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Research Paper

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Integrative Analysis of Stillbirth and Impaired Fetal Growth in India: Epidemiological Insights and Public Health Implications

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ABSTRACT

Stillbirth is strongly related to impaired fetal growth. Perinatal loss, commonly defined as stillbirth is the death of a fetus before birth. This condition can be brought on by intrauterine growth restriction and poses significant financial, physical, and psychosocial challenges for families. The latest rate of stillbirth and low birth weight in India is 17.3% and 18.24% respectively which is significantly higher in rural areas than in urban areas. This study introduces an integrated analysis pipeline tailored to elucidate the prevalence of stillbirth in India. Leveraging PubMed data using keywords like low birth weight, stillbirth, fetal mortality, perinatal loss, and preterm birth, we assembled a comprehensive dataset containing PubMed IDs, author information, titles, years, journal details, countries, abstracts, and publication types. Employing natural language processing (NLP), we identified factors linked to stillbirth. The analysis utilized Python programming with biopython and scikit-learn packages, and visualization methods such as bar charts, pie charts, and word clouds were employed to depict the trends and geographical distribution of stillbirth cases over time. Despite India's economic growth and increased public health investment in nutritional support, the burden of stillbirth has remained steady in recent years. There is a crucial need to prioritize the quality of antenatal care services for pregnant women, focusing on raising awareness and sensitization to improve maternal nutrition.

INTRODUCTION

Stillbirths, which occur when a fetus dies at or after 20 weeks of gestation, are devastating outcomes that impact families worldwide. An estimated 2.4 million babies are stillborn annually, creating an enduring legacy of sorrow and unresolved issues despite tremendous breakthroughs in maternal and neonatal healthcare. This quiet tragedy poses a serious public health concern and goes beyond the experiences of individual families. It highlights disparities in access to high-quality healthcare by disproportionately affecting low- and middle-income nations. Families are left with a great deal of emotional strain that has long-lasting psychological and social effects. In addition to having an emotional impact, stillbirth increases maternal morbidity, or sickness, which emphasizes the need for further advancements in prenatal care.

Developing successful therapies requires an understanding of the patterns and causes of stillbirth. Epidemiology, the science that studies patterns of health and disease in populations, becomes an invaluable tool in this situation. Through the use of epidemiological analysis, researchers can examine data, pinpoint risk factors for stillbirth, and evaluate how well preventive measures are working. Epidemiologists can determine which populations are most vulnerable, where regional disparities exist, and how stillbirth rates have evolved over time by examining birth and death records, hospital data, and demographic surveys. This information guides the creation of focused initiatives, such as enhanced prenatal care accessibility, specialized treatment for pregnancies at high risk, and awareness-raising campaigns encouraging healthy living both before and throughout pregnancy. The timing and causes of stillbirths are not well documented in India. Just the load has been discussed in the national reports that are currently available. Nearly two-thirds of stillbirths occurred antepartum, with the remaining cases occurring intrapartum, according to a recent assessment of the literature. The most common cause of stillbirths (25%) was shown to be the mother's condition, which was followed by fetal causes (14%), placental causes (13%), congenital malformations (6%), and intrapartum problems (4%). Twenty percent of the stillbirths had no recognized cause.



Fig 1. Typical example of Stillbirth

Epidemiological studies are primarily necessary to comprehend the intricate interactions between biological, social, and environmental factors that lead to stillbirth. Utilizing meticulous analysis and statistical methods, epidemiologists seek to identify risk factors, elucidate underlying mechanisms, and promote preventive measures to reduce the occurrence of stillbirth. Significant differences in stillbirth rates between populations and areas have been found by epidemiological research. In low- and middle-income nations, where access to quality maternal healthcare services may be restricted, the burden of stillbirth is disproportionately higher globally. Even in high-income nations, there are significant differences that are determined by factors such as region, ethnicity, and social standing. Despite medical progress, an estimated 2.4 million babies are stillborn every year, a tragedy that has serious emotional and public health consequences. Understanding stillbirth requires an understanding of epidemiological analysis, which is the study of health patterns in populations. That aids in our resolution of important queries By whom is it affected. Data analysis shows the variation in stillbirth rates according to socioeconomic position, ethnicity, maternal age, and availability of prenatal care. This indicates which populations are more vulnerable. In what location does it happen. Variations in stillbirth

rates by geography indicate places that need more funding and focused treatments. What are the reasons behind it. Research finds risk factors that are not often obvious, but include things like: medical disorders affecting mothers (pre-eclampsia, diabetes) Lifestyle decisions (alcohol use, smoking). Complications of pregnancy (fetal growth restriction, anomalies of the placenta).

Based on data from the Sample Registration Survey (SRS), India had a stillbirth rate of 3.0 per 1,000 live births in 2020. The adjusted estimates for the stillbirth rate in India between 2016 and 2021, based on gestation age, were 11.2 (CI:10.8–11.7) per 1,000 total births, according to the National Family Health Survey (NFHS) analysis for that year. For the years 2016–2020, the corrected estimates according to SRS were 3.8 per 1,000 total births. In 2019 and 2021, India's predicted stillbirth rate was 13.9 and 12.2 per 1,000 total births, respectively, according to the UNIGME report on the global burden of stillbirths.

The Health Management Information Systems (HMIS) 2019–20 report shows that there is significant variance in stillbirth rates throughout Indian states. Kerala has 3.7 stillbirths per 1,000 total births, whereas Chandigarh and Dadra & Nagar Haveli have 22.0 and 35.2 stillbirths per 1,000 total births, respectively. Stillbirth rates were greater in seventeen states and/or Union Territories than they were nationwide.

Objective

The objective of addressing stillbirth has multiple purposes, including lowering its frequency, comprehending its causes, enhancing detection and diagnosis, offering assistance to impacted families, and promoting research and innovation in the field. The main goal is prevention at its heart; efforts are focused on boosting maternal and fetal health, identifying and mitigating modifiable risk factors, and putting evidence-based interventions into practice to lower the possibility of stillbirth occurrence. At the same time, a critical emphasis is placed on comprehending the intricate causes of stillbirth and exploring biological, genetic, environmental, and socioeconomic factors to provide focused preventative and therapeutic approaches. The optimization of outcomes is heavily dependent on early identification and diagnosis, which is why research is being done to improve screening techniques, diagnostic instruments, and monitoring technologies to recognize at-risk pregnancies and take proactive action. In order to promote health equity and enhance outcomes for all families, it is imperative to address discrepancies in stillbirth rates and outcomes. This calls for focused interventions. Another crucial goal is to offer kind and thorough support to families impacted by stillbirth. This includes counseling, peer support groups, memorialization alternatives, and bereavement support services to assist families in navigating their loss and achieving recovery. In addition, progress in stillbirth prevention, diagnosis, and treatment depends on the progression of research and innovation; cooperative research projects and creative approaches enhance knowledge and support evidence-based practice. Stakeholders can significantly lower the number of stillbirths, assist impacted families, and advance maternal and fetal health internationally by working together to achieve these goals.

Pattern of Stillbirth

Epidemiology sheds light on inequalities, risk factors, and areas that require intervention by analyzing the prevalence, causes, and trends of stillbirth within populations. Through the analysis of diverse epidemiological patterns linked to stillbirth, scholars and medical professionals can pinpoint communities at high risk, assign priority to resources, and customize preventive measures to efficiently cater to particular requirements. Regional variations in the incidence of stillbirths represent a significant epidemiological trend. The prevalence of stillbirths varies greatly throughout nations and areas, which is indicative of variations in maternal health metrics, socioeconomic level, and healthcare infrastructure. The greatest rates of stillbirth occur in South Asia and Sub-Saharan Africa, where there are over 30 per 1000 births, as opposed to less than 5 in high-income nations. These regional differences highlight the significance of context-specific strategies for managing and preventing stillbirths that are adapted to meet the particular requirements and difficulties of various communities. In the fight against stillbirth, epidemiological study is essential since it Revealing Patterns: By analysing data, epidemiologists can spot patterns and trends in the incidence of stillbirths. The results of this research show which people are most at risk, the locations of geographic hotspots, and the temporal trends that develop over time. Risk Factor Identification Epidemiologists can identify important risk factors by examining the

relationships between different variables and the incidence of stillbirth. To assess the strength of these connections, statistical metrics such as odds ratios and risk ratios are useful. Serving as a Guide for Intervention Development: Developing focused interventions requires an understanding of the "whys" for stillbirth. The results of epidemiological research can guide public health initiatives like better prenatal care access, high-risk pregnancy treatment, and awareness campaigns encouraging healthy living both before and during pregnancy. Evaluation and Monitoring: To assess the efficacy of initiatives designed to lower the risk of stillbirths, epidemiological methods are essential. This enables ongoing program and policy improvement.

Worldwide Stillbirth a burden

With major ramifications for families and healthcare systems around the world, the prevalence of stillbirths is a serious public health concern. Millions of families are affected by stillbirths every year, which is a tragic event that persists despite advancements in maternal and newborn health. The World Health Organization (WHO) estimates that roughly 2.4 million stillbirths occur annually [World Health Organization, 2020], making it an important issue in the field of global health. The great global diversity in stillbirth rates is one of its most conspicuous features. Globally, stillbirth rates have decreased over time, but there are still large differences, with low- and middle-income nations bearing a disproportionate share of the burden. The highest stillbirth rates are found in Sub-Saharan Africa and South Asia, where rates can reach above 30 per 1000 births in certain regions [World Health Organization, 2020]. On the other hand, high-income nations usually report stillbirth rates that are less than 5 per 1000 births. These regional differences are caused by several factors. Access to Healthcare In low-resource settings, prenatal care, skilled birth attendance, and emergency obstetric care are among the quality maternal and newborn healthcare services that are limited in availability. This contributes significantly to the stillbirth rate. Delays in seeking and obtaining the right care during pregnancy and labor are caused by obstacles to healthcare access, such as financial limitations, lack of infrastructure, and remote location. Socioeconomic Factors Several socioeconomic factors, such as poverty, education attainment, and work status, have a substantial impact on stillbirth rates. Due to variables like poor nutrition, restricted access to prenatal care, and a higher frequency of comorbidities, people from disadvantaged socioeconomic backgrounds are more likely to have unfavourable pregnancy outcomes. Maternal Health: Areas with greater stillbirth rates are more likely to have higher rates of maternal health issues, including hypertensive disorders, diabetes, infections, and nutritional deficiencies. Poorer pregnancy outcomes and higher rates of stillbirth are caused by limited access to preventative healthcare, diagnostic services, and therapy of maternal diseases.

Care Quality: Variations in the standard of maternity and newborn healthcare services, such as the accessibility of qualified medical personnel, necessary medical equipment, and facilities, affect the number of stillbirths. Avoidable stillbirths occur in many low-resource countries due to inadequate healthcare facilities, a shortage of skilled workers, and subpar clinical procedures. To effectively address regional differences in stillbirth rates, a multimodal strategy that includes investments in healthcare infrastructure, health education, socioeconomic development, and equity-focused policies is needed. Reduced stillbirth rates and improved access to vital maternal and newborn services, as well as addressing socioeconomic determinants of health, are the results of global efforts to fortify healthcare systems and support maternal and newborn health.

A multitude of factors, such as socioeconomic conditions, healthcare access, and public health efforts, have influenced the complicated pattern of developments in stillbirth rates in India throughout time. In comparison to many high-income nations, India has historically had high stillbirth rates, which is a reflection of both socioeconomic inequality and problems with maternity and neonatal treatment. But in recent years, there have been positive changes. Stillbirth rates have been gradually declining as a result of increased access to prenatal care, professional birth attendance, and emergency obstetric services. Furthermore, specific maternal health measures, like improved nutrition for mothers, early identification and treatment of pregnancy problems, and raising knowledge of safe delivery techniques, have contributed to a decrease in stillbirth rates. Problems still exist despite these advancements, especially in underserved and rural areas where access to medical treatment is still restricted. In order to address these inequities, community-based interventions, capacity-building programs, and ongoing investments in healthcare infrastructure are needed. In addition, ongoing observation of stillbirth patterns and assessment of intervention initiatives are critical for informing evidence-based tactics and lowering stillbirth rates in India.

Risk factors

Pregnancy outcomes can be improved and stillbirth rates can be decreased by identifying and addressing these risk factors through focused treatments, risk assessment, and complete prenatal care. Providing comprehensive treatment to expectant mothers and reducing the risk of stillbirth requires the collaboration of obstetricians, genetic counselors, maternal-fetal medicine specialists, and mental health professionals in multidisciplinary teams. The timing and causes of stillbirths are not well documented in India. Just the load has been discussed in the national reports that are currently available. Nearly two-thirds of stillbirths occurred antepartum, with the remaining cases occurring intrapartum, according to a recent assessment of the literature. The most common cause of stillbirths (25%) was shown to be the mother's condition, which was followed by fetal causes (14%), placental causes (13%), congenital malformations (6%) and intrapartum problems (4%). Twenty percent of the stillbirths had no recognized cause [9].

Maternal Health Conditions

Maternal Age: Pregnant adolescents and advanced mothers, who are usually 35 years of age and older, are linked to a higher risk of stillbirth. Inadequate prenatal care and socioeconomic considerations may be a difficulty for adolescent moms, but older mothers may be more vulnerable to pregnancy problems such as diabetes, hypertension, and placental anomalies.

Medical Conditions Affecting Mothers: Stillbirth risk is increased by pre-existing maternal health issues such as thrombophilias, diabetes, chronic hypertension, and autoimmune illnesses. These disorders may result in consequences that could kill the fetus, including placental abruption, fetal growth restriction, and placental insufficiency. **Diseases:** During pregnancy, bacterial, viral, and parasitic diseases in the mother can be harmful to the fetus and raise the chance of stillbirth. Certain infections, including syphilis, toxoplasmosis, listeriosis, and cytomegalovirus (CMV), can harm or kill a fetus once they cross the placenta.

Pregnancy Complications:

Placental Abnormalities: Placental structural abnormalities, which affect the fetal supply of oxygen and nutrients, can cause stillbirth. These abnormalities include placental abruption, which is the premature separation of the placenta from the uterine wall, placenta previa, which is the placenta covering the cervix entirely or partially, and placental insufficiency.

Complications from the Umbilical chord: Deviations from normalcy in the umbilical chord, such as prolapse, entanglement, and compression, can impair fetal blood flow and oxygenation, hence elevating the chance of stillbirth.

Complications of Pregnancy: Preeclampsia, eclampsia, placental abruption, placenta previa, and intrauterine growth restriction (IUGR) are among the several pregnancy problems that greatly increase the risk of stillbirth.

Lifestyle Factors;

Factors related to the Mother's Lifestyle: Pregnancy-related factors that raise the chance of stillbirth include drinking alcohol, smoking, using illegal drugs, and not eating a healthy diet.

Fetal development, placental function, and maternal health may be adversely affected by these variables.

Psychosocial and Socioeconomic Factors: Higher rates of stillbirth are associated with socioeconomic disadvantages, such as poverty, scarce access to healthcare, and insufficient social support. There is an increased chance of stillbirth due to psychosocial stressors, depression, intimate partner abuse, and maternal stress.

Other Risk Factors:

Fetal Factors: Multiple gestations (twins, triplets) and chromosomal disorders raise the risk of stillbirth. Intrauterine fetal death can result from genetic diseases, structural flaws, and problems associated with numerous pregnancies.

Previous Stillbirth: Pregnant women who have previously experienced a stillbirth are more likely to encounter another one in the future. It is possible to lower the danger in following pregnancies by comprehending the underlying causes of earlier stillbirths and by offering the proper monitoring and treatment.

Fetal factors and Stillbirth

Congenital Anomalies: birth defects or congenital malformations are other names for structural or functional abnormalities that exist from birth. The body's systems and organs, such as the heart, brain, spine, limbs, and internal organs, can all be impacted by these abnormalities. Anomalies that are born with defects can range in severity from minor to potentially fatal. Congenital heart malformations, limb deformities, neural tube defects, and cleft lip and palate are a few examples of congenital anomalies. A congenital anomaly that is incompatible with life or that causes problems during pregnancy or labor can raise the risk of stillbirth. Chromosome abnormalities are caused by mistakes in the number or structure of chromosomes, which are the structures that hold the genetic code of an individual. These anomalies may arise in the early stages of fetal development or during the production of sperm or eggs. Trisomies (like Down syndrome or trisomy 21), monosomies, and structural abnormalities (such as translocations and deletions) are common forms of chromosomal abnormalities. A major contributing factor to stillbirth is chromosomal abnormalities, especially when those defects are life-incompatible or result in severe developmental abnormalities.

Intrauterine Growth Restriction

When a fetus does not grow to its predicted potential while within the womb, the disease is known as intrauterine growth restriction or IUGR. Placental insufficiency, maternal health issues (such as diabetes or hypertension), fetal genetic variables, and environmental factors are some of the causes of this. In intrauterine growth restriction (IUGR), the fetus may be smaller than anticipated for its gestational age and may be more vulnerable to issues like stillbirth, preterm delivery, and morbidity and death in the newborn. The fetus may receive less oxygen and nutrients as a result of IUGR, which could hinder fetal growth and development.

Gestational diabetes mellitus is a significant risk factor for stillbirth

Health hazards to the mother and fetus are severe when it comes to gestational diabetes mellitus (GDM), a disorder marked by elevated blood sugar levels during pregnancy. A stillbirth is the death of a fetus after 20 weeks of gestation, and it is one of the most catastrophic effects of untreated gestational diabetes. With a focus on clinical manifestations, risk factors, underlying mechanisms, and preventive measures intended to lower the incidence of stillbirth in pregnancies complicated by gestational diabetes, this essay delves into the intricate relationship between the two conditions. Elevated blood sugar levels during pregnancy are a sign of gestational diabetes mellitus, which is caused by the body not producing enough insulin to satisfy heightened demands. Predisposing the fetus to a variety of unfavorable consequences, including stillbirth, this metabolic imbalance can have a significant impact on fetal development and wellbeing. Although there is still much to learn about the precise mechanisms behind the link between gestational diabetes and stillbirth, a number of factors are thought to elevate the risk. Fetal macrosomia, or excessive fetal growth, is one of the main processes by which gestational hyperglycemia is associated with stillbirth. A fetal pancreas that produces too much insulin is stimulated by elevated maternal blood glucose levels, which can cross the placenta and lead to fetal hyperinsulinemia and subsequent overgrowth. Fetuses with macrosomia have a higher probability of shoulder dystocia, birth traumas, and other difficulties throughout the labor and delivery process, all of which can lead to a higher chance of stillbirth. Furthermore, the metabolic abnormalities linked to gestational diabetes can affect placental function and result in placental insufficiency, which deprives the fetus of nutrients and oxygen and increases the risk of intrauterine death. A comprehensive strategy that targets modifiable risk factors, encourages early detection and intervention, and maximizes maternal glycemic control is needed to prevent stillbirth in pregnancies complicated by gestational diabetes. In order to identify pregnancies at risk and to put the right treatment plans in place, prenatal screening and diagnostic tests for gestational diabetes are essential. To attain and sustain ideal glycemic control throughout their pregnancy, expectant mothers diagnosed with gestational diabetes should participate in routine blood glucose monitoring, dietary counseling, and lifestyle adjustments.

Prevention strategies

A comprehensive strategy addressing several maternal, fetal, and environmental factors is necessary to prevent stillbirths, which is a challenging task. While timely detection and management of pregnancy difficulties are made possible by early and adequate prenatal care, comprehensive preconception care is essential for identifying and managing underlying health disorders that may raise the risk of stillbirth. Optimizing maternal and fetal health outcomes throughout pregnancy can be achieved by screening for chronic health disorders like diabetes and hypertension and effectively controlling them. Promoting healthy lifestyle choices, such as giving up alcohol and illegal substances, quitting smoking, and keeping a balanced diet, can help lower the chance of stillbirth even further. Other crucial elements of stillbirth prevention initiatives include diagnosing and treating infections, reducing exposure to chemicals and pollutants in the environment, and offering psychosocial support to expectant mothers. Pregnant women can lessen the chance of unfavorable outcomes and promote prompt intervention by keeping an eye on the patterns of fetal movement and raising awareness of changes in fetal activity. To develop evidence-based prevention efforts and lower the incidence of stillbirth worldwide, healthcare practitioners, researchers, policymakers, and community stakeholders must continue their surveillance, research, and collaboration.

Preconception Care: Identifying and treating underlying medical disorders, including as diabetes, hypertension, and obesity, that may raise the chance of stillbirth, might assist women of reproductive age. A focus on treating modifiable risk factors and attaining optimal health before pregnancy should be emphasized in preconception counselling.

Early and Adequate Prenatal Care: Throughout pregnancy, it is crucial to evaluate the health of the mother and fetus to ensure that they receive frequent, early prenatal care. During prenatal check-ups, medical professionals can check for and treat illnesses like infections, hypertensive problems, and gestational diabetes that may raise the chance of stillbirth. Early measures can lower the chance of stillbirth and help prevent complications.

Treatment of Chronic Health illnesses: To improve the health of both the mother and the unborn child, pregnant women with pre-existing medical illnesses such as diabetes, hypertension, autoimmune diseases, and thrombophilia should get specific treatment and management. The risk of stillbirth linked to these disorders can be decreased by careful monitoring of blood pressure, blood glucose levels, and drug administration.

Identification and Treatment of Complications During Pregnancy: Early detection and adequate care of pregnancy problems, including intrauterine growth restriction (IUGR), gestational diabetes, preeclampsia, and placental anomalies, are made possible by screening. Fetal distress indicators can be found and stillbirths can be avoided by close monitoring of the mother's and the fetus's health, which includes routine ultrasound scans and assessments of fetal movement.

Encouragement of Healthy Lifestyle Practices: Creating a balanced diet, quitting smoking, staying away from alcohol and illegal substances, getting regular exercise, and maintaining a healthy lifestyle can all help lower the risk of stillbirth in expectant mothers. These practices' significance for the health of mothers and fetuses should be emphasized in health education and counselling.

Control of Infections: Reducing the risk of stillbirth during pregnancy requires timely detection and treatment of infections. Intrauterine infections and associated problems can be avoided by screening for and treating maternal infections, urinary tract infections, colonization with group B streptococcus (GBS), and other sexually transmitted infections.

Environmental Risk Reduction: As a pregnant woman, you can lower your chance of stillbirth by limiting your exposure to toxins, pollutants, and dangerous substances in the environment. As they can hurt the health of the mother and fetus, pregnant women should stay away from tobacco smoking, secondhand smoke, air pollution, pesticides, and industrial pollutants.

Psychosocial Support: During pregnancy, pregnant people can experience less stress, anxiety, and depression if they have access to psychosocial support services such as social support networks, mental health services, and counseling. Reducing the incidence of stillbirth and enhancing maternal well-being require addressing mental health concerns among mothers. Pregnancy-related education can help avoid stillbirth by emphasizing the need

to keep an eye on fetal movement patterns and advising expectant mothers to seek medical assistance if they observe a decline in activity. Being aware of fetal activity variations can help to avoid negative outcomes and initiate timely intervention.

Sustaining Research and Monitoring: To develop evidence-based preventative policies, it is imperative that research about the causes and risk factors of stillbirth be pursued indefinitely. Additionally, continual monitoring of stillbirth rates and trends must be conducted. To properly handle this public health concern, cooperation between researchers, medical professionals, legislators, and community stakeholders is required. Worldwide efforts to lower the occurrence of stillbirth and improve pregnancy outcomes for people and families can be made by healthcare practitioners through the implementation of various preventive techniques and the promotion of complete prenatal care.

Medical interventions

A wide range of techniques are used in medical interventions for stillbirth to help parents navigate the complex grief process while attending to their physical, emotional, and psychological needs. When a stillbirth occurs, the goal of medical intervention is to identify and confirm the death. Healthcare professionals evaluate embryonic viability and verify the lack of fetal heartbeat using a variety of diagnostic techniques, including ultrasound scanning and fetal heart rate monitoring. Healthcare professionals tell parents of the diagnosis of stillbirth with tact and compassion after it has been confirmed, giving them tools, resources, and support as they figure out what to do next. Parents need urgent and continuous supportive care to meet their physical, emotional, and psychological needs after receiving a stillbirth diagnosis. Facilitating conversations regarding parents' choices for care and decision-making, providing emotional support and validation, and providing a calm, private area for parents to grieve are all examples of supportive care. Providing parents with empathy, compassion, and nonjudgmental assistance as they negotiate the intricacies of their loss, healthcare providers play a critical role in helping parents through the grieving process. Cesarean delivery or labor induction is advised in many stillbirth cases to deliver the baby and make the pregnancy easier to finish. This enables parents to say goodbye, spend time with their children, and start the grieving and healing process. When choosing the best delivery technique, medical professionals carefully take into account variables like gestational age, mother's health, and parental preferences. Healthcare practitioners ensure that parents' choices and preferences are acknowledged and fulfilled by prioritizing their physical comfort, emotional well-being, and dignity during the delivery process. The physical comfort and well-being of the parents during labor induction or cesarean birth depend on effective pain management. Healthcare professionals may give a range of pain management choices, such as epidural anesthetic, intravenous pain management, and nonpharmacological therapies like massage, posture, and relaxation techniques. To reduce discomfort and foster a sense of empowerment and control during the delivery process, individualized pain management regimens are customized to parents' choices, medical histories, and clinical needs.

For parents to deal with their loss and get through the mourning process after the birth of their child, they need continuous bereavement support services. To help parents connect with others who have suffered comparable losses, this may entail providing them with access to peer support networks, bereavement counseling, and support groups. Along with helpful advice and tools, healthcare experts may help individuals discover meaning and purpose amid loss, manage their emotions, and cope with sorrow. Family, friends, and other loved ones who may also be impacted by the stillbirth and in need of help and direction are also covered by grief support services. Following the birth of their child, parents require thorough postpartum care. In addition to giving pain relief and wound care as needed, this also entails keeping an eye out for any difficulties or health issues and delivering lactation support and guidance to parents who plan to breastfeed. Additionally, healthcare professionals help parents make meaningful memories and memorialize their newborn by facilitating conversations about choices for memorialization, such as photographs, footprints, handprints, and keepsakes. In the weeks and months that follow a stillbirth, parents are provided with continuous follow-up care and counseling to assist them in navigating the intricacies of bereavement. Frequent check-ins with medical professionals, referrals to mental health specialists for family or individual counseling, and availability of extra

support services upon request are a few possible outcomes of this. In order to give parents continuity of care and support throughout their grief process, healthcare providers stay reachable and sensitive to their changing requirements.

Advancements in research and treatment

Improvements in the knowledge, prevention, and care of stillbirth have been made possible by advances in both research and treatment. Researchers and medical experts have made incredible progress in the past few years in determining the underlying causes of stillbirth, identifying risk factors, and creating creative strategies to lower the occurrence and lessen the effect on families. Parents and medical professionals alike can now look forward to more effective methods of managing and preventing stillbirths thanks to these improvements.

The identification of important risk factors and contributing factors related to stillbirth is one of the most important advances in the field. Large-scale epidemiological investigations have revealed maternal health issues like obesity, diabetes, and hypertension to be important risk factors for stillbirth. An increased risk of stillbirth has also been linked to other variables such as genetic abnormalities, infections, fetal growth limitation, and placental abnormalities. The complicated interactions between various factors that contribute to stillbirth have been better understood which have also influenced the creation of focused preventative tactics and interventions. Technological developments in prenatal screening and diagnostics have completely changed the early diagnosis and treatment of diseases linked to stillbirth. Healthcare professionals may now diagnose prenatal abnormalities, track the health of the fetus, and identify possible difficulties early in pregnancy thanks to advancements in ultrasound imaging, fetal monitoring, and genetic testing. By facilitating prompt medical management, careful observation, and targeted measures to improve mother and fetal outcomes, early detection and intervention can help reduce the chance of stillbirth. The prevention and treatment of stillbirths has seen a shift in focus in recent years toward customized and precision medicine techniques. By enabling researchers to investigate the genetic and molecular causes of stillbirth, advances in genomic and molecular technology have opened the door to focused therapies and individualized treatment plans. Researchers can create novel diagnostic tests, predictive tools, and therapeutic therapies that are customized to each patient's needs by discovering genetic variations, biomarkers, and molecular pathways linked to stillbirth. Research on stillbirth and its treatment has advanced faster due to the integration of diverse techniques and collaborative efforts. Researchers, clinicians, advocates, and policymaker from all over the world come together in collaborative research consortia like the International Stillbirth Alliance (ISA) and the Stillbirth Collaborative Research Network (SCRN) to work together on research projects, exchange knowledge and skills, and progress the field of stillbirth prevention and management. These cooperative programs enable the sharing of information, ideas, and resources, which promotes creativity and quickens the process of lowering stillbirth rates and improving outcomes for stillbirth-affected families.

Apart from the progress in research, there have been noteworthy breakthroughs in the provision of grief services and supportive care to families afflicted by stillbirth. Presently, medical professionals understand the value of providing parents of stillborn children with compassionate, all-encompassing treatment that includes psychological, emotional, and physical assistance during the grieving process. Parents can connect with others who have suffered similar losses, express their grief, and share their experiences in a safe and encouraging environment through specialized perinatal bereavement programs, support groups, and counselling services. These programs support parents as they work through the intricacies of grieving, discover purpose and healing in the wake of a stillbirth, and reassemble their lives with resiliency and hope. Future directions for stillbirth prevention, diagnosis, and treatment are being investigated by ongoing research projects. New technologies that can analyze large-scale information, find new risk factors, and more accurately forecast stillbirth risk include artificial intelligence, machine learning, and big data analytics. These technologies have the potential to advance the field of stillbirth research. Furthermore, novel strategies like regenerative medicine, placental interventions, and fetal therapies are being investigated as possible treatments for disorders linked to stillbirth, providing new hope for better results for the families touched by this tragic loss. Research initiatives are underway to study future directions for the prevention, diagnosis, and treatment of stillbirths. Big data analytics, artificial intelligence, and machine learning are examples of new technologies that can analyse vast amounts of data, identify new risk factors, and more precisely predict the probability of stillbirth. The study of stillbirths may benefit from these technological advancements. New approaches to treating problems associated with stillbirths, such as fetal therapies, placental interventions, and regenerative medicine, are also being researched. These developments offer hope for improved outcomes for the families affected by this devastating loss. After a

stillbirth, grief is arguably the most common and lasting emotion parents experience. Parents who lose a baby experience an enormous sense of emptiness and sorrow because it symbolizes the death of hopes, dreams, and expectations for the future. As parents try to make sense of what has happened and look for explanations for their baby's death, guilt and self-blame are common reactions to stillbirth. Another frequent feeling that parents go through after a stillbirth is anger, which can be directed at the cosmos, themselves, or other people. People who question why their own child was taken from them could feel unfairly treated and harbor anger against individuals who become pregnant and have healthy children. Psychological effects of stillbirth can include anxiety and depression.

Methodology

The study methodology utilized in stillbirth comprises a multimodal approach with the goal of comprehending the intricacies of stillbirth incidence and its consequences. A comprehensive study of the literature is usually the first step taken in order to assess previous research and pinpoint knowledge gaps. By using the keyword stillbirth, the most often used terms in the articles and tracking variations in their frequency over time are the main goals of the analysis. The Entrez database is a search engine for life sciences literature, and the code uses the Biopython library to connect with it. By using PubMed's e-search API, it starts a search for papers about "stillbirth". Specific parameters are applied to the search, such as relevance sorting and a maximum result count of 1000. Next, using the e-fetch API, comprehensive publication details are fetched using the retrieved PubMed IDs. Upon retrieving publishing details, the algorithm proceeds to process the data to extract pertinent details including the authors' affiliation country, title, abstract, journal, year of publication, and language. It handles situations in which certain details, such as abstracts or publication years, might be absent. It also filters out non-English papers and standardizes publication years to numerical format for simpler analysis. The piece of code functions under the assumption that there is a dataset with research articles on "stillbirth". Depending on the particular study aims and data characteristics, the libraries and techniques employed may need to be modified. This is only a basic example of the analysis that can be expanded upon using more advanced methods and graphics.

IMPORT LIBRARIES:

Libraries, sometimes referred to as modules or packages in Python, are sets of prewritten code that offer a variety of features to make programming chores easier and more efficient.

The code starts by importing necessary libraries like

NumPy: NumPy is a basic Python library for scientific computing. In addition to a set of mathematical functions to effectively work with these arrays, it supports big, multi-Dimensional arrays and matrices. **Pandas:** For Python data analysis and manipulation, Pandas is a potent package. It provides data structures such as DataFrame and Series, which simplify activities related to working with organized data, filtering, grouping, and analysis.

Matplotlib: A well-liked Python charting package, Matplotlib allows for the development of static, interactive, and publication-quality visuals. To construct line plots, scatter plots, bar charts, histograms, and more, it offers a large variety of plotting functions. **Seaborn:** This high-level interface for making visually appealing and educational statistical visuals is built on top of Matplotlib. It provides additional capabilities for statistical estimates and visualization, and makes the process of producing complex visualizations simpler.

biopython: This module gives users the ability to retrieve and analyze biological data from web resources such as PubMed. **random:** The random number generator in this package is useful for activities like sampling and data shuffles. **Plotly:** Dynamically explorable interactive visuals are made possible using this library. **string:** Tools for working with strings are included in this package, including text information extraction capabilities.

nltk: When developing Python applications to work with data in human languages, NLTK is a top platform of choice. In addition to a collection of text processing tools for tokenization, stemming, tagging, parsing, and other uses, it offers user-friendly interfaces to more than 50 corpora and lexical resources.

Word cloud: Word clouds, or visual depictions of word frequency, are created with the help of this library.

Apyori: Association rule mining, which helps find associations between various elements in a dataset, is done with the aid of this package.

SEARCH PubMed

The search function looks for papers relating to the phrase and “stillbirth” in the PubMed database using the Entrez module from Biopython. The articles that meet the search parameters have their PubMed IDs (IdList) retrieved.

FETCH ARTICLE DETAILS:

To obtain comprehensive details on the articles found in the preceding phase, the fetch details function once more makes use of the Entrez module. Among the details provided are:

title: The title of the article.

abstract: The abstract of the article.

journal: The journal in which the article was published.

language: The language in which the article was written. **publicationtype:** The type of publication (e.g., article, review, letter). **pubdate_year:** The year in which the article was published. **pubdate_month:** The month in which the article was published. **has_affiliation_list:** The affiliation information of the authors.

links: the links of articles.

DATA CLEANING AND TRANSFORMATION

Extracting country Information: To extract nation names from the affiliation information, the code use regular expressions. Our analysis of research patterns across national boundaries is made possible by this. **Filtering Missing Country Information:** To guarantee the quality of the data, the code removes rows that lack country information. **Month Names for Standardization:** To facilitate analysis and maintain consistency, the code converts month names to numeric format. **Converting Publication Year to Numeric:** To facilitate calculations and analysis, the code changes the publishing year to a numeric format.

DATA EXPLORATION

Publications across Countries: To pinpoint research hotspots and possible regional disparities, the algorithm examines how publications are distributed throughout various nations.

Publications over Time Trend: To determine times of higher or lower research activity, the code looks at publications over time. **Sorting Articles in English:** The English-language article code filters to highlight a certain language group.

Publications Trends in India: The algorithm primarily looks into research activities in India by analyzing the trend of publications in that nation over time.

TEXT PROCESSING

The text data is cleaned and pre-processed by the text_process function using the following procedures:

Remove punctuation: This phase eliminates punctuation, which is unnecessary for word frequency analysis. Examples of this include commas, periods, and question marks.

Removes stopwords: Common words like "the," "and," and "a" that don't really mean anything on their own are eliminated in this phase.

Joins synonyms: In order to prevent inflating the frequency of distinct variants of the same word, this stage finds and unites synonyms into the same phrase.

Tokenization: The abstracts are split into individual words or tokens.

Bag-of-Words Representation: A Bag-of-Words (BoW) representation of the text data is produced using the scikit-learn CountVectorizer. Each document is transformed into a vector using this format, each element of which reflects the number of a particular word in the document. We are able to examine the frequency of particular terms in various documents by using the generated matrix.

TF-IDF Representation: Utilizing scikit-learn's TfidfTransformer, the text data is represented as Term Frequency-Inverse Document Frequency (TF-IDF). The weights assigned to words in this form are determined by their overall corpus importance. TF-IDF values indicate the possible significance of words that are often occurring inside a document but infrequent overall.

Word Frequency Analysis: In both the BoW and TF-IDF representations, the algorithm examines the frequency and weight of every word. This enables us to determine the terms that are most frequently used as well as those that are crucial for comprehending the corpus's entire content.

Word Cloud Generation: A word cloud based on word frequencies is produced using the wordcloud library. We can quickly identify prospective thematic areas of research and see the most prominent words thanks to this display. Calculating cumulative word frequencies to observe overall trends.

Word Frequency Trends: Identifying the top 0.15% most frequently used words to focus on the most significant terms. The code determines the total cumulative word frequency for every year. This enables us to examine the temporal variations in word frequency and spot growing or waning patterns.

Bar Chart Race: Word frequencies over time are visualized as an animated bar chart race using the `bar_chart_race` package. This graphic aid offers a captivating means of investigating the evolving terrain of study subjects.

ASSOCIATION RULE MINING:

Apriori Algorithm: To implement the Apriori algorithm for association rule mining, the code makes use of the `apyori` package. The goal of this is to find common itemsets and association rules within the dataset.

Rule Generation: The Apriori algorithm's frequently occurring itemsets are the basis for the code's generation of association rules. These rules show the connections between various terms and ideas found in the dataset.

Rule Evaluation: Based on measures like support, confidence, and lift, the code assesses the created association rules.

DATA VISUALIZATION

To offer insights into the dataset, the code creates a variety of visualizations, and the mostly used visualization techniques are

Pie Chart: A pie chart is a statistical visual in the form of a circle that has been sliced into slices to represent numerical proportions. Every slice is a proportionate portion of the whole, and each slice's size indicates the percentage of the total that it represents. Usage: The distribution of categorical data or the relative sizes of several categories within a dataset are frequently shown using pie charts. When comparing the contributions of various categories to the whole, they work well for showing proportions.

Bar Chart: An illustration of data in which distinct categories or values are represented by rectangular bars

with different heights or lengths is called a bar chart. Every bar has a height or length that corresponds to the value it represents. Application: Bar graphs are useful for comparing values or quantities among several groups or categories. They work well for showing patterns, trends, or distinctions between categories in categorical data.

Word Cloud: A word cloud, sometimes referred to as a tag cloud, is a picture of text data that shows words arranged differently in terms of size and alignment. Usually, the size of a word in a cloud corresponds to how frequently or how important it occurs in the text. Use Word clouds are frequently employed to condense and display textual information, such as search terms found on a webpage, social media site, or agreement. They offer a simple, rapid method for determining which words are most important or common in a document.

Line Plot: A line plot, sometimes called a line chart or a line graph, is a kind of graph in which the data points are joined by straight lines. It is employed to display the relationship across a continuous interval or period between two continuous variables. Application: When data points are gathered consecutively or over time, line plots are a useful tool for displaying trends, patterns, or correlations between variables. They are frequently used to evaluate and understand time-series data or patterns in applications related to science, engineering, and finance.

Result:

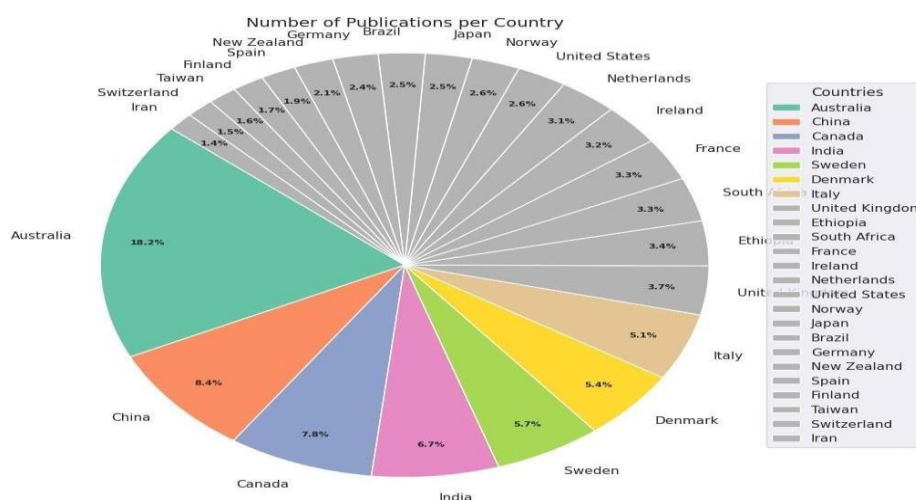


Fig 2. Number of publications per country for Stillbirth

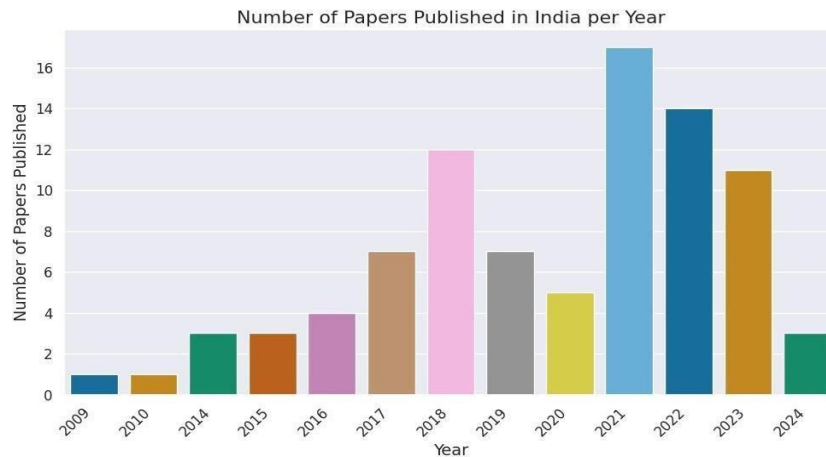
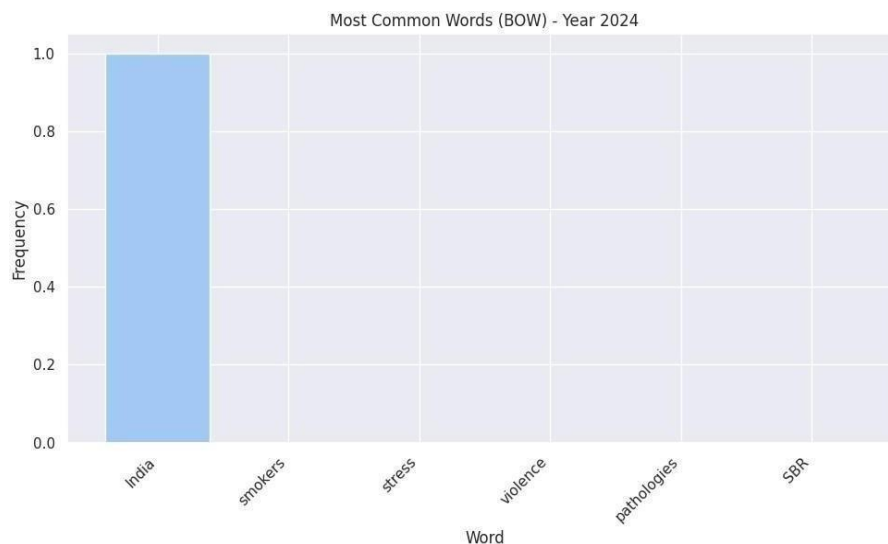


Fig 3. Number of paper published in India per year for Stillbirth



Fig 4. Word cloud of Stillbirth

Fig 5. Most common words used in 2024 for Stillbirth.



Current scenario of stillbirth in India:

In India, stillbirths continue to be a major public health concern, indicating larger problems with the health of mothers and children. The nation still struggles with a high stillbirth rate, especially in rural and underprivileged areas, despite advancements in maternal care services and healthcare infrastructure. Regional variations in stillbirth rates serve as a visual cue of the unequal distribution of healthcare resources and socioeconomic

advancement among various states and areas. Higher stillbirth rates are frequently observed in states with poor socioeconomic indices; these rates are compounded by conditions including poverty, restricted access to healthcare facilities, and insufficient prenatal care.

Because it can be difficult for them to get emergency obstetric care and qualified birth attendants, rural populations are disproportionately affected by stillbirths. Anemia, malnourishment, and pregnancy problems are among the maternal health issues that greatly increase the incidence of stillbirths in India. Pregnant women continue to experience a high prevalence of anemia, which raises the risk of unfavorable pregnancy outcomes, such as stillbirth. The issue is made worse by a lack of knowledge on maternal nutrition, a delay in starting prenatal care, and restricted access to necessary medical treatments, especially for underprivileged populations. Healthcare access and utilization disparities continue to exist, with major obstacles preventing tribal communities, lower-caste individuals, and residents of distant or rural areas from receiving maternity and newborn healthcare services. The correct assessment of the stillbirth burden in India is hindered by significant challenges related to data collecting and reporting. The accurate calculation of stillbirth rates and trends is hampered by underreporting, misclassification, and missing data, which makes it difficult to design evidence-based treatments and efficiently track progress. enhancing data collection and reporting methods requires bolstering health information systems, standardizing stillbirth monitoring protocols, and enhancing the quality and coverage of vital registration systems. In India, initiatives are being made, albeit to differing degrees, to avoid stillbirths and enhance the health of mothers and children. With programs like Janani Suraksha Yojana (JSY) and Pradhan Mantri Surakshit Matritva Abhiyan (PMSMA), the Government of India created the National Health Mission (NHM) to offer pregnant women and newborns accessible, inexpensive, and high-quality healthcare services. A key element of attempts to reduce stillbirths is the implementation of community-based interventions, maternal health awareness campaigns, and capacity-building activities for healthcare personnel. A multi-sectoral strategy that goes beyond the healthcare industry is necessary to address the underlying causes of stillbirth, which include sociocultural issues, inadequate healthcare infrastructure, and poverty.

CONCLUSION:

Finally, stillbirths continue to be a grave and important public health concern that have a huge impact on families and healthcare systems around the globe. The burden of stillbirth endures, a quiet sorrow that frequently goes unnoticed, despite advances in medical technology and improvements in the care provided to expectant mothers and newborns. With an estimated 2.4 million stillbirths worldwide each year, the incidence of stillbirth highlights the critical need for prompt action to stop these deaths and assist impacted families

We have looked at the risk factors, preventive measures, and epidemiological trends related to stillbirth throughout. Regional inequalities in stillbirth rates have been brought to light by epidemiological studies, with low- and middle-income nations accounting for the bulk of instances worldwide. The multifaceted etiology of stillbirth has been highlighted by the emergence of maternal health issues, pregnancy difficulties, and socio-economic factors as major risk factors. For the purpose of lowering the stillbirth rate and enhancing pregnancy outcomes, it is vital to comprehend these risk variables in order to build tailored therapies.

A range of care is included in preventive interventions for stillbirth, from the preconception to the postnatal stages. In order to prevent stillbirths, it is essential to promote maternal health and well-being, provide access to high-quality prenatal care, and address socioeconomic disparities. Further important components of attempts to prevent stillbirths include community-based interventions, health education programs, and the provision of emotional support to impacted families. Healthcare systems can work to lower the incidence of stillbirth and lessen its effects on families by incorporating these tactics into comprehensive programs for mother and child health. Additionally, there are hopeful new paths for managing and preventing stillbirths thanks to developments in science and medical technology. Advances in fetal monitoring technologies, prenatal screening, and diagnostic methods have the ability to identify high-risk pregnancies and fetal anomalies early on, enabling prompt interventions to avoid stillbirth. Furthermore, current investigations into the basic mechanisms driving stillbirth offer new perspectives on possible targets for treatment and ways to avoid it. To advance stillbirth

prevention and enhance outcomes for impacted families, interdisciplinary collaborations, joint research projects, and investments in cutting-edge technology are vital. It is essential to take a comprehensive, multi-sectoral strategy to tackling the problem of stillbirth, taking into account the social, economic, and cultural factors that influence health. In order to lower the stillbirth rate and enhance mother and child health outcomes, it is crucial to strengthen health systems, provide access to basic healthcare services, and support women's empowerment. In addition, developing a culture of empathy and understanding requires eradicating stigma, educating the public about stillbirth, and offering grieving families empathetic assistance. In the end, coordinated actions at the individual, local, national, and international levels are needed to prevent stillbirths. Through prioritizing the prevention of stillbirths, making investments in the health of mothers and children, and tackling the fundamental factors that influence health, we may work towards a day when every pregnancy ends in a safe delivery and every family gets the assistance they require to prosper. As a team, we can strive for a future in which every kid has the chance to reach their full potential and stillbirths are extremely uncommon.

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