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Indiana Infant Mortality Report: 2002 Period Linked Birth/ Infant Death Data Set

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Abstract

Objective - This report presents 2002 period infant mortality statistics in Indiana from the linked birth/infant death data set (linked file) by race, a variety of infant and maternal characteristics, and leading causes of death.

Methods - The numerator for the 2002 period linked file consists of Indiana resident infant deaths (less than one year of age) occurring in 2002. In 2002, 99.2 percent of all infant death records could be linked to their corresponding birth certificate, whether the birth occurred in 2002 or 2001. The denominator file for this data set is the 2002 natality file, that is, all births occurring in 2002 to Indiana residents. To be included in the linked file, the infant must have been a resident of Indiana at birth and at death. Descriptive tabulations of data from the linked file are presented for all infants and by race of mother according to birth certificate.

Results - The overall infant mortality rate (IMR) in Indiana in 2002 was 7.5 infant deaths per 1,000 live births, essentially unchanged from the rate in 2001. For infants born to black mothers, the IMR was 14.2 deaths per 1,000 live births, more than double the rate of 6.6 for infants born to white mothers. Among Hispanics, the IMR was 6.8 compared to 6.6 among the non-Hispanic whites and 14.2 among the non-Hispanic blacks. The IMR of male infants (8.2) was 21% higher than female infants (6.8), and IMR of plural births (41.4) was more than six times the rate for singleton births (6.3). In 2002, two thirds of all infant deaths occurred in the 7.6% of infants born at low birthweight. The IMR for low birthweight infants (63.6) was more than 25 times the IMR of 2.5 among normal birthweight infants. Infant mortality rates were higher for infants whose mothers had less than high school education, were unmarried, received late/inadequate/no prenatal care, or smoked during pregnancy.

Among the very low birthweight or very preterm infants, the IMR of infants born to black mothers was not significantly different from those born to white mothers. Among the normal birthweight or term infants, however, the IMR among black infants was 74-95% higher than the rate among whites. Racial disparity in IMR persisted regardless of maternal characteristics, but the racial gap grew wider among infants whose mothers were older, more educated, married, received early and adequate care, or did not smoke. In general, the effect of sociodemographic characteristics such as mother's age, education, or marital status on infant mortality was weaker among blacks compared to whites.

For all races combined and for whites, the three leading causes of infant death were congenital anomalies, disorders related to low birthweight and short gestation, and sudden infant death syndrome (SIDS). These three causes accounted for 42-44% of the total infant deaths. Among blacks, the three leading causes of infant death were disorders related to low birthweight and short gestation, congenital anomalies, and accidents.

Introduction

This report presents information on IMR from the Indiana 2002 period linked birth/infant death data set (linked file). In the linked file, death records for infants who were Indiana residents and died under one year of age during 2002 were linked to their corresponding birth certificate. The purpose of linkage is to use the additional information available on the

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birth certificate for conducting a more in-depth analysis of the pattern of infant mortality. The demographic and health variables included in the analysis of infant mortality are race, plurality, sex, birthweight, gestational age, maternal age, maternal education, live birth order, marital status, prenatal care, and smoking during pregnancy. Results are reported for all races combined and for whites and blacks separately. Due to the relatively small number of births and infant deaths among Hispanics, only the overall IMR is reported for this population. In this report, Office of Management and Budget race definition of "Black or African American" is referred to as "Black" and ethnicity definition of "Hispanic or Latino" is referred to as "Hispanic".

The descriptive statistics presented here are useful in understanding the basic relationships between the individual risk factors and infant mortality. The IMRs are reported according to a specific maternal or infant characteristic and are unadjusted for the possible effects of other risk factors that are often present simultaneously. The preferred method for a better understanding of the interrelationship of multiple risk factors for infant mortality is multivariate analysis. The goal of this report, however, is to provide a basic understanding of the relationships of various risk factors to infant mortality.

Methods

Period linked file - To create the 2002 period linked file, death certificate numbers of infants under one year of age who were Indiana residents and died in 2002 were matched and linked to their birth certificates. Accuracy of linking was determined by measuring consistency between various items common to both the birth and the death certificates such as date of birth, infant's first name, infant's last name, infant's sex, and mother's maiden name. This link created a single record, containing information on the birth and death certificates, from the two previously separate records. In 2002, 644 (99.2 percent) of the 649 Indiana resident infant death records were successfully matched with their corresponding birth records (Table A). Of the matched births/infant death records, six were not Indiana residents at the time of birth. The remaining 638 matched infant deaths (residents of Indiana at both birth and death) comprised the final Indiana 2002 period linked file.

Table A. Number and percent of infant death records linked and not linked to their corresponding birth record by age at death and residency status: Indiana, 2002 linked file

Link status of infant death records	Infant age at death		
	All	Neonatal	Post-neonatal
		Number	
Total infant deaths - Indiana resident at death	649	441	208
Linked to birth record	644	436	208
Indiana resident at birth	**638**	**434**	**204**
Not Indiana resident at birth	6	2	4
Unlinked	5	5	0
		Percent	
Linked records	99.2	98.9	100.0
Unlinked records	0.8	1.1	0.0

The 5 unlinked infant death records were neonatal deaths (<28 days). As a result, the percent linked varied by age at death, from 98.9% for neonatal deaths to 100% for postneonatal deaths with an overall linkage of 99.2%. Due to the high percentage of records linked, weighting of data was not considered necessary. Because the overall infant mortality rate (IMR) in this report is based on the 638 linked birth/death records and does not include the unlinked records (5 infants), the total IMR is understated by 0.8 percent on the average.

Infant mortality rates - Infant mortality rates are calculated by dividing the number of infant deaths in a period (numerator) by the number of live births in the same period (denominator), times 1,000 or 100,000. The 2002 period linked file contains a numerator file that includes all Indiana infant deaths in 2002 that have been linked to their corresponding birth certificates, whether the birth occurred in 2002 or in 2001, and a denominator file that includes all Indiana live births during 2002.

The IMR is subject to random (or chance) variation in the number of births or deaths involved. Rates based on fewer than 20 deaths are considered unstable because their 95 percent confidence interval is about as wide as the rate itself (1). Therefore, in this report, IMRs based on less than 20 deaths are not reported. Additional explanation of random variation and stability of rates is presented in the Technical Notes.

Race and Hispanic origin - The racial and ethnic designation used in this report is that of the mother from the birth certificate. The linked file provides more accurate data for computing the IMRs by race and Hispanic origin compared to that reported in the general mortality report (2). In the linked file, the race of the mother from the birth certificate is used both in the numerator and the denominator of the IMR. In contrast, in the general mortality report, the race information in the denominator is that of the mother from the birth certificate, while the race information in the numerator is the race of the decedent recorded on the death certificate as reported by an informant or on observation. As a result of this difference in the method of reporting race data in the linked file and general mortality file, race-specific IMRs from these two data files can be different.

Birthweight and gestational age edits - Birthweight and gestational age edits were performed according to National Center for Health Statistics (NCHS) guidelines (3). Birthweights below 227 and above 8,650 grams were considered as unknown. Birthweights within the acceptable range of 227 to 8,650 grams were checked for consistency with gestational age. Gestational age in completed weeks was calculated from the date of last normal menstrual period to the date of birth. The clinical estimate was used for 2.8% of the records in which the date of last menses was missing (1.8%) or when the computed gestational age was either out of the acceptable range of 17 to 47 weeks (0.8%) or inconsistent with the birthweight (0.2%).

Cause of death - Cause of death coding in this report is according to the Tenth Revision, International Classification of Diseases (ICD-10) (4).

Statistical significance - Throughout the text, any statement that a given IMR is higher or lower than another rate implies a statistically significant difference. Detailed information about the statistical tests used in this report is presented in the Technical Notes.

Results

Infant mortality by race and Hispanic origin of mother

The overall 2002 Indiana IMR was 7.5 infant deaths per 1,000 live births. There was a wide racial disparity in IMR as indicated by a rate of 6.6 for whites and 14.2 for blacks. Among Hispanics, the IMR of 6.8 was not significantly higher compared to non-Hispanic whites (6.6) but was significantly lower compared to blacks (Table 1).

Among all races, two thirds of infant deaths occurred during the neonatal period (<28 days of age). Among Hispanics, however, neonatal deaths accounted for 76% of all deaths. The racial disparity in the mortality rate was evident for both the neonatal and postneonatal periods. Compared to non-Hispanic whites, the neonatal mortality rate was higher by 111%, and postneonatal mortality rate was higher by 123% among blacks (Table 1).

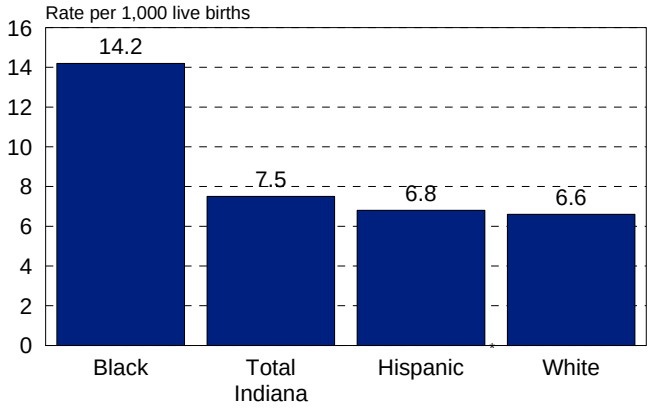

Figure 1. Infant mortality rates by race and Hispanic origin: Indiana, 2002 linked file

Infant mortality by selected infant and maternal characteristics

Infant mortality rates by various infant and maternal characteristics are shown in Table 2 for all infants and for infants born to white and black mothers. The number of live births and infant deaths in corresponding categories is shown in Table 3. Among Hispanics, breakdowns of infant deaths by various infant and maternal characteristics resulted in small numbers of deaths and unstable IMR in most categories and, therefore, are not reported. Combining several years of data in future reports would provide enough numbers of infant deaths among Hispanics to yield stable IMRs in different categories.

Table 1. Infant, neonatal, and postneonatal deaths and mortality rates by race and Hispanic origin of mother: Indiana, 2002 linked file

Race and Hispanic origin of mother	Live births	Number of deaths			Mortality rate per 1,000 live births		
		Infant	Neonatal	Post-neonatal	Infant	Neonatal	Post-neonatal
Total	84,839	638	434	204	7.5	5.1	2.4
Race							
White	74,013	491	333	158	6.6	4.5	2.1
Black	9,243	131	86	45	14.2	9.3	4.9
Other	1,498	13	12	1	*	*	*
Unknown	85	3	3	0	*	*	*
Hispanic origin							
Hispanic	6,145	42	32	10	6.8	5.2	*
Non-Hispanic, All races	78,346	592	398	194	7.6	5.1	2.5
Non-Hispanic, White	67,655	449	300	149	6.6	4.4	2.2
Non-Hispanic, Black	9,205	131	86	45	14.2	9.3	4.9
Non-Hispanic, Other/Unknown	1,486	12	12	0	*	*	*
Unknown	348	4	4	0	*	*	*

*Figure does not meet standard of reliability or precision; based on fewer than 20 deaths in the numerator.

Table 2. Infant mortality rates by selected characteristics and race of mother: Indiana, 2002 linked file

Characteristics	Race of mother		
	All races[1]	White	Black
	Infant mortality rates per 1,000 live births		
Total	7.5	6.6	14.2
Age at death			
Total neonatal (0-27 days)	5.1	4.5	9.3
Early neonatal (<7 days)	4.0	3.5	7.5
Late neonatal (7-27 days)	1.1	1.0	*
Postneonatal (28-364 days)	2.4	2.1	4.9
Sex			
Male	8.2	7.2	15.5
Female	6.8	6.1	12.6
Plurality			
Single births	6.3	5.6	11.9
Multiple births	41.4	35.2	69.1
Birthweight			
Less than 2,500 grams	63.6	61.0	72.0
Less than 1,500 grams	280.2	274.3	285.1
1,500-2,499 grams	15.6	15.2	*
2,500 grams or more	2.5	2.3	4.5
Gestational age			
Less than 37 weeks	40.7	36.8	58.2
Less than 32 weeks	206.7	197.0	222.2
32-36 weeks	9.6	9.1	*
37 weeks or more	2.6	2.4	4.2
Age of mother			
Under 20 years	9.1	8.0	13.6
Under 18 years	10.1	8.7	*
18-19 years	8.6	7.7	*
20 years and over	7.3	6.5	14.3
20-24 years	9.1	8.1	14.6
25-29 years	6.6	5.7	15.0
30-34 years	6.0	5.7	*
35 years and over	6.7	5.5	*

Table 2. Infant mortality rates by selected characteristics and race of mother: Indiana, 2002 linked file (Cont.)

Characteristics	Race of mother		
	All races[1]	White	Black
	Infant mortality rates per 1,000 live births		
Educational attainment of mother			
Less than 12 years	10.2	9.0	17.6
0-8 years	6.1	6.1	*
9-11 years	11.5	10.1	18.8
12 years	7.8	7.2	12.2
More than 12 years	5.5	4.8	13.1
13-15 years	6.4	5.4	13.6
16 years and over	4.7	4.2	*
Live-birth order			
First	7.1	6.8	9.5
Second	6.8	6.1	13.8
Third	8.1	6.7	17.9
Fourth+	9.1	6.9	19.9
Marital status			
Married	5.8	5.8	10.2
Unmarried	10.5	8.4	15.4
Trimester prenatal care began			
First trimester	6.4	5.7	12.6
After first trimester	8.1	7.2	12.6
Second trimester	8.0	7.4	11.8
Third trimester	*	*	*
No care	46.8	*	*
Prenatal care index[2]			
Adequate plus	9.4	8.5	16.8
Adequate	3.7	3.6	*
Intermediate	4.6	3.8	*
Inadequate	7.3	6.4	12.0
No care	46.8	*	*
Maternal smoking			
Smoking	12.1	10.5	27.1
Not smoking	6.4	5.7	11.8

[1]Includes races other than black or white and unknown race.

*Figure does not meet standard of reliability or precision.

[2]Based on APNCU index (Kotelchuck, M. Am J Public Health 1994;84:1414-1420).

Table 3. Infant deaths and live births by selected characteristics and race of mother: Indiana, 2002 linked file

Characteristics	Infant deaths			Live births		
	All races[1]	White	Black	All races[1]	White	Black
Total	638	491	131	84,839	74,013	9,243
Age at death						
Total neonatal (0-27 days)	434	333	86	--	--	--
Early neonatal (<7 days)	339	259	69	--	--	--
Late neonatal (7-27 days)	95	74	17	--	--	--
Postneonatal (28-364 days)	204	158	45	--	--	--
Sex						
Male	354	271	73	43,237	37,732	4,721
Female	283	220	57	41,599	36,280	4,521
Unknown	1	0	1	3	1	1
Plurality						
Single births	516	402	106	81,891	71,485	8,880
Multiple births	122	89	25	2,946	2,528	362
Unknown	0	0	0	2	0	1
Birthweight						
Less than 2,500 grams	409	312	86	6,434	5,113	1,195
Less than 1,500 grams	327	248	69	1,167	904	242
1,500-2,499 grams	82	64	17	5,267	4,209	953
2,500 grams or more	194	158	36	78,061	68,638	8,003
Unknown	35	21	9	344	262	45
Gestational age						
Less than 37 weeks	440	329	99	10,824	8,941	1,702
Less than 32 weeks	352	260	80	1,703	1,320	360
32-36 weeks	88	69	19	9,121	7,621	1,342
37 weeks or more	195	159	32	74,008	65,067	7,541
Unknown	3	3	0	7	5	0
Age of mother						
Under 20 years	88	62	25	9,701	7,773	1,842
Under 18 years	31	20	10	3,062	2,312	713
18-19 years	57	42	15	6,639	5,461	1,129
20 years and over	548	428	106	75,130	66,234	7,401
20-24 years	225	171	50	24,731	21,039	3,430
25-29 years	160	123	32	24,101	21,456	2,133
30-34 years	105	91	11	17,615	15,954	1,190
35 years and over	58	43	13	8,683	7,785	648
Unknown	2	1	0	8	6	0

Table 3. Infant deaths and live births by selected characteristics and race of mother: Indiana, 2001 linked file (Cont.)

Characteristics	Infant deaths			Live births		
	All races[1]	White	Black	All races[1]	White	Black
Educational attainment of mother						
Less than 12 years	183	136	46	17,893	15,080	2,612
0-8 years	26	25	0	4,289	4,070	166
9-11 years	157	111	46	13,604	11,010	2,446
12 years	215	171	43	27,719	23,883	3,518
More than 12 years	214	165	40	38,775	34,700	3,061
13-15 years	122	89	30	19,140	16,635	2,203
16 years and over	92	76	10	19,635	18,065	858
Unknown	26	19	2	452	350	52
Live-birth order						
First	229	192	31	32,085	28,157	3,248
Second	189	150	35	27,710	24,603	2,545
Third	123	89	32	15,212	13,197	1,789
Fourth+	89	55	33	9,744	7,994	1,657
Unknown	8	5	0	88	62	4
Marital status						
Married	312	293	22	53,796	50,360	2,166
Unmarried	325	198	109	31,004	23,630	7,073
Unknown	1	0	0	39	23	4
Trimester prenatal care began						
First trimester	435	346	80	68,331	60,755	6,341
After first trimester	121	88	32	14,967	12,140	2,540
Second trimester	102	76	25	12,690	10,318	2,126
Third trimester	19	12	7	2,277	1,822	414
No care	27	14	13	577	357	210
Unknown	55	43	6	964	761	152
Prenatal care index[2]						
Adequate plus	247	195	47	26,299	23,062	2,797
Adequate	133	116	17	36,024	32,506	2,880
Intermediate	47	34	12	10,317	8,861	1,212
Inadequate	69	48	21	9,389	7,476	1,748
No care	27	14	13	577	357	210
Unknown	115	84	21	2,233	1,751	396
Maternal smoking						
Smoking	196	155	38	16,210	14,698	1,402
Not smoking	441	336	92	68,453	59,173	7,810
Unknown	1	0	1	176	142	31

-- Category not applicable.

[1] Includes races other than black or white and unknown race.

[2] Based on APNCU index (Kotelchuck M., Am J Public Health 1994; 84:1414-1420).

Sex of infant - The mortality rate of male infants (8.2) was 21% higher than the mortality rate of female infants (6.8). Blacks had higher IMRs for both males and females compared to whites (Table 2, Figure 2). The IMR of black infants was higher by 115% among male infants and by 107% among female infants compared to whites.

Plurality - In 2002, the IMR was 41.4 for multiple births, more than six times the IMR of 6.3 for singletons. For both multiple and singleton births, IMRs among black infants were approximately two times the rates among white infants (Table 2, Figure 3).

Birthweight and gestational age - Low birthweight and short gestational age are the two most important risk factors for infant health and survival. In 2002, low birthweight (<2,500 grams) and very low birthweight (<1,500 grams) infants comprised 7.6% and 1.4% of the live births and 67.8% and 54.2% of the infant deaths, respectively (Table 4). Therefore, the majority of infant deaths occurred to a small proportion of live births weighing less than 2,500 grams at birth (Figure 4). A similar pattern was observed for gestational age. Racial differences were evident in the distribution of birthweight and gestational age. Among black infants, 13.0% of live births were low birthweight and 18.4% were preterm compared to 6.9% and 12.1% among whites, respectively (Figure 5, Table 4).

Low birthweight infants are at significantly increased risk of death than normal birthweight infants. The IMR of 63.6 among low birthweight infants was more than 25 times the rate of 2.5 for normal birthweight infants (Table 2). The IMR for very low birthweight (<1,500 grams) infants was 280.2 deaths per 1,000 live births, more than 110 times the rate for normal birthweight infants. Similarly, the IMR for infants born prematurely (<37 weeks) was 40.7, more than 15 times the rate of 2.6 among term infants (Table 2). Among very preterm infants (<32 weeks), the IMR was 206.7, 80 times the rate for term infants. For moderately preterm infants (32-36 weeks of gestation), the rate was 9.6, 3.7 times the rate for term births.

Among black infants, the IMR of normal birthweight infants was 4.5, 95% higher than the IMR of 2.3 among whites (Table 2). However, among very low birthweight infants, who are at the highest risk for death, the black IMR of 285.1 was very close to the corresponding IMR of 274.3 for whites, indicating that racial disparity in IMR is diminished at lower birthweights (Figure 6). A similar pattern of racial disparity in infant mortality was observed among the preterm and term infants. Among term infants (>=37 weeks), the IMR of blacks was 74% higher than the IMR of whites whereas among very preterm infants (<32 weeks), blacks had a 13% higher IMR (not statistically significant) compared to whites (Table 2, Figure 7). A protective effect of black race for survival at lower gestational age has been reported in the U.S (5).

Maternal age – Among all races**,** the IMR decreased as the mother's age increased from below 20 years of age to 30-34 years (Table 2). The IMR rate for teen mothers (less than 20 years of age) was 9.1 deaths per 1,000 live births, 24% higher (not statistically significant) than the rate of 7.3 for adult mothers (20 years of age and older). Among blacks, however, the IMR of teen mothers (13.6) was not higher (not statistically significant) than the IMR of adult mothers (14.3).

At all age intervals, black mothers were more likely to experience infant deaths than white mothers. Racial disparity in IMR grew wider as the mother's age increased. Among teen mothers, the IMR of black infants was 70% higher compared to white infants, which was not statistically significant, whereas among adult mothers, black IMR was 120% higher than white IMR (Table 2, Figure 8).

Maternal education - The percent of births to mothers who had not finished high school was 21.2% among all races, 20.5% among whites, and 28.4% among blacks (Table 4). Overall, the IMR decreased as mother's education increased (Table 2). For mothers with less than 12 years of education, the IMR was 10.2, 31% higher than the rate of 7.8 for high school graduates and 117% higher than the rate of 4.7 for college graduates.

White mothers followed a similar pattern of IMR along the various educational categories as all races combined (Table 2). Among white mothers, the IMR for those who did not finish high school (9.0) was 88% higher than the IMR for those who had more than high school education (4.8). Among blacks, however, the IMR for mothers with less than 12 years of education (17.6) was only 34% higher than the rate for those with some college education (13.1).

Racial disparity in IMR persisted along various educational categories, but the gap widened with increasing educational level. Among mothers with less than 12 years of education, black IMR was 95% higher than white IMR, whereas among those with some college education, black IMR was 175% higher than the white IMR (Table 2, Figure 9). Similar findings have been reported from North Carolina indicating that higher education magnifies racial differences in infant mortality on a multiplicative scale (6). The possible reasons include greater stress, fewer economic resources, and poorer quality of prenatal care among blacks.

Live-birth order – Among all races, the IMR was lowest for the second live birth order (6.8) compared to the first (7.1), third (8.1), and fourth/higher (9.1) birth orders, however, the differences were not statistically significant (Table 2). Compared to whites, the IMR of blacks was higher by only 40% among first live births but was higher by 126-189% among those with second or higher live birth orders (Figure10).

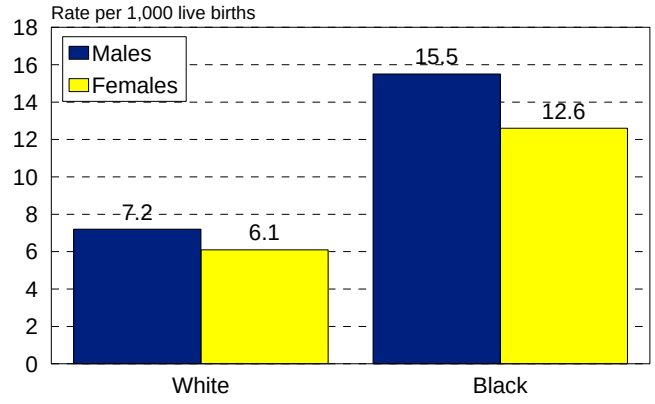

Figure 2. Infant mortality rates by sex and race: Indiana, 2002 linked file

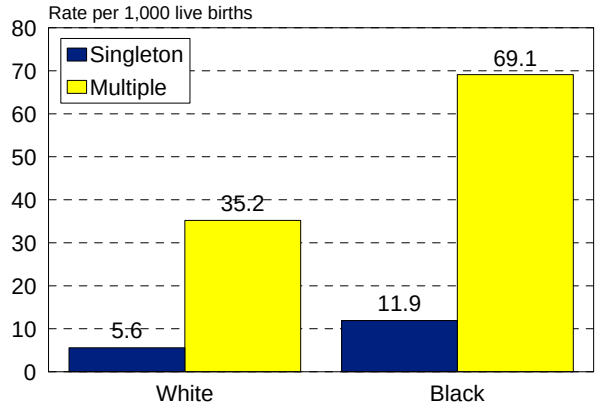

Figure 3. Infant mortality rates by plurality and race: Indiana, 2002 linked file

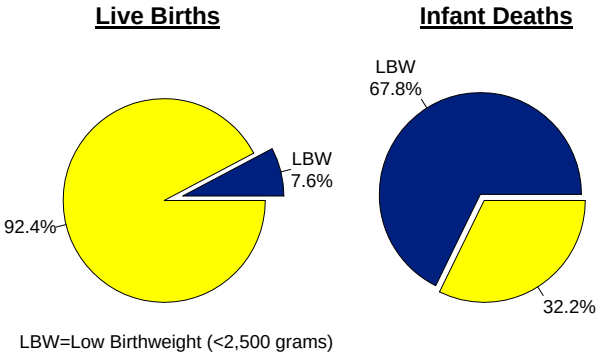

Figure 4. Prevalence of low birthweight: Indiana, 2002 linked file

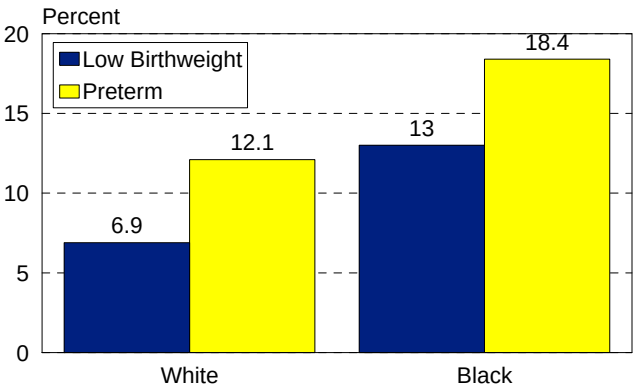

Figure 5. Prevalence of low birthweight and preterm birth by race: Indiana, 2002 live births

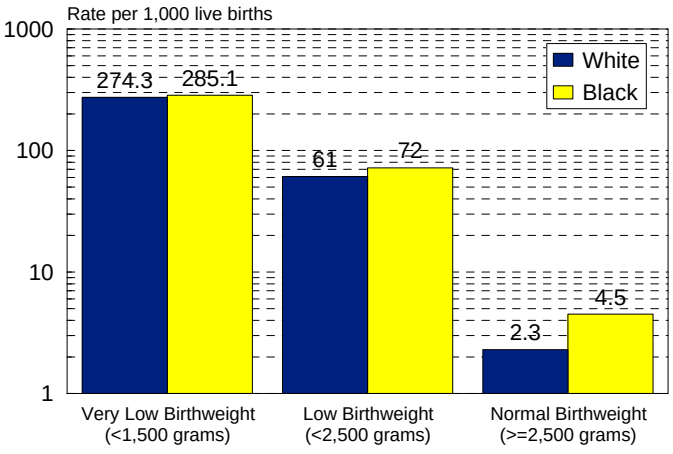

Figure 6. Infant mortality rates by birthweight and race: Indiana, 2002 linked file

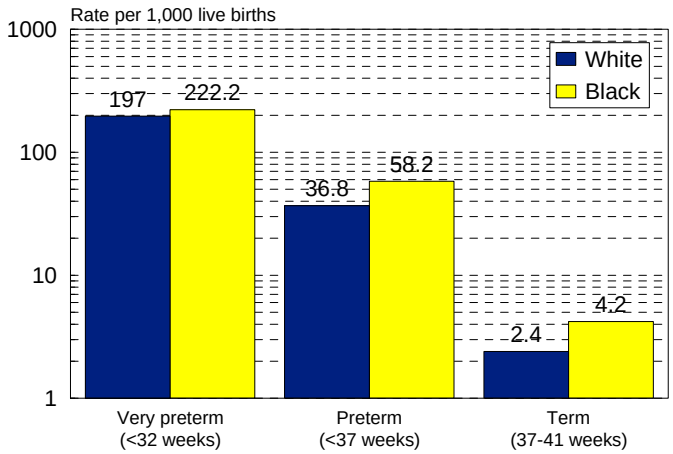

Figure 7. Infant mortality rates by gestational age and race: Indiana, 2002 linked file

Marital status - Among all races combined, the IMR for unmarried mothers was 10.5, 81% higher than the rate of 5.8 for married mothers (Table 2). Among the white population, the IMR of 5.8 for married mothers was significantly lower than the rate of 8.4 for unmarried mothers. Among the blacks, the IMR of unmarried mothers (15.4) was 51% higher than the rate among unmarried mothers (10.2), but the difference was not statistically significant (Table 2, Figure 11). The proportion of unmarried mothers differed substantially between the white and the black populations. Among whites, 31.9% of the live births and 40.3% of the infant deaths were to unmarried mothers in contrast to 76.6% and 83.2% among black mothers, respectively (Table 4).

Prenatal care - Infants born to mothers who began prenatal care after the first trimester had a mortality rate of 8.1, which was 27% higher than the rate for those who began prenatal care in the first trimester (6.4). The mortality rate for infants born to mothers who had no prenatal care was 46.8, more than 7 times the rate for those infants whose mothers received care during the first trimester (Table 2).

In 2002 in Indiana, 82.2% of the mothers initiated prenatal care during the first trimester. Racial disparity was apparent in the initiation of prenatal care. Among live births, 27.9% of black mothers did not receive prenatal care during the first trimester compared to 16.6% of white mothers (Table 4). The mortality rate was significantly higher among black infants compared to whites even when the prenatal care was initiated during the first trimester (Table 2, Figure 12). Mortality rates for black or white infants whose mothers had no prenatal care or began care in the third trimester could not be estimated, because the numbers of births and deaths in these high-risk categories were not large enough to establish reliable mortality rates.

In addition to initiation of the prenatal care as a measure, different prenatal care indices have been developed as alternative measures based on the timing of the prenatal care, as well as the number of prenatal visits, and the gestational age of the infant at birth. Among these indices are the Kessner/Institute of Medicine (IOM) index which defines care as “adequate”, “intermediate”, and “inadequate” (7). In this report, the Kotelchuck Adequacy of Prenatal Care Utilization (APNCU) index is used (8). This index also includes the adequate-plus care category for those women with unexpectedly large number of prenatal visits given the gestational age at delivery and the month prenatal care began.

The Kotelchuck index does not assess the quality of the prenatal care, simply its utilization. The prenatal care utilization is considered inadequate if care is initiated after the fourth month of pregnancy regardless of the number of visits. Once prenatal care is initiated during the first four months of pregnancy, then the index is classified into inadequate, intermediate, adequate, or adequate plus if the ratio of actual-to-expected number of visits is less than 50%, 50-79%, 80-109%, or 110% and more, respectively. The prenatal care index is considered unknown for mothers who have missing information/inconsistent values on the initiation of prenatal care, the number of visits, or gestational age, and for mothers with duration of gestation below 20 weeks and above 44 weeks (unacceptable values).

For mothers who received prenatal care, the IMR was highest in the adequate-plus category and lowest in the adequate category for all races combined as well as for whites and for blacks (Table 2). The IMR increased by more than 250% for adequate-plus care and by 197% for inadequate care compared to those who received adequate prenatal care. Adequate-plus category mainly includes women who are considered at high risk and receive extra prenatal services and have a disproportionately high share of low birthweight infants compared to other categories (9).

The mortality rate for infants with unknown information on adequacy of prenatal care was 48.0 deaths per 1,000 live births among whites and 53.0 among blacks (extrapolated from Table 3), a rate close to those with no prenatal care. Therefore, the population of mothers with missing information on adequacy of prenatal care must have mainly included those with no care at all who are at high risk for infant mortality and indicates a possible underestimation of IMR among infants whose mothers had no prenatal care. The proportion of infant deaths with an unknown prenatal care utilization index was 17.1% among whites and 16.0% among blacks.

Difference between the two major races was manifested by a higher proportion of inadequate care among blacks compared to whites in both the live birth and the infant death populations (Table 4). Infant mortality rates were higher among blacks compared to whites among all care categories (Figure 13), but the difference was statistically significant among infants of mothers who received adequate-plus care.

Maternal smoking - Significant increases in the risks of fetal and infant mortality have been demonstrated among infants born to smoking mothers (10). In 2002 in Indiana, 19.1% of all live births were to mothers who smoked during their pregnancy (Table 4). Smoking during pregnancy was more prevalent among white mothers (19.9%) than among black mothers (15.2%). The mortality rate for infants whose mothers smoked was 12.1, 89% higher than the rate of 6.4 among births to nonsmokers. The blacks had significantly higher infant mortality rates relative to whites regardless of the mother’s smoking status. The racial gap in IMR, however, was wider among smoking mothers than among the nonsmokers (Table 2, Figure 14).

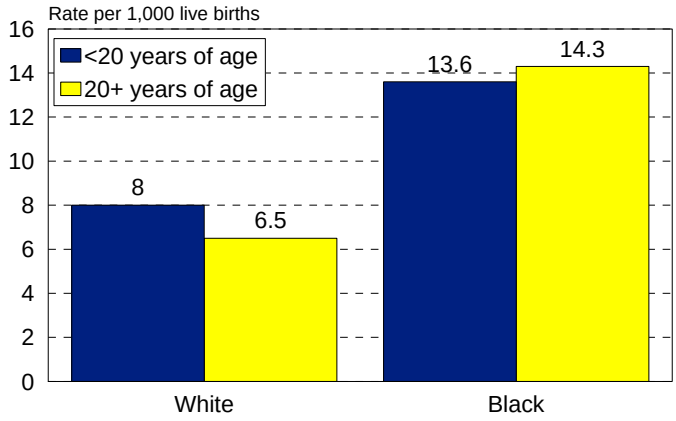

Figure 8. Infant mortality rates by mother's age and race: Indiana, 2002 linked file

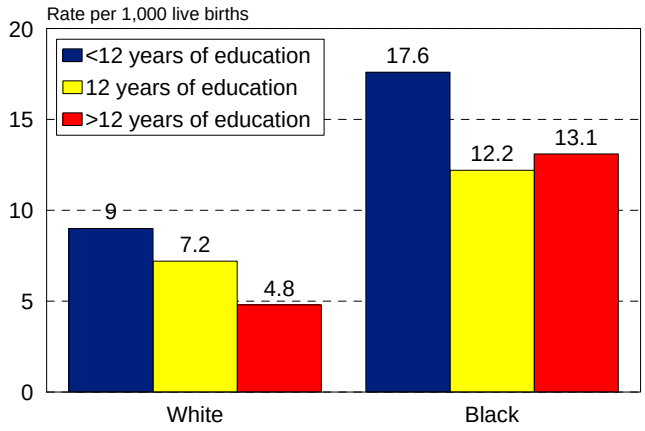

Figure 9. Infant mortality rates by mother's education and race: Indiana, 2002 linked file

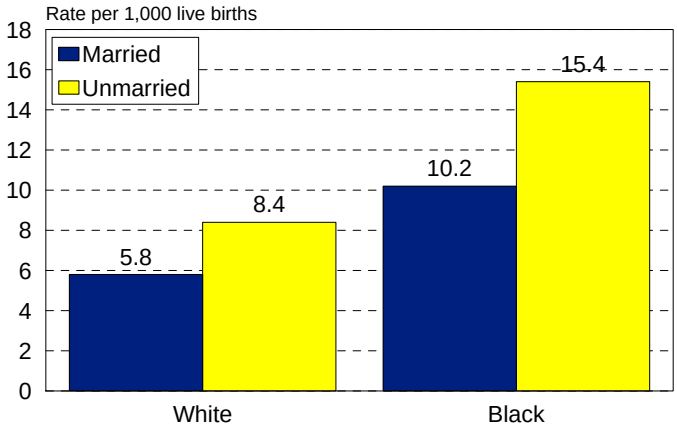

Figure 10. Infant mortality rates by mother's marital status and race: Indiana, 2002 linked file

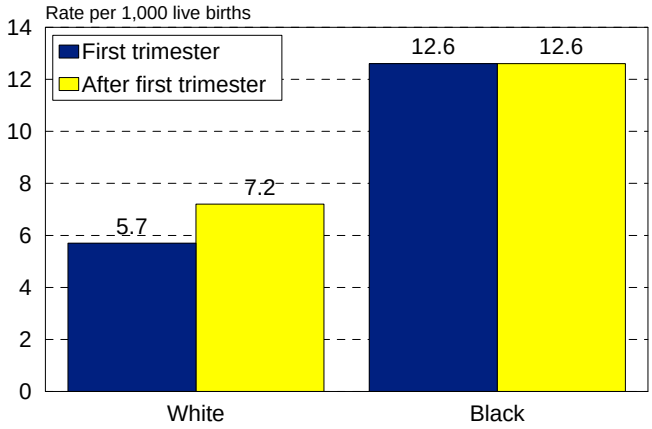

Figure 11. Infant mortality rates by trimester prenatal care began and race: Indiana, 2002 linked file

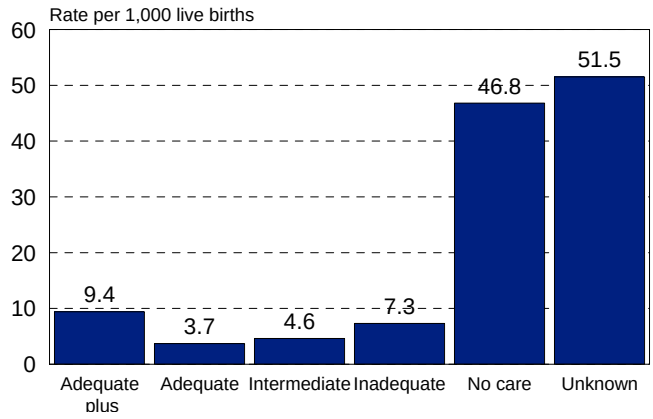

Figure 12. Infant mortality rates by adequacy of prenatal care: Indiana, 2002 linked file

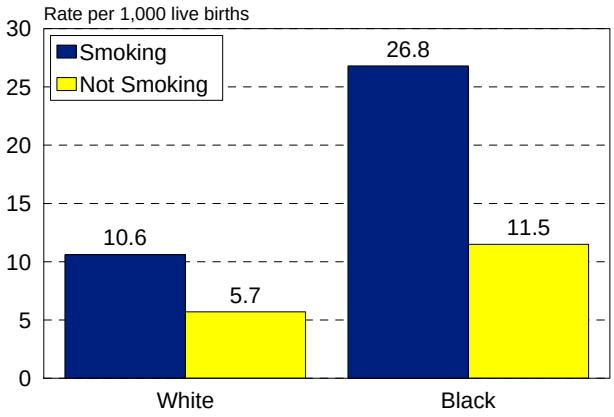

Figure 13. Infant mortality rates by maternal smoking and race: Indiana, 2002 linked file

Table 4. Percent of live births and infant deaths with selected maternal and infant characteristics by race of mother: Indiana, 2002 linked file

Characteristics	Live births			Infant deaths		
	All[1]	White	Black	All	White	Black
Infant						
Male	51.0	51.0	51.0	55.0	55.2	55.5
Multiple birth	3.4	3.4	3.8	17.9	16.8	17.8
Low birthweight (<2,500g)	7.6	6.9	12.9	67.8	66.3	70.6
Very low birthweight (<1,500g)	1.4	1.2	2.6	54.0	52.5	56.3
Preterm (<37 weeks)	12.8	12.1	18.4	69.2	67.3	76.0
Very preterm (<28 weeks)	2.0	1.8	3.9	55.2	53.1	61.2
Mother						
<20 years of age	11.4	10.5	20.0	13.7	12.6	18.6
<12 years of education	21.2	20.5	28.5	30.0	28.9	35.4
Fourth and higher order births	11.5	10.8	17.9	14.0	11.5	24.0
Unmarried	36.6	31.9	76.5	48.6	40.2	82.9
Prenatal care - Not in first trimester	17.8	16.6	27.9	20.8	19.8	25.2
Prenatal care - Inadequate[2]	11.4	10.3	19.7	13.0	11.7	18.5
Smoked during pregnancy	19.1	19.9	15.3	31.0	31.6	29.7

[1]Includes races other than black or white.

[2]Based on APNCU index (Kotelchuck, M. Am J Public Health 1994;84:1414-1420).

Table 5. Infant deaths and mortality rates for the 5 leading causes of death by race of mother: Indiana, 2002 linked file

(Rates per 100,000 live births in specified group)

Cause of Death	All races			White			Black		
(ICD-10 code)	Rank	Number	Rate	Rank	Number	Rate	Rank	Number	Rate
All causes	---	638	752.0	---	491	663.4	---	131	1417.3
Congenital anomalies	2	114	134.4	1	96	129.7	2	17	*
Disorders related to short gestation & low birthweight	1	118	139.1	2	85	114.8	1	27	292.1
Sudden infant death syndrome	3	39	46.0	3	34	45.9	5	5	*
Newborn affected by maternal complication of pregnancy	4	36	42.4	4	28	37.8	4	8	*
Accidents	5	34	40.1	5	23	31.1	3	11	*

*Figure does not meet standard of reliability or precision

--- Category not applicable

Leading causes of infant death

Infant mortality rates for the five leading causes of death in Indiana by race are presented in Table 5. The three leading causes of infant deaths in 2002 for whites were congenital anomalies, followed by disorders related to short gestation and low birthweight, and sudden infant syndrome (SIDS). These three causes accounted for 42.5% of all infant deaths and 43.8% of infant deaths among whites. Among blacks, the three leading causes of death had a different ranking compared to whites and included disorders related to short gestation and low birthweight as the leading cause, followed by congenital anomalies and accidents. These three causes accounted for 42.0% of infant deaths among blacks. Among whites, the fourth and fifth leading causes of infant death were newborns affected by maternal complications of pregnancy and accidents accounting for 10.4% of all deaths, whereas among blacks SIDS and newborns affected by maternal complications of pregnancy, respectively, accounted for 9.9% of deaths.

For infant deaths due to low birthweight and short gestation, the mortality rate was 292.1 per 100,000 live births for infants born to black mothers, 2.5 times the rate of 114.8 for infants born to white mothers. For other single causes of infant deaths, the number of deaths among infants born to black mothers was not large enough to give a stable IMR.

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Technical Notes

Random variation and stability of rates

In this report, the number of infant births and deaths represents complete counts for the State of Indiana. Therefore, the reported infant mortality rates are not subject to sampling error. However, when rates are compared over time, between areas, or among various subgroups, the number of events and the corresponding rates are subject to random variation. That is, the rate that actually occurred may be considered as one of a large number of possible different outcomes (rates) that could have arisen under the same circumstances (11). As a result, rates in a given population may tend to fluctuate from year to year even when the health of that population is unchanged. The simplest method for addressing the issue of random variation is the computation of 95% confidence interval. This interval indicates that it has 95% probability of including the true rate.

Random variation in rates based on a relatively small number of events tend to be larger than that for rates based on more frequently occurring events. A useful rule is that any rate based on fewer than 20 cases in the numerator (infant deaths in this report) will have a 95% confidence interval which is about as wide as the rate itself (1). For example, in an area with 20 deaths out of 1,000 live births, it can be said that the true rate is within 20 +/- 10 per 1,000, which is not precise information. For this reason, in this report, infant mortality rates based on fewer than 20 deaths are not reported. One way to deal with the stability problem is to combine several years of data to increase the number of events, reduce the effect of random variation, and improve the reliability of the mortality rates.

When the number of events, in this case the number of infant deaths, is large, the relative standard error (RSE) is small, and the binomial distribution is used to estimate the 95% confidence interval. When the number of events in the numerator (infant deaths) is less than 100, the confidence interval for the rate can be based on a Poisson distribution (12). The formula for RSE of the IMR is:

$$RSE = 100 \times SQRT (1/D+1/B),$$

where D is the number of deaths, B is the number of births, and SQRT denotes square root of the expression in parentheses.

The formula for 95% confidence interval based on binomial distribution is:

Lower: $IMR - 1.96 \times IMR \times RSE/100$

Upper: $IMR + 1.96 \times IMR \times RSE/100$

The formula for 95% confidence interval based on Poisson distribution using Table I is:

Lower: $IMR \times L (D_{adj})$

Upper: $IMR \times U (D_{adj})$

where D_{adj} is the adjusted number of infant deaths used to take into account the RSE of the number of infant deaths and live births and is computed as follows:

$$D_{adj} = \frac{D \times B}{D + B}$$

$L (D_{adj})$ and $U (D_{adj})$ refer to the values in Table I corresponding to the value of D_{adj}.

Comparison of two infant mortality rates

If either of the two IMRs to be compared (R_1 or R_2) is based on less than 100 infant deaths, first compute the 95% confidence interval for each rate and then check to see if they overlap. If they do overlap, the difference is not statistically significant at the 0.05 level. If they do not overlap, the difference is considered statistically significant.

If both rates are based on 100 or more deaths, the following Z-test is used to test for significance:

$$Z = \frac{R_1 - R_2}{SQRT [(R_1)^2 \times (RSE_1/100)^2 + (R_2)^2 \times (RSE_2/100)^2]}$$

If Z is equal to or greater than 1.96, the difference is statistically significant at the 0.05 level; and if Z is less than 1.96, the difference is not statistically significant.

Table I. Values of L and U for calculating 95 percent confidence limits for numbers of events and rates when the number of events is less than 100.

N	L	U	N	L	U	N	L	U
1	0.02532	5.57164	34	0.69253	1.39740	67	0.77499	1.26996
2	0.12110	3.61234	35	0.69654	1.39076	68	0.77654	1.26774
3	0.20622	2.92242	36	0.70039	1.38442	69	0.77806	1.26556
4	0.27247	2.56040	37	0.70409	1.37837	70	0.77955	1.26344
5	0.32470	2.33367	38	0.70766	1.37258	71	0.78101	1.26136
6	0.36698	2.17658	39	0.71110	1.36703	72	0.78244	1.25933
7	0.40205	2.06038	40	0.71441	1.36172	73	0.78384	1.25735
8	0.43173	1.97040	41	0.71762	1.35661	74	0.78522	1.25541
9	0.45726	1.89831	42	0.72071	1.35171	75	0.78656	1.25351
10	0.47954	1.83904	43	0.72370	1.34699	76	0.78789	1.25165
11	0.49920	1.78928	44	0.72660	1.34245	77	0.78918	1.24983
12	0.51671	1.74680	45	0.72941	1.33808	78	0.79046	1.24805
13	0.53246	1.71003	46	0.73213	1.33386	79	0.79171	1.24630
14	0.54671	1.67783	47	0.73476	1.32979	80	0.79294	1.24459
15	0.55969	1.64935	48	0.73732	1.32585	81	0.79414	1.24291
16	0.57159	1.62394	49	0.73981	1.32205	82	0.79533	1.24126
17	0.58254	1.60110	50	0.74222	1.31838	83	0.79649	1.23965
18	0.59266	1.58043	51	0.74457	1.31482	84	0.79764	1.23807
19	0.60207	1.56162	52	0.74685	1.31137	85	0.79876	1.23652
20	0.61083	1.54442	53	0.74907	1.30802	86	0.79987	1.23499
21	0.61902	1.52861	54	0.75123	1.30478	87	0.80096	1.23350
22	0.62669	1.51401	55	0.75334	1.30164	88	0.80203	1.23203
23	0.63391	1.50049	56	0.75539	1.29858	89	0.80308	1.23059
24	0.64072	1.48792	57	0.75739	1.29562	90	0.80412	1.22917
25	0.64715	1.47620	58	0.75934	1.29273	91	0.80514	1.22778
26	0.65323	1.46523	59	0.76125	1.28993	92	0.80614	1.22641
27	0.65901	1.45495	60	0.76311	1.28720	93	0.80713	1.22507
28	0.66449	1.44528	61	0.76492	1.28454	94	0.80810	1.22375
29	0.66972	1.43617	62	0.76669	1.28195	95	0.80906	1.22245
30	0.67470	1.42756	63	0.76843	1.27943	96	0.81000	1.22117
31	0.67945	1.41942	64	0.77012	1.27698	97	0.81093	1.21992
32	0.68400	1.41170	65	0.77178	1.27458	98	0.81185	1.21868
33	0.68835	1.40437	66	0.77340	1.27225	99	0.81275	1.21746

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