Review Article

Drawing the Linkage Between Women's Reproductive Health, Climate Change, Natural Disaster, and Climate-driven Migration: Focusing on Low- and Middle-income Countries - A Systematic Overview

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Abstract

Background: One of the most important aspects of women's well-being and welfare is RSH (reproductive and sexual health). Reproductive health is not an exception to the threat that CCC (climate change and climate crisis) poses to numerous facets of public health. Firstly, the present review seeks to identify the influence of climatic changes, natural disasters, and climate-driven migration on RSH. Secondly, to identify knowledge gaps regarding the same. **Material and Methods:** Two databases (Scopus and PubMed) were scanned using Boolean operation. The literature search aimed to find records pertaining to topics of RSH and climate change. Using the PRISMA-ScR method, records were screened and shortlisted based on established inclusion criteria. This literature search was carried out in November 2022. In the shortlisted records, preference for the comprehensive review articles was given. **Results:** The present review is based on 38 records that collectively revealed that climate crisis and natural disasters have many negative impacts on female reproductive health. These effects are observed in different phases of life, ranging from teenage to menopause. The unique strength of the present review is that it draws a relationship between female reproductive health and the direct as well as indirect effects of the CCC. The available literature about LMICs is predominantly confined to drought, flood, and earthquake. Disasters like tsunamis, cyclones, and avalanches remain unexplored. **Conclusion:** From the available literature, it is quite evident that CCC has an adverse effect on a woman's reproductive life as well as a bearing on future generations' health. Filling these knowledge gaps is pivotal for designing more effective disaster and health policies. Policymakers should take into consideration these detrimental effects while designing health schemes and policies for females.

Keywords: Climate change, climate crisis, disaster, forced migration, reproductive, women

Introduction

Reproductive and sexual health (RSH) is one of the most crucial parts of the overall well-being and health of women. The RSH of women is not confined to women only but transcends to the health of off-springs, which is the next generation of a nation. Since the latter half of the 19th century, CCC (climate change and climate crisis) has emerged as one of the most threatening concerns for various aspects of public health, with reproductive health being no exception.[1,2] By and large the impact of climate change and climatic crises have a strikingly high toll on human life. As per the WHO (World Health Organization) prediction, the climatic crisis will lead to over 250 thousand mortalities annually between 2030 to 2050. The projected financial burden of healthcare due to CCC will be USD 4 billion by the year 2030.[3]

The impact of CCC on human life could be seen as a direct impact, such as loss due to recurrent natural disasters, whereas in the long-run aftermath, it is the disrupted life of large masses primarily due to forced migration.[4] As per IOM (International

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Organization for Migration) about a quarter to one billion individuals are projected to migrate by the year 2050 due to CCC and natural disasters,[5] out of this displaced population, female migrants will contribute 80%.[6] In LMICs (low- and middle-income countries) females in general face increased climate-related health risks as compared to males. The reason behind this is greater vulnerability to natural hazards as well as poor health-seeking behavior due to patriarchal and cultural norms.[7]

Researchers have reported the risk of unfavorable pregnancy outcomes (such as low birth weight and spontaneous abortion) increased by exposure to heatwaves and air pollution.[8,9] The situation gets further exacerbated for females of low-income households in rural areas with prevailing patriarchal norms.[10] The effect of CCC on human beings as well as the whole planet is multifaceted, ranging from disturbed ecosystems to rising sea levels. Research has shown the frequency of occurrence and magnitude of natural disasters (such as floods, landslides, and avalanches) have increased due to climate change.[11]

Studies have reported CCC affects agricultural productivity in different ways, varying from lowered groundwater levels to reduced rainfall. This ultimately leads to food shortage in the region, as well as disrupts the agricultural business.[12,13] LMICs in southeast Asia have witnessed more prominent effects of the CCC than developed nations. To cope with these effects at an individual level in LMICs, people tend to move from affected areas to more stable areas. Further, it has been reported that LMICs with higher income inequalities are burdened more due to natural disasters.[14]

The review of the literature showed that there are some reviews related to the topic; however, to the best of our understanding, no review was found that develops a linkage between RSH and CCC by incorporating the physiological studies of pollutant effects. The present review attempts to do so, which will provide deeper insights and answer the question, how is CCC affecting female RSH? The present systematic review intends to investigate the bearing of CCC on the RSH of women residing in LMICs. Secondly, to identify the knowledge gaps pertaining to the topic.

Methodology

A preliminary screening of the published research papers was carried out to identify the reappearing keywords in different papers. After the identification of keywords, a search was conducted on the Scopus and PubMed databases using the Booleans logic search tool. Initially, various combinations of keywords with different logic commands (namely 'AND' and 'OR') were searched. In line with the set objective, the search query was developed in two parts, separated by 'OR' operation logic. The first part was to find the studies linking either climate change or natural disasters with migration. The second part was for finding studies that link either climate-driven migration or migration in general with the reproductive health of females. Using the following string, records were searched on both databases:

((("climate change"[Title/Abstract] OR "natural disaster"[Title/Abstract]) AND (migrat[Title/Abstract] OR migrant[Title/Abstract])) OR (("climate change"[Title/Abstract] OR natural disaster[Title/Abstract]) AND (women[Title/Abstract] OR woman[Title/Abstract] OR female*[Title/Abstract]) AND (reproduct*[Title/Abstract] OR maternal[Title/Abstract] OR antenatal[Title/Abstract]))*

The search was conducted on November 1, 2022. The search identified 3065 records in Scopus and 2515 records in the PubMed database. There was no publication year constraint for the records, however, the articles published in the last 5 years were given preference. PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews) guidelines were used for searching, compiling, and analyzing the records, as depicted in Figure 1.

After initial screening of the titles for duplication check and abstract screening, 306 records were found. Eligibility checks of the articles were conducted based on relevancy, language, full-text availability, and proper referencing, which led to the

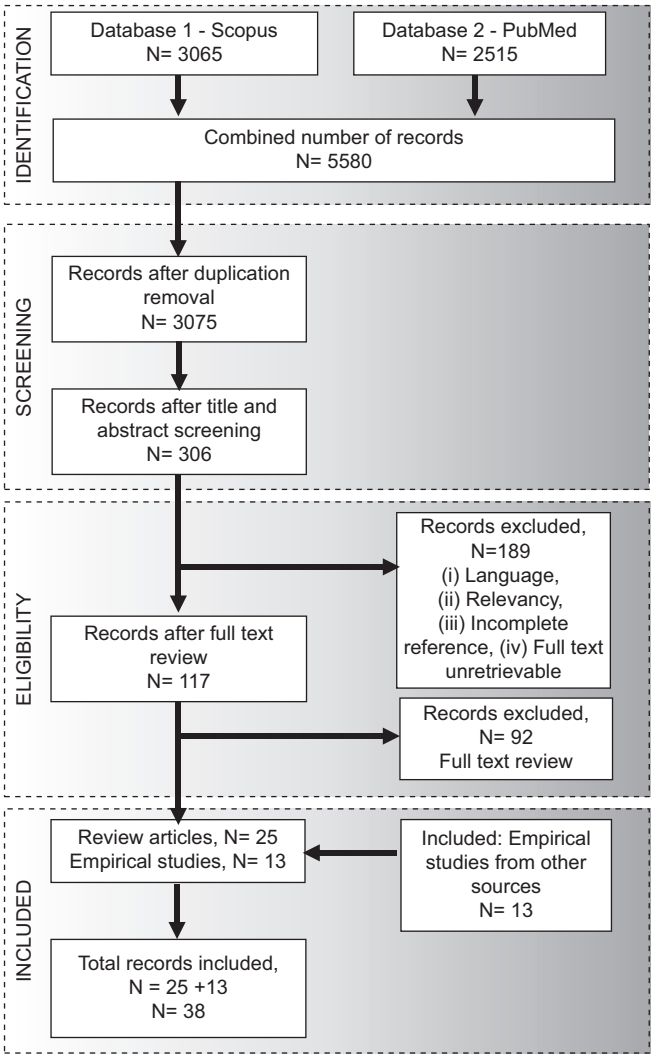

Figure 1: PRISMA-ScR flow chart depicting step-by-step screening of records

exclusion of 189 records. Screening was conducted by two researchers separately which led to the exclusion of 92 records. Three conflicts were found and resolved until a consensus was reached. The aim of the review was to develop a nexus between RSH and CCC, which are two distinct fields of inquiry; therefore, systematic reviews and highly cited review articles were given preference over empirical studies, which led to the selection of 25 articles. The reviewing of articles was performed from November 2, 2022, till December 30, 2022, on the bibliography software, Mendeley (version 2.43.0) utilizing "tagging" functionality. Before final inclusion, the quality assessment of the records was conducted using a modified CASP (Critical Appraisal Skills Programme) checklist developed by Oxman *et al*.[15] The article was scored on eight parameters. For each fulfilled parameter, 1 point was awarded. The highest score (record fulfilling all criteria) was 8. To ensure quality, any record having a score less than 5 was planned to be excluded; however, no such records were found. Lastly, 13 highly relevant and cited articles from the reference list selected articles were included. Hence, the total number of records included is 38.

Inclusion criteria: (i) Articles related to the impact of CCC on the reproductive or sexual health of females of any age group. (ii) Articles describing the impact of climatic calamity or natural disaster on reproductive health and forced migration as an intermediary factor. Exclusion criteria: (i) Articles that do not have full-text available (ii) Article having incomplete reference list, that is, not as per in-text citations or vice versa. (iii) Language not English (iv) Full-text missing or unretrievable.

Results

The present review comprised a total of 38 records. However, the review is predominantly based on 25 review articles. The critical appraisal of the 25 review articles revealed the overall acceptable quality of records [Table 1]. The mean total score of the included review articles was 7.12 (SD= ±0.97).

Three themes were derived by clubbing various CCC effects based on which the selected articles were analyzed. The literature collectively revealed that climate change has a huge impact on the RSH of women. These impacts may be directly or indirectly influencing women's RSH. Direct effects may be the impact of climatic factors (such as heatwaves) or environmental factors (such as chemical pollutants and EDCs) on pregnancy outcomes. In contrast, indirect effects may be the unavailability of health services for pregnant women due to damaged healthcare facilities by natural calamities such as earthquakes or may be restricted accessibility and availability due to forced climate-driven migration. A summary of characteristics and key findings of included review records are depicted in Table 2.

The selected articles were analyzed based on the three identified themes and types of CCC effects on the RSH of women in LMICs. The three themes are (i) direct effects on female reproductive function, (ii) indirect effects of natural calamity, and (iii) indirect effects of climate-driven migration.

Direct effect of climate change on RSH

The review of the literature suggests there is a huge range of detrimental effects of CCC on female reproductive health. It is evident from the review that human activities lead to a disrupted environment, leading to climate and environmental change over longer periods, ultimately affecting the reproductive health of women. Literature shows that climatic and environmental factors act on various phases of female reproductive life.

Researchers have reported the worldwide mean age for menarche has been reduced in the last decade due to increased pollution levels and food nutritive quality, both of which are directly associated with CCC.[16] Researchers have reported that the pollutants and chemicals discharged into the environment from industrial and agricultural activities have a serious impact on climate in the long term, and in the short-term pose dire inimical effects on women's reproductive health. A study reported these synthetic chemicals with prolonged half-lives have the potential to disturb the endocrine system of women, ultimately affecting reproductive health.[17] Research has also found an association between exposure to these EDCs (endocrine-disrupting chemicals) and aggravated bronchial asthma,[18] which is directly associated with reduced fecundability due to hampered ovarian function and early menopause.[19,20]

Studies have reported that increased temperature and heat waves impose a greater risk to pregnant women. During pregnancy, physiological and anatomical changes are in the process therefore thermoregulation by the woman's body is highly prone to heat stress.[21,22]

A study reported a statistically significant association between raised average global temperature and adverse pregnancy outcomes, such as low birth weight, stillbirth, etc.[23] A review of articles revealed that environmental pollutants (such as particulate matter, oxides of sulfur and nitrogen, ozone, etc.) could lead to an augmented risk of gestational diabetes, preterm birth, stillbirths, and spontaneous abortion.

The CCC also has a bearing on the incidence and distribution of vector-borne, food-borne, and waterborne diseases. Studies have reported in topical LMICs that climate change has led to increased temperature and prolonged rainy seasons, causing more breeding of mosquitoes and pathogens. Researchers have reported arboviral infection during pregnancy may lead to abnormal fetal development and microcephaly.[24] Furthermore, it has been reported that floods leading to increased incidence of malaria infection could lead to more incidence of miscarriage, fetal deaths, neonatal mortality, and preterm births. Increased environmental temperature could further enhance the risk of cholera, leptospirosis, and other Vibrio-caused diseases, which will have similarly negative outcomes of pregnancy.[25]

Breastfeeding and proper lactation are an integral part of RSH in women. The review of articles suggests the detrimental effect

Table 1: Critical appraisal of the records using a modified CASP checklist

Study	P1	P2	P3	P4	P5	P6	P7	P8	T_s
Neff *et al*. (2022)	+	+	-	+	+	+	-	+	6
Sharma *et al*. (2022)	+	+	+	+	+	+	+	+	8
Afzal *et al*. (2022)	+	+	+	+	+	+	+	+	8
Strid *et al*. (2022)	+	+	+	+	+	+	-	+	7
van Daalen *et al*. (2022)	+	+	+	+	+	+	+	+	8
Bakken *et al*. (2021)	+	-	-	+	+	+	+	+	6
Lorenzetti *et al*. (2021)	+	+	-	+	+	+	-	+	6
Fatouros *et al*. (2021)	+	+	+	+	+	+	+	+	8
Waddell *et al*. (2021)	+	-	+	+	+	+	-	+	6
van Daalen *et al*. (2021)	+	+	+	+	-	+	-	+	6
Freed *et al*. (2021)	+	+	+	+	+	+	+	+	8
Schwerdtle *et al*. (2020)	+	+	+	+	+	+	+	+	8
Chersich *et al*. (2020)	+	+	+	+	+	+	+	+	8
Caneloxn *et al*. (2020)	+	+	+	+	+	+	+	+	8
Kumar *et al*. (2020)	+	+	-	-	+	-	+	+	5
Tiotiu *et al*. (2020)	+	+	+	+	+	+	+	-	7
Björvang *et al*. (2020)	+	+	+	+	+	+	+	+	8
Bekkar *et al*. (2020)	+	+	+	+	+	+	-	+	7
O'Kelly *et al*. (2020)	+	+	-	+	+	+	+	+	7
Konkel *et al*. (2019)	+	+	+	+	+	+	+	+	8
Pajewska *et al*. (2019)	+	-	+	+	+	+	-	+	6
Jennings *et al*. (2019)	+	+	+	+	+	+	+	+	8
Chaudhary *et al*. (2017)	+	-	+	+	+	+	+	+	7
Patel *et al*. (2015)	+	+	-	+	-	+	+	+	6
Amegah *et al*. (2014)	+	+	+	+	+	+	+	+	8
Budhathoki *et al*. (2018)	+	+	+	+	-	+	-	+	6
Nandi *et al*. (2018)	+	+	+	+	+	+	+	-	7
Norling (2022)	+	+	+	+	+	+	+	+	8
Fernandes *et al*. (2022)	+	+	+	+	+	+	+	+	8
Bukhari *et al*. (2015)	+	+	+	+	+	+	+	-	7
Haque *et al*. (2020)	+	+	-	-	+	-	+	+	5
Pardhi *et al*. (2020)	+	+	+	+	+	+	+	-	7
Lindvall *et al*. (2020)	+	+	+	+	+	+	+	+	8
Ahmed (2020)	+	+	+	+	+	+	-	+	7
Debnath *et al*. (2009)	+	+	+	+	+	+	+	+	8
Masson *et al*. (2019)	+	+	+	+	+	+	+	+	8
Bonell *et al*. (2022)	+	-	+	+	+	+	-	+	6
Grindler *et al*. (2015)	+	-	+	+	+	+	+	+	7

P1 - Clearly defined research question; P2 - Appropriate search strategy/Methodology; P3 - Relevant and important records included/recent and relevant development included; P4 – appropriate analysis; P5 - Combined result presented appropriately; P6 - Results are in line with objective; P7 - All important outcomes/implications considered; P8 - Suggestion corroborated by results; T_s – Total Score. "+" signifies fulfilled parameter; "-" signifies not fulfilled parameter

of CCC and environmental pollutants can be seen on newborns, too. As the composition of human milk varies with the lactation stage, studies suggest environmental pollutants may disturb the composition of human milk,[26] as well as hazardous pollutants may pass from the mother's body to the neonate through breast milk, such as heavy metals.[27,28] Climate and environmental change lead to exposure to EDCs. Researchers have reported that exposed women to these chemicals experience early menopause (by approximately 1.9 to 3.8 years), as compared to non-exposed women.[29] Furthermore, studies have also reported exposure to such chemicals may worsen and prolong the symptoms of menopause, such as hot flashes.[30]

Effect of natural calamity on RSH

Studies have reported various effects of natural calamities and disasters on women's reproductive health. However, it is noteworthy to mention that studies suggest that RSH is not an isolated aspect of women's health that is impacted by natural disasters. In the event of natural calamity, physical trauma, and mental trauma play a crucial role, which acts as an intermediary factor and eventually affects the RSH of the women.[31]

Researchers have reported that maintaining menstrual hygiene after a natural disaster becomes daunting for females. Evidence from the Nepal 2015 earthquake female survivors revealed

Table 2: Characteristics of the articles included and key findings

Study	Design and Methodology	Country/Region	Issue focused	Key finding
Neff *et al*. (2022)	Non-systematic: Narrative review	Generalized	Air pollution, environmental and climatic crisis	Exposure to EDCs and other environmental pollutants leads to faster reproductive aging, before time menopause onset and worsening of menopausal symptoms
Sharma *et al*. (2022)	Systematic review using PRISMA approach	Nepal	Earthquake	During a natural calamity, WASH facilities are compromised, especially after earthquakes, leading to a higher risk of RTI (Reproductive Tract Infections) and STDs (Sexually Transmitted Diseases)
Afzal *et al*. (2022)	Systematic review using PRISMA approach	Indian Subcontinent	Migration	In the absence of a male partner, the reproductive health behavior of married women gets worse, mostly observed in patriarchal societies with poor socioeconomic environments
Strid *et al*. (2022)	Systematic review using PRISMA approach	Generalized	Earthquakes, hurricanes, flooding, tsunami	Lack of evidence regarding reproductive and sexual behavior after different kinds of disasters. Contradictions of evidence were reported, majority of the studies indicating after any major event, the sexual activity of women reduces as well as the contraceptive use decreases whereas some reported contrary findings.
van Daalen *et al*. (2022)	Systematic review using PRISMA approach	Generalized	Various natural disaster	Increased risk of GBV (gender-based violence) in the post-disaster period, especially during the disaster relief phase. There is a lack of quantitative empirical results that reflect the impact of natural disasters on sexual violence.
Bakken *et al*. (2021)	Non-systematic: topical review	East African countries	Flooding, water lodgment, mosquito growth	Flooding and erratic high rainfall are some of the leading causes of increased malaria cases during pregnancies which ultimately causes various negative pregnancy outcomes, especially in LMICs in tropical and equatorial belts
Lorenzetti *et al*. (2021)	Non-systematic: Narrative review	Generalized	Climate changes, environmental pollution, and mother's dietary contaminants	Highlighted various chemical compounds and their sources that could contaminate the breastmilk. These chemicals are present in the environment and could get into a child from the mother via breastfeeding
Fatouros *et al*. (2021)	Systematic review using PRISMA approach	LMICs; Nigeria, Iran, South Asia, and Vanuatu	Natural disasters: earthquakes, tsunamis, cyclones, and floods	Physical trauma and mental trauma at the time of natural disaster act as intermediary factors and eventually affect the RSH behavior of the women
Waddell *et al*. (2021)	Non-systematic: topical review	Generalized	Hurricanes	Reported a six-month time lag between a disaster event and the emergence of diseases including RTIs and UTIs
van Daalen *et al*. (2021)	Systematic review using PRISMA approach	Generalized	Climate-driven migration	Climate-driven migration affects different aspects of women's health, change of residence comes as a cultural shock as well as increases physical and mental vulnerability. This all gets reflected in the overall health of females, including reproductive health
Freed *et al*. (2021)	Systematic review using PRISMA approach	North America and European nations (OECD member countries)	Various natural disaster	Access to contraception is one of the biggest challenges faced by women during natural calamities. Reported a dire need to strengthen actions to prevent these barriers leading to the prevention of unwanted pregnancies and STDs
Schwerdtle *et al*. (2020)	Systematic review using PRISMA approach	Generalized	Climate-driven migration	Reported a dearth of empirical research examining the relationship between CCC, health, and migration. The connections between forced relocation and health in the context of CCC are highly diverse, making it unlikely that general conclusions will be drawn. Highlighted various short-term and long-term negative impacts of natural disasters
Chersich *et al*. (2020)	Systematic review using PRISMA, and meta-analysis	27 countries (including 7 LMICs)	Increased environmental temperature	Reported that dangers of untoward pregnancy outcomes are highest in LMICs such as fetal deformities
Canelo'n *et al*. (2020)	Systematic review using PRISMA approach	Generalized	Global warming and deteriorating air quality	Climate changes lead to earlier onset of menarche, which ultimately leads to various health problems in females including reproductive and sexual problems

Contd...

Table 2: Contd...

Study	Design and Methodology	Country/Region	Issue focused	Key finding
Kumar *et al*. (2020)	Non-systematic: scoping review	Mainly Developed nations: USA, UK, Taiwan, Spain, Italy, France, Korea, China, Thailand	Environmental crisis due to EDCs	EDCs have the potential to cause malignancies, endocrine problems, metabolic diseases, and reproductive abnormalities. The Industrial Revolution led to the generation and emission of EDCs into the atmosphere, water bodies, and ultimately dietary items. This is related to the abrupt increase in the incidence of many diseases, especially metabolic disorders
Tiotiu *et al*. (2020)	Non-systematic: scoping review	Generalized	Air quality	Air pollutants and SHS (secondhand smoke) lead to exacerbation of asthma and contribute to an overall reduction of health and quality of life
Björvang *et al*. (2020)	Non-systematic: Narrative review	Generalized	Environmental crisis due to EDCs	Regardless of the ban by the government EDC producing chemical use for years, many EDCs are reported to be present in the follicular liquid of human ovaries. These are responsible for reduced folliculogenesis causing reduced fecundability
Bekkar *et al*. (2020)	Systematic review using PRISMA approach	USA	Extreme environmental temperature and air Pollution	Positive associations were found between air pollution incidence and poor outcomes in the USA. Exposure to ozone or fine particulate matter or high temperature is linked with a higher risk of premature childbirth (79%) and below normal weight (86%)
O'Kelly *et al*. (2020)	Non-systematic: Narrative review	South-east Asia and Africa	Climatic changes and mosquitoes related diseases	Climate changes are one of the leading causes of increased vector-borne diseases, which ultimately contributes to negative pregnancy outcomes, especially in LMICs of southeast Asia
Konkel *et al*. (2019)	Non-systematic: Narrative review	Generalized	Global warming and extreme environmental temperature	temperature surpassing usual extremes (either cold or hot) leads to an increased incidence of untoward pregnancy outcomes
Pajewska *et al*. (2019)	Quasi-Systematic review	Generalized	Climate crisis and water pollution, mother's dietary contaminants	Discussed polychlorinated biphenyls (organic pollutants), and arsenic, lead, and cadmium (heavy metals) that could contaminate the breastmilk. These have detrimental effects on women as well as neonates
Jennings *et al*. (2019)	Systematic review using PRISMA approach	LMIC	Natural disasters, disease outbreaks, and wars	Reported the RSH needs of the young and adolescent female population are often ignored in post-disaster relief work. Few such initiatives have been taken in the recent past; however, this needs to be implemented as a usual practice, along with quality evaluation of such initiatives.
Chaudhary *et al*. (2017)	Systematic review using PRISMA approach	Nepal	Earthquake	women's safety and GBV should be given utmost priority while organizing shelter camps for pregnant and postpartum women. Suggested to incorporate sexual hygiene and emergency RSH items in relief kits
Patel *et al*. (2015)	Non-systematic: Narrative review	Generalized	Environmental crisis due to EDCs	Exposure to EDCs in adult females has shown adverse effects on folliculogenesis, hormonal synthesis, and oocyte quality
Amegah *et al*. (2014)	Systematic review using PRISMA, and Meta-analysis	LMICs	Air Pollution	Home solid fuel combustion raises the risk of a variety of unfavorable pregnancy outcomes. Highlighted the potential and need for clean fuel for households
Budhathoki *et al*. (2018)	Mixed method: Primary data	Nepal	Earthquake	Reported a huge unmet need for menstrual products among females within the first week of the earthquake. Dependency on the on-cloth piece increases post-disaster
Nandi *et al*. (2018)	Quantitative: Secondary data	India	Earthquake	Earthquakes lead to a significant increase in childbirth rates in the affected regions. Reduction in birth spacing. Changes most prominent in illiterate, tribal, and Muslim masses
Norling (2022)	Quantitative: Secondary data	LMICs (African Nations)	Various natural disasters and epidemics	Fertility decreased after the droughts and floods were reported, approximately from 6.8 to 3.5. Fertility decreases after epidemics for women near the start or end of their reproductive phase But increases for those in the age group 20-40

Contd...

Table 2: Contd...

Study	Design and Methodology	Country/Region	Issue focused	Key finding
Fernandes *et al*. (2022)	Quantitative: Secondary data	Mozambique	Cyclone	Reported disruption in maternal and child health-seeking behavior, reflected in various key indicators such as ANC visits, child vaccination, etc., Recovery took almost 3 months, i.e., key indicators value getting back to a similar level as before the cyclone
Bukhari *et al*. (2015)	Quantitative: Primary data	Pakistan	Flood	In light of patriarchal norms, women's movement in the relief camps is restricted. Camps were found to be unhygienic, lack toilet privacy, and no dedicated breastfeeding space. Unmet nutritional needs of pregnant and lactating women. Identified overcrowding as the root cause
Haque *et al*. (2020)	Quantitative: Primary data	Bangladesh	Climate-driven migration: flood	Reported that women who experienced forced migration due to CCC are less likely to undergo an ANC checkup, and also less likely to have an adequate count of ANC checkups
Pardhi *et al*. (2020)	Qualitative: Primary data	India	Climate-driven migration: drought	Pregnant and women with children face a heightened risk of diseases at the destination. Pregnant migrant mothers, in particular, cannot access essential antenatal care and struggle to find a place to sleep or rest during the day
Lindvall *et al*. (2020)	Qualitative: Primary data	Somalia, Kenya, and Ethiopia	Climate-driven migration: drought	Reported inadequate access to basic healthcare facilities in the relief/refugee camps. Underscored the need for research on internally displaced populations, with emphasis on mental health and gender-based violence
Ahmed (2020)	Qualitative: Primary data	Pakistan	Migration impacts	Reported agricultural productivity is reduced due to many factors, CCC being one of them. Male outmigration happens without the wives. Due to patriarchal norms a wide range of challenges arises, which ultimately results in disrupted social life and overall health, including RSH
Debnath *et al*. (2009)	Mixed method: Primary data	Bangladesh	Migration impacts	Introduced the concept of the 'mixed-blessing' phenomenon associated with the effect of migration on married females. Highlighted gradual but forced male outmigration presents augmented autonomy to women, simultaneously increasing various responsibilities. Findings are supportive of self-negligent behavior by females
Masson *et al*. (2019)	Mixed method: Primary data for qualitative analysis Secondary data for quantitative analysis	The Republic of Chad	Post-disaster GBV	Highlighted the gender inequalities in the underdeveloped region during the disaster relief phase. Reported due to GBV the females are not able to proactively able to manage and cope with the ongoing crisis. The authors reported a cascading effect of GBV on the livelihood of female survivors
Bonell *et al*. (2022)	Quantitative: Primary data	Gambia	Extreme Heatwaves	Reported an increased chance of fetal strain due to heat waves (OR 1.12, $P<0.01$). Concluded heat waves could lead to negative pregnancy outcomes
Grindler *et al*. (2015)	Quantitative: Secondary data	USA	Environmental crisis due to EDCs	Identified 15 EDCs that have a significant detrimental impact on ovarian physiology. Reported this could lead to early menopause which could have a serious effect on the woman's health and fertility

that immediate disaster relief kits do not consist of menstrual hygiene items, such as menstrual pads.[32] Further, there is a scarcity of clean water and sanitation after the disaster event. Humanitarian field researchers suggest that there is a dire requirement to plan a relief mission for a disaster in a gender-sensitive way, and sexual hygiene products should be considered as relief items post-disaster.[33] Similarly, due to hampered logistics supply post-disaster, the availability of modern contraceptives could be reduced, leading to unmet needs of women of reproductive age.[34,35]

Few studies conducted in LMICs reported a negative correlation between female fertility and the occurrence of natural calamities such as drought or earthquake. However, the reproduction rates increase dramatically beyond the normal trend after a few months of the event.[36,37] The evidence are very limited regarding the exact dynamics of the disaster event and reduction in conception; however, it is implied due to increased mental stress, reduced physical capacity, and unavailability of contraceptives after natural disasters and calamities, female face challenges in conception.[38]

Another study conducted in an underdeveloped nation revealed that due to a cyclone, the number of antenatal care visits and postpartum visits decreased.[39] Literature suggests this is due to the shifting priority of the health system from general public health services to trauma and emergency medical

services. Another reason highlighted is physical damage to the primary healthcare facilities; furthermore, there is an ephemeral reduction in the usual healthcare manpower in the affected region.[40]

Besides the aforementioned immediate effects of natural calamities, researchers have also highlighted delayed and indirect factors that come into play during the relief phase. A study in Pakistan revealed that in the relief shelters, there is an increased risk of sexual harassment and sexual violence against female flood survivors. The reasons behind this are overcrowding and lack of privacy related to toilet use and defecation.[41]

Effect of climate-driven migration

The peculiarity of male migration in LMICs of economic activity is that the migrants are not accompanied by their wives. Wives stay back in their hometown usually with kids and in-law parents. However, if the women migrate with their husbands or family, they usually experience many reproductive healthcare problems.[42] These challenges are most prominent during transit, such as unmet need for contraception, unsafe abortion, lack of Antenatal Care (ANC) checkup, etc.[43,44]

When the dissolution of social networks and changes in sociocultural norms occur in a patriarchal society, a most vulnerable section of society emerges. The challenges become more intense, and the situation gets exacerbated further in case of push-migration happening due to climate or natural disasters.

A comparative study conducted in Bangladesh reported that pregnant women who migrated due to flood are more likely to miss the ANC visit as compared to non-migrant pregnant women.[45] This is corroborated by a study conducted in India that revealed forced migration of women due to drought causes reduced ANC service utilization, such as the number of ANC visits, IFA (iron-folic acid) consumption, and tetanus vaccination.[46] Moreover, a study concluded that the internally displaced pregnant women have a higher risk of non-institutional delivery assisted by non-skilled personnel and reduced PNC (postnatal care) visits, ultimately leading to increased neonatal mortality.[47] Researchers have reported that women migrating due to CCC face different types of GBV (gender-based violence). These assaults could be external as well as internal to the household. Internal GBV may be intimate partner violence or sexual violence by other male members of the family. External GBV may arise in the form of sexual harassment or rape when women try to access the relief services such as food or shelter.[48,49] Researchers have reported that in the Indian subcontinent, men-dominated climate-driven migration (such as due to drought and agricultural income collapse) has a spin-off effect that the female members of the household may experience GBV and sexual assault in the absence of the male in the household.[50] A study in Bangladesh reported women with migrated husbands face serious sexual violence problems at their place of work or at residence. The assaulter could be a drunk stranger or a close male family relative.[51] In addition to making women (especially Left-Behind Wives) vulnerable to short-term threats like cuts and unintended pregnancies, sexual harassment and GBV also result in long-term social issues like HIV infection, social stigmatization, ostracization by household members, husbands doubting the integrity of their wives, etc.[52] The summarized findings of the aforementioned three themes are depicted in Figure 2.

Discussion

The unique strength of the present review is that it draws a relationship between female reproductive health and the direct as well as indirect effects of the CCC. The research articles included in the present review collectively revealed that change in climate and environment has only negative impacts on female reproductive health. This is in accord with reviews conducted by Freed *et al*., stating various negative effects.[53] It is important to point out that the review had a similar methodology and scanned similar electronic databases. The objective is similar but narrower in terms of the type of natural calamity focused. Further, it differs in the focused reproductive aspect (i.e., contraception only) as well as geographical region, that is, OECD (Organization for Economic Co-operation and Development) member countries. The present review findings are also corroborated by another review paper that has followed a thematic analysis approach and discussed various CCC on different groups of vulnerable populations including women in general, and specifically pregnant females.[38]

The findings suggest that these effects can be observed in women of different age groups varying in the form, from hormonal imbalances to heavy metal toxicity by breast milk. Further, the indirect consequences of CCC arising during natural calamity arise in different forms, ranging from the unavailability of RSH medical facilities to sexual violence related to migration and refugee camps.

Findings suggest that there is a lack of evidence on how the contraceptive behavior of females gets altered by the major natural calamities (namely big thunderstorms, cyclones, floods, and earthquakes) that cause significant destruction and displacement of people. From the available studies, it is evident that RSH should be included and given due attention during disaster relief work as well as climate-driven migration. However, only a handful of studies have provided concrete evidence in the context of India.[4,44] There exists a knowledge gap regarding the analysis of the unmet need regarding various aspects of RSH, namely, contraception, etc., Furthermore, there is a need for research to find out how these unmet needs are translated into future burdens on the health system and healthcare costs.

It is noteworthy to mention research that on the impact of disasters is largely limited to literature from the Americas

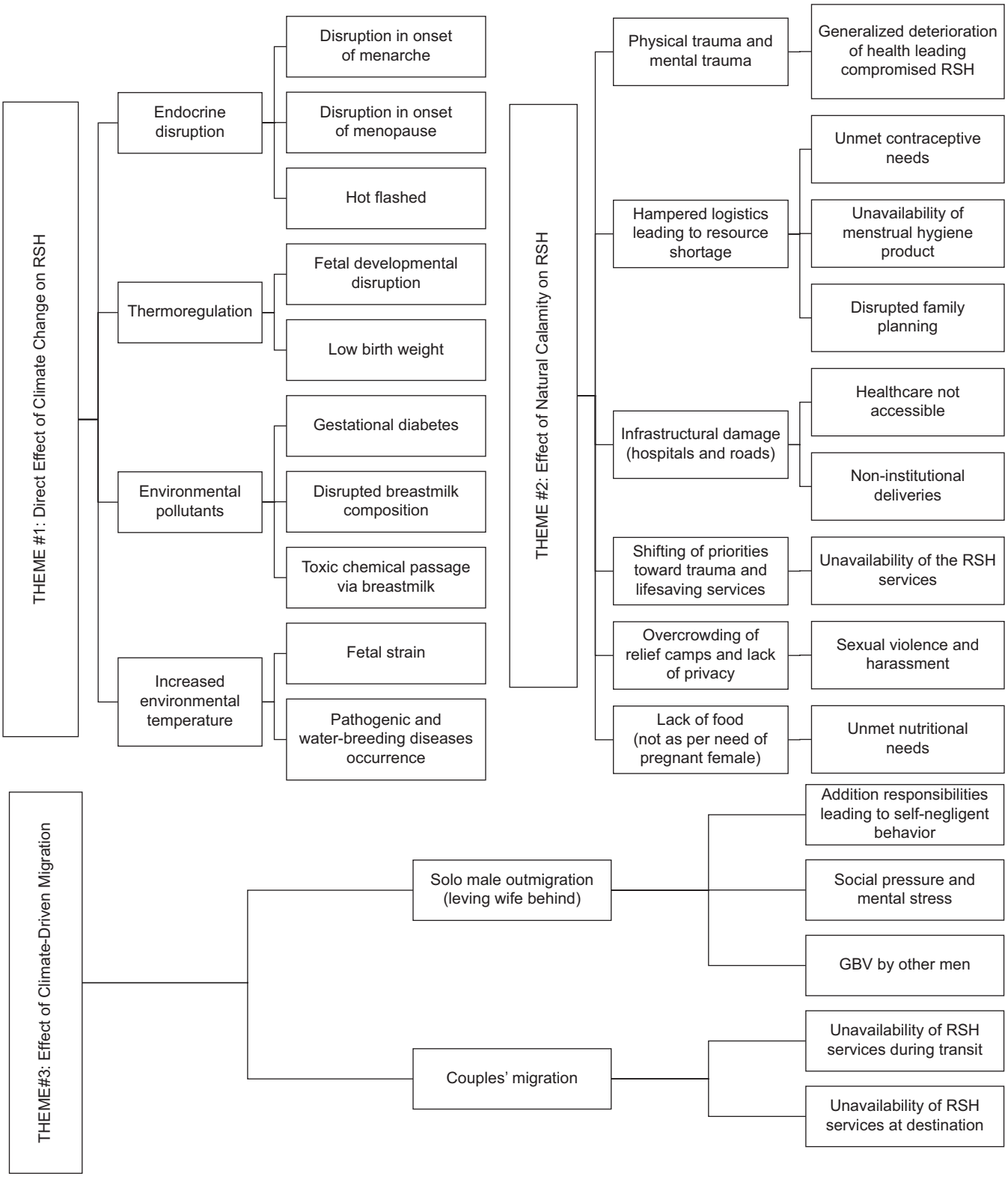

Figure 2: Summary of the impact of CCC on female reproductive health aspects

and Europe. More studies focusing on disastrous events and CCC events in southeast Asian and African nations should be carried out. Lastly, we recommend a cohort study that could be carried out focusing on the population residing in natural disaster-prone areas such as Bihar (for floods) and West Bengal and Odisha (for cyclones). This will help in developing strengthened climate action and health policies.

Conclusion

It is no longer possible to overlook how CCC and natural disasters (caused by CCC) affect reproductive health. Changing climate and frequent natural catastrophe poses a threat to global health and disproportionately impacts underprivileged people. The body of literature in this area is expanding, and there is room for new study. The available literature about LMICs is predominantly confined to drought, flood, and earthquake. Disasters like tsunamis, cyclones, and avalanches remain unexplored. From the available literature, it is quite evident that CCC has detrimental effects on a woman's reproductive life at different phases as well as having a bearing on the future generations' health. Policymakers should take into consideration these detrimental effects while designing health schemes and policies for females. For instance, a dedicated awareness program regarding climate change for the backward rural population can be launched. This could be achieved by public broadcast messages by the government. Further, changes in existing reproductive health schemes can be made so that at times of natural calamities and disasters, the RSH needs of women in affected areas can be incorporated. This should be performed on priority for those areas of LMICs where natural disasters are recurrent, such as floods in the Bihar province of India.

Further research on the identified knowledge gaps is required. Based on the evidence generated, intervention strategies could be developed for the same. This is essential to safeguarding the global health of women in the future.

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Conflicts of interest

There are no conflicts of interest.

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