

Summary of Investigation of Recent Increase in Infant Mortality in Delaware
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Delaware Health and Social Services
Division of Public Health



After a decade of declining infant mortality rates (IMR), Delaware noted an increase beginning in the mid-1990s. In 1994–1996, Delaware’s IMR was 7.1/1,000 live births, while in 1999–2001, it was 8.8/1,000, a 24% increase. This paper describes a series of data analysis conducted by the Delaware Division of Public Health to characterize the increase.

Changes in Multiple Births, Birthweight, or Birthweight-specific Mortality Rates?

Several hypotheses to explain the increase in the IMR were investigated.¹ For this analysis, the 3-year period when Delaware’s IMR was lowest (1994–1996) was used as a baseline and compared with the most recent 3-year period for which data was available (1999–2001). IMR was adjusted for changes in multiple birth rates over time. The multiple-birth rate-adjusted IMR represents IMR in a given period, assuming the same plurality distribution as in 1994–1996. In this same way, IMR was adjusted for other factors, as described below. Refer to Figure 1.

- The rising multiple birth rate (from 3.0% in 1994–1996 to 3.6% in 1999–2001) may be responsible for the increased IMR, as multiple births have higher infant mortality than singleton births. However, direct adjustment for the increasing multiple birth rate did not explain much of the IMR increase (the plurality-adjusted IMR for 1999–2001 was 8.6, while unadjusted was 8.8). Moreover, infant mortality increased among singletons, not only twins and triplets-plus.
- The rising rate of low birthweight (LBW) and VLBW infants may be responsible. VLBW increased from 1.7% in 1994–1996 to 1.9% in 1999–2001 and VLBW infants are at the highest risk for infant mortality. Direct adjustment for birthweight distribution revealed that about a third of the increase in IMR was attributable to the fact that more LBW and VLBW babies were being born. The 1998–2000 birthweight-adjusted IMR was 8.2/1,000, still a 15% increase from the baseline of 7.1/1,000.
- An increase in birthweight-specific mortality may be responsible. There was very little change over time in IMR for normal birthweight and moderately LBW infants, but among VLBW infants, IMR increased from 235/1,000 to 312/1,000 (a 33% increase; Figure 2). When, in addition to the adjustment for birthweight distribution, the VLBW IMR was also assumed to remain constant, the adjusted IMR for 1999–2001 was 6.9/1,000. When the VLBW infants were broken down into plurality subgroups, we found that singletons had a 14% increase in mortality, twins had a 96% increase, and triplets-plus had more than a 450% increase in IMR.

¹Hathcock L, Silverman P, Drees M et. al. Increasing Infant Mortality Among Very Low Birthweight Infants – Delaware, 1994–2000. *MMWR* 52(36); 862–866. 2003.

Conclusion 1:

The IMR increase in Delaware had primarily occurred because of increased mortality among LBW and VLBW infants, and, to a lesser extent, an increase in the number of VLBW infants. Had these two trends not occurred, Delaware's IMR would have remained stable and similar to the national average.

Figure 1. Adjusted infant mortality rates (IMR), by plurality and birthweight distributions — Delaware, 1994-2001

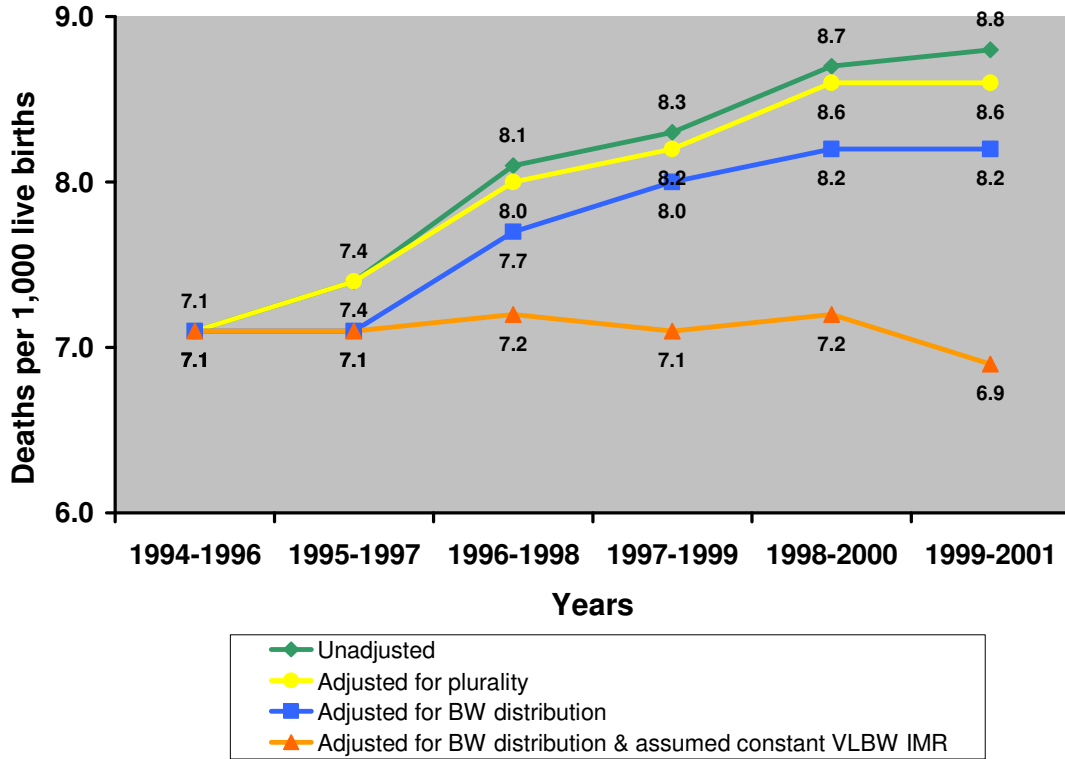
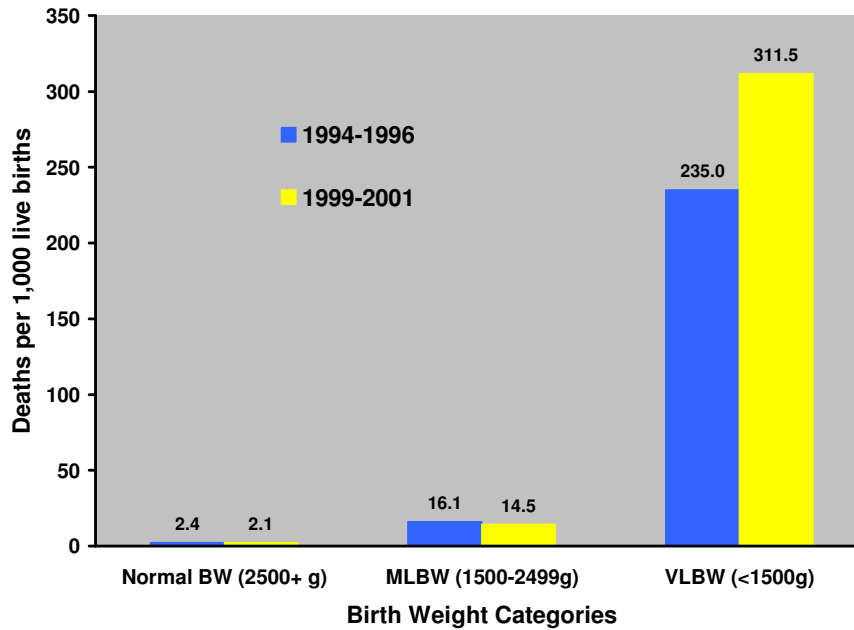


Figure 2. Birthweight-specific mortality rate trends — Delaware, 1994–2001.



A New High Risk Population?

We then performed a univariate analysis of the maternal characteristics of these VLBW infants.

Table 1. Infant Mortality Rate of Very Low Birthweight Infants by Selected Characteristics of Mother, Delaware.

		1994-1996	1998-2000
Mother's Age	<20 years	247.6	299.1
	20-29 years	271.0	297.6
	>29 years	151.9	287.1
Marital Status	Not married	313.4	297.5
	Married	149.8	290.4
County or City of Residence	Kent County	280	276
	Sussex County	288	283
	Wilmington City	293	264
	New Castle County other than Wilmington	177	315
Source of Payment	Self-pay	425.0	442.3
	Medicaid	281.6	259.9
	Private	181.2	294.7
1st Trimester of Prenatal Care	No	280.5	230.8
	Yes	224.1	301.8

Conclusion 2:

Mortality increased primarily among infants of non-traditional risk mothers (greater than 29 years, married, more educated, privately insured, initiated prenatal care in first trimester, residence in New Castle County outside Wilmington).

White verses Black: Different Problems?

We performed a series of Kitagawa analyses², which is a method of looking at a risk factor (in this case, birthweight) and analyzing the changing distribution of that risk factor and the changing mortality related to that risk factor at the same time. By doing multiple analyses of different subpopulations (racial/ethnic groups, plurality groups, etc.), one can begin to tease out the various issues related to infant mortality in the different groups.

The overall analysis (Table 2) confirmed that one-third (or 0.5/1,000) of the absolute increase in IMR (1.5) was due to birthweight distribution, while the remaining two-thirds was due to increased birthweight-specific mortality. Approximately half of the total increase in IMR is attributable to infants of less than 500 grams.

Table 2. Kitagawa analysis, all Delaware residents, 1994–1996 and 1998–2000.

	BW dist.	BW-specific mortality	Total
<500 g	0.4	0.3	0.7
500-999 g	0.1	0.5	0.6
1,000-1,499 g	0.0	0.2	0.2
Total	0.5	1.0	1.5
Total VLBW	0.5	1.0	1.5

However, when analyzed separately by race, we found that the extent to which these two factors contributed was quite different. Among whites (Table 3), there was a very small total increase in IMR (0.3/1,000), which was entirely due to birthweight-specific mortality rather than birthweight distribution. Among blacks (Table 4), aside from there being a larger overall increase in IMR (4.6/1,000), much of the increase was in the less than 500 gram birthweight group, and was split between birthweight distribution (~40%) and birthweight-specific mortality (~60%). The 500-999 gram group was affected among whites and blacks, while the less than 500 gram group was primarily affected among blacks.

Table 3. Kitagawa analysis, whites, 1994–1996 and 1998–2000.

	BW dist.	BW-specific mortality	Total
<500 g	0.0	0.1	0.1
500-999 g	0.0	0.4	0.3
1,000-1,499 g	0.0	0.1	0.1
Total	0.0	0.4	0.3
Total VLBW	0.0	0.5	0.5

Table 4. Kitagawa analysis, blacks, 1994–1996 and 1998–2000.

	BW dist.	BW-specific mortality	Total
<500 g	1.6	1.1	2.7
500-999 g	0.1	1.0	1.1
1,000-1,499 g	0.1	0.2	0.3
Total	1.8	2.8	4.6
Total VLBW	1.8	2.4	4.1

² Kitagawa, *EM. Components of the Difference Between Two Rates*. Am. Stat. Assoc. J. December 1955.

In addition, these analyses found that plurality distribution (i.e., more multiples being born) played a larger role in IMR for whites than for blacks, and singleton infant deaths played a larger role for blacks than for whites. Among all singletons, the increase in IMR was nearly entirely due to birthweight-specific mortality, while among multiple births, only ~40% was due to birthweight-specific mortality and ~60% was due to birthweight distribution (i.e., more small babies).

Conclusion 3:

There are likely two major components to the increase in IMR in Delaware. The birthweight distribution issue is largely in the less than 500 gram population and primarily affects blacks. The increasing birthweight-specific mortality problem is primarily in 500–999gram infants and affects both blacks and whites. These patterns suggest that there may be very different issues related to the increased IMR in these two birthweight groups.

Sicker Babies

We found that the proportion of infant deaths in the early neonatal period (days 0 to 6 of life) increased from 52% to 62% between 1994–1996 and 1999–2001, while decreasing in the late neonatal (days 7 to 27) and postneonatal periods. Within the early neonatal group, the increase was entirely explained by an increase in deaths on days 0 or one of life. Because this suggested that babies are being born more “sick,” we searched for other evidence that this may be the case either due to maternal or other risk factors.

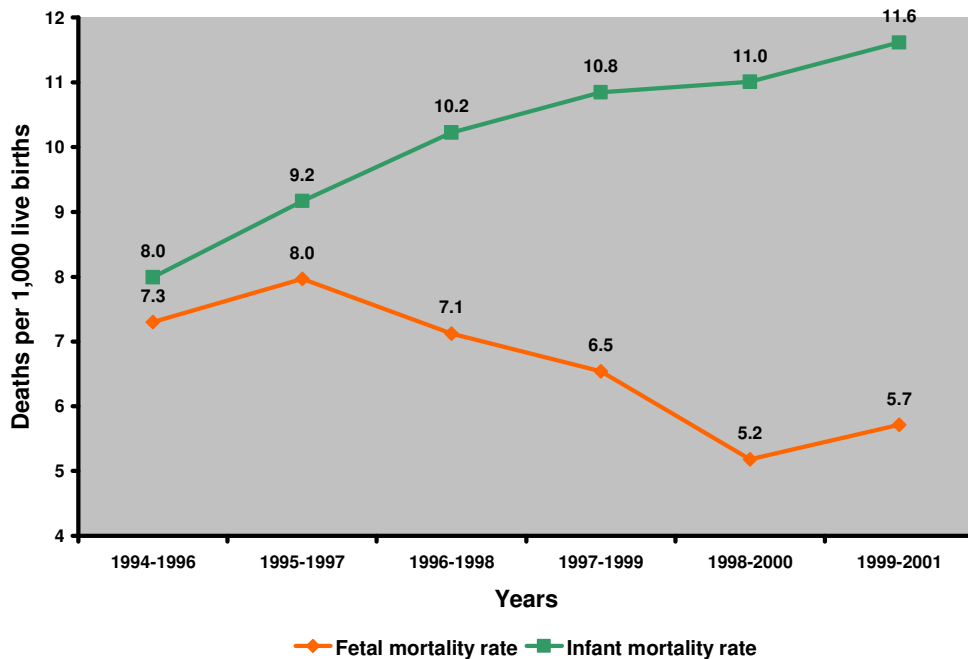
- We first looked at IMR trends among VLBW infants by cause of death as recorded on death certificates. We found that deaths caused by maternal complications increased from 15.5/1,000 to 28.4/1,000 (not statistically significant), while those from respiratory distress of the newborn increased from 7.8/1,000 to 25.1/1,000 ($p < 0.05$). There were no significant changes in the IMR for deaths due to short gestation, LBW, congenital malformations, or SIDS. However, cause of death for infants, particularly VLBW infants, is not always recorded reliably.
- We also examined birth certificate data and found no significant increases in any specific newborn complications or birth defects, but these are known to be underreported. Among the labor complications, fetal distress increased from 3.2% of all births in 1994–1996 to 5.1% in 1998–2000 (a 50% increase), and from 8.3% to 11.7% of VLBW births (a 41% increase).
- We examined the hospital discharge database but there appeared to be significant underreporting of newborn complications, particularly in the latter time period.
- Dr. David Paul, a neonatologist at Christiana Care Health Center, had done independent research on approximately 1,400 VLBW infants born in their facility during 1993–2002 and found that the Score for Neonatal Physiology (SNAP) calculated on the first day of life had increased (indicating more illness) between the 1996–1999 and 2000–2003 cohorts. Thyroid (T4) levels were also obtained on day five of life and decreased (indicating greater illness) during the study period.

Various hypotheses were suggested to explain the possibility of “sicker” babies:

- Perhaps due to maternal or other risk factors, babies are being born more “sick” and their deaths have very little to do with the care they receive after birth.
- Obstetric care may have changed resulting in either postponement of fetal deaths (but with resultant neonatal deaths) or in truly worse obstetric outcomes.
- There could be a change in reporting and/or classification of late fetal deaths, such that infants that previously would have been considered fetal deaths are now considered live births and thus are included in the calculation of IMR (whereas fetal deaths are not).

The first hypothesis is largely unexplored. If either of the second two hypotheses are true we would expect to see declining fetal mortality rates (FMR) concurrent to an increase in the IMR, and the overall perinatal mortality rate would remain stable. Unfortunately the reporting of fetal deaths in Delaware is incomplete and therefore statewide FMR is unreliable. However, we did examine infant and fetal deaths recorded in the Christiana Care Health Center’s database (where a large proportion of Delaware’s infants are born), and found that indeed, Christiana’s FMR has declined as their IMR has increased (Figure 3). Whether this is due to classification or survival issues, or both, has yet to be determined.

Figure 3. Fetal and infant mortality rates of infants born to Delaware resident mothers at Christiana Hospital, 1994-2001.



Finally, because of the non-traditional material risk factors associated with Delaware’s increasing IMR, there is concern that infertility treatment, including Assisted Reproductive Technology (ART) may be responsible. Evidence exists that singletons born through use of ART have higher rates of LBW and congenital malformations than infants who were conceived naturally. Because insurance coverage for ART often is limited or lacking (and is not mandated in Delaware), parents of infants conceived from these treatments tend disproportionately to have high socioeconomic status. Infertility itself may result in less healthy pregnancies.

Although the rising multiple birth rate itself was shown not to be responsible for the increase in IMR in Delaware, the fact that IMR is increasing so dramatically among VLBW twins and triplets-plus, and less dramatically among singletons, warrants investigation of infertility treatments. Unfortunately there is no data regarding infertility treatments in the linked birth-death certificate database. However, CDC does maintain an ART database, which includes data from ART providers regarding outcomes of their procedures, including plurality and birthweight (but not infant mortality). Using this database, we determined that there had been a 13% increase in ART use in Delaware from 1996–2000, and use also increased in surrounding states (women frequently cross state lines to access ART). We estimated that 1% of Delaware’s 2000 birth cohort were conceived using ART, as were 7.5% of VLBW infants born in 2000. Approximately 17% of multiple births in Delaware were likely due to ART, while approximately 56% occurred naturally and 28% were due to other infertility treatments. This increase in use of ART in Delaware is similar to that in other states, and in fact some states (such as Massachusetts, where insurance coverage of ART procedures is mandated) have experienced greater increases in ART use without increases in infant mortality rates.

Conclusion 4:

There is evidence that babies are being born sicker today than in 1994-1996. While several hypotheses have been suggested, the reason for this is not clear.

Sicker Moms?

If infants are sicker at birth, perhaps part of the issue is that the women giving birth are also sicker, or at least less healthy. Infertility again may be contributing here, as there are published studies that suggest that older mothers may have biologic factors that make them less capable of maintaining a healthy pregnancy. Subfertile couples, who take more than one year to conceive but do not undergo any infertility treatment, may be at higher risk for having low birthweight infants. We have no evidence in Delaware to confirm or disprove this concept. We did look at other data sources for mothers’ health, however.

- Birth certificate data (Table 5) revealed increases in diabetes, pregnancy-associated high blood pressure, and other medical risk factors between the two time periods. There were also increases in the rates of procedures, such as tocolysis (medication to stop premature labor) performed, and increases in labor complications, such as placental abruption, among mothers of VLBW infants.
- Similarly, hospital discharge data (Table 6) revealed an increase in diabetes, infections, and other pregnancy complications, and a decrease in deliveries classified as “normal.” Of note, however, is that both hospital discharge and birth certificate data suffer from incomplete recording.
- Lastly, we examined Behavioral Risk Factor Surveillance System (BRFSS) data (Table 7), which is a telephone survey of non-institutionalized residents of Delaware. We limited our analyses to answers given by women of childbearing age (defined as 18–44 years). Unlike the previous data source, BRFSS provides some insight into women’s preconception health, as it includes all women, not just those who are already pregnant. Questions that address access to health care showed significant improvement in access. However, rates of binge drinking, overweight and obesity had increased between the two time periods. Self-reported rates of diabetes and high blood pressure were unchanged.

None of the data sources (BRFSS, birth certificate, or hospital discharge) showed an increase in smoking or regular alcohol use.

Table 5. Number (%) of infants with selected maternal medical risk factors, obstetric practices, and labor complications, all Delaware VLBW births, as recorded on birth certificates

	1994–1996 N = 515		1998–2000 N = 598	
	n	%	n	%
Maternal complications				
Preg-assoc. hypertension	61	11.8	81	13.5
Cardiac disease	3	0.6	7	1.2
Acute/chronic lung disease	8	1.6	24	4.0
Diabetes	10	1.9	27	4.5
Obstetric procedures				
Ultrasound	247	48.0	511	85.5
Tocolysis	41	8.0	143	23.9
Amniocentesis	11	2.1	23	3.8
Induction of labor	43	8.3	65	10.9
Labor complications				
Abruptio placenta	26	5.0	60	10.0
Prem. rupture of membranes	123	23.9	157	26.3
Precipitous labor	15	2.9	35	5.9
Breech/malpresentation	83	16.1	114	19.1
Other complications of labor	67	13.0	99	16.6

Table 6. Maternal complications as recorded in hospital discharge data, all Delaware residents.

Maternal complication	1994–1996 N = 26,148		1998–2000 N = 29,092	
	n	%	n	%
Normal delivery	3,843	14.7	2,631	9.0
Infections	166	0.6	496	1.7
Other conditions	1,580	6.0	2,079	7.1
– Diabetes	37	0.1	87	0.3
Other pregnancy complications	337	1.3	1,003	3.4
Umbilical complications	5,489	21.0	7,458	25.6
Other indications for care related to labor, NOS	731	2.8	1,833	6.3

Table 7. BRFSS data, Delaware women aged 18-44 years, 1994–2001

	1994–1996 n = 1,991		1998–2000 n = 2,314	
	n	%	n	%
No health plan	273	13.7	249	10.8
Needed to see doctor but could not due to cost	313	15.7	279	12.1
Had routine checkup within last year	1,418	71.2	1,812	78.3
Any binge drinking (≥5 drinks per occasion) (95/97 & 99/01 data only)	83	6.0	207	12.0
Overweight (BMI ≥27.3)[¶]	485	24.4	434	28.4
Obese (≥120% of ideal body weight)[¶]	571	28.7	716	46.9

[§] 1994/1996: n = 1,324; 1998/2000: n = 1,533

[¶] Latter groups uses 1998-99 data only, because definitions used for overweight/obesity changed between 1999 and 2000, therefore 2000 data is not easily comparable. 1998/1999: n = 1,529

Conclusion 5:

There is some data suggesting that the health of pregnant women and women of childbearing age is worsening, but the implications of this on the increased infant mortality rate is not clear.

Summary

- The IMR increase in Delaware had primarily occurred because of increased mortality among LBW and VLBW infants, and, to a lesser extent, an increase in the number of VLBW infants. Had these two trends not occurred, Delaware’s IMR would have remained stable and similar to the national average.
- Mortality was increasing primarily among infants of non-traditional risk mothers (greater than 29 years, married, more educated, privately insured, initiated prenatal care in first trimester, residence in New Castle County outside Wilmington).
- There are likely two major components to the increase in IMR in Delaware. The birthweight distribution issue is largely in the less than 500 gram population and primarily affects blacks. The increasing birthweight-specific mortality problem is primarily in 500–999gram infants and affects both blacks and whites. These patterns suggest that there may be very different issues related to the increased IMR in these two birthweight groups.
- There is evidence that babies are being born sicker today than in 1994-1996. While several hypotheses have been suggested, the reason for this is not clear.
- There is some data suggesting that the health of pregnant women and women of childbearing age is worsening, but the implications of this on the increased infant mortality rate is not clear.

What Next?

The increase in IMR in Delaware is a complex problem. There is strong evidence that the population affected is different than we have seen before. New approaches, appropriately targeted to a different population, will probably be required.

The analyses described in this paper suggests the need for additional research:

- Evaluate the impact of changes in fetal death reporting on the IMR. Infants that previously would have been considered fetal deaths could now be considered live births and thus included in the calculation of IMR (whereas fetal deaths are not). Because fetal death reporting in Delaware is unreliable, it will be necessary to review existing hospital records to ascertain complete reports. A protocol for a pilot project for this purpose is under development.
- Evaluate the impact of changes in obstetric care that may have resulted in either postponement of fetal deaths (but with resultant neonatal deaths) or in truly worse obstetric outcomes.
- Evaluate the impact of changes in maternal or other risk factors, including prepregnancy health, that may be responsible for babies being born more “sick.” This includes the role of ART or other infertility treatment.
- Determine if any of the above issues can explain the different patterns of IMR observed among black and whites.
- New data sources may be necessary to understand this problem. For example, consideration should be given to adding method of conception (ART) to birth certificates, and to re-evaluating the role of a Fetal and Infant Mortality Review (FIMR) Program.