Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Maternal Mortality Trends in Kerala, India: A Descriptive Epidemiological Analysis

K P Shahana
Vellore Institute of Technology
J Balamurugan
balamurugan.j@vit.ac.in

Vellore Institute of Technology

Research Article

Keywords: maternal mortality, obstetric health, sustainable development goal, five-year plans, geographical variations, antenatal care

Posted Date: January 22nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-8400791/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Maternal Mortality Trends in Kerala, India: A Descriptive Epidemiological Analysis

Shahana K P[1], Balamurugan J

[1] Vellore Institute of Technology, Research Scholar, School of Social Science & Languages, Vellore, India.

[2] Vellore Institute of Technology, Faculty of Sociology, School of Social Science & Languages, Vellore, India

* Corresponding author: Balamurugan J, balamurugan.j@vit.ac.in

ABSTRACT:

Background: Kerala has achieved remarkable success in reducing maternal mortality rate (MMR) and stands as one of the high-performing states within India, with MMR approaching the Sustainable Development Goal (SDG) 3.1 target. This achievement reflects to the implementation of sustainable five-year plans that prioritize the strengthening of healthcare and infrastructure. The plans focus on maternal health, institutional delivery coverage and improving antenatal and obstetric care.

Methods: The study employs a descriptive epidemiological design to analyse trends in maternal mortality across Kerala. Data were collected from three sources: the Sample Registration System (SRS), the National Family Health Survey (NFHS) and Health at Glance: Kerala Annual Health Reports. These sources provided comprehensive information on mortality trends, service coverage indicators and district-level variations over the study period.

Results: The findings shows that a consistent reduction in maternal mortality is seen for the last ten years from 2014-2024 across Kerala. However, significant district-level variations persist which are driven by socio-economic and geographic disparities. These disparities cause a gap in the quality of care.

Conclusion: While Kerala has made notable reduction in the maternal health system by implementing programmes there persist challenges. Further efforts are required to bring down the maternal mortality and to reach universal health coverage. Reducing district-level inequalities and providing quality care ensures fair maternal healthcare delivery which results in low maternal mortality.

Key words: maternal mortality, obstetric health, sustainable development goal, five-year plans, geographical variations, antenatal care.

BACKGROUND:

Maternal mortality remains a critical global health challenge [1]. The sustainable development goal 3.1 targets establishes that countries should reduce global maternal mortality ratio to less than 70 deaths per 100,000 live births by 2030 [2-3]. The World Health Organization estimates that approximately 295,000 maternal deaths occurred globally in 2017 [4]. The leading direct causes of maternal mortality include haemorrhage, hypertensive disorders of pregnancy, infections and other account for approximately 70% of maternal deaths [2]. Currently global progress indicates that while absolute numbers of maternal deaths have declined since 2000. The pace of reduction remains insufficient to achieve the 2030 target. Regional disparities in progress toward SDG 3.1 shows that the low-income countries have high mortality rate as compared to high-income countries [5]. Studies suggest that for the achievement of SDG 3.1 the maternal health system need to give more focus [3].

India shows significant progress in reducing maternal mortality over the past years. According to the Office of the Registrar General & Census Commissioner, India (2022), the maternal mortality ratio has reduced from 570 deaths in 1990 to 97 deaths per 100,000 live births in 2020. It shows that lower utilization of antenatal care and immunization services contributes to higher maternal mortality [6]. The probability of achieving lower antenatal care remained highest among disadvantaged social groups which indicates socio-economic disparities. Regional analysis demonstrates that southern states, particularly Kerala and Tamil Nadu have achieved lower maternal mortality ratios compared to northeastern states [6]. Education, economic status and residential location play an important role lower MMR [7].

Kerala shows an achievement on the maternal mortality as 30 per 100,000 live births in 2024. Kerala have achieved lower maternal mortality rates despite other high-income countries,

who are having higher per capita expenditure. The state's maternal mortality ratio has reduced from 94 in 1990 to 30-35 in 2020 per 100,000 live births [8]. This achievement reflects to the well organised administrative and health services in Kerala. High female literacy rate, equitable distribution of resources and integrated delivery of maternal healthcare contributes to the achievement [9]. Kerala's health system shows 99% institutional delivery rates. A comprehensive antenatal and postnatal coverage and obstetric care is given at all administrative levels. The transition towards maternal mortality reduction involves multiple interconnected health dimensions. These includes the infrastructure elements and the skilled birth attendance. A comprehensive obstetric service, functional transportation facilities and having sufficient and skilled human resource constitute to the lower maternal mortality rate. Studies recognises the intersection between maternal mental health and mortality outcomes in high-performing systems. Conditions including maternal depression, anxiety disorders and psychological distress during pregnancy. Post partum periods contribute to the adverse mental conditions which lead them to have an unstable mental health and physical health [10]. Kerala, recognised as one of the high performing states still have a deficiency in performing and giving more emphasis to the mental health conditions.

The maternal achievements can be directly integrated to the policy and programmes implementation. Thus, the five-year planning programmes implemented by the government have major role in the reduction of maternal mortality rate [11]. The population-focused family planning approaches through integrated reproductive and child health programs has transformed into comprehensive reproductive, maternal, newborn, and child health. This transformation reflected on evolving policy recognition of maternal health as rights-based and equity-centred concern [12]. The National Health Mission launched in 2005 represented a paradigm shift towards state-focused governance. This governance structure increased maternal health financing and integration of vertical health programs within strengthen primary

healthcare system. Kerala state has adopted policy framework which focus on the maternal health care and access to quality health systems. State focus on integrating maternal health services to the primary health centres which made it easier and more accessible to everyone. The primary healthcare deliveries increased the effectiveness of the policies which enabled maternal mortality reduction [13].

The study investigates the maternal mortality trends and rates in Kerala. From the past years a reduction is maternal mortality is evident. When compared to the north-east states southern states show low mortality rate. The reduction in mortality was not an immediate process. It was a slow process that happened in different steps by implementing policies and programmes which emphasis maternal health. The study mainly focusses on Kerala, a southern state in India and analyses the maternal mortality trends over the past ten-years. The evidence for the study is collected from the SRS MMR data, NFHS-4 and NFHS-5 and Health at Glance annual health report by government of Kerala. Thus, by analysing those data and integrating the achievements and gaps with the policy implementation have done. The five-year plans from 2014 to 2024 were taken for he studies and analysed that how does that implementation of the policies and programmes make a way to SDG 3.1 target achievement. Thus, the study integrates epidemiological analysis, health system assessment and policy framework examination. It understands that how Kerala has achieved maternal mortality reduction and SDG 3.1 achievement.

2.METHODS:

The quantitative method is used to accurately understand how maternal mortality changed in Kerala over the period 2014 to 2024. The study uses descriptive epidemiological design, which is well structured to make effective use of existing government data sources [14]. The design

is specifically chosen to make a comprehensive analysis of the maternal mortality trends in Kerala, India. A ten-year period from 2014 to 2024 for analysis. By taking the epidemiological design the study aimed to identify the patterns, disparities and access associated with the healthcare and maternal mortality. This method is well suited to track progress towards public health target and to assess the state and district level health interventions.

2.1: ANALYTICAL FRAMEWORK:

The analytical framework of the study was structured across different levels. The primary level of analysis focused on the overall Maternal Mortality Ratio (MMR) trends as the Kerala state level across the period 2014-2024. This initial assessment aimed to analyse states change over time in maternal health. This was possible by providing a foundational understanding of whether Kerala has maintained historically favourable position relative to national trends. The secondary level analysis investigates the 14 administrative districts in Kerala. By analysing the district level data, it helps to identify district-level maternal mortality burden patterns and pointing geographical disparities in progress of reduction targets. NFHS-4 and NFHS-5 are also taken for the study. The study also focuses on the five-year plans to analyse the policies and programmes that implemented by government of Kerala for improving the maternal healthcare and to reduce the maternal mortality. Details of all datasets and their access points are provided in the Data Availability section.

2.2: SORCES AND DATA EXTRACTION

The foundation of the quantitative study relays on integration of three authoritative datasets. These ensures the comprehensive sequential coverage, reliability and analytical depth. The primary source of the study was Sample Registration System (SRS) Maternal Mortality Reports, which provides state level maternal mortality ratio and trends. Study looks deep into Kerala’s Health at Glance annual health reports (2014-2024) providing district wise

administrative data on maternal deaths, abortions, institutional deliveries and facility-based performance. Adding to this, data from National Family Health Survey (NFHS-4 and NFHS-5) were used to capture key maternal heath indicators such as early antenatal care registration, institutional delivery rated TTD vaccination coverage and anaemia prevalence.

2.3: VARIABLES AND OPERATIONAL DEFINITIONS

The study identified and organised all its data into clear categories to make the study more structured and accurate. The primary outcome variables are: Maternal Mortality Ratio (MMR), which is defined as the number of maternal deaths per 100,000 live births. This is reported by the Sample Registration Survey. The Maternal Mortality Rate is defined as the total number of maternal deaths occurring per year. The key maternal health process indicators provide insights into the utilisation and quality of maternal health services. Pregnant Women Registration was defined as the proportion of pregnant women who registered for formal maternal health services. Early Antenatal Care (ANC) initiation is the proportion of women who initiated their first ANC visit before 12 weeks of gestation. Tetanus-Diphtheria (TTD) vaccination Coverage was defined as the proportion of pregnant women who received the recommended doses of TTD vaccination. Anaemia Prevalence in Pregnancy was measured as the proportion of pregnant women with haemoglobin levels below 11g/dL. Institutional Delivery Coverage was defined as the proportion of births that occurred in health facility (either in public or private). These variables provide context on the reproductive health services.

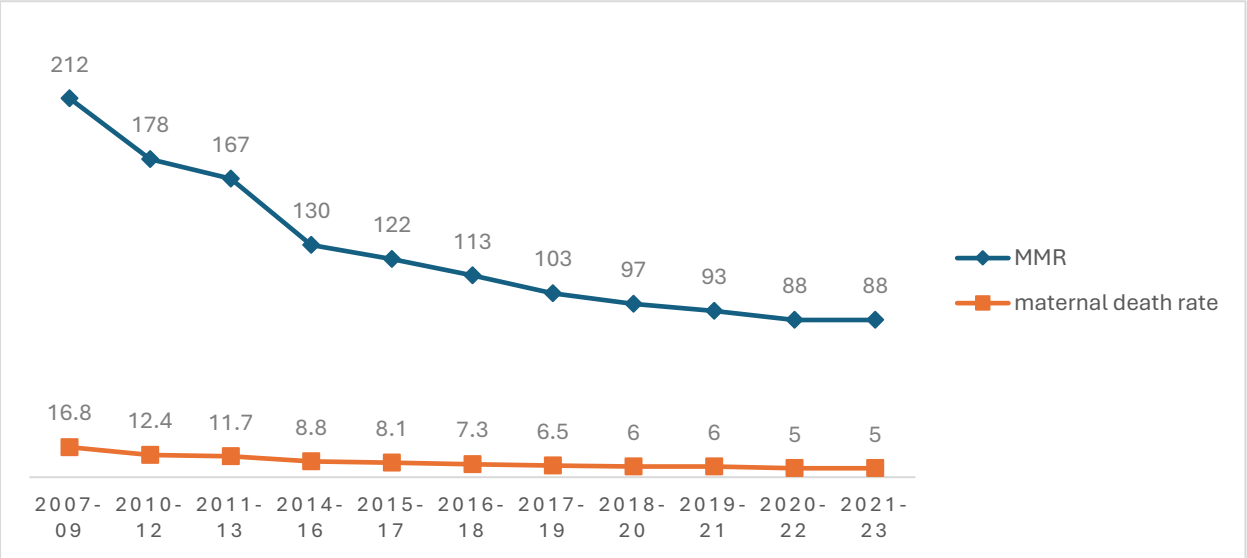
3.RESULTS

3.1 NATIONAL AND STATE WISE MMR TRENDS

India's national Maternal Mortality Ratio (MMR) declined substantially from 212 per 100,000 live births in 2007-09 to 88 per 100,000 live births in 2021-23. This represents 58% of relative reduction over the years. *Figure.1* reveals variation over the period. From 2007-09 to 2014-16

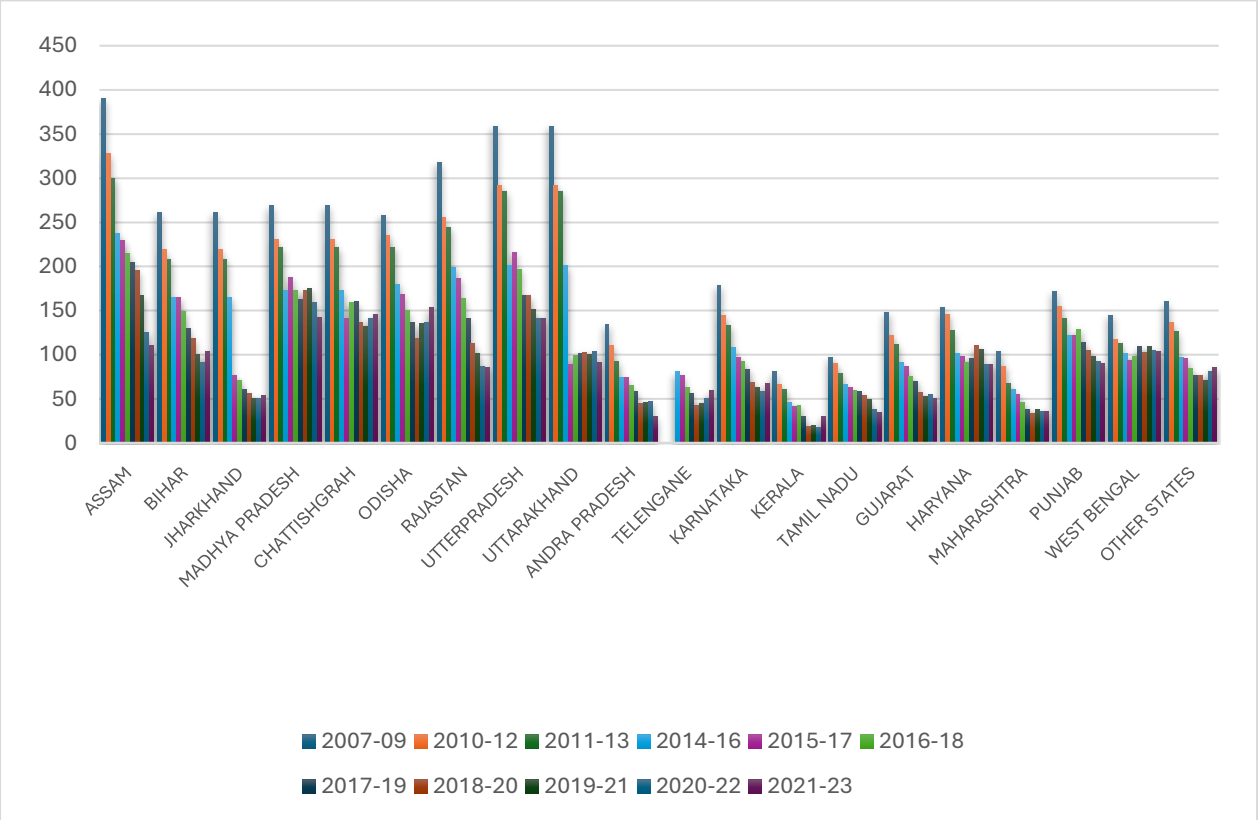
the MMR declined rapidly. But from 2014-16 to 2021-23 shows a slower progress. The stagnation evident in 2020-23. At this period MMR remained constant at 88 for three consecutive years.

figure1: Trend in MMR and maternal death rate in India



Source: SRS on maternal mortality India 2007-09 to 2021-23

Figure2: State wise MMR in India

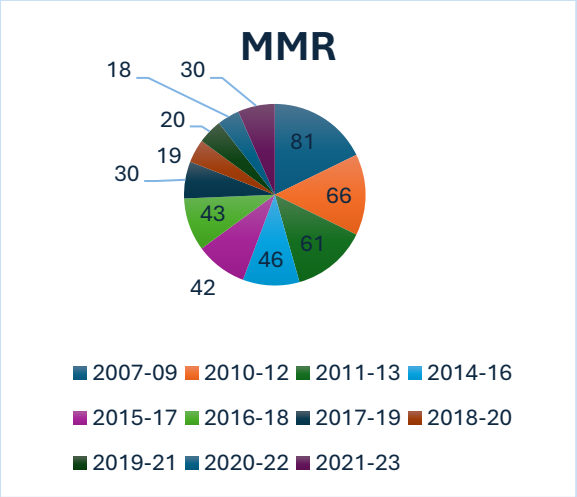


Source: SRS on maternal mortality in India 2007-09 to 2021-23.

Figure2 shows the state level MMR variation. States like Kerala, Tamil Nadu, Andra Pradesh and Maharashtra consistently maintained lower MMR throughout the period. States like Assam, Bihar, Jharkhand, Madhya Pradesh and others have a much higher MMRs. The data highlights that, India has made a significant level of reduction in maternal mortality. Data shows that the northern states have a higher maternal mortality relative to the southern states in India.

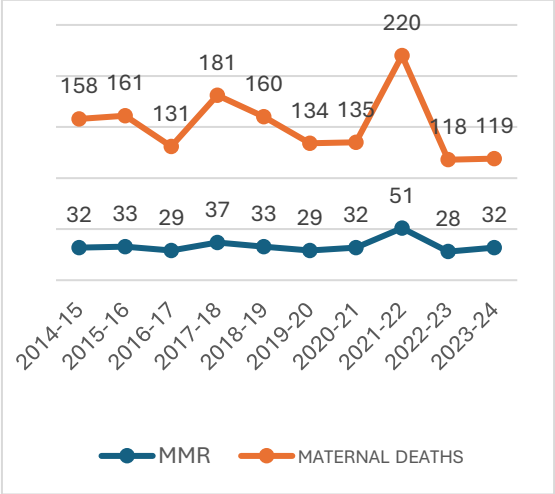
3.2 KERALA AND MMR TRENDS

Figure3: MMR of Kerala



Source: SRS MMR 2007-2021

Figure4: MMR and maternal death in Kerala



Source: Annual health report Kerala 2014-24

Figure: 3 illustrates the SRS maternal mortality in India, shows a substantial and consistent decline in Kerala's MMR. A steady reduction from 81 (2007-09) to 30 (2021-23) is seen. This change over time align with the national trend of decreasing MMR in India. This sustained low MMR in Kerala is aligned with the high literacy rates and effective implementation of maternal health care services. In figure: 4, the MMR range between 28 to 51. There see fluctuations in the maternal rate in every year. But looking in to the year 2021-22 it shows MMR of 51 and 220 maternal deaths. It shows a notable increase in the death rate. This is due to the challenges

faced during the COVID-19. The death rate is largely contributed by the pandemic. The delay in accessing care, rise in indirect obstetric causes and the wide spread of the disease become the rote cause. However, the MMR rate returened in to 28 and 32 in the following years (2022-23 and 2023-24). This reduction demonstrates the Kerala's strong recovery and resilience. Overall, the trends highlights the strong maternal care and survillance to maintain low MMR levels.

3.2.1 Maternal Suicide And Meternal Death By Place And Time.

Figure5: Time and maternal death

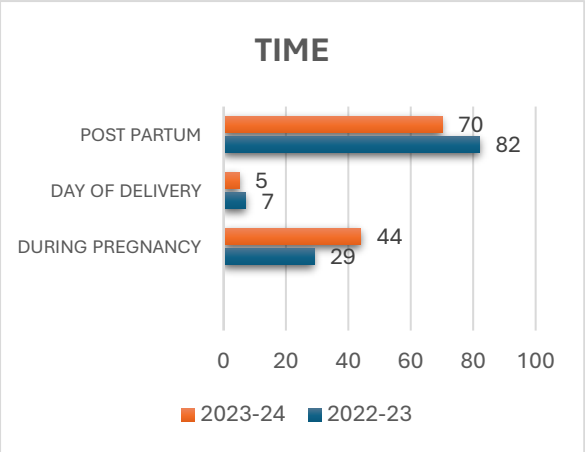
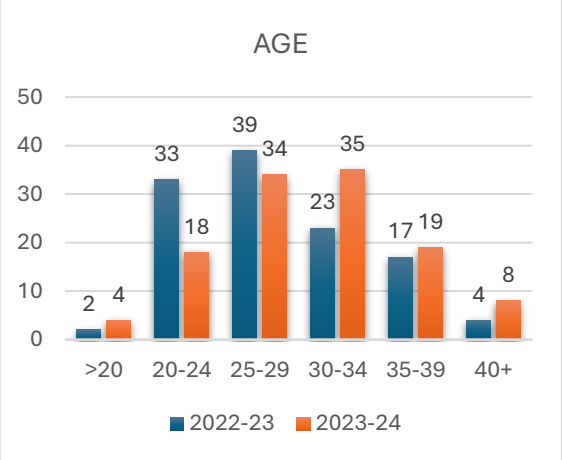


Figure6: Age and maternal death

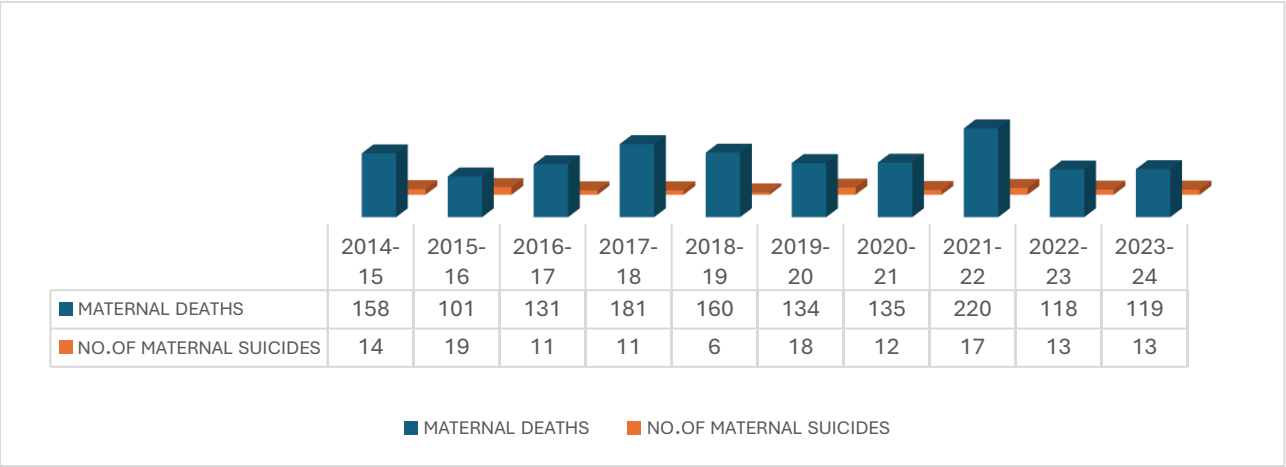


Source: Annual health report Kerala 2014-2024

Figure: 5 indicates that most of the maternal deaths in Kerala occurs during the period of post partum. This shows that the highest risk period for a mother come after the delivery. It highlights the importance of postnatal monitoring, analysing complications and giving the care. Death rate during the pregnancy havs increased. This indicates the rising danger during the antenatal months. Death on the day of delivery have a slight decrease. This shows better intrapartum care during delivery. Figure: 6 illustrates that age wise the maternal risk and mortality rate has shifted towards the older maternal age groups. Maternal death below the age of 20 rise the concern about adolescent pregnancies. From 20-29 death rate have dropped. This

reduction indicates that health care inverteintions are targeting younger mothers and thus reflected in the mortality rate. Age from 30-40+ the maternal death has increased.this hows that the age becomes a complex factor of pregnancy. Thus it also highlights that the vulnerable ones that require targeted support.

Figure7: Maternal death and no.of maternal suicides



Source: Annual health report Kerala 2014-2024

Figure:7 indicates that the rate of maternal suicide is compariteviliy low. But still the little proportion contributes an concerning share of deaths. It was particularlly during the period of covid-19 the death rate is high. The rise in suicide is proportional with the mental health. The increased psychological stress, postpartum depression and sisruption in support system pay a way for suicide tendency. Economic and financial strain also plays an important role in it.

3.3 DISTRICT WISE MMR TRENDS

Table1: District wise maternal mortality ratio (2014-15 to 2023-24)

district	2014 -15	2015 -16	2016 -17	2017 -18	2018 -19	2019 -20	2020 -21	2021 -22	2022 -23	2023 -24
TVM	22	30	33	38	16	29	38	54	19	26
KLM	55	38	19	51	34	40	44	65	13	20
PTA	26	14	14	7	47	7	31	49	32	35
ALP	41	48	46	21	46	25	46	95	27	23
KTM	24	37	36	30	17	53	29	68	20	45
IDK	0	51	47	55	26	57	38	67	32	72
EKM	19	17	17	25	12	28	21	30	19	19
TSR	26	32	24	28	34	14	23	56	27	19
PKD	47	48	51	62	56	36	44	67	39	31
MLP	37	42	25	33	42	26	30	50	24	29
KKD	30	26	14	56	37	25	29	32	34	19
WYD	79	28	40	28	61	48	15	46	41	47
KNR	25	14	34	27	18	14	19	27	29	36
KSD	29	58	42	40	30	55	60	67	66	108
Kerala	32	33	29	37	33	29	32	51	28	32

Source: Annual health report Kerala (2014-2024)

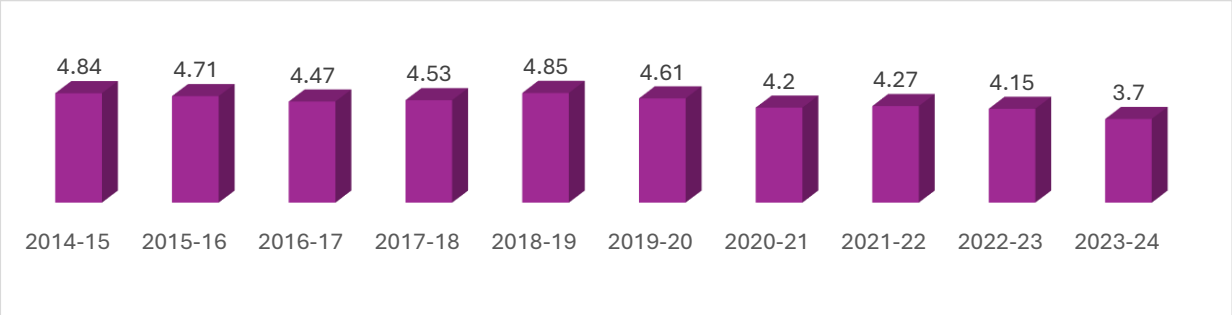
Table: 1 presents the district-wise maternal mortality in Kerala. It shows that from 2014 to 2024 reveals significant variation across the region despite the state maintaining an overall low MMR. Most of the years the MMR is between 29-37. But a notable fluctuation in the MMR 51 was on 2021-22, reflecting on the impact of covid-19. Districts like Ernakulam,

Thiruvananthapuram, Kozhikode and Kannur reported low MMR. These reflects to the strong healthcare access and service quality. This stable performance linked to better obstetric care infrastructure, higher ANC utilization and effective referral systems. Districts such as Wayanad, Idukki, Pathanamthitta and Palakkad shows high burden and more fluctuations. These regions are characterised as hilly terrain, tribal population and relatively limited access to emergency obstetric care. These factors contribute to a high maternal mortality.

The pandemic year 2021-22, recorded sharp increase in the death rate in all districts. This suggests systematic disruption, delay in care seeking and increased high-risk pregnancies. Still the state maintained an impressive maternal mortality record.

3.4: TRENDS IN TOTAL DELIVERIES IN KERALA

Figure8: Trends in total deliveries in Kerala 2014-15 to 2023-24 (in lakhs)



Source: Annual health report Kerala (2014-2024)

Figure 8 shows that Kerala's total deliveries exhibited a general decline oner 2014-15 to 2023-24. The number of deliveries decreased from an initial 4.84 lakhs to 3.7 lakhs. This shows a substantial absolute reduction of 1.14 lakhs deliveries and relative decline of 23.55% over the period. The decline rate shows fluctuations over the periods. This decline aligns with the demographic trends in Kerala. The state is noted for its aging population and decline in total fertility rates (TFR). Increasing support to maternal and child health programs remarkable ones in the state. TRF dropped below replacement level of 1.7 on the recent years. This drop reflects on the societal and economic factors influencing family planning decisions. Those includes

education levels, economic empowerment of women and delayed childbirth. Rise in female access to reproductive healthcare and contraceptive use also plays a major role in the reduction trends.

4. DISCUSSION

Kerala's maternal mortality rate from 2024-2024 demonstrates a clear picture of sustainable progress. Kerala shows a significant reduction in the maternal death, which picturise a stable healthcare framework supported by series of strategic policy initiatives. These initiatives are closely aligned with the Sustainable Development Goal (SDG) 3. The goal specifically ensures the healthy lives and wellbeing for all. SDG 3.1 emphasis on the reduction of maternal mortality ratio (MMR) to less than 70 per 100,000 live births by 2030 [15-16]. In Kerala's context MMR has significantly reduced from 4.8-fold lower in 2014 to 2.4-fold lower in 2024. Thus, Kerala maintain MMR below the national average. This shows the effectiveness of long-standing infrastructure, stable healthcare and high literacy rate among populations [17]. These foundational strengths have provided a resilient framework for maternal health service utilisation [18], which are prime factors for reducing maternal and newborn mortality [19]. These came to action by comprehensive policy frameworks and consistent implementation of it. Factors like education, financial performance and a stable healthcare system helps to improve maternal outcomes [7].

Kerala's MMR of 32 per 100,000 live births present a favourable picture. But the district level MMR data shows variations. This demonstrates the that social factors are determinants of maternal health. The social determinants of health framework highlights how factors such as economic status, education and residence impact the access to services and health outcomes [7]. The southern districts show low MMR throughout the period. Compared to this, northern districts show a comparatively high MMR. The northern districts are characterised by terrain,

lower population density and high geographical disparities. This shows that implementation barriers such as limited access to medical care due to distance and socioeconomic factors hinder maternal health service effectiveness in the northern region [20].

Institutional delivery coverage in Kerala reached near saturation level. NFHS4 and NFHS5 shows the increase to 94.7% (2019-21). But still there exist 2-10% of deliveries occurring outside the institution levels. These non-institutional deliveries represent complication management gaps as skilled birth attendance and institutional delivery advocated for reducing maternal and perinatal mortality [21]. Early antenatal care (ANC) initiation before 12 weeks gestation showed substantial improvement across the state. NFHS-5 shows 68.9% registration which shows an increase of 15.7% from NFHS-4. ANC pay a way for early risk assessment and timely interventions. The places such as Kannur, Wayanad and Kasargod shows below 60% indicated reduced effectiveness of ANC [22-23]. This suggest that the timing and quality of ANC is important irrespective of frequency of visits [22]. The low blood level haemoglobin<11g/Dl shows Anaemia. NFHS-5 shows 35.8% Anaemia rate. Anaemia prevalence above 40% is shown in the northern districts of Kerala. This indicates risk factor for haemorrhage-related complications, which leads to maternal death [24].

4.1: POLICY AND PROGRAMMATIC RESPONSES: KERALA'S FIVE-YEAR PLAN AND SDG-3 ALIGNMENT.

Kerala's achievement in reducing maternal mortality is rooted in the successive strategic five-year plans. The state through these plans has a superior maternal health outcome, a stable health infrastructure, high female literacy and sustained policy commitments [7,25]. SDG-3.1 targets the maternal mortality rate reduction below 70 per 100,000 live births by 2030. Kerala's MMR is already below the target (less than 30). This shows the improvement and quality of health care in Kerala [26]. This reduction constructed with national average of 97 per 100,000 live

births [11]. Such achievements are noted as states long standing investment in health infrastructure, high female education and comprehensive primary healthcare [18,27]. The rate of institutional delivery increase also plays an important role in reducing maternal mortality rate [28].

The five-year plans prioritised antenatal care (ANC). 99% of pregnant women received ANC access. This includes essential screening for hypertension, anaemia and gestational diabetes [29]. This helps in reducing maternal complications. Early and adequate ANC is crucial as it allows timely assessment of complications, which reduce the risk and maternal death rate [30]. Institutional delivery rate is another impressive factor in the reduction of Kerala's MMR. Institutional delivery has reached a universal coverage level of 99%, shows the sustainable policy emphasis on facility-based births ensure skilled attendance at deliver [21]. Government and private maternal hospitals and health services integrate well into community health networks thus, ensure safe deliveries [26]. The tetanus-diphtheria (TTD) vaccination coverage among pregnant women increased from 82.3% (2015-16) to 86.5% (2019-20) between NFHS-4 and NFHS-5. Anaemia a major risk factor for postpartum haemorrhage leading maternal deaths [31] have reduced from 36.2% to 35.8% between NFHS-4 and NFHS-5. Kerala's five-year plan suggests strategies to reduce anaemia. This is done by focusing on improved screening, providing iron supplements like iron tablets and by addressing underlying nutritional and social determinants [7]. Maternal health monitoring tools such as digital health records and geographic information system facilitates immediate care during obstetric emergencies [29]. These innovations make a way to reach the goal of SDG-3.1.

Kerala's five-year plan always gives prime importance to the health sector. Thus, it focuses on the maternal healthcare as well as the mortality reduction. Five-year plans incorporate with the sustainability principles. It tries to give universal healthcare services. These includes reproductive health services and institutional care, which are essential for reducing maternal

mortality rate. Kerala has adopted policies to address socioeconomic determinants of maternal mortality. This includes maternal nutrition programs, literacy campaigns and gender sensitive health policies that empower women [32-33]. Suicide accounts approximately 8-10% of all maternal deaths that is 3-4 deaths per 100,000 live births suggests risk of suicide. This occurs due to a complex interplay of stress, physiological changes and the evolving societal pressure on women [34-35]. The concentration of maternal suicide aligns with the postpartum depression [36]. This section is a bit under focused by the five-year plans. Thus, the further five-year plans must restructure maternal health programs to ensure pre and postnatal mental health components [37].

4.2: GAPS IN ACHIEVING SDG-3.1 AND FUTRURE RECOMMENDATIONS

Kerala's MMR reversal to 30 per 100,000 (2021-23) from 18 per 100,000 live births (2020-22) according to the SRS MMR data, challenges beyond mere coverage expansion. It depicts the importance of quality more than the quantity. Even if the institutional deliver rate reached the universal coverage, it still shows maternal mortality a bit high. This suggests that the five-year plans must shift their focus to ensure the quality of emergency obstetric and newborn care services and not just merely on increasing access [38-39]. Looking into the geographical disparities, five-year plans should have the policies appropriately more than "one-size-fits for all." The future plans should adopts differentiated, equity-focused strategies as the northern districts in Kerala shows high mortality. This focus should help to improve the infrastructure, enhance transportation for emergency referrals and skilled birth attendants [40]. Mental health is an important factor as there is maternal death happening due to suicides. These suicides mostly happen because of poor psychological support. Thus, plan should focus on giving psychological awareness and support for the pregnant women.

5. CONCLUSION

Kerala's maternal mortality ratio has reduced from 2014 to 2024. This achievement is substantial when compared to the northern regions of India where mortality rate remains high. Early antenatal care plays an important role in the reduction of maternal mortality rate. The focus on the quantity and quality of healthcare service in maternal health care helps in reducing the mortality rate. Addressing the socioeconomic disparities, maternal mortality in Kerala needs to have a shift from coverage-centric approach to quality-centric and equity-focused approach. Maternal suicide rate is an area that need to give more focus. This paradigm shifts demands for the implementation of differentiated, district-specific interventions. It also advocates for enhancing surveillance mechanism and establish programs for perinatal mental health for reducing maternal deaths.

LIST OF ABBREVIATIONS:

MMR: Maternal Mortality Ratio

SRS: Sample Registration System

NFHS: National Family Health Survey

SDG: Sustainable Development Goal

ANC: Antenatal Care

TTD: Tetanus-Diphtheria

TVM: Thiruvananthapuram

KLM: Kollam

PTA: Pathanamthitta

ALP: Alappuzha

KTM: Kottayam

IDK: Idukki

EKM: Ernakulam

TSR: Thrissur

PKD: Palakkad

MLP: Malappuram

KKD: Kozhikode

WYD: Wayanad

KNR: Kannur

KSD: Kasargod

DECLARATION:

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and material

The datasets for the study are publicly available and obtained from government repositories. Maternal mortality data were sourced from the Sample Registration System (SRS) through a series of Special Bulletins on Maternal Mortality in India for the periods 2007-2009, 2010-

2012, 2011-2013, 2014-2016, 2015-2017, 2016-2018, 2017-2019, 2018-2020,2019-2021, 2020-2022 and 2021-2023. These are published by the Office of the Registrar General & Census Commissioner, India Ministry of Home Affairs. These Bulletins are publicly available via the Census of India website https://censusindia.gov.in/census.website/data/SRSMMB.

Supplementary maternal health and service coverage indicators were obtained from National Family Health Survey (NFHS-4: 2015-2016 and NFHS-5: 2019-2021) conducted by the International Institute for Population Sciences (IIPS) under the Ministry of Health and Family Welfare, Government of India. NFHS datasets and reports are available through the official portal https://rchiips.org/nfhs.

State-level health system indicators were drawn from the Kerala Annual Health Reports (Health at Glance) for the years 2018, 2019-2020, 2020-2021, 2021-2022, 2022-2023 and 2023-2024. These are published by the Department of Health and Family Welfare, Government of Kerala. These reports are publicly available from the official Government of Kerala health department repositories https://dhs.kerala.gov.in/en/reports.

Policy and programmatic context were analysed using the Five-Year Plans of the Government of Kerala for the periods 2014-2017, 2017-2022 and 2022-2027. These are obtained from publications of the Kerala State Planning Board and Official government portals. The data are available the websites: 2012-2017: https://spb.kerala.gov.in/sites/default/files/2021-03/12th-plan.pdf, 2017-2022: https://spb.kerala.gov.in/sites/default/files/2021-09/13PlanEng.pdf & 2022-2027: https://spb.kerala.gov.in/sites/default/files/2022-06/approach%20paper_vc_final_09062022%20english_website.pdf

Competing interests

The authors declare that they have no competing interests.

Funding

This research did not receive any financial support.

Authors' contribution

K P., contributed to the concept of design, data analysis and writing original draft. J.B contributed to the conceptualisation and review of manuscript. All the authors read and approved the final manuscript for submission.

Acknowledgements

Not applicable

REFERENCES:

1. Sajedinejad S, Majdzadeh R, Vedadhir A, Tabatabaei MG, Mohammad K. Maternal mortality: a cross-sectional global study. Glob Health. 2015;11(1):4.
2. Manyeh AK, Nathan R, Nelson G. Maternal mortality in Ifakara Health and Demographic Surveillance System: Spatial patterns, trends and risk factors, 2006–2010. PLoS One. 2018 Oct 22;13(10): e0205370.
3. Sanga LA, Mtuy T, Philemon RN, Mahande MJ. Inter-pregnancy interval and associated adverse maternal outcomes among women who delivered at Kilimanjaro Christian Medical Centre in Tanzania, 2000-2015. Plos one. 2020 Feb 6;15(2): e0228330.

4. Walls A, Plaat F, Delgado AM. Maternal death: lessons for anaesthesia and critical care. BJA education. 2022 Apr 1;22(4):146-53.
5. Sharma B, Smith R, Sharma BB, Pennell C. Maternal mortality ratios in LMICs. AJOG Glob Rep. 2025;5(1):100438.
6. Nouman N. Maternal and Child Health in the Context of Global Health: A Focus on India.
7. Hamal M, Dieleman M, De Brouwere V, de Cock Buning T. Social determinants of maternal health: a scoping review of factors influencing maternal mortality and maternal health service use in India. Public Health Rev. 2020;41(1):13.
8. Meh C, Sharma A, Ram U, Fadel S, Correa N, Snelgrove JW, et al. Trends in maternal mortality in India over two decades in nationally representative surveys. BJOG. 2022;129(4):550–561.
9. Purohit T, Purohit P, Satender C, Batwal P. A correlation analysis between maternal health service indicators aggregate scoring and maternal mortality ratio: a quantitative study of states in India. SN Compr Clin Med. 2024;7(1):15.
10. Chauhan A, Potdar J. Maternal mental health during pregnancy: a critical review. Cureus. 2022;14(10).
11. Roy P, Sahu DP, Behera BK, Pal D. Health system interventions to reduce maternal mortality in India: a narrative review. DY Patil J Health Sci. 2024;12(4):119–124.
12. Taneja G, Sridhar VSR, Mohanty JS, Joshi A, Bhushan P, Jain M, et al. India's RMNCH+A strategy: approach, learnings and limitations. BMJ Glob Health. 2019;4(3).
13. Mustafa A, Shekhar C, Shri N. A situation analysis of child delivery facilities at primary health centers in rural India and its association with likelihood of selecting PHC for child delivery. BMC Health Serv Res. 2021;21(1):1210.

14. Fox MP, Murray EJ, Lesko CR, Sealy-Jefferson S. On the need to revitalize descriptive epidemiology. Am J Epidemiol. 2022;191(7):1174–1179.
15. Dowou RK, Amu H, Saah FI, Adeagbo O, Bain LE. Increased investment in universal health coverage in Sub-Saharan Africa is crucial to attain SDG 3 targets on maternal and child health. Arch Public Health. 2023;81(1):34.
16. Er-Rays Y, M'dioud M. Evaluating the effectiveness of maternal, neonatal, and child healthcare in Moroccan hospitals and SDG 3 using two-stage data envelopment analysis and Tobit regression. Eval Rev. 2025;49(2):343–379.
17. Babu C. Maternal deaths in India: a review of trends and programmes. Int J Prev Curat Community Med. 2021;7(3):17–21.
18. Joseph G, Da Silva ICM, Wehrmeister FC, Barros AJ, Victora CG. Inequalities in the coverage of place of delivery and skilled birth attendance: analyses of cross-sectional surveys in 80 low- and middle-income countries. Reprod Health. 2016;13(1):77.
19. Robbers G, Vogel JP, Mola G, Bolgna J, Homer CS. Maternal and newborn health indicators in Papua New Guinea, 2008–2018. Sex Reprod Health Matters. 2019;27(1):52–68.
20. Saha R, Paul P. Institutional deliveries in India's nine low-performing states: levels, determinants and accessibility. Glob Health Action. 2021;14(1):2001145.
21. Goudar SS, Goco N, Somannavar MS, Vernekar SS, Mallapur AA, Moore JL, et al. Institutional deliveries and perinatal and neonatal mortality in Southern and Central India. Reprod Health. 2015;12(Suppl 2): S13.
22. Girotra S, Malik M, Roy S, Basu S. Utilization and determinants of adequate quality antenatal care services in India: evidence from NFHS-5 (2019–21). BMC Pregnancy Childbirth. 2023;23(1):800.

23. Nigatu AM, Gelaye KA. Factors associated with preference of institutional delivery after antenatal care attendance in Northwest Ethiopia. BMC Health Serv Res. 2019;19(1):810.
24. Amponsah-Tabi S, Dassah ET, Asubonteng GO, Ankobea F, Annan JJ, Senu E, et al. Assessment of quality of antenatal care and pregnancy outcomes in a tertiary hospital in Ghana. PLoS One. 2022;17(10): e0275933.
25. Arroyave L, Saad GE, Victora CG, Barros AJ. Inequalities in antenatal care coverage and quality: analysis from 63 low- and middle-income countries using ANCq indicator. Int J Equity Health. 2021;20(1):102.
26. Sreekumari U, Nair S. Trends in causes of maternal mortality in a tertiary care centre in Kerala, India. Int J Reprod Contracept Obstet Gynecol. 2018;7(11):4370–4375.
27. Koch E, Thorp J, Bravo M, Gatica S, Romero CX, Aguilera H, et al. Women's education level, maternal health facilities, abortion legislation and maternal deaths: a natural experiment in Chile, 1957–2007. PLoS One. 2012;7(5): e36613.
28. World Health Organization. Trends in maternal mortality: 1990–2015. Geneva: WHO; 2015.
29. Vlad I, Paily VP, Sadanandan R, Cluzeau F, Beena M, Nair R, et al. Improving quality for maternal care: a case study from Kerala, India. F1000Research. 2016; 5:166.
30. Ryan BL, Krishnan RJ, Terry A, Thind A. Do four or more antenatal care visits increase skilled birth attendant use and institutional delivery in Bangladesh? BMC Public Health. 2019;19(1):583.
31. Musarandega R, Nyakura M, Machekano R, Pattinson R, Munjanja SP. Causes of maternal mortality in Sub-Saharan Africa: a systematic review (2015–2020). J Glob Health. 2021; 11:04048.

32. Chakrabartty SN. Maternal mortality and morbidity: action for India. J Intern Med Health Aff. 2024;3(2).
33. Bhalotra S, Clarke D, Gomes JF, Venkataramani A. Maternal mortality and women's political power. J Eur Econ Assoc. 2023;21(5):2172–2208.
34. Chin K, Wendt A, Bennett IM, Bhat A. Suicide and maternal mortality. Curr Psychiatry Rep. 2022;24(4):239–275.
35. Trost SL, Beauregard JL, Smoots AN, Ko JY, Haight SC, Moore Simas TA, et al. Preventing pregnancy-related mental health deaths: insights from 14 US maternal mortality review committees. Health Aff (Millwood). 2021;40(10):1551–1559.
36. Hansotte E, Payne SI, Babich SM. Positive postpartum depression screening practices and subsequent mental health treatment for low-income women: a systematic review. Public Health Rev. 2017;38(1):3.
37. Prom MC, Denduluri A, Philpotts LL, Rondon MB, Borba CP, Gelaye B, et al. Interventions integrating perinatal mental health care into routine maternal care in LMICs: a systematic review. Front Psychiatry. 2022; 13:859341.
38. Kaur J, Franzen SRP, Newton-Lewis T, Murphy G. Readiness of public health facilities to provide quality maternal and newborn care in Bihar, India. BMJ Open. 2019;9(7): e028370.
39. Ameh C, Msuya S, Hofman J, Raven J, Mathai M, Van Den Broek N. Status of emergency obstetric care in six developing countries five years before MDG targets. PLoS One. 2012;7(12): e49938.
40. Sidney K, Ryan K, Diwan V, De Costa A. Utilization of a state-run public–private emergency transportation service for childbirth in Madhya Pradesh, India. PLoS One. 2014;9(5): e96287.