Evolving stillbirth rates among Black and White women in the United States, 1980–2020: A population-based study

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Summary

Background Given slowing secular declines and persistent racial disparities, stillbirth remains a major health burden in the US. We investigate changes in stillbirth rates overall and for Black and White women, and determine how maternal age, delivery year (period), and birth year (cohort) have shaped trends.

Methods We designed a sequential time-series analysis utilising the 1980 to 2020 US vital records data of live births and stillbirths at ≥24 weeks gestation. Stillbirth rates overall and among Black and White women were examined. We undertook an age-period-cohort analysis to evaluate temporal changes in stillbirth trends.

Findings Of 157,192,032 live births and 710,832 stillbirths between 1980 and 2020, stillbirth rates per 1000 births declined from 10.6 (95% confidence interval [CI] 10.5, 10.7) in 1980 to 5.8 (95% CI 5.7, 5.8) in 2020. Stillbirth rates declined from 9.2 to 5.0 per 1000 births among White women (rate ratio [RR] 0.54, 95% CI 0.53, 0.55), and from 17.4 to 10.1 per 1000 births among Black women (RR 0.57, 95% CI 0.55, 0.59). Black women experienced persistent two-fold higher rates compared to White women (2.01, 95% CI 1.97, 2.05 in 2020). Stillbirth rates declined until 2005, increased from 2005 to the mid-2010s and plateaued thereafter. Strong cohort effects contributed to declining rates in earlier cohorts (1930–1955) and increasing rates among women born after 1980.

Interpretation Age, period, and birth cohorts greatly influenced US stillbirth rates over the last forty years. The decline in stillbirth rate was evident between 1980 and 2005, however subsequent declines have been minimal, reflecting no further gains for cohorts of women born in 1955–1980 and stagnation of period effects starting in 2005. A significant racial disparity persisted with a two-fold excess in stillbirth rates for Black compared to White women, underscoring the need for targeted health and social policies to address disparities.

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Keywords: Stillbirth; Trends; Maternal age; Maternal birth cohort; Lifecourse; Race

Abbreviations: RR, rate ratio; CI, confidence interval; APC, age-period-cohort

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Research in context

Evidence before this study

Stillbirth affects over 2.6 million pregnancies worldwide, placing an overwhelming psychological and emotional burden on families and providers, and results in substantial economic costs to society. Stillbirth rates show continued marked disparities among Black women compared to White women.

Added value of this study

This sequential time-series analysis of over 710,000 stillbirths and 157 million live births in the US over four decades reveals a slowing of the longstanding secular decline in stillbirth rates. Changing characteristics of maternal birth cohorts positively affected stillbirth trends over this period, but only in early birth cohorts, while continued improvements in period effects continued until 2005. Patterns of change over time were broadly similar for Black and White women, despite very different age-specific stillbirth risks. This translated into persistent two-fold racial disparities in stillbirth rates between Black and White women, with a rate among Black women in 2020 that was higher than the corresponding rate in 1980 among White women.

Implications of all the available evidence

These findings underscore complex influences that shape the dynamics of stillbirth. The impact of exposures at the time of fetal development and birth and how this impacts stillbirth rates later in life for those women (birth cohort effect) provides new direction to explore stillbirth rates along a lifecourse perspective. Specifically, there is absence of improvement in stillbirth outcomes of subsequent generations of women born between 1955 and 1980 birth cohorts. The slowing of period effects in stillbirth rates suggest that positive changes in maternal characteristics (more education, less smoking during pregnancy) have been outweighed by a greater prevalence of negative exposures such as older maternal age and increasing obesity. Large, persistent disparities between White and Black women point to failed efforts to reduce racial inequalities in stillbirth rates and highlights the critical need for new, targeted policies.

Introduction

Globally, about 48.2 million pregnancies resulted in stillborn fetuses since the year 2000 with 2 million stillbirths in 2019 alone.[1] Despite advances in the delivery of prenatal and intrapartum health care, stillbirth (fetal death occurring at or beyond 20 weeks' gestation) remains a substantial burden in high-income countries.[2–4] In the United States (US), about 24,000 stillbirths occur each year,[5,6] complicating one in 160 deliveries; and 80% of these occur at preterm gestations.[5] Further, while the stillbirth rate in the US has shown a steady decline since the 1940s, the decline in more recent years has slowed,[3,5] with an estimated modest annual reduction of about 2% between 2000 and 2015.[4,7] In fact, while the overall stillbirth rate may be lower, an increase in the rates of extreme preterm (<28 week) stillbirth is evident.[8] Thus, stillbirth continues to place overwhelming psychological and emotional burden on families and providers and presents considerable economic burden on society.[9]

Previous studies have identified factors associated with stillbirth in the US, however these factors remain numerous and complex, ranging from obesity and smoking to genetic abnormalities and medical co-morbidities.[2,10] Black women experience stillbirth rates that are over two-fold higher compared to White women.[11] Few studies have examined temporal changes in stillbirth rates. These trends could arise due to secular changes in the prevalence of causal risk factors such as environmental and health care factors that affect all women (period effects) or due to specific cohorts of women moving through the life course with persistently high or low exposure to causal risk factors (birth cohort effects).[12] An age-period-cohort (APC) analysis can provide unique insights into these trends by identifying the age, period, and birth cohort interactions to underscore changes in risk factors that influence rates of stillbirth. These different effects have implications for intervention and understanding etiology. A previous APC study that evaluated stillbirth trends in the US from 1981 to 2000 observed strong age and period effects on stillbirth trends along with a temporal decline in stillbirth rates in the US.[13]

We explored temporal changes in stillbirth rates ≥24 weeks over a 40-year period among Black and White women in the US to determine how maternal age, advances on delivery of prenatal and intrapartum care (period effects), and social and environmental effects (such as socioeconomic status, education, nutrition, smoking and substance use, alcohol use, environmental conditions, etc.) through their life course (birth cohort effects) have shaped these trends. Elucidating the factors that lead to the temporal trends in stillbirth is crucial to determine how cultural and environmental factors impact trends in stillbirth across maternal birth cohorts and birth periods.

Methods

We designed a sequential time-series analysis utilizing the vital records data of fetal deaths and live births in the US between 1980 and 2020. The sequential time-series data are drawn from yearly counts of fetal deaths and live births in the vital statistics records. These counts were used to estimate rates of stillbirth per 1000 live births and stillbirth by maternal age and year. These data, ascertained from fetal death and live birth certificates, are assembled by the National Center for Health Statistics of the Centers for Disease Control and Prevention. The data come from vital records in each of the 50 states and the District of Columbia, are reported by the attending physician or the vital statistics coordinator at each hospital and undergo checks for quality control and editing. Since these data were fully de-identified and publicly available, we did not require ethics approval. This manuscript has been structured to follow the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Definitions and cohort composition

Between 1980 and 2020, there were 160,173,769 live births and 1,196,445 fetal deaths in the US delivered at ≥20 weeks' gestation. For this study, we defined stillbirth as a fetal death at ≥24 weeks' gestation prior to the complete expulsion or extraction from its mother, with no signs of life. We used this definition to avoid biases in the classification of stillbirths at the borderline of viability (at <24 weeks of gestation) which could affect trend analyses.[14] We excluded missing gestational age, gestational age <24 weeks, and maternal age <11 years and ≥50 years (Supplementary Fig. S1). After all exclusions, 157,192,032 live births and 710,832 stillbirths delivered at 24 or more weeks' gestation remained for analysis.

Statistical analysis

We examined changes in stillbirth rates at ≥24 weeks between 1980 and 2020 (expressed per 1000 total births), as well as trends among Black and White women. We undertook an APC analysis to evaluate temporal changes in stillbirth rates. The effect of maternal age (classified in 5-year groups as <20, 20–24, ..., 45–49 years), period (single years), and birth cohorts (single years) on stillbirth trends were first examined in the following four formats: rates by period with strata of age, rates by cohort within strata of age, rates by age within strata of period, and rates by age within strata of cohort. Trend patterns from these four plots guided the APC modeling and analyses.

APC modeling was based on Poisson regression modeled as the number of stillbirths cross-classified by age, period, and cohort (all in single years), with the total number of births (live birth plus stillbirth) as an offset (denominator). We overcame the linearity problem in an APC analysis[15] by imposing certain constraints. Age-effects on stillbirth rates were first estimated for the reference (2020) period. We then estimated an overall linear trend in rates; this estimate is the additive linear effects of period and cohorts, which represents the average annual change in stillbirth rates. Deviations from linearity (i.e., non-linear component) that can be attributed to period and cohort effects were then assessed (the "curvature" effect). These parameter estimates can be interpreted as the direction and magnitude of the change in the linear trend by period and cohort. We applied natural spline transformation for age, period, and cohort (10 knots each) to enable non-linear smooth functions.

Sub-group analysis

We undertook three sets of sensitivity analyses. First, we examined stillbirth (at ≥24 weeks) trends through an APC analysis separately for singleton and twin births. In a second analysis, we evaluated trends in stillbirths at ≥28 weeks in relation to age, period, and birth cohorts. This analysis was designed to address if potential biases in the registration of periviable stillbirth may have affected stillbirth trends.[14] Third, we undertook an analysis to examine stillbirth trends at preterm (24–36 weeks) and term (≥37 weeks) gestations.

The APC analysis was performed in R implemented in the *Epi* package in the RStudio (version 1.2) and in SAS (version 9.4; SAS Institute, Cary, NC).

Role of the funding source

This was an unfunded project.

Results

Sociodemographic characteristics among women by stillbirth status at ≥24 weeks are described in Table 1. The overall stillbirth rate declined from 10.6 to 5.8 per 1000 total births between 1980 and 2020, with the decline over this period being of roughly similar magnitudes among Black women and White women (Table 2 and Fig. 1). Despite the decline, the race-disparity in stillbirth rates was persistent, showing a two-fold higher rate among Black women compared to White women. Moreover, the stillbirth rate among Black women in 2020 was higher than the corresponding rate among White women in 1980 (Fig. 1).

For every period, stillbirth rates were high at very young ages (12–14-years), declined with advancing age, and began to increase among women aged 35 years or more (Table 3). Stillbirth rates by period within strata of maternal age showed a decline in rates in all periods in the 12–14, 15–19, and 45–49 age groups; in other age groups, the rates declined up to the 2000s and plateaued thereafter (Table 3 and Supplementary Fig. S2). Stillbirth rates also declined with increasing birth cohort within strata of maternal age groups. The association between maternal age and stillbirth showed a reversed 'J'-shaped pattern for every five-year period (Supplementary Fig. S3); within each 10-year birth

Maternal characteristics	Total population (n = 157,902,864) No. ($\%_{col}$)	Live birth (n = 157,192,032) No. ($\%_{col}$)	Stillbirth (n = 710,832)	
			No. ($\%_{col}$)	Rate[a]
Year of birth				
1980–84	15,536,472 (9.8)	15,426,114 (9.8)	110,358 (15.5)	7.1
1985–89	18,664,735 (11.8)	18,565,141 (11.8)	99,594 (14.0)	5.3
1990–94	20,159,659 (12.8)	20,059,776 (12.8)	99,883 (14.1)	5.0
1995–99	19,432,326 (12.3)	19,345,727 (12.3)	86,599 (12.2)	4.5
2000–04	20,153,646 (12.8)	20,076,389 (12.8)	77,257 (10.9)	3.8
2005–09	21,080,235 (13.4)	21,007,956 (13.4)	72,279 (10.2)	3.4
2010–14	19,870,327 (12.6)	19,796,541 (12.6)	73,786 (10.4)	3.7
2015–20	23,005,464 (14.6)	22,914,388 (14.6)	91,076 (12.8)	4.0
Maternal age (years)				
12–14	292,711 (0.2)	290,380 (0.2)	2331 (0.3)	8.0
15–19	16,295,501 (10.3)	16,209,214 (10.3)	86,287 (12.1)	5.3
20–24	39,788,596 (25.2)	39,608,075 (25.2)	180,521 (25.4)	4.5
25–29	45,603,405 (28.9)	45,417,026 (28.9)	186,379 (26.2)	4.1
30–34	36,389,780 (23.1)	36,241,970 (23.1)	147,810 (20.8)	4.1
35–39	16,161,359 (10.2)	16,079,662 (10.2)	81,697 (11.5)	5.1
40–44	3,186,626 (2.0)	3,162,805 (2.0)	23,821 (3.4)	7.5
45–49	184,886 (0.1)	182,900 (0.1)	1986 (0.3)	10.7
Maternal race				
Black	24,962,153 (15.8)	24,779,481 (15.8)	182,672 (25.7)	7.3
White	123,396,274 (78.8)	122,904,116 (78.2)	492,158 (69.2)	4.0
Other races	9,544,437 (6.0)	9,508,435 (6.1)	36,002 (5.1)	3.8
Plurality				
Singleton	153,333,355 (97.1)	152,674,957 (97.1)	658,398 (92.9)	4.3
Twins	4,389,508 (2.8)	43,42,104 (2.8)	47,404 (6.7)	10.8
Triplets or more	177,781 (0.1)	174,971 (0.1)	2810 (0.4)	15.8
Gestational age (weeks)				
24–27	931,407 (0.6)	770,760 (0.5)	160,647 (22.6)	172.5
28–31	2,007,297 (1.3)	1,880,193 (1.2)	127,104 (17.9)	63.3
32–33	2,374,106 (1.5)	2,304,507 (1.5)	69,599 (9.8)	29.3
34–36	12,554,699 (8.0)	12,430,769 (7.9)	123,930 (17.5)	9.9
37–38	36,939,513 (23.4)	36,842,278 (23.5)	97,235 (13.7)	2.6
39–40	72,259,996 (45.8)	72,173,417 (45.9)	86,579 (12.2)	1.2
≥41	30,766,197 (19.5)	30,720,908 (19.6)	45,289 (6.4)	1.5
Preterm delivery				
Preterm (<37 weeks)	17,867,509 (11.3)	17,386,229 (11.1)	481,280 (67.7)	26.9
Term (≥37 weeks)	139,915,706 (88.7)	139,736,603 (88.9)	229,103 (32.3)	1.6
Infant sex				
Female	76,960,139 (48.8)	76,744,685 (48.8)	215,454 (37.1)	2.8
Male	80,812,419 (51.2)	80,447,347 (51.2)	365,072 (62.9)	4.5

[a]Rate refers to stillbirth rate per 1000 total births (live births plus stillbirth).

Table 1: **Sociodemographic characteristics of women based on stillbirth status and stillbirth rate: United States 1980–2020.**

cohort, stillbirth rates also demonstrated a reversed 'J'-shaped association with maternal age.

Stillbirth rates among Black women were lowest in their early 20s, whereas the nadir was in the late 20s among White women (Table 4). The APC analysis of stillbirth rates (2020 reference period) shows high stillbirth rates at young ages, a decline in the rate with advancing age, and increases thereafter (Fig. 2). Compared to the rate in 2020, stillbirth rates showed a temporal decline until 2005, increased slightly from 2005 to mid-2010s and plateaued thereafter. The annual decline in stillbirth rate was larger among White women (–1.97%, 95% CI -1.99, –1.94) compared to Black women (–1.52%, 95% –1.56, –1.48). A strong cohort effect on trends in stillbirth rate was evident in earlier birth cohorts, with higher rates among White women born in the 1930s and 1940s (compared to the 1970 reference cohort). While a similar cohort effect was also

	Total number of births (number of stillbirths)			Stillbirth rate (95% CI) per 1000 total births			Rate ratio (95% CI)[a]
	1980–2020	1980	2020	1980–2020	1980	2020	
Total population	157,902,864 (710,832)	2,666,646 (28,301)	3,635,736 (20,949)	4.5 (4.5, 4.5)	10.6 (10.5, 10.7)	5.8 (5.7, 5.8)	0.54 (0.53, 0.55)
Black women	24,962,153 (182,672)	394,196 (6869)	589,987 (5942)	7.3 (7.3, 7.4)	17.4 (17.0, 17.8)	10.1 (9.8, 10.3)	0.57 (0.55, 0.59)
White women	123,396,274 (492,158)	2,196,956 (20,189)	2,662,967 (13,208)	4.0 (4.0, 4.0)	9.2 (9.1, 9.3)	5.0 (4.9, 5.0)	0.54 (0.53, 0.55)
Rate ratio (95% CI)[b]				1.84 (1.83, 1.85)	1.90 (1.85, 1.95)	2.01 (1.97, 2.05)	

CI, confidence interval. [a]Rate ratio refers to the stillbirth rate in 1980 in comparison to the rate in 2020. [b]Rate ratio refers to the stillbirth rate among Black women compared to White women.

Table 2: **Stillbirth rates at ≥24 weeks gestation overall and among White and Black women: United States 1980–2020.**

evident among Black women, the rate ratios were smaller in magnitude. Cohort effects show a positive increase in stillbirth among the youngest cohort, more so among Black women, starting in approximately those born around 1990 and later, reflective of a more plateaued period effect on stillbirth rates among more recent generations.

Sub-group analysis

We examined stillbirth trends among singleton and twin births. The analysis for singleton births (Supplementary Fig. S4; top panel) showed the patterns of age, period and cohort trends were similar to the overall analysis. However, stillbirth rates by maternal age among twins sharply declined up to 20 years among Black women and plateaued thereafter; among White women, the rate declined up to 30 years and plateaued thereafter (Supplementary Fig. S4; bottom panel). While the effect of birth cohort among singleton and twin births were similar, the period decline was steeper for twin stillbirth (average annual change of −3.17%, 95% CI -3.78, −3.61) than singleton stillbirth (−1.57%, 95% CI -1.60, −1.55).

An analysis of stillbirth trends among preterm and term deliveries showed that although the effects were similar to the overall effects, on average, stillbirth rates declined more among term stillbirth (average annual change −3.09%, 95% CI -3.12, −3.05) than for preterm stillbirth (average annual change −1.84%, 95% CI -1.86, −1.81). For Black women, no appreciable cohort effects were observed for preterm stillbirths (Supplementary Fig. S5).

With restriction of the trends ≥28 weeks' gestation (Supplementary Fig. S6), the age, period, and birth cohort effects on stillbirth trends were very similar to stillbirth trends ≥24 weeks' gestation (Fig. 2).

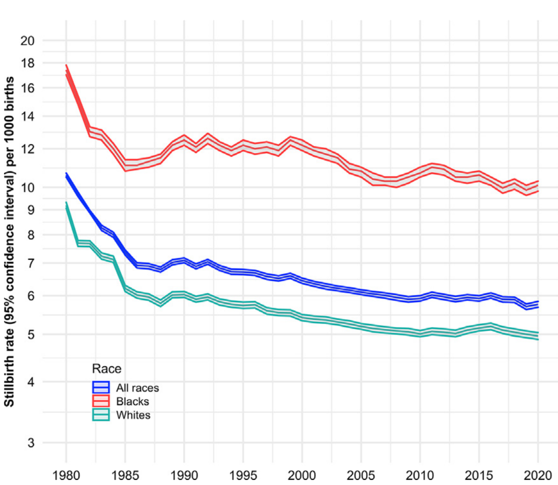

Fig. 1: Stillbirth rates (at ≥24 weeks gestation) overall and among Black and White Women: the United States, 1980–2020.

Discussion

Temporal changes in rates of stillbirth in the US over four decades (1980–2020) highlight several major findings. We show that the decline in stillbirth rates since 2005 has been slowing with minimal improvement in recent years due to negligible cohort effects and lack of period declines. Further, despite the overall decline in stillbirth rates at ≥24 weeks' gestation over the last 40 years, a 2-fold disparity in stillbirth rates persists between Black and White women, with a higher rate in 2020 among Black women than in 1980 among White women. Extremes of maternal age, notably 12–19 years and ≥35 years, show increased rates of stillbirth over time. Early declines in stillbirth reflected improved reproductive outcomes of successive maternal birth cohorts for women born before 1970.

Prior studies have suggested that the etiology of stillbirth is multifactorial and complex, making it challenging to identify those at risk.[2] The decline in stillbirth rates are largely attributed to general improvements in education, earlier registration to prenatal care and improved intrapartum care, as well as reductions in prevalence rates of smoking, alcohol and illicit drugs.[4,16] This study provides insights into epidemiologic characteristics (such as biological aging, influence of interventions, and cumulative exposures since birth) that drive changes in population rates of stillbirth by focusing on three closely related factors: maternal age, period, and maternal birth cohorts. Further, this study identifies vulnerable groups of high-risk women (such as advanced maternal age and Black women) who should be prioritized for stillbirth prevention and treatment.

Stillbirth year		Exact maternal age at stillbirth (years)								Birth cohort
		15	20	25	30	35	40	45	49	
									15 (133.3)	1930
								484 (49.6)	23 (–)	1935
							6876 (28.7)	628 (28.7)	69 (29.0)	1940
						33,796 (14.2)	11,322 (13.9)	876 (19.4)	65 (–)	1945
					118,918 (10.1)	69,851 (9.2)	20,947 (12.7)	1523 (17.7)	159 (37.7)	1950
				189,706 (8.6)	186,425 (7.0)	102,337 (8.5)	28,298 (9.9)	2279 (18.9)	246 (16.3)	1955
			161,467 (10.8)	247,914 (6.2)	226,727 (6.5)	117,524 (7.3)	37,182 (9.6)	3077 (12.7)	332 (9.0)	1960
		17,627 (16.6)	190,347 (7.3)	249,397 (6.0)	214,223 (5.9)	131,083 (7.2)	41,029 (8.0)	3486 (12.0)	430 (9.3)	1965
1980	↗	23,465 (9.7)	206,298 (7.2)	211,554 (6.1)	225,413 (5.6)	145,441 (5.3)	43,446 (8.6)	3980 (13.1)	515 (13.6)	1970
1985	↗	27,484 (10.4)	180,819 (7.0)	207,330 (5.8)	214,312 (4.8)	133,938 (6.0)	44,309 (8.6)	3856 (14.8)		1975
1990	↗	30,546 (10.0)	198,591 (6.7)	229,185 (4.9)	230,345 (5.3)	159,430 (6.1)	48,478 (7.9)			1980
1995	↗	21,703 (9.8)	187,893 (5.6)	214,834 (5.3)	247,193 (5.0)	164,410 (5.8)				1985
2000	↗	18,193 (8.1)	178,283 (6.0)	216,221 (5.4)	235,908 (5.1)					1990
2005	↗	13,554 (7.7)	135,421 (6.2)	179,401 (5.3)						1995
2010	↗	7663 (10.0)	102,365 (6.3)							2000
2015	↗	4737 (7.2)								2005
2020	↗									

Table 3: **Stillbirth rates (per 1000 total births) by maternal age, period, and maternal birth cohort: United States, 1980–2020.**

Extremes of maternal age are a strong risk factor for stillbirth in the US.[2] The bimodal peak can likely be attributed to different aetiologies – increased lethal genetic abnormalities or congenital anomalies in older women[17] and lower socioeconomic status and poor prenatal care in younger women. As more women elect to postpone their pregnancies (delayed childbearing), the age at first birth has notably increased over time.[18] This may contribute to a persistence of stillbirth even though there may be concomitant decreased stillbirth numbers due to more widespread population-based genetic screening or better antenatal and intrapartum care. Changes in the maternal age distribution over time likely contribute to the stagnation in declines by birth cohort seen after 1960. Also, while there may be improvements in cohorts over time such as decreased smoking and increased education, there are other factors to offset these positive changes such as older age and increased body mass index, which ultimately lead to successive birth cohorts without better reproductive outcomes.

The analysis of maternal age on stillbirth rates highlights a stark contrast in risk patterns between Black and White women in the US, leading to highest excess risk between Black and White women at ages 30–40 years, and lowest at extremes of age. While the reasons for this are debated and may relate to differences in childbearing patterns, this difference shapes the age structure of disparities with the highest gaps between Black and White stillbirth rates between 30 and 40 years of age. This may suggest age as a stronger driving factor for stillbirth or a possibly overall heightened awareness of stillbirth prevention with more fetal monitoring, for example, in women at extremes of age. While singleton stillbirths exhibit this similar pattern, it is interesting to note the sharper declines in stillbirth rates to age 20 and age 30 followed by plateauing in Black and White women, respectively, and widening of the disparity with increasing age in twins. This highlights the potential role of increased utilisation of in vitro fertilisation and possible pre-implantation genetic testing in White women.

The strong temporal decline in stillbirth until 2005 may be due to multiple contributing factors and driven by improvements in antenatal management. The American College of Obstetricians and Gynecologist (ACOG) guidelines on surveillance for high-risk maternal and fetal conditions,[19] as well as enhanced screening via sonography and genetic testing have, in turn, led to more aggressive obstetrical interventions for reduced stillbirth and better outcomes. The widespread implementation of electronic fetal monitoring has nearly eliminated intrapartum stillbirths.[20] Declining stillbirth rates after implementation of these strategies provide empirical evidence that speaks to the efficacy of these interventions. The steeper period declines in twins and among women that delivered at term compared to preterm may also largely be due to these changes. In contrast, during this time, there were minimal changes in period preterm stillbirth rates, especially for Black women, for whom cohort improvements were also not observed. This suggests that preterm, and particularly very preterm, stillbirths may have benefited less from advances in obstetric management. Additionally, the

	Overall	White women	Black women
Maternal age (years)	Rate (95% confidence interval) of stillbirth per 1000 births in 2020		
15	4.6 (4.5, 4.7)	3.9 (3.8, 4.0)	5.8 (5.6, 6.0)
20	3.6 (3.6, 3.7)	3.2 (3.1, 3.3)	5.2 (5.0, 5.3)
25	3.3 (3.2, 3.3)	2.9 (2.8, 2.9)	5.3 (5.1, 5.5)
30	3.1 (3.1, 3.2)	2.8 (2.7, 2.9)	5.8 (5.6, 6.0)
35	3.7 (3.6, 3.7)	3.3 (3.3, 3.4)	6.8 (6.6, 7.0)
40	5.5 (5.4, 5.6)	5.0 (4.9, 5.1)	9.5 (9.2, 9.8)
45	8.5 (8.3, 8.7)	8.0 (7.8, 8.2)	13.5 (12.8, 14.2)
49	12.1 (11.7, 12.5)	11.6 (11.1, 12.0)	17.9 (16.7, 19.2)
Year of stillbirth (period)	Age-adjusted rate ratio (95% confidence interval) of stillbirth		
1980	2.17 (2.13, 2.21)	2.23 (2.19, 2.27)	2.07 (2.00, 2.14)
1985	1.56 (1.54, 1.58)	1.62 (1.59, 1.64)	1.41 (1.37, 1.45)
1990	1.46 (1.44, 1.48)	1.47 (1.44, 1.49)	1.48 (1.44, 1.53)
1995	1.26 (1.24, 1.28)	1.29 (1.26, 1.31)	1.29 (1.25, 1.33)
2000	1.18 (1.16, 1.19)	1.16 (1.14, 1.18)	1.29 (1.25, 1.33)
2005	0.92 (0.91, 0.93)	0.90 (0.88, 0.92)	1.01 (0.98, 1.04)
2010	0.96 (0.95, 0.98)	0.98 (0.96, 1.00)	0.99 (0.97, 1.02)
2015	1.03 (1.01, 1.05)	1.02 (1.00, 1.04)	1.03 (1.00, 1.07)
2020	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Maternal birth cohort (year)	Age-adjusted rate ratio (95% confidence interval) of stillbirth		
1935	1.58 (1.55, 1.62)	1.55 (1.50, 1.59)	1.26 (1.20, 1.31)
1945	1.28 (1.26, 1.29)	1.25 (1.24, 1.27)	1.15 (1.13, 1.18)
1955	1.03 (1.02, 1.04)	1.02 (1.01, 1.02)	1.06 (1.05, 1.07)
1965	0.98 (0.97, 0.99)	0.98 (0.97, 0.98)	1.03 (1.01, 1.04)
1975	0.97 (0.96, 0.98)	0.98 (0.97, 0.99)	0.96 (0.95, 0.98)
1980	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
1985	1.02 (1.02, 1.03)	1.02 (1.01, 1.03)	1.01 (0.99, 1.02)
1995	1.08 (1.07, 1.09)	1.07 (1.06, 1.08)	1.12 (1.10, 1.14)
2005	1.14 (1.12, 1.17)	1.12 (1.09, 1.15)	1.30 (1.25, 1.34)

Table 4: **Stillbirth rate at ≥24 weeks' gestation and rate ratio for stillbirth with 95% confidence interval for selected maternal age, period, and maternal birth cohorts: United States, 1980–2020.**

slower stillbirth rate decline for Black women may be secondary to delayed entry to prenatal and/or poor prenatal care in this group.

The slowing of stillbirth rates starting in 2005 may possibly be due to simultaneous competing factors that offset the decline in earlier years. Late terminations of pregnancy largely contribute to stillbirth in Europe,[21] yet the extent of their contribution in the US is less clear. The national effort in 2007 to reduce elective deliveries before 39 weeks gestation in accordance with ACOG and Joint Commission standards may have impeded continued declines,[22] and findings suggest increased risk of stillbirth with advancing gestation at term.[23] More broadly, there may be a slowdown in medical advances and obstetrical intervention to predict or prevent stillbirth.

There is also worsening of co-morbidities such as obesity, pregestational diabetes, chronic hypertension, and preeclampsia/eclampsia, particularly in the older age groups, all of which are established risk factors for stillbirth.[2,10] Unfortunately, there is a dearth of effective strategies to reduce modifiable stillbirth risk factors.[8,24] Such problems as well as issues with access to prenatal care may contribute to the inability to offset prior factors that allowed for improvement in stillbirth rates. Additionally, the recent rise in parental ages could interestingly contribute to the increase in de novo mutations and birth defects, attenuating a further decline in stillbirth rates.[25] The increased availability and uptake of technologies such as prenatal diagnosis,[26] including whole exome sequencing and improvements in detection of fetal anomalies with ultrasound and magnetic resonance imaging[27] may have also impacted stillbirth trends.

This APC study point to racial inequalities in stillbirth. Compared to White women, Black women have higher rates of obesity, pregestational diabetes, chronic hypertension, and placental abruption, all contributing to higher stillbirth rates.[28] However, studies also report increased stillbirth among Black women independent of

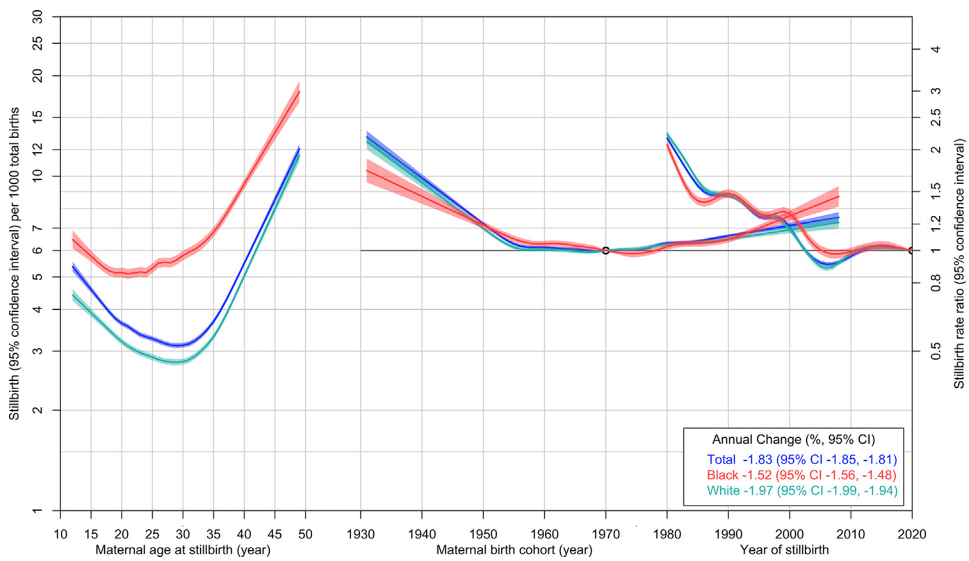

Fig. 2: Age-period-cohort analysis of stillbirth (at ≥24 weeks gestation) trends overall and among Black and White Women in the United States, 1980–2020. Legend: Age-specific stillbirth rates are for the reference period 2020. The rate ratios for stillbirth are adjusted for maternal age.

co-morbidities.[29] This excess risk may result from differential access and quality of maternity care, illustrated in research on maternal morbidity during pregnancy,[30] as well as other adverse effects of structural racism and implicit and explicit biases. For example, based on a nationally representative sample of births in the US, low and decreasing levels of racial segregation, a well-documented and multi-generational measure of structural racism,[31] is associated with decreased odds of stillbirth, with Black people benefitting more than White people. Stress may be one underlying mechanism and chronic exposure to social inequality is also hypothesised to accelerate decline and lead to earlier deterioration in health for Black compared to White women (termed the "weathering hypothesis").[32,33] The two-fold higher stillbirth rates for Black compared to White women over four decades, persistent despite major advances in obstetric medicine, calls for health and social policies that explicitly aim to reduce these stark disparities.

Strengths and limitations

In addition to its large size, the study employed a multifaceted analysis that explored key factors that contribute to trends in the prevalence rate of stillbirth (specifically, maternal age, period, and birth cohorts). The trends in stillbirth rates and the persistent racial disparity is consistent with prior studies[6] which provides reassurance that stillbirths were correctly identified. The concordance of findings in APC effects on stillbirth trends between the overall analysis (i.e., stillbirths at ≥24 weeks) versus the sensitivity analysis restricted to stillbirths at ≥28 weeks' gestation provides reassurance that changes in registration of births at the borderline of viability[14,34] do not explain the trends in stillbirth rates.

Two important limitations of the study merit discussion. First, women may have contributed more than one pregnancy over four decades of the study duration. There is increased risk of stillbirth among those with prior stillbirth, and while the analysis does not account for this "clustering" phenomenon, the bias likely has minimal impact relative to the large population size. Second, we do not distinguish maternal race by Hispanic ethnicity since data on Hispanic ethnicity was only made available consistently in the revised 2003 birth certificates.

Conclusions

Age, period, and birth cohorts strongly influence the complex dynamics that have shaped stillbirth risk over time in the US. Our understanding of these factors provides insights into possible amenable factors of stillbirth. The major reduction in stillbirth rates with subsequent stagnation since 2005 raises alarm about the current state of reproductive health in the US and highlights the need for major improvements in stillbirth prevention. Further, failure to close the racial disparity in stillbirths underscores the urgent public health needs to address persistent racial disparities through targeted preventative policies. Such efforts may ultimately diminish the gap in stillbirth rates between Black women and White women and reduce its overall burden.

Contributors

CVA and HLG had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the statistical analysis.

Concept and design: CVA, JZ.

Acquisition, analysis, or interpretation of data: CVA, JCF, JSB, HLG, KMK, JZ.

Drafting of the manuscript: CVA, JCF, JZ.

Critical revision of the manuscript for important intellectual content: CVA, JCF, JSB, HLG, KMK, JZ.

Statistical analysis: CVA.

Obtained funding: Not applicable.

Administrative, technical, or material support: CVA.

Supervision: CVA.

Data sharing statement
All data utilized in this study can be accessed from the Centers for Disease Control and Prevention (http://www.cdc.gov/) or from the National Bureau of Economics Research (https://www.nber.org).

Declaration of interests
All authors declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years; and no other relationships or activities that could appear to have influenced the submitted work.

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Appendix A. Supplementary data
Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2022.100380.

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