WFS data, while this difference was only 5% in the life tables data for an overlapping 10-year period.(8) A limitation of all data sources is that they do not allow a direct assessment of female infanticide, which would be very important for identifying gender discrimination.

The literature is focused on the possibility of gender bias against girls. Yet, higher-than-expected male mortality could imply that boys experience mortality to a degree disproportionate to their biological disadvantage. Some evidence is provided by historical changes in sex ratios in high-income countries, as reported by Drevenstedt et al (2008).(7) This study revealed that the decline in infectious diseases and the relative increase in perinatal causes led male-to-female ratios in infant mortality to increase, after which the improvement of obstetric and neonatal care led to a subsequent decline in the sex ratio.(7)

We also noticed a lack of standardization in data aggregation levels. The use of national data, for example, may be problematic as they do not account for subnational variability in household and family characteristics, including behaviors influenced by son-biased values, for instance. Studies from India document important differences among the Northern and Southern states, with less evidence of gender bias in the latter.(14-16, 151)

Studies assessing multiple countries often used data sources covering different time periods or failing to study a representative sample of a given world region. Studies of time trends will be more informative than those reporting on single points in time, as sex ratios may vary as a function of historical elements such as war mortality, fertility transitions, and famines.

A related issue, addressed in some articles, is evidence that reductions in excess female mortality observed might be related to increasing pre-natal sex selection practices, supporting a substitute hypothesis, which states that infanticide and neglect of girls are being replaced by sex-selective abortion of female fetuses, contributing to the ‘missing women’ phenomenon.

Some authors argue that population sex ratios would be a more appropriate measure to assess gender bias given that these combine pre- and post-natal discrimination and account for sex-selective migration.(79) Population sex ratios were not covered in this review since we were interested primarily in methods for mortality analyses and assessment of the impact on live born children. Nonetheless, a few studies included in this review combined assessments of gender bias in mortality (the so-called ‘post-natal female deficit’) and prenatal sex selection.(15, 25, 39, 40, 75)

The investigation of factors associated with sex ratios falls outside of the scope of the present work, but it is noteworthy that many studies complemented their survival analyses with the assessment of potential determinants including health care behaviors,(10, 20, 110) health status,(79) socioeconomic characteristics, (27, 44, 81, 82, 87, 95, 109, 124) family composition,(73, 96, 107, 108, 121, 146) fertility choices and differential stopping behavior.(16, 105, 124, 139, 146) Also, the societal position and value of girls and women, including education, power, autonomy, control over resources, and economic and social status, may affect their survival probabilities.(80)

The authors of the studies under review call for further investigation on the causes of unexpected sex differentials and for the introduction of more systematic monitoring of sex differences in child mortality. Qualitative research is also necessary to document the unfair distribution of resources and discriminatory treatment of boys and girls. The mechanisms of gender discrimination are complex and multilayered, ranging from deliberate neglect in health-seeking behaviors to bias in resource allocation, which is difficult to assess solely through quantitative analyses. Moreover, additional research is needed to understand national and regional differences in the economic and societal roles of girls and women, which seems to affect female survival.

Some caveats in the review process must be recognized. As scoping reviews do not assess study quality, some of the literature reviewed may be methodologically flawed. Also, the screening process and data extraction were not performed in duplicate. Nevertheless, our work fills a gap in the literature by summarizing studies carried out over a long-time span, and by contributing to the understanding of analyses on sex differentials in mortality of children. The main strength of our review is the use of comprehensive combinations of terms for building the search strategy, which produced a list of about 17,000 studies to be screened. Through this search, we were able to identify the huge diversity of journals in distinct fields – such as Epidemiology, Demography, and Economics – that have published on this topic, documenting that gender and survival issues affect multiple aspects of global well-being. Additionally, the visual representation of the words used in the titles of the works reveals the diversity of terminologies, which has presented an extra challenge for the review screening process.

Rather than comparing results that emerged from analyses performed with multiple methods, our review focused on the discussion of methodological approaches for identifying gender bias and addressed the need for standardization of methodologies.

In summary, much effort has been made to measure, interpret, and explain sex differentials in early childhood mortality. Over time, there have been advances regarding data availability and quality, and in the sophistication of statistical methods on the relationship between male and female mortality, allowing definitions of what would be the so-called ‘normal’ and in the identification of unexpected differences. Yet, many authors still fail to account for the role of mortality levels in contributing to sex ratios. The issue of what constitutes the expected values of sex ratios for a given level of mortality is still open to debate but the use of model life tables and historical time series still have a role to play.

To overcome the limitations, future research on this topic should account for overall mortality levels, address different groups of age at death, and account for causes of deaths whenever possible. We also suggest the use of more than one reference value to allow interpretation of findings in light of different parameters, and the use of formal statistical testing that account for the variability of estimates of sex ratios.

Addressing factors possibly associated with the sex differentials and the mechanisms underlying the biased estimates is also crucial and should cover distal as well as proximal factors. Time trends analyses, performed with a consistent methodology, can help understand both the sex differentials in a historical perspective and their relationship with changes in development level, improvements in health care, and advances in the gendered nature of social norms.

The results presented here underscore the need for further work on how to identify appropriate references for evaluating sex differentials on child mortality, leading to the formulation of policy interventions aimed at closing the unfair gender gap in childhood survival. Finally, we reinforce the call of Sustainable Development Goal 17.18 for disaggregation of data in order to identify more vulnerable groups within countries.

Authorship contributions

JCC conducted the search and data extraction; JCC and CGV contributed to the design of the research, to the analysis of the results, and the writing of the manuscript.

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Competing interests

The authors declare no competing interests.

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Table 1 – Summary of characteristics of *reference studies.*

Author, year	Observed data	Measure	Age group	Definition of expected values: Reference population	Definition of expected values: Assessment method	Definition of expected values: Expected value	Comparison method	Type of reference	Citations#
Clark, 1987	India, published estimates	Sex ratio*	1-59 months	25 'Third World' countries, World Fertility Surveys	Average sex ratio	99.6	Magnitude of observed and expected sex ratios, significance assessment	Descriptive	33 / 1
Johansson and Nygren, 1991	China, 1988 Two-per-thousand Fertility Survey	Sex ratio	IMR	Countries with information for at least four years 1976-1984, United Nations Demographic Yearbook	Average sex ratio	130	Magnitude of observed and expected sex ratios	Prescriptive	457 / 16
Svedberg, 1991	23 Sub-Saharan African countries, published estimates, 1953-1983	Sex ratio, Excess mortality	IMR	Sweden official statistics, 1983-1987	Sex ratio of Swedish population		Ratio of ratios (observed/ expected) above or below the unity	Descriptive	282 / 9.4
			CMR						
Goodkind, 1995	Vietnam	Sex ratio	IMR	East Asian populations	Average sex ratio	97	Magnitude of observed and expected sex ratios	Descriptive	110 / 4
			CMR			95			
Hill and Upchurch, 1995	35 LMICs, DHS, 1986-1993	Sex ratio*	IMR	England and Wales, France, Netherlands, New Zealand, and Sweden, Coale and Demeny (1983) West model, 1820-1964	LOWESS curve for the association between sex ratios and male U5MR (from 25 to 300)	130-118	Difference between observed and expected sex ratio for each value of male mortality	Prescriptive	301 / 12
			CMR			122-103			
			U5MR			129-111			
Klasen, 1996	20 LMICs, Census and World Fertility Surveys	Sex ratio; Male mortality	IMR	Coale and Demeny (1983) West and North models and Sweden official statistics, 1983-1987	Sex ratio of reference populations		Ratio of ratios (observed/ expected) above or below the unity	Descriptive	142 / 6
			CMR						
Chaudhuri, 2011	India, 2005-06 National Family and Health Survey	Female mortality	IMR	Kerala state, India (same survey)	Linear regression for sex ratio based on male U5MR and being from Kerala	Expected female mortality derived from expected sex ratio based on the regression coefficients	Excess female mortality if observed value greater than expected; probit model	Prescriptive	5 / 0.6
Srinivasan and Bedi, 2011	Tamil Nadu, India, Vital Events Survey, 1996-1999	Female mortality	IMR	Values from Waldron (1983), Johansson and Nygren (1991), Hill and Upchurch (1995), United States and United Kingdom life tables	Female mortality in function of male mortality based on the values reported in previous studies	Expected female mortality = 80% of male mortality	Difference between observed and expected values	Prescriptive	45 / 5
Chaudhuri, 2012	13 Indian states, National Family Health Surveys, 1992, 1998 and 2005	Female mortality	IMR	Kerala state, India (same surveys)	Multivariate logistic regression	Regression coefficients	Incidence of excess female mortality = difference between observed female IMR in each state and the benchmarking female IMR (Kerala)	Prescriptive	96 / 12

Author, year	Observed data	Measure	Age group	Definition of expected values			Comparison method	Type of reference	Citations#
				Reference population	Assessment method	Expected value			
Monden and Smits, 2013	35 Sub-Saharan African and Southern Asian countries, DHS, 2000s	Sex ratio	CMR	Austria, Belgium, United Kingdom, France, Germany, Netherlands, Scandinavian countries, USA, Canada, New Zealand, and Australia, Human Mortality Database, since 1920	Average sex ratio	117	Magnitude of observed and expected sex ratios	Prescriptive	34 / 5
			U5MR			125			
Jamison et al, 2013	India and China, published estimates	Sex ratio	U5MR	Demographic and health surveys from LMICs	Average sex ratio	118	Magnitude of observed and expected sex ratios; estimates of excess of female mortality based on male mortality	Descriptive	1134 / 162
Alkema et al, 2014	195 countries, areas, and territories, multiple sources, 990-2012	Sex ratio	IMR	195 countries, areas, and territories, multiple sources, 1990-2012	Global relation between sex ratios and mortality levels; Bayesian model	120, 126 and 115 for IMR of 5, 20 and 150	Assessment of outlying values	Descriptive	82 / 14
			CMR			121-101 for CMR of 5 to > 30			
			U5MR			125-109 for U5MR of 20-400			
Chaudhuri, 2015	14 Indian states, National Family Health Surveys, 1992, 1998 and 2005	Female mortality	IMR	Bihar vs 13 Indian states; Bihar vs 8 less gender bias Indian states (same surveys)	Multivariate logistic regression	Coefficient of interaction between being from Bihar and female sex		Descriptive	6 / 1.2
Guilmoto et al, 2018	India, 2011 Census	Female mortality	U5MR	46 countries without known gender discrimination, World Population Prospects	Quadratic regression for the relation between female and male U5MRs	Expected female U5MR for each level of male U5MR	Difference between observed and expected female U5MR; absolute excess female mortality	Prescriptive	23 / 12

# Citations = total and per year since publication; * Sex ratio originally presented as female-to-male
IMR = infant mortality rate; CMR = child mortality rate; U5MR = under-five mortality rate; DHS = Demographic and Health Surveys; LMICs = low- and middle-income countries; LOWESS = Locally weighted least squares smoothing; SD = standard deviation

Table 2 – Summary of characteristics of *comparative studies.*

Author, year	Observed data	Measure	Age group	Definition of comparison		
				Reference population	Reference value (when applicable)	Comparison method
Hammoud, 1977	Algeria, Democratic Yemen, Egypt, Iraq, Jordan, Kuwait, Libyan Arab Jamahiriya, Morocco, Syrian Arab Republic and Tunisia, multiple sources, 1951-1974	Sex ratio	IMR	Mauritius, Canada, Chile, Mexico, Paraguay, United States, Hong Kong, Japan, Philippines, Thailand, Denmark, Hungary, Portugal, Yugoslavia and Australia (United Nations and World Health Organization)	-	Magnitude of observed and expected sex ratios
			CMR			
Khosla, 1980	17 states, India, Health statistics, 1971-1975	Sex ratio	NMR	46 countries from 1970-1974 (WHO annual statistics)	-	Magnitude of observed and expected sex ratios
			PNMR			
			IMR			
Choe, 1987	Korea, 1974 National Fertility Survey, 1960-1974	Sex ratio	IMR	Coale and Demeny (1983) West and North models, levels 19, 20 and 21 and life tables for 10 countries (Israel, Jordan, Kuwait, Hong Kong, Sarawak, Panama, Belize, Jamaica, Guyana, Portugal)	122-133; 81-140	Magnitude of observed and expected sex ratios; Hazard models for multivariate analysis
			CMR		111-124; 71-118	
Das Gupta, 1987	Rural Punjab, India, Khanna Study, 1984	Sex ratio	U5MR*	Khanna 1957-1959 and Matlab Thana 1974-1977	-	Magnitude of sex ratios
Karkal, 1987	India, Sample Registration System, 1970-1980	Sex difference	0, 1, 5 years	South Asia region	-	
Makinson, 1987	Egypt, 1980 World Fertility Survey	Female mortality	U5MR*	Coale and Demeny (1966) West model, level 13.7	Observed female mortality	Magnitude of sex-specific mortality, multivariable logistic model
Chowdhury et al, 1990	Bangladesh, Matlab Demographic Surveillance System, 1977-1985	Female mortality	NMR	Comparison of 204 sex discordant twin pairs with a random sample of 2,371 singletons	Odds ratio 98	Logistic regression and McNemar's test to assess sex differences and conditional survivorship
			IMR		Odds ratio 140	
Pebley and Amin, 1991	26 rural villages in India, Narangwal Study	Sex ratio	Under-3*	Study comparison area	-	Expected mortality rates 1971-1973 without intervention (control villages)
Tabutin, 1992	Algeria, Morocco, Tunisia and Egypt, multiple sources, 1965-1988	Sex ratio	IMR	United Nations model life tables for developing countries	"general pattern" for the reference countries	Magnitude of observed and expected sex ratios
			CMR			
Choe et al, 1995	China, 1988 Two-per-Thousand Survey of Fertility and Birth Control, 1965-1987	Sex ratio	IMR	Coale and Demeny (1983) West and North models, level 20, and Japan 1953-1960	119, 123, 129	Magnitude of sex ratios; multivariate proportional hazard models
			CMR		111, 113, 115	
Clark, 1995	Gwembe District, Zambia, Gwembe Study, 1956-1992	Sex-specific mortality	IMR	Twin pairs and singletons	-	Comparison of sex-specific mortality rates
Johansson, 1996	Meiji, Japan, Published estimates, 1908	Sex ratio	IMR	Swedish estimates (1750-1900), Preston standard (1976)	-	Magnitude of observed and expected sex ratios
			CMR			

Author, year	Observed data	Measure	Age group	Definition of comparison		
				Reference population	Reference value (when applicable)	Comparison method
Muhuri and Menken, 1997	Matlab, Bangladesh	Sex ratio	1-5 years	Study comparison area	-	Magnitude of sex ratios; logistic regression
Goodkind, 1999	North Korea, 1993 Census	Sex ratio	IMR	Previous studies (Makinson 1994; UN 1998); South Korea, China and Taiwan	115-140	Magnitude of observed and expected sex ratios
			CMR		100-120	
Datta and Bairagi, 2000	Bangladesh, Matlab Demographic Surveillance System, 1977-1995	Sex ratio	IMR	Coale and Demeny (1983) West model and study comparison area	Excess female mortality from the equation [(observed sex ratio) - (expected sex ratio)] / (observed sex ratio)] (x 100)	
Yount, 2001	14 Middle Eastern countries, United Nations, 1970s and 1980s	Sex ratio	IMR	Same datasets for expected and observed estimates	From Hill and Upchurch (1995) estimated from the same dataset	Magnitude of observed and expected sex ratios
			CMR			
			U5MR			
Li et al, 2004	Chinese county in Shaanxi province, 1997 Household survey and community survey	Sex ratio	IMR	Published estimates of sex ratios from Li and Feldman (1996); Coale and Demeny (1983) West model	120-140	Magnitude of sex ratios; likelihood ratio test; t test; multivariate logistic regression and Cox survival
			CMR		100-120	
			U5MR		> 100	
Fuse and Crenshaw, 2006	93 countries, United Nations Statistics Division, 2000	Sex ratio	IMR	Published estimates Johansson and Nygren (1991); Hill and Upchurch (1995); Tabutin and Willems (1995)	115 to 130	Magnitude of sex ratios
Jayaraj, 2009	India, Vital Registration System (1991 and 2001) and published estimates	Female mortality	U5MR	Coale and Demeny (1966) West model, levels 18 and 19	Relative survival advantage of females (RSASF)	Magnitude of observed and expected RSAF
Oster, 2009	India, National Family Health Surveys, 1992 and 1998	Female mortality	Under-10*	Ethiopia, Kenya, Malawi, Namibia, Tanzania, and Zambia, DHS, 1992-2001	Regression coefficients, allowing for the interaction between being from India and female sex	Difference-in-differences
Costa et al, 2017	60 LMICs, DHS, 2005-2014	Female mortality	U5MR	Same DHS datasets for expected and observed estimates	From Hill and Upchurch (1995) and Alkema et al (2014) estimated from the same dataset	Excess female mortality (%) = observed/ expected

*Specific subgroups of age (refer to Supplementary Table S1)
IMR = infant mortality rate; CMR = child mortality rate; U5MR = under-five mortality rate; DHS = Demographic and Health Surveys; LMICs = low- and middle-income countries

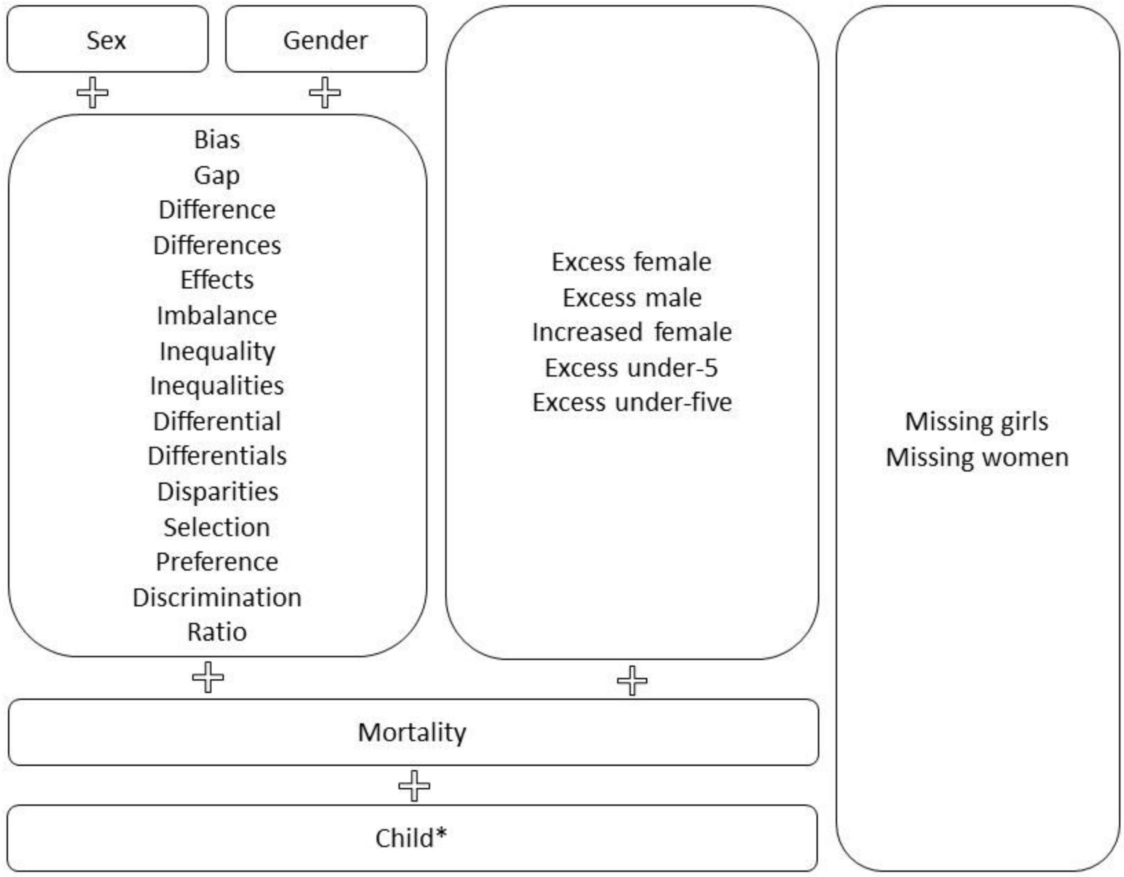

Figure 1 – Search strategy

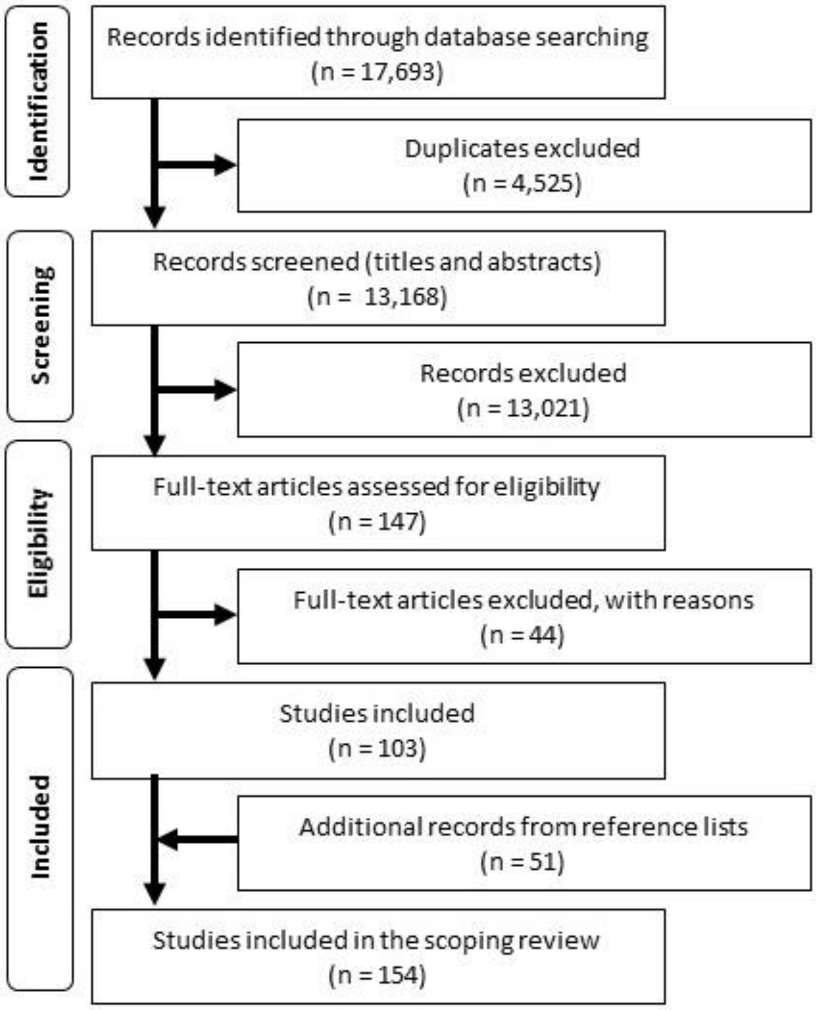

Figure 2 – Study selection flow diagram

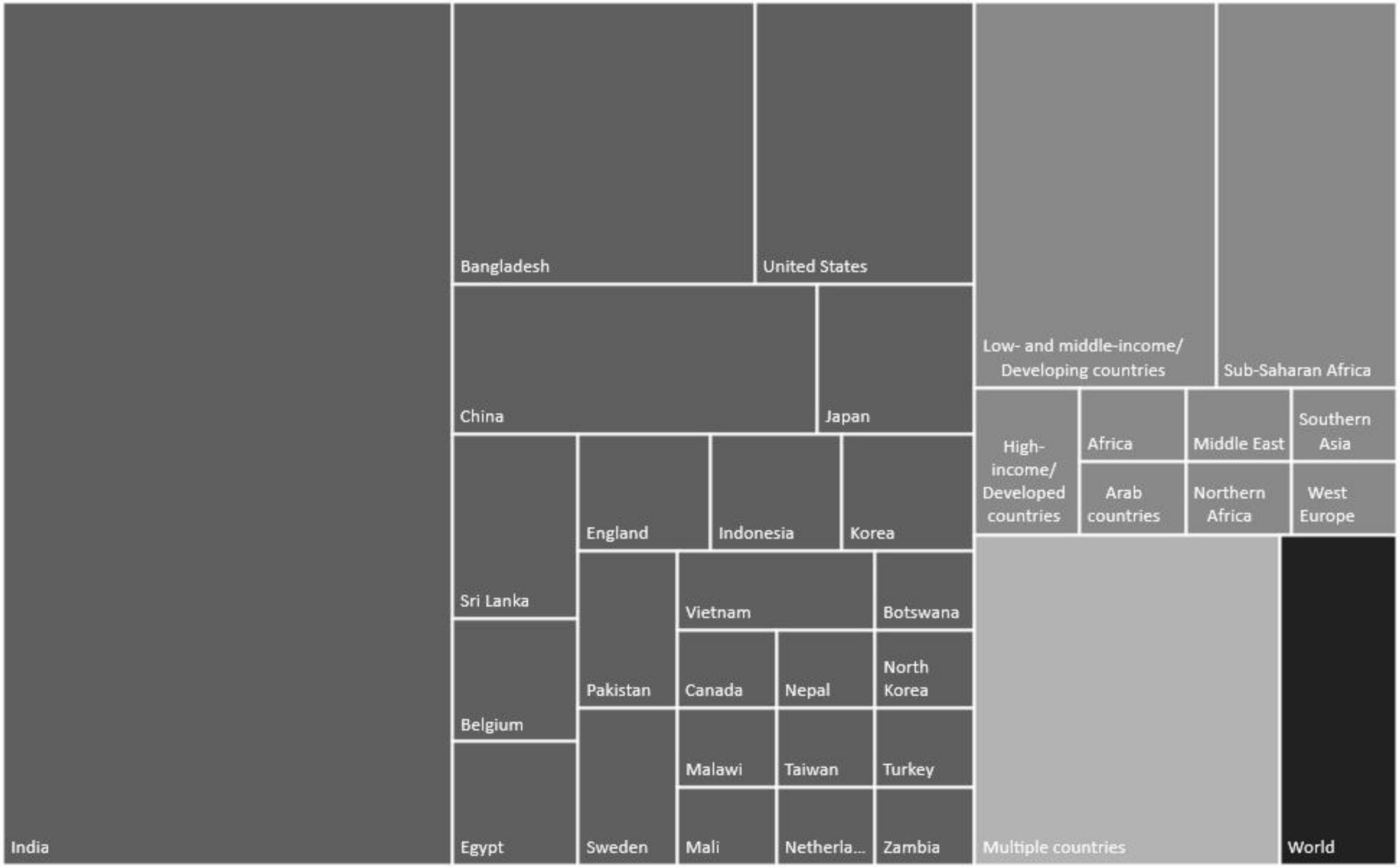

Figure 3 – Place under study

Supplementary Material

Supplementary Table S1 – Summary of characteristics of all 154 studies included in the review.

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Abernethy, V and Yip, R (1990)	Tennessee, United States	Birth-data records	1976-1983	Post-neonatal	Narrative	M:F ratio	NA	Analysis of variance
Abramowicz, M and Barnett, HL (1970)	New York, United States and 13 countries (Australia, Chile, Denmark, England and Wales, Guatemala, Jamaica, Japan, Luxembourg, Mexico, New Zealand, Sweden, Switzerland, and United States)	NY: Department of Statistics, New York city Department of Health Countries: United Nations Publication, 1954	NY 1870-1960, countries 1915-1949	Infant	Narrative	M:F ratio	NA	Scatter plot
Agnihotri, SB (2001)	India	Sample Registration Survey	1982-1997	Infant Child	Narrative	M-F difference F-M difference slope of linear regression	NA	Linear regression
Ahmed, FAE (1990)	Egypt	Census	1976	Infant Under-two Under-three Under-five	Narrative	M:F ratio	NA	Magnitude of sex ratios; OLS regression
Alam N, et al (2007)	Matlab, Bangladesh	Demographic Surveillance System	1976-1999	Neonatal Post-neonatal Child	Narrative	M:F odds ratio	NA	Sex-specific mortality over time; descriptive sex ratio by birth cohort; logistic regression by cohort and area
Alam, N and Bairagi, R (1997)	Matlab, Bangladesh	Demographic Surveillance System	1978-1994	Child	Narrative	M:F ratio F:M ratio	NA	Sex-specific mortality and sex ratio over time; logistic regression for each birth cohort and comparison to control area
Alkema, L et al (2014)	195 countries, areas and territories	Survey data, censuses, vital registration systems, sample registration and surveillance systems	1990-2012	Infant Child Under-five	Reference, descriptive	M:F ratio; Excess female mortality	Same 195 countries with information (relationship between own data)	Bayesian hierarchical models for identifying outliers
Alter, G et al (2004)	five sets of Eurasia Project villages (China, Japan, Italy, Belgium, Sweden)	Eurasia Project	1789-1899	Infant Child	Narrative	M:F ratio	NA	Magnitude of sex ratios
Altindag, O (2016)	Turkey	Demographic and Health Survey	1993, 1998, 2003, and 2008	Infant	Narrative	F-M difference	NA	Difference-in-differences regression model

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Amin, S (1990)	26 villages in the district of Ludhiana, rural Punjab, India	Narangwal Study	1964-1973	Neonatal (0-1 month) Postneonatal (2-12 months) Childhood (13-36 months) Under-three	Narrative	Relative risk	NA	Multivariate hazard models
Arnold, F (1992)	26 low- and middle-income countries	Demographic and Health Survey	1986-1989 (mortality in the 10 years preceding the interview)	Neonatal Post-neonatal Infant Child	Narrative	M:F ratio	NA	Sex ratio above or below one
Arnold, F (1997)	44 low- and middle-income countries	Demographic and Health Survey	1986-1995 (mortality in the 10 years preceding the interview)	Neonatal Post-neonatal Infant Child Under-five	Narrative	M:F ratio	NA	Magnitude of sex ratios; significance assessment
Arnold, F et al (1998)	India	National Family Health Survey	1992-1993	Child	Narrative	Excess female mortality (%); Relative Risk	NA	Multivariate hazard models
Arokiasamy, P (2004)	India	National Family Health Survey	1992-1993 (births in the four years preceding the interview)	Neonatal Post-neonatal Child	Narrative	F:M ratio; Odds ratio	NA	Logistic regression
Arokiasamy, P (2007)	India	National Family and Health Survey	1992 and 1998 (mortality in the 10 years preceding the interview)	Neonatal Post-neonatal Child	Narrative	F:M ratio	NA	% excess based on sex ratio; multivariate logistic regression model
Ashorn, P et al (2002)	Lungwena, rural Malawi	Prospective cohort	NA	Under-three	Narrative	M:F relative risk	NA	Cox regression
Attané, I (2009)	Chinese provinces, autonomous regions, and municipalities	Census	2000	Infant	Narrative	F:M ratio	NA	Correlation and multiple linear regression
Bakwin, H (1929)	United States	United States Birth, Stillbirth, and Infant Mortality Statistics	1918-1924	Infant	Narrative	M:F ratio	NA	Sex ratio above or below one
Balsara, SL et al (2013)	United States	NCHS and CDC linked birth and deaths records	1999-2007	Infant Child	Narrative	M:F relative risk; M-F difference of rates	NA	Magnitude of relative risks and difference in number of deaths
Basu, AM (1989)	Uttar Pradesh and Tamil Nadu, India	Survey of cultural influences on demographic behavior	NA	Under-five	Narrative	Sex-specific mortality; M:F ratio	NA	Magnitude of sex-specific mortality and sex ratios
Berman, SM et al (1987)	Georgia, United States	Linked birth certificate-death certificate records	1974-1981	Neonatal	Narrative	M:F ratio	NA	Mantel-Haenszel test

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Bhargava, A (2003)	Uttar Pradesh, India	National Family Health Survey	1992-1993 (births in 1982-1992)	Infant	Narrative	Maximum likelihood estimates	NA	Probit models
Bhaumik, U et al (2004)	Massachusetts, Unites States	Linked birth and death certificate data	1989-1995	Neonatal Post-neonatal Infant	Narrative	F-M difference	NA	Chi-squared test; Non-linear regression
Bhuiya, A and Streatfield, K (1991)	Matlab, Bangladesh	Demographic Surveillance System	births in 1982	0 month 1-5 months 6-11 months 12-17 months 18-35 months	Narrative	Risk of dying by sex Hazard logit coefficients by sex	NA	Multivariate hazard model; maximum-likelihood logit model
Boco, AG (2014)	30 sub-Saharan African countries	Demographic and Health Survey	2004-2012 (births in the five years preceding the interview)	Under-five	Narrative	M:F odds ratio	NA	Multilevel discrete-time hazard models
Bourne, KL and Walker, GM (1991)	The 14 major states and Delhi, India	Census	1981	Under-one Under-two Under-three Under-five	Narrative	Actual rates and median	NA	Sign test (F> M or M>F), median polish
Caldwell, P and Caldwell, JC (1990)	India	Sample Registration System, Census	1976-1981	Under-five	Narrative	F:M ratio	NA	Magnitude of sex ratios
Chaudhuri, S (2011)	India	National Family Health Survey	2005-2006	Infant	Reference, prescriptive	Excess female mortality	Kerala state, India (same dataset)	Linear regression for sex ratio based on male U5MR and being from Kerala; difference between observed and expected female mortality; probit model for the likelihood of excess female mortality
Chaudhuri, S (2012)	13 states, India	National Family Health Survey	1992-1993, 1998-1999, and 2005-2006 (births in 1950-2010)	Infant	Reference, prescriptive	Incidence of missing girls	Kerala state, India (same dataset)	Multivariate logistic regression
Chaudhuri, S (2015)	Bihar	National Family Health Survey	1992, 1998, and 2005	Infant	Reference, prescriptive	Excess female mortality (%) Odds Ratio	13 states and India as whole, 8 states (same dataset)	Multivariate logistic regression; proportion of excess female deaths; Hill and Upchurch (1995) estimates
Chen, J et al (2007)	rural areas of China	National Family Planning and Reproductive Health Survey	2001 (births between 1989-2000)	Infant	Narrative	Odds ratio	NA	Multilevel logistic regression models with Markov Chain Monte Carlo method
Choe, M et al (1998)	Egypt, Bangladesh, and Republic of Korea	Egyptian Demographic and Health Survey; Bangladesh Fertility Survey; Korean Family and Health Survey	1988, 1989, 1991	2-5 years Under-five	Narrative	M:F ratio, odds ratio, relative risk	NA	Discrete time hazard model, logistic regression

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Choe, MK (1987)	Korea	World Fertility Survey	1974 (births in 1960-1965 and 1966-1974)	Infant Child	Comparative, not standard	M:F ratio	West and North life tables (Coale and Demeny, 1983) and life tables for 10 countries (Israel, Jordan, Kuwait, Hong Kong, Sarawak, Panama, Belize, Jamaica, Guyana, Portugal)	Magnitude of sex ratios; multivariate hazard models by sex
Choe, MK et al (1995)	China	Two-per-Thousand Survey of Fertility and Birth Control	1988 (births between 1965-1987)	Infant Child (1-5 years)	Comparative, standard	M:F ratio	West and North life tables, level 20 (Coale and Demeny, 1983) and Japan (1953-1960)	Magnitude of sex ratios; Hazard models for firstborn and later-born children
Chowdhury, MK et al (1990)	Matlab, Bangladesh	Demographic Surveillance System	1977-1985	Neonatal Infant Under-nine	Comparative	F:M odds ratio, conditional survivorship	Singletons from the same population	Survival analysis by sex; McNemar's test
Chowdhury, R (2017)	Haryana, India	Cluster randomized trial examining the Integrated Management of Neonatal and Childhood Illness programme	2008-2010	1st day 1st week Neonatal Post-neonatal	Narrative	Odds ratio	NA	Multiple logistic regression
Chunkath, SR and Athreya, VB (1997)	Tamil Nadu, India	Directorate of Public Health Survey	1995	Post-neonatal Infant Early, late neonatal	Narrative	F-M difference F:M ratio	NA	Differences and ratios by district
Clark, A (1987)	India	Published estimates	1970-1978	Post-neonatal under-five	Reference, descriptive	F:M ratio	World Fertility Surveys from 25 countries	Average sex ratio and significance assessment based on confidence limits
Clark, S et al (1995)	Gwembe District, Zambia	Gwembe study (longitudinal)	1956 and 1992	Infant	Comparative, not standard	sex-specific mortality rates	twin pairs and singletons	Magnitude of sex-specific mortality rates
Cleland, J and Harris, K (1998)	27 low- and middle-income countries	Demographic and Health Survey	DHS - phase I (births in the 10 years preceding to the interview)	6-60 months	Narrative	M:F ratio	NA	Sex ratio above or below one, Cox-Mantel test
Costa, JC et al (2017)	60 low- and middle-income countries	Demographic and Health Survey	2005-2014	Under-five	Comparative, standard	Excess female mortality (observed/expected)	Demographic and Health surveys (same datasets for expected and observed estimates) using expected values from Hill and Upchurch (1995) and Alkema et al (2014)	Excess female mortality (%)
Crognier, E et al (2006)	southern Morocco and Bolivian Altiplano	Health and Fertility Survey of the Province of Marrakech, Survey by the Bolivian Institute of Altitude	1984 and 1998-1999	0-2 years 2-5 years	Narrative	Percentage of surviving offspring by sex	NA	Survival analysis employing Kaplan-Meier estimator

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Das Gupta, M (1987)	rural Punjab, India	Khanna study (survey)	1984	Neonatal Post-neonatal Infant 12-23 months 24-59 months 0-59 months	Comparative, not standard	M:F ratio	Khanna 1957-1959 and Matlab Thana 1974-1977	Magnitude of sex ratios
Das Gupta, M and Bhat, PNM (1997)	India	Census	1981 and 1991	Under-five	Narrative	M:F sex ratio	NA	Percentual of excess female mortality based on sex ratio
Datta, A and Bairagi, R (2000)	Matlab, Bangladesh	Demographic Surveillance System	1978-1995	Infant	Comparative, standard	F:M sex ratio, excess female mortality	West model life table (Coale and Demeny, 1983) and study comparison area	Magnitude of sex ratios and estimates of excess female mortality
Devos, I (1996)	Belgium	Published estimates	1890-1910	Infant Child	Narrative	M:F ratio	NA	Sex ratio above or below one
Diamond-Smith, N et al (2020)	153 districts, India	Census	2000 and 2011	0-6 years	Narrative	F:M ratio	NA	Change in sex ratio over time
Drevenstedt, GL et al (2008)	15 high-income countries	Human Mortality Database	1751-2004	Infant	Narrative	M:F ratio	NA	Linear regression of sex ratio on overall mortality level
D'Souza, S and Chen, LC (1980)	Matlab, Bangladesh	Demographic Surveillance System	1974-1977	Neonatal Post-neonatal Infant Child	Narrative	Sex-specific mortality rates F:M ratio	NA	Significance assessed using t-test
Eggerickx, T and Tabutin, D (1994)	Belgium	Census	1890	Infant Child	Narrative	M:F ratio	NA	Sex ratio above or below one
El-Badry, MA (1969)	Ceylon, India and Pakistan	United Nations Demographic Yearbook, published estimates, Abridged life tables, Population Growth Experiment	1953-1965	Infant Child	Narrative	Sex-specific mortality rates F:M ratio	NA	Magnitude of sex ratios
Fauveau, V et al (1991)	Matlab, Bangladesh	Demographic Surveillance System	1986-1987	Child	Narrative	F:M relative risk	NA	Incidence density ratios
Finlay, R (1981)	Cartmel, Cumbria, Englnd	Cartmel family reconstitution and probate records	1600-1750	Infant Child	Narrative	M:F ratio	NA	Magnitude of sex-specific mortality
Flato, M and Kotsadan, A (2015)	29 low- and middle-income countries	Demographic and Health Survey	1986-2011	Infant	Narrative	Sex-specific rate	NA	Magnitude of estimates
Fuse, K and Crenshaw, EM (2006)	93 countries	United Nations	2000	Infant	Comparative, standard	M:F ratio	Hill and Upchurch (118 to 130), Tabutin and Willems (110), Johansson and Nygren (130)	Magnitude of sex ratios, correlation; OLS regression
Garenne, M (2003)	25 sub-Saharan African countries	Demographic and Health Survey and World Fertility Survey	1977-1998	Neonatal Post-neonatal Child	Narrative	M:F sex ratio	NA	Student's t test; chi-square test

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Gellatly, C and Petrie, M (2017)	India	National Family Health Survey	1992-1993, 1998-1999, and 2005-2006	Infant	Narrative	Mortality hazard M:F ratio	NA	Logistic regression
Gleason, SM (2003)	India	Census	1981	Under-five	Narrative	Marginal effects from the sex-specific regression models	NA	Robust “seemingly unrelated regression” method
Goodkin, D (1995)	Vietnam	Census	1979 and 1989	Infant Child	Reference, descriptive	M:F sex ratio	Variety of populations in East Asia	Magnitude of sex ratios
Goodkin, D (1999)	North Korea	Census	1993	Infant Child	Comparative, not standard	M:F ratio	Previous studies (Makinson 1994; UN 1998) expected IMR = 115-140 and CMR = 100-120; South Korea, China and Taiwan	Magnitude of sex ratios
Guilmoto, C et al (2015)	Indonesia	Census	2010	before 15-19 years	Narrative	M:F ratio	NA	Magnitude of sex ratios
Guilmoto, C et al (2018)	Indian states and districts	Census	2011	Under-five	Reference, prescriptive	Excess female mortality	46 countries without known sex selection in mortality (World Population Prospects, 1950-2015); quadratic regression for the association between female and male mortality rates	Comparison of observed and expected female mortality rates
Hammoud, EI (1965)	12 countries	United Nations Demographic Yearbook	1954-1955	Infant	Narrative	M:F ratio	NA	Magnitude of sex ratios; rank correlation of infant mortality rates and sex ratios
Hammoud, EI (1977)	Algeria, Democratic Yemen, Egypt, Iraq, Jordan, Kuwait, Libyan Arab Jamahiriya, Morocco, Syrian Arab Republic and Tunisia	United Nations Demographic Yearbook, WHO World Health Statistics Annual (1971 and 1972), national publications	1951-1974	Infant Child	Comparative, not standard	M:F ratio	Mauritius, Canada, Chile, Mexico, Paraguay, United States of America, Hong Kong, Japan, Philippines, Thailand, Denmark, Hungary, Portugal, Yugoslavia and Australia (United Nations and World Health Organization)	Magnitude of sex ratios
Harpending, HC and Pennington, R (1991)	Botswana	Family survey system	]1959-1975[	Infant Child	Narrative	Sex-specific mortality rates	NA	Chi-square test
Hill, K and Upchurch, D (1995)	35 low- and middle-income countries	Demographic and Health Survey and World Fertility Survey	1980-1990; 1970-1980	Infant Child Under-five	Reference, prescriptive	F:M ratio Female disadvantage index	Five countries from 1800 to 1964 (subset of Coale and Demeny (1983) life tables); LOWESS curve for the association between sex ratios and male under-five mortality	Index of female disadvantage (observed - expected sex ratios)
Holmes SJ and Mentzer VP (1931)	19 countries	Published estimates	1911-1929	Infant 2-3 months 4-12 months	Narrative	M:F ratio	NA	Magnitude of sex ratios

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Humphrey, L et al (2012)	London, England	Burial and baptism registers	1750-1839	Neonatal Infant	Narrative	M:F relative risk Coefficients from sex-specific biometric model	NA	Significance of relative risks, biometric model by sex
Iqbal, N et al (2018)	195 countries	UNICEF	2015	Under-five	Narrative	M:F ratio Sex-specific U5MR Excess female mortality	NA	Multivariable linear regression; likelihood ratio test
Jamison, DT (2013)	India and China	Demographic and Health Survey	2000s	Under-five	Reference	M:F ratio	Demographic and Health Surveys from low- and middle-income countries	Magnitude of sex ratios and estimates of excess female mortality
Janssens, A et al (2010)	The Netherlands	Death registration (community level) and Population Registers (individual level)	1875–1899	Infant 1 year 2-4 years	Narrative	Age-specific mortality ratios by sex M:F ratio Propensity to die	NA	Description of sex ratios, discrete-time multi-level event history analysis using logistic regression
Jayaraj, D (2009)	India	Vital Registration System and published estimates	1991 and 2001	Under-five	Comparative	Relative survival advantage of females (RSAF)	RSAF for West model life tables of levels 18 and 19 (Coale and Demeny, 1966)	Comparison of RSAF magnitude
Johansson, S (1996)	Meiji, Japan	Published estimates	1908	Infant Child	Comparative, standard	M:F ratio	Swedish estimates (1750-1900), Preston standard (1976)	Magnitude of sex ratios
Johansson, S and Nygren, O (1991)	China	Fertility survey by State Family Planning Commission	1988	Infant	Reference, prescriptive	Sex ratio Excess female mortality	Developed countries and developing countries without strong sex preferences, from 1976 to 1984 (1985 UN Demographic Yearbook)	Magnitude of sex ratios
Kalsi, P (2017)	India	District Level Household Survey	1987-2001	Infant Child	Narrative	Regression coefficients (dependent binary variable for dead children)	NA	Difference-in-difference-in-differences regression model
Karkal, M (1987)	India	Sample Registration System	1970-1980	0, 1, 5 years	Comparative, not standard	F-M difference	South Asia (1970-1975 and 1976-1980)	Magnitude of sex differences
Karlsson, O et al (2019)	India	National Family Health Survey	2005-2006 and 2015-2016	Neonatal Post-neonatal Child	Narrative	Mortality probability	NA	Sex-specific logit model
Khosla, T (1980)	17 Indian states	Health Statistics of India	1970	Neonatal Post-neonatal Infant	Comparative, not standard	M:F ratio	46 countries from 1970-1974 (WHO annual statistics for 1977)	Simple comparison of sex ratios magnitude

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Kikuzawa, S (1999)	Yokouchi, Japan	Annual census registers	1671-1871	Under-three	Narrative	Sex-specific mortality Coefficients of sex-specific regression models	NA	Magnitude of sex-specific mortality; logistic regression
Kishor, S (1993)	India	Indian Development District Database (census + other sources)	1981	Under-five	Narrative	logged female mortality, male mortality and F:M ratio	NA	"Spatial disturbance model" approach and maximum likelihood estimation techniques
Klasen, S (1996)	Sub-Saharan Africa	World Fertility Surveys, Census, Urban surveys, Rural surveys	1954-1983	Infant Child	Reference, prescriptive	Sex ratio	Coale and Demeny (1983) West model life tables (non-European populations), North model (Northern European) and Swedish data	Excess male mortality = observed sex ratio / expected sex ratio (from reference population)
Koenig, MA and D'Souza, S (1986)	Matlab, Bangladesh	Demographic Surveillance System	1966-1973 and 1973-1974	1-60 mo	Narrative	Cumulative probabilities F:M ratio	NA	Life-table probabilities by sex
Krishnan, A et al (2013)	India	Ballabgarh Health and Demographic Surveillance System	2006-2011	Neonatal Under-three	Narrative	F:M hazard ratios	NA	Kaplan-Meier survival curves, log rank test
Krishnan, A et al (2014)	India	Ballabgarh Health and Demographic Surveillance System	1972-1997	Neonatal Post-neonatal Child	Narrative	Sex-specific rates	NA	Chi-squared test, linear regression
Kumar, G (1989)	India	Official Life Tables, Registrar General of India and Mitra	1941-1950, 1951-1960, 1961-1970	0, 1, 2, 3, 4 years	Narrative	M:F ratio Sex-specific rates	NA	Magnitude of estimates
Kuntla, S et al (2014)	India	National Family and Health Survey	1992-2006	Child	Narrative	F-M difference	NA	Decomposition analyses
Langford, C and Storey, P (1993)	Sri Lanka	Census	1921-1981	Infant Child	Narrative	M:F ratio	NA	Magnitude of sex ratios
Langford, CM (1984)	Sri Lanka	Reports of the Registrar General of Ceylon on Vital Statistics, Bulletins on Vital Statistics and census	1921-1971	Infant Child	Narrative	M:F ratio	NA	Sex ratio above or below one
Langsten, R (1981)	Matlab, Bangladesh	Vital registration system of the Matlab field research and published estimates	1966-1977	Infant Child	Narrative	F:M ratio	NA	Sex ratio above or below one
LeGrand, TK and Mbacke, CS (1995)	Bamako, Mali; Bobo-Dioulasso, Burkina Faso; Fissel and Thienaba, rural Senegal	Enquête sur la mortalité infantile dans le Sahel	births in 1981-1983	1-23 months	Narrative	F:M ratio	NA	Discrete hazard regression

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Li, J and Lavely W (2003)	Diandong county (a pseudonym)	Survey	1994 (births in the three years preceding the interview)	Infant	Narrative	Sex-specific mortality	NA	Sex-specific mortality
Li, S et al (2004)	China	Household survey and community survey	1997 (deaths from 1994 to 1996)	Neonatal Postneonatal Child	Comparative	M:F ratio	Published estimates from Li and Feldman (1996) and West model life table (Coale and Demeny, 1983)	Magnitude of sex ratios; likelihood ratio test; t test; multivariate logistic regression and Cox survival
Lin, M-J et al (2014)	Taiwan	National Birth Registries and Death Registries	1980-1992 for births and 1980-1996 for deaths	Neonatal (also death at 6, 12, 18, 24, 36 and 48 months)	Narrative	Sex-specific rates F:M ratio	NA	Sex-specific mortality rates by parity; regression models of deaths allowing for the interaction terms including sex
Maitra, P and Rammohan, A (2011)	15 major states in the country, India	National Family Health Survey	1998-1999	Infant	Narrative	Sex-specific probabilities	NA	Probit model
Makinson, C (1987)	Egypt	World Fertility Survey	1980	0 months 1-2 months 3-11 months 12-23 months 24-59 months	Comparative, standard	Sex-specific rates	West model life table, level 13.7 (Coale and Demeny, 1983)	Magnitude of sex-specific mortality, multivariable logistic regression
Martin, WJ (1951)	England and Wales	Official statistics	1841-1947	Infant Under-five	Narrative	M:F ratio	NA	Magnitude of sex ratios
Mbacke, CSM and LeGrand, TK (1992)	Mali	Demographic and Health Survey	1987 (births in the five years preceding the interview)	0, 1-2, 3-5, 6-11, 12-23, 24-59 months Neonatal Post-neonatal Child	Narrative	F:M ratio	NA	Magnitude of sex ratios
McMillen, MM (1979)	United States	Vital statistics	1922-1936 and 1950-1972	Infant	Narrative	M:F ratio	NA	Magnitude of sex ratios
McNay K, et al (2005)	England and the Wales	Vital Registration System	1851-1860	0–9 years	Narrative	F:M ratio	NA	Sex ratio above or below one
Modin, B (2002)	Sweden	Uppsala Birth Cohort Study	1915-1929	Infant 1-10 years	Narrative	Odds ratio Relative risk	NA	Logistic regression (infancy) and Poisson (childhood) for boys and girls, separatly
Monden, CWA and Smits, J (2012)	35 sub-Saharan African and southern Asian countries	Demographic and Health Survey	2000s	Neonatal Post-neonatal Infant Child Under-five	Reference, prescriptive	M:F ratio	Austria, Belgium, UK, France, Germany, Netherlands, Scandinavian countries, USA, Canada, New Zealand, and Australia (Human Mortality Database, 1920 up to U5MR < 2.5%)	Magnitude of sex ratios
Muhuri, PK and Menken, J (1997)	Matlab, Bangladesh	Matlab Census and the Demographic Surveillance System	1982	1-5 years	Comparative, not standard	F:M ratio	Study comparison area	Magnitude of sex ratios; logistic regression

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Muhuri, PK and Preston, SH (1991)	Matlab, Bangladesh	Matlab Census and the Demographic Surveillance System	1981-1982	6 months - 5 years	Narrative	F:M ratio Odds ratio	NA	Magnitude of sex ratios; logistic regression
Murthi, M et al (1995)	296 districts in 14 of the 15 most populous states, India	Census	1981	Under-five	Narrative	Female disadvantage	NA	female disadvantage = 100 * (q5f-q5m)/q5f (negative values indicate female advantage)
Nadarajah, T (1983)	Sri Lanka	Census	1952-1972	Infant Child	Narrative	M:F ratio	NA	Magnitude of sex ratios
Nandi, A (2015)	India	District Level Household Survey	2002-2004	Infant	Narrative	Sex-specific percentage of deaths	NA	Difference-in-differences regression model
Narayana, D (2008)	15 Indian states, districts of Tamil Nadu	Sample Registration System, Danish International Development Agency project on healthcare	1971-2005, 1998	Infant	Narrative	F:M ratio, annual percentage reduction by sex	NA	Magnitude of estimates
Oster, E (2009)	India	National Family Health Survey	1992 and 1998 (births in 10 years preceding the interview)	Under-ten, including <6mo, 6mo-1year, 1-2yrs, 2-4yrs, 4-6yrs, 6-8yrs, 8-10yrs	Comparative, not standard	Interaction between female sex and birth in India	DHS from sub-Sahara African countries (Ethiopia, Kenya, Malawi, Namibia, Tanzania, and Zambia)	Difference-in-differences to compare mortality in India and sub-Saharan Africa
Padmanabha, P (1982)	India	Sample Registration System	1970-1978	Infant Child	Narrative	sex-specific mortality rates F:M ratio	NA	Magnitude of sex ratios
Park, H (2018)	Unyang, Korea	Family register data	1909-1977	1-5 years	Narrative	Sex-specific probabilities	NA	Logistic regression
Patra, N (2011)	India	National Family Health Survey, Sample Registration System	1992-1993, 1998-1999 and 2005-2006 (births in the five years preceding the interview)	Infant	Narrative	F:M ratio	NA	Magnitude of sex ratios
Pebley, AR and Amin, S (1991)	Ludhiana district, Punjab, India	Narangwal Study	1968-1973	Infant 1-3 years 0-3 years	Comparative, standard	M:F ratio	Control region (with no intervention)	Magnitude of sex ratios
Pham, TL et al (2012)	Vietnam	Demographic and Health Survey	1997 and 2002 (births between 1961 and 2002)	0–1, 1–6, 6–12, 12–24, 24–60, and > 60 months	Narrative	Sex-specific no-frailty coefficients	NA	Proportional hazard model
Pongou, R et al (2012)	31 sub-Saharan Africa	Demographic and Health Survey	1986-2006	Infant	Narrative	Sex effect in mortality	NA	Linear probability model
Pongou, R et al (2017)	31 sub-Saharan Africa	Demographic and Health Survey	1987-2005	Infant	Narrative	M-F difference	NA	Regression-based decomposition analysis

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
Raj, A et al (2019)	India	National Family Health Survey	1992, 1998 and 2005 (births within one to five years preceding the interview)	Infant	Narrative	Odds ratio	NA	Logistic regression
Ren, XS (1995)	Shaanxi, Liaoning, and Guangdong provinces, China	China In-depth Fertility Survey	1985 and 1987	Neonatal Post-neonatal Child	Narrative	M:F ratio log odds	NA	Logistic regression
Rose, E (1999)	India	Additional Rural Incomes Survey	1969-1971; surviving children born between 1961 e 1964	Up to school age	Narrative	Ratio of survival probabilities	NA	Multinomial logit model
Rosenblum, D (2012)	India	Reproductive and Child Health Survey	2002-2004	Under-five	Narrative	Sex-specific mortality rates	NA	Ordinary least squares regression and logit estimation
Rosenstock, S et al (2013)	Nepal	Newborn Washing Study (clinical trial)	2002-2006	Neonatal	Narrative	Odds ratio	NA	Chi-square test, t test and binomial regression model
Rosenzweig, MR and Schultz, TP (1982)	India	Household sample, Census	1971, 1961	Under-five	Narrative	M-F difference	NA	OLS regression
Rutstein, SO (1984)	41 low- and middle-income countries	World Fertility Survey	births in the 10 years preceding the survey	Neonatal Post-neonatal Infant Under-five Toddler (1 year) Child (2-3 years)	Narrative	M:F ratio	NA	Magnitude of sex ratios
Sabir, NI and Ebrahim, GJ (1984)	Lahore, Pakistan	Household survey	NA	Infant 1-2 years >2 years	Narrative	Number and percent of deaths by sex	NA	Number and percent of deaths by sex
Sathar, ZA (1987)	Pakistan	Census, Population Labour Force and Migration Survey, and Micro-nutrient Survey	1965-1979	Neonatal Post-neonatal Child 1-2 years	Narrative	Sex-specific mortality rates M:F ratio	NA	Magnitude of sex ratios
Sawyer, CC (2012)	World	Survey data, censuses, vital registration systems, sample registration and surveillance systems	1970s, 1980s, 1990s, and 2000s	Infant Child Under-five	Narrative	M:F ratio	NA	method from UN IGME
Shapiro, S (1954)	United States	Birth certificates	1951	Neonatal	Narrative	sex-specific mortality rates	NA	Magnitude of sex-specific mortality rates
Silverman, JG et al (2011)	India	Demographic and Health Survey	2005-2006	Infant Under-five	Narrative	Relative risk	NA	Cox proportional hazard models
Srinivasan, S and Bedi, AS (2008)	Tamil Nadu, India	Vital Events Surveys	1996-1999 and 2003	Infant	Narrative	Sex-specific number of deaths and	NA	Magnitude and significance of sex ratios

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
						mortality rates F-M difference		
Srinivasan, S and Bedi, AS (2011)	Tamil Nadu, India	Vital Events Surveys	1996, 1997, 1998, 1999 and 2003	Infant	Reference, descriptive	Female mortality	Published estimates (Waldron, 1983; Johansson and Nygren, 1991; Hill and Upchurch, 1995; life tables from United States and United Kingdom) to define the expected female mortality based on male mortality (expected to be about 77-85% of male mortality)	Expected female = 0.8 male mortality; deficit = observed - expected
Steen, EE et al (2014)	Sweden	Swedish Medical Birth Register	1996-2007	Early neonatal Late neonatal Post-neonatal Infant	Narrative	Odds ratio	NA	Multiple logistic regression; Kruskal-Wallis/Wilcoxon tests
Stephenson, R et al (2017)	38 low- and middle-income countries	Demographic and Health Survey	2010+	Neonatal Post-neonatal Infant Child	Narrative	Ratio of categories of twins	NA	Multilevel logistic regression
Subramanian, SV et al (2006)	India	Demographic and Health Survey	1998-1999 (deaths in the two years preceding the interview)	Infant 2-5 years	Narrative	F:M sex ratio	NA	Multilevel logistic regression
Sudha, S and Rajan, SI (1999)	India	Census	1981 and 1991	Under-five	Narrative	M:F ratio	NA	Magnitude of sex ratios over time
Sudha, S and Rajan, SI (2003)	India	Census	1981 and 1991	Child	Narrative	sex ratio	NA	Sex ratio above or below one
Svedberg, P (1991)	23 sub-Saharan African countries	Published estimates	1953-1983	Infant Child	Reference	M:F ratio	Sweden (1983-1987)	Excess male mortality = observed sex ratio / expected sex ratio (from reference population)
Tabutin, D (1978)	France, Canada, England and Wales, Belgium, Sweden	Official statistics report, published estimates	1740-1939	Infant Child	Narrative	M:F ratio	NA	Magnitude of sex ratios
Tabutin, D (1992)	Algeria, Morocco, Tunise, Egypt	Multiple sources	1965-1988	Infant Child	Comparative, not standard	M:F ratio	United Nations model life tables for developing countries	Magnitude of sex ratios
Tabutin, D and Willems, M (1995)	Sub-Saharan Africa	Demographic and Health Survey and World Fertility Survey	1970s and 1980s	Infant Child Under-five	Narrative	M:F ratio	NA	Sex ratio above or below one
Tabutin, D and Willems, M (1998)	24 countries (the whole of Europe, including Russia, Canada and the United States of America,	Literature, historical demographic statistics, specialists, statistical offices and research centres	1600-1930	Infant Child	Narrative	M:F ratio	NA	Magnitude of sex ratios

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
	Australia, New Zealand and Japan)							
Tabutin, D et al (2001)	38 African countries	National surveys	1970-97	Neonatal Post-neonatal Infant Child	Narrative	M:F ratio	NA	Sex ratio above or below one; overmortality level (difference between 100 and the ratio)
Takahashi, E (1954)	Japan	Vital statistics	1941-1949	Neonatal	Narrative	M:F ratio	NA	Magnitude of sex ratios
Tarozzi, A (2012)	India	National Family Health Survey	1992-1993, 1998-1999 and 2005-2006	Neonatal Infant Child Under-five	Narrative	F:M ratio	NA	Magnitude of sex ratios over time
Teitelbaum, MS (1971)	Scotland, Denmark, Swede, England and Wales, and Norway	Unpublished data from US National Center for Health Statistics	1901-1963	Early neonatal Perinatal	Narrative	Relative male risk of death M:F sex ratio	NA	Magnitude of sex ratios
Timaus, I et al (1998)	41 low- and middle-income countries	Demographic and Health Survey	1986-1994 (births in the 10 years preceding the interview)	Infant Child	Narrative	sex-specific mortality M:F ratio	NA	Magnitude of sex ratios
Ueyama, M (2007)	55 low- and middle-income countries	Demographic and Health Survey	1970-2000?	Under-five	Narrative	F:M ratio F-M difference	NA	Magnitude of sex ratios
United Nations (2011)	149 countries	Vital registration, demographic surveys, and censuses	1970s-2000s	Infant Child Under-five	Narrative	M:F ratio	NA	Magnitude of sex ratios
United Nations Secretariat (1998)	88 countries with a population of one million or more in 1990	Multiple sources	1970-1988	Infant Child Under-five	Narrative	M:F ratio	NA	Magnitude of sex ratios
Wahab, A et al (2001)	Purworejo District, Indonesia	Surveillance system	1995-1996	Infant	Narrative	M:F odds ratio Hazard ratios for each sex	NA	Cox proportional hazard models
Waldron, I (1987)	Developing countries	United Nations life tables and World Fertility Survey	1964-1980	Infant Child	Narrative	M:F ratio	NA	Magnitude of sex ratios
Wyllie, J (1933)	Canada	Official statistics	1921-1930	Neonatal Infant	Narrative	M:F ratio	NA	Magnitude of sex ratios
Xu, BH et al (1994)	China and Hong Kong	10 Percent Sampling Tabulation on the 1990 Population Census; 10 Percent Sampling Tabulation on the 1982 Population Census; China's Cancer Epidemiology Survey of	1973-1975, 1981, 1990	0, 1, 2, 3, 4 years	Narrative	M-F difference M:F ratio	NA	Ratio and difference

Study identification	Place	Mortality data source	Period of data	Age group	Analysis type	Measure	Reference population	Comparison method
		1976; World Health Statistics Annual Series from Hong Kong						
Yount, KM (2001)	14 Middle Eastern countries	United Nations	1970s and 1980s	Infant Child Under-five	Comparative, standard	F:M ratio	Hill and Upchurch (1995)	Female disadvantage index
Yount, KM (2014)	75 low- and middle-income countries	Demographic and Health Survey	1985-2008	Child	Narrative	F-M difference	NA	Multivariate models using fixed- and random effects approaches
Zhao, D et al (2017)	United States	United States National Center for Health Statistics	1995-2004	Perinatal Infant	Narrative	M:F odds ratio	NA	Conditional logistic regression

Supplementary Figure S1 – Frequency of words used in the titles of the selected studies

4 * Comunicado à imprensa

Desigualdades de gênero no cuidado das crianças pode ser responsável por mortalidade de meninas acima de níveis esperados em países de baixa e média renda

Um estudo desenvolvido no *Centro Internacional para a Equidade em Saúde* da Universidade Federal de Pelotas avaliou elementos que podem estar relacionados a uma maior mortalidade de meninas em países de renda baixa e média. Os resultados são parte da pesquisa de doutorado desenvolvida pela estudante Janaína Calu Costa sob orientação do Professor Cesar Victora. “Nós avaliamos características de 80 países que poderiam estar associadas com diferenças na mortalidade de meninos e meninas. Observamos que os meninos que ficaram doentes receberam mais cuidados adequados do que as meninas, o que levou a uma distorção na mortalidade destas crianças em relação ao que seria esperado se ambos recebessem atenção de profissionais qualificados”, comenta Janaína.

De acordo com o que já está estabelecido pela ciência, os meninos são biologicamente mais frágeis que as meninas e apresentam maior mortalidade, mesmo em situações em que não haja discriminação. Quando a mortalidade dos dois sexos é semelhante ou há maior mortalidade entre as meninas, é possível que elas estejam recebendo menos cuidado, geralmente motivado pelas condições em que vivem, seja o valor social que as meninas e mulheres têm na sociedade, sejam as condições financeiras da família. “Nossa hipótese é que muitas vezes as famílias precisam escolher qual criança será alimentada, qual vai receber cuidados médicos e muitas favorecem os meninos, pois são os membros da família que podem ajudar no trabalho, enquanto as meninas podem gerar mais despesas, especialmente quando os pais precisam pagar dote, por exemplo”.

Os pesquisadores também avaliaram como essas diferenças têm sido estudas por autores do mundo todo e perceberam que métodos muitos diferentes foram utilizados ao longo do tempo, o que pode levar a resultados inconclusivos ou até mesmo subestimados. “Geralmente os estudos usam dados históricos de países que hoje são considerados ‘desenvolvidos’ para comparar com a situação atual dos países de baixa e média renda”. Segundo a autora, a principal limitação destes estudos é que as características da população e as causas de morte nos países mais pobres não são as mesmas, então aquelas estimativas podem não ser as mais adequadas. Os resultados destes estudo são importantes para guiar pesquisas futuras, já que puderam ser analisadas as vantagens e limitações de mais de 150 pesquisas realizadas com populações de todo o mundo.

Os autores acreditam que os resultados dos estudos podem ajudar a impulsionar esforços para alcançar a igualdade de gênero, já que o papel que as mulheres têm em cada sociedade impacta diretamente na saúde e na sobrevivência de crianças, mas ainda com mais força na sobrevivência das meninas. “Conseguimos explorar algumas características das populações que estão relacionadas com menor sobrevivência das meninas, agora precisamos explorar mais profundamente o mecanismo dessa relação para ajudar a salvar vidas daquelas que estão morrendo apenas pelo fato de serem meninas”, conclui a autora.