Exploring the causes of Maternal mortality in Karnataka and Crafting Strategies for Prevention

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Abstract. The objective of this study is to analyze the factors that cause maternal deaths and the effect of medications given to reduce them in Karnataka. To carry out this work,3 years data (2017-2020) is collected from the Official Karnataka government website (Health Management System) which describes both maternal and infant health and causes of deaths district-wise in Karnataka. Maternal data is extracted and analyzed by grouping the districts into 4 administrative divisions. A linear regression process is used for selecting the relevant factors. It is observed that overall maternal deaths have reduced by 0.09% from 2017 to 2020. But there are districts like Bengaluru Urban, Bijapur, and Yadgir where there has been an increase in maternal deaths by 0.189%, 0.356%, and 0.07% respectively. While the drastic decrease was observed in districts Belagavi, Gulbarga and Dharwad by 0.495%, 0.415%, and 0.138% respectively. In the year 2019-20, Bengaluru Urban recorded the highest number of deaths (83) among all other districts. The factors that caused maternal deaths include severe anaemia(p=0.9999), GDM(p=0.962), and obstetric complications(p=0.02). Upon observation it was found that districts with elevated rates of maternal mortality also experienced a surge in severe anemia , gestational diabetes mellitus(GDM) and obstetric complications. While a decline in mortality rates was observed in certain districts , including Bengaluru Rural, Hassan ,Uttar Kannada and Shivamogga. Interestingly, these districts also showed a reduction in severe anemia and gestational diabetes mellitus (GDM) cases. Based on the analysis, it can be concluded that addressing the treatment of anemia, reducing the prevalence of GDM , and effectively managing obstetric complications are crucial steps toward achieving the goal of a maternal mortality rate.

Keywords: Maternal death,Severe anaemia,obstetric complications,gestational diabetes mellitus,.

1 Introduction:

The Sustainable Development Goals (SDGs)[1] established by the United Nations outline a comprehensive framework for global development, aiming to address critical issues and enhance the quality of life for all individuals. Goal 3

specifically focuses on ensuring good health and well-being for everyone. One of its key targets is to reduce the [6]global maternal mortality ratio to less than 70 per 100,000 live births by 2030. Maternal mortality remains a vital indicator of a nation's healthcare system and its ability to provide adequate care for expectant mothers. Achieving this goal is crucial as maternal health is not just a matter of reproductive rights but also a fundamental human right. Governments worldwide, including India, are striving to implement measures to reduce maternal mortality rates and improve maternal health outcomes.

The Indian Ministry of Health and Family Welfare[7] has made reducing maternal mortality a priority.The government has invested significantly to achieve this goal, with the introduction of various programs and initiatives aimed at improving maternal health and well-being. The study highlights the importance of adequate nutrition and quality health care during pregnancy in reducing maternal mortality rates, and emphasizes the importance of comprehensive maternal care programs. The Indian Ministry of Health and Family Welfare has made reducing the maternal mortality rate a priority.The government has invested significantly to achieve this goal, with the introduction of various programs and initiatives aimed at improving maternal health and well-being of pregnant women. Plans and strategies to enhance public health services have been outlined by the Indian National Development Council, with a particular emphasis on addressing the health needs of women and adolescent girls.

In an effort to improve maternal and child health outcomes, the government has set ambitious targets to lower maternal mortality through a series of five-year plans.

In Karnataka, a southern state in India, efforts to reduce maternal mortality have been particularly notable. Despite facing challenges such as having one of the highest maternal mortality ratios[2], Karnataka has made significant progress in reducing maternal deaths through the implementation of various healthcare schemes and programs. Initiatives such as Tayi Bhagya[3], Prasuthi Araike[4], and Ayushman Bharat Arogya[5] Karnataka have played a crucial role in improving access to maternal healthcare services and ensuring better maternal outcomes.

As we strive to achieve Goal 3 of the SDGs, it is essential to recognize the complex nature of maternal health and the interconnected factors influencing maternal mortality rates. This paper aims to delve deeper into the factors affecting maternal deaths, examining the progress made, challenges faced, and strategies employed in Karnataka towards achieving the ambitious goal of reducing maternal mortality. Through a comprehensive analysis, we aim to identify actionable steps and interventions necessary to accelerate progress and ensure the well-being of mothers across the region.

2 LITERATURE SURVEY

The literature on maternal healthcare in Karnataka spans over two decades, unraveling a narrative that combines resilience with persistent challenges. Be-

ginning in the late 1990s, researchers probed into the grim realities of maternal mortality, exposing a landscape riddled with preventable causes. Hemorrhage, sepsis, unsafe abortion, hypertensive disorders, and obstructed labor emerged as leading culprits, reflecting systemic deficiencies such as a shortage of skilled healthcare professionals, inadequate nutrition, and shortcomings in healthcare infrastructure [9]. This period marked a clarion call for targeted interventions encompassing improved facilities, comprehensive staff training, and equitable access to nutrition to effectively combat maternal mortality.

A concurrent exploration focused on the utilization of maternal healthcare services among rural women [13]. While progress was evident due to government initiatives and enhanced accessibility, persistent disparities remained. Community-based initiatives played a pivotal role in bridging these gaps and empowering women with essential care and knowledge.

Shifting to the year 2016, attention turned to Dakshina Kannada district, where tribal women were at the forefront of study [14]. Antenatal care presented promises of safety and well-being, yet implementation revealed stark realities. Although a considerable number attended their first antenatal visit in the first trimester, a fraction received necessary immunizations, exposing gaps in ANC visits and essential healthcare services.

The narrative deepened further into the postnatal period, where a study highlighted the neglect of new mothers [15]. Postnatal services fell short in reaching those in need, emphasizing the necessity for a holistic approach to maternal healthcare beyond childbirth.

In 2017, the spotlight shifted to migrant women in Bangalore City [16]. Hindered by location and circumstances, they faced limited access to maternal healthcare, often resorting to returning to their native places for childbirth. This underscored the imperative for tailored interventions and a deeper understanding of migrant needs to ensure equitable access to maternal healthcare services.

Amidst challenges, glimpses of progress emerged in 2012 [17]. Maternal mortality rates declined, yet disparities persisted, particularly along caste lines. Awareness campaigns became pivotal in advocating for universal access to antenatal care and institutional deliveries, signaling potential for inclusive maternal health programs.

A comprehensive survey in 2002 across South India shed light on the unifying force of antenatal care in bridging social divides [18]. However, challenges persisted, as evidenced by rising obstetric complications in Koppal from 2007 to 2015 [19]. This period exposed systemic flaws in service delivery, highlighting the urgent need for comprehensive reform.

In conclusion, the literature on maternal healthcare in Karnataka portrays a narrative of resilience amidst challenges, underscoring the importance of collective efforts to safeguard the health and well-being of mothers and their children across generations. While existing studies primarily focused on ANC registrations and their impact on maternal and adolescent health, gaps remain in understanding other influential factors affecting maternal mortality rates and the

efficacy of interventions in mitigating these risks. Further research is warranted to delve deeper into these critical areas to inform more effective maternal healthcare policies and practices.

3 METHODOLOGY

3.1 Data Collection and Description

To carry out this work we collected three years of data(2017-18, 2018-19, 2019-20) from government official website[20] regarding maternal health. Maternal health data is extracted and used for analysis.

Data Preprocessing
When integrating the three Excel sheets, issues arose due to discrepancies in attribute names across the datasets, despite conveying similar meanings. Subsequently, the integrated dataset contained attributes with missing values.
All NaN values were replaced with the mean for normally distributed data and with the median for right-skewed or left-skewed data. It's important to note that mode was not used because the dataset did not contain categorical data.
Attributes having null values and are positively skewed are replaced by median values.

3.2 ANALYSIS :

For simpler analysis, we have divided the districts into four administrative divisions i.e., Belagavi, Bengaluru, Mysore and Kalburgi division.

- The districts Bagalkot, Belagavi, Dharwad, Gadag, Haveri, Uttara Kannada, and Bijapur are part of the Belagavi division.
- The districts Bengaluru Rural, Bengaluru Urban, Chikballapur, Chitradurga, Davengere, Kolar, Ramnagar, Shivmogga, and Tumkur fall under the Bengaluru division.
- The districts Ballari, Bidar, Kalaburgi, Koppal, Raichur, Vijayanagar, and Yadgiri are included in the Kalaburgi division.
- The districts Chamarajanagar, Chikmagalur, Dakshina Kannada, Hassan, Kodagu, Mandya, Mysore, and Udupi belong to the Mysore division.

This study examines the maternal mortality rates[8] in various districts for the years 2017-18, 2018-19, and 2019-20. The key performance metric employed is the Mortality Rate per district, which is computed by dividing the total deaths in a district by the total Antenatal Care (ANC) registrations and then multiplying by 1000.

The formula for Mortality Rate per district is expressed as follows:

$$MortalityRate = \left(\frac{TotalDeaths}{TotalANCRegistrations} \right) \times 1000. \quad (1)$$

The subsequent analysis is driven by the skewness observed in the Mortality Rate per district within specific divisions. If the data exhibits skewness, the median of the Mortality Rate per district is employed. On the other hand, if the data distribution is not skewed, the mean of the Mortality Rate is utilized.

3.3.1 Maternal deaths

Maternal deaths are a tragic and preventable loss that highlights the urgent need for improved healthcare interventions. Among the leading causes contributing to these devastating outcomes are conditions such as anemia[10], gestational diabetes mellitus (GDM)[11], and various obstetric complications[12].

Table 1: Maternal Deaths

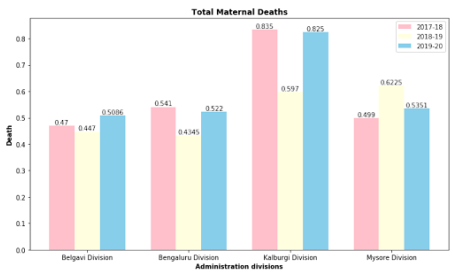
Year	Total ANC registrations	Total Maternal Deaths	Total % of Deaths
2017 -2018	10,97,344	758	0.718%
2018 -2019	11,40,111	657	0.576%
2019 -2020	11,51,533	724	0.628%

Table 1 represents the analysis of maternal mortality trends in Karnataka State reveals a notable reduction in total maternal deaths during the 2019-20 period compared to 2017-18, reflecting a decrease of 0.09%. This decline can be attributed to the effective implementation of strategies such as Anaemia Mukt Bharat (AMB), Janani Suraksha Yojana (JSY), and Pradhan Mantri Surakshit Matritva Abhiyan (PMSMA). However, despite this overall decrease, certain areas within the state have witnessed an increase in maternal mortality ratios. In subsequent sections, a comprehensive examination of various divisions in Karnataka will be undertaken to assess the trends in maternal deaths within these divisions and explore the underlying factors contributing to these deaths.

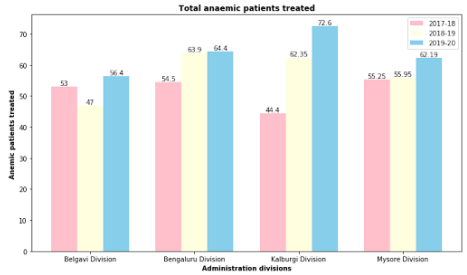
Table 2: Percentage of deaths and its causes in Belgaum division

District	Deaths	Causes		
		Anaemia	GDM	Obstetric Complications
Gadag	34%	✓	-	✓
Haveri	8%	✓	-	-
Bijapur	7%	✓	-	✓

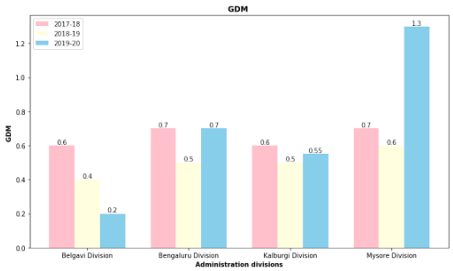
Belgaum division: Figure 1 presents an analysis of maternal health outcomes in the Belgaum division, highlighting varied factors influencing maternal death rates from 2017-2018 to 2019-20. Belgaum district shows a significant decrease in maternal deaths, suggesting progress in healthcare interventions. However,



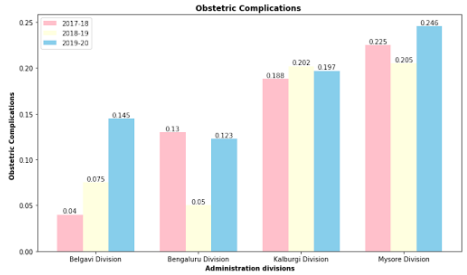
(a) Maternal Deaths



(b) Total Anaemic patients treated



(c) GDM



(d) Obstetric Complications

Dharwad still faces high mortality rates despite improvements, indicating ongoing challenges. Gadag, Bijapur, and Haveri witness rising maternal deaths, potentially signaling healthcare service deficiencies. On the other hand, Uttara Kannada showcases a decline in mortality rates, hinting at successful healthcare initiatives.

Subsequent examination indicates that the several factors that contribute to maternal mortality are intricately linked.

In Figure C, Gestational Diabetes Mellitus (GDM) prevalence varies across Karnataka's districts. Belgaum, Bijapur, and Haveri show decreasing GDM cases, potentially improving maternal health outcomes. Conversely, Dharwad's increasing GDM cases align with high maternal mortality rates. Gadag's stagnant GDM rates may not impact mortality significantly. Uttara Kannada's rising GDM cases correspond with increased maternal mortality, while Bijapur's decreasing GDM cases contrast with rising maternal deaths, suggesting other contributing factors like Anaemia and Obstetric complications.

Another important component, obstetric complications, shows different patterns in different regions. As depicted in Figure B, Gadag's increase in complications correlates with its rise in maternal deaths. Conversely, the decline in Uttara Kannada mirrors the state's overall decrease in maternal deaths. However, the stagnant rates observed in Haveri and Belgaum may not exert a substantial impact on mortality patterns.

The treatment of anaemia and the use of 180 IFA tablets offer insights into maternal health outcomes. Dharwad's declining anaemia treatment may con-

tribute to its high mortality rates. Increased usage of 180 IFA tablets correlates with decreased deaths in districts like Belgaum and Dharwad, highlighting a positive impact. Discrepancies in Bijapur emphasize the complexity of maternal health outcomes.

Table 3: Percentage of deaths and its causes in Bengaluru division

District	Deaths	Causes		
		Anaemia	GDM	Obstetric Complications
Davanagere	124.78%	-	✓	✓
Ramnagar	322.66%	-	✓	✓

Bengaluru Division: From Figure A, it is evident that maternal health outcomes within the Bengaluru division have shown an increase in maternal deaths across districts from 2017 to 2021. However, mortality rates have fluctuated significantly, with a decrease observed in 2018-19 followed by a subsequent rise in 2021. In districts like Bengaluru Rural,Bengaluru Urban, Chikballapur , Chitradurga, Kolar, Shivamoga, and Tumkur, there has been a reduction in maternal deaths over the years. Conversely, in other districts such as Davangere and Ramanagara, similar trends to those in the Bengaluru division have been noted, with a decline in maternal deaths recorded in 2018 followed by an increase in subsequent year. This variation in trends across districts has influenced the overall pattern observed in the Bengaluru division. When comparing Davangere to other districts, it is noticeable that deaths have drastically increased in the year 2020-2021, which has been the highest contributor to the rise in maternal deaths across the division.

As seen in Figure C, Gestational Diabetes Mellitus (GDM) cases have decreased in Bengaluru Urban, Chikballapur, Chitradurga, Kolar, Shivmogga, and Tumkur, resulting in lower maternal deaths. Conversely, GDM cases increased in Davangere and Ramanagara, leading to higher maternal deaths in these areas. To reduce maternal deaths, it's crucial for the government and healthcare professionals to collaborate on strategies to decrease GDM cases in affected districts.

Obstetric complications significantly contribute to maternal death rates. There's been a rise in obstetric complication cases in almost all districts, notably in Davangere and Ramanagara, leading to increased maternal deaths. While an increase in obstetric complication cases was noted in Chikballapur , Shivamogga and Tumkur, a decrease in maternal deaths suggests that these districts have demonstrated commendable efforts in reducing anemia and GDM cases. This reduction in obstetric complications highlights their effective strategies in maternal healthcare management.

In nearly all districts, except for Chikballapur and Chitradurga, cases of anemia have seen a reduction due to effective government interventions. Notably,

Davangere witnessed a decrease in anemia cases, but experienced an increase in deaths, attributed to the rise in GDM and obstetric complication cases.

The administration of 180 IFA tablets has been instrumental in reducing anemia cases in districts such as Davangere, Kolar, Ramanagar , Shivamogga, and Tumkur. This proactive measure has effectively decreased the prevalence of anemia and maternal deaths in these districts.

Table 4: Percentage of deaths and its causes in kalburgi division

District	Deaths	Causes		
		Anaemia	GDM	Obstetric Complications
Ballari	9.5%	-	-	✓
Yadgir	121%	✓	-	-

Kalburgi Division: From Figure A, it is apparent that the Kalburgi division experienced an overall decrease in maternal deaths over the years 2017, 2018, 2019, and 2020. Initially, deaths decreased in the year 2018-19, but later rose again. Within the Kalburgi Division, maternal deaths increased in Ballary and Yadgir , while they decreased in Bidar, Gulbarga, and Koppal districts.

In Figure C, an analysis of factors influencing maternal deaths reveals an increase in Gestational Diabetes Mellitus (GDM) cases in districts such as Ballary, leading to a corresponding rise in deaths. Conversely, GDM cases decreased in Bidar, Gulbarga, and Koppal, leading to a reduction in deaths in these districts. Thus, the government should take appropriate steps to mitigate obstetric complications in affected districts.

As depicted in figure D, there has been an increase in Obstetric complication cases in Ballary, leading to a rise in maternal deaths in that region. Conversely, districts within the Kalburgi division, including Bidar, Gulbarga, Raichur, and Yadgir, have seen a reduction in obstetric complications.

Anemia remains a significant factor influencing maternal mortality, characterized by a decline in cases in Ballary, Bidar, Gulbarga, and Koppal owing to enhanced distribution of 180 IFA tablets. Conversely, Raichur and Yadgir experienced an increase in anemia cases due to reduced IFA tablet distribution, resulting in elevated mortality rates in these districts.

Table 5: Percentage of deaths and its causes in Mysore division

District	Deaths	Causes		
		Anaemia	GDM	Obstetric Complications
Chikmagalur	27.2%	-	-	✓
Dakshina kannada	47.4%	-	✓	✓
Mysore	14.4%	✓	✓	✓

Mysore Division: As illustrated in Figure A, there has been an overall increase in maternal deaths over the years within the Mysore division. The rise in deaths is notable in Chikmagluru, Dakshin Kannada, and Mysore districts, contributing to the overall increase in maternal mortality. Conversely, a decrease was observed in Chamrajnagar, Hassan, Kodagu, Mandya, and Udupi districts.

Analyzing the impact of GDM, it decreased in Chamrajnagar, Chikmaglur, and Udupi, resulting in reduced deaths in those districts. Despite the decrease in GDM cases in Chikmaglur, there has been an increase in deaths, attributed to other contributing factors like Obstetric complications. Conversely, GDM cases increased in Dakshin Kannada and Mysore correlating with increased deaths in Dakshin Kannada and Mysore.

Regarding obstetric complications, cases increased in Chamrajnagar, Chikmaglur, Dakshin Kannada, and Mysore, aligning with the trend in deaths. Conversely, a decrease in obstetric complication cases was observed in Hassan, Kodagu, Mandya, and Udupi, leading to decreased deaths in these districts.

Anemia cases decreased in Chamrajnagar, Chikmagalur, Dakshin Kannada, Hassan, Kodagu, and Mandya due to increased distribution of 180 IFA tablets. Conversely, anemia increased in Mysore and Udupi, leading to higher deaths in Mysore. However, despite higher anemia cases in Udupi, reduced deaths were noted due to significant reductions in GDM and obstetric complications. This emphasizes the need for comprehensive government intervention to address all factors contributing to maternal mortality.

4 Conclusion

The alarming increase in maternal deaths observed in districts such as Dharwad, Gadag, Bijapur, Haveri, Davangere, Ballary, Yadgir, Chikmagluru, Dakshin Kannada, and Mysore underscores the urgent need for targeted interventions to address the multifaceted factors contributing to this trend. Factors including GDM, obstetric complications, and anemia have played significant roles in driving up maternal mortality rates in these regions.

To achieve the ambitious target outlined in Goal 3 of the Sustainable Development Goals, it is imperative for the government to prioritize maternal healthcare initiatives in these districts. Policies aimed at promoting ANC registrations and ensuring access to essential healthcare services, including the distribution of vital supplements like 180IFA tablets to combat anemia, are crucial steps towards reducing maternal deaths.

By implementing comprehensive strategies and encouraging active participation from healthcare providers and communities alike, the government can effectively work towards reducing maternal mortality rates and ultimately achieving the desired goal of less than 70 maternal deaths per 100,000 live births. It is only through concerted efforts and targeted interventions in these high-risk districts that tangible progress can be made towards ensuring good health and well-being for all mothers and newborns.

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