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COMMENTARY

State Infant Mortality Rate Calculations Vary by Classification of Pre-Viable Infants

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Introduction

The infant mortality rate of a state or country is used a measure of the overall health of that region [1]. The infant mortality rate is defined as the number of deaths of children under one year of age per 1,000 live births, and although this definition is standard worldwide, the variability in definitions and reporting standards for live births and fetal deaths makes comparisons between and among regions problematic [2]. Prior research has noted a difficulty comparing rates of Infant Mortality (IMR) in the United States to rates in other countries due to variation in reporting of births at the early stages of viability [3]. Some European countries require a minimum gestational age of 22 weeks or a birth weight threshold of 500 g to register a live birth, while the United States and Canada register higher numbers of infants weighing less than 500 g; this results in higher reported infant mortality rates [2].

Comparisons between and even within states in the United States suffer from similar difficulties; the number of live births along with the number of deaths of pre-viable infants differ due to regional reporting differences [4]. When these data are used as the basis for policy making, they could potentially result in the mistargeting of resources from states with the greatest need to states whose levels of need may be over-inflated based on an artifact of the reporting standard. In addition, the definitions create challenges when developing and delivering targeted interventions because they obscure the line between those infants and mothers who would benefit from postnatal interventions to prevent infant mortality (e.g., those born at gestational ages > 22 weeks) and those who require prenatal interventions (e.g., those with peri-viable gestational ages or fetal deaths) to prevent miscarriages, fetal death, and extremely preterm birth [5].

While the Centers for Disease Control and Prevention (CDC) promulgates a national definition of live birth and fetal death, some states include clarifying statements of what constitutes a fetal death while others do not [4]. This results in major differences in fetal death reporting requirements by state [4]. For example, in New York, all fetal deaths -- regardless of gestational age -- are reported. In Ohio, all fetal deaths of gestation ≥ 20 weeks are reported, while in Kansas, fetal deaths of weight ≥ 350 grams are reported [4]. As a result, the non-live birth of an infant weighing 300 grams at 19 weeks of gestation would be reportable in New York and not in Kansas or Ohio. In contrast, if that infant were born at 20 weeks of gestation, the death

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would only be non-reportable in Kansas based on the weight requirement. Infant mortality and fetal death rates may be distorted in states where rules create a documentation requirement that suggest a false dichotomy between the two criteria, or a documentation gap where a birth event neither meets the criteria of an infant live birth nor a fetal death, as in the latter Kansas case. To our knowledge, the only available collection of these state-level definitions and requirements is from 1997 [4]. Updates to fetal death definitions and further specification of live birth definitions that are consistent across states are necessary to prevent documentation differences.

There are also differences between states in documentation of deaths from pre-viable births. While no infant born at 21 weeks and 5 days gestation or less has ever lived past infancy in the United States, numerous infants at these early, pre-viable, gestational ages are classified as live births based on the definition criteria. There is evidence that all U.S. states have publicly reported infant mortality data from pre-viable gestational ages; however, these rates differ between states due to the proportion of pre-viable live births reported [6]. Further investigation regarding these statewide differences and the effects on infant mortality rates is necessary to understand why there is a need for new reporting standards.

This paper uses Ohio Vital Statistics birth records derived from an evaluation of the Ohio Infant Mortality Reduction Initiative (OIMRI) and national data from the Centers for Disease Control and Prevention to explore these challenges and suggest changes that would improve our ability to compare state-level data.

Methods

Ohio birth records and death records from Ohio Vital Statistics were used to examine deaths within Ohio. Records were linked using birth certificate numbers. Due to data availability and the scope of the original evaluation these analyses were completed for, only data for years 2008-2015 are used from these Ohio datasets. National data for all states and Washington DC from 2007 to 2017 were acquired from the CDC Wonder database [6]. Variables used included number of live births, number of infant deaths, and gestational age at birth. Descriptive statistics including counts, percentages, birth rates, and infant mortality rates were calculated.

Results

In Ohio birth record data, 554 (6.83%) of deaths from 2008-2015 were from infants under 20 weeks of gestation, and 1,461 (18.01%) of the infant deaths were from pre-viable live births (< 22 weeks), despite accounting for under 0.2% of all live birth records (Table 1). The infant mortality rate for all linked records in our Ohio dataset was 7.16 per 1000 births. However, when infants born at less than 22 weeks were excluded, the state's infant mortality rate became 5.87 per 1000 births.

In CDC Wonder data for 2007-2014 for all states and Washington DC, all U.S. states have publicly reported infant mortality data from pre-viable gestational ages (Table 2) [6]. The percentage of all infant deaths from < 22 weeks of gestation ranges from 8.3% in West Virginia to 24.0% in Rhode Island (Ohio's percentage was 18.4%). While infants born at less than 22 weeks of gestation-

Table 1: Contribution of gestational age to the infant mortality rate in Ohio, 2008-2015.

Weeks gestation at birth	Number of deaths (2008-2015)	% of all deaths from this category	Portion of Total IMR from this group (# deaths/total number of Ohio Births 2008-2015)[1] x 1000	IMR excluding each category (Total IMR - portion from each gestation category)
< 20 weeks	554	6.83	0.49	6.67
< 21 weeks	941	11.60	0.83	6.33
< 22 weeks	1461	18.01	1.29	5.87
< 23 weeks	2035	25.08	1.80	5.37
< 24 weeks	2562	31.58	2.26	4.90
< 25 weeks	2975	36.67	2.63	4.54
< 27 weeks	3507	43.22	3.10	4.07
< 29 weeks	3859	47.56	3.41	3.76
< 31 weeks	4118	50.75	3.64	3.53
< 35 weeks	4813	59.32	4.25	2.91
< 39 weeks	6324	77.94	5.58	1.58
< 43 weeks	7777	95.85	6.87	0.29
< 49 weeks	7863	96.91	6.94	0.22
All gestation (Total IMR)	8114[2]	100.00	7.16	

[1]The number of total births for the matched Ohio birth and death records was 1,132,798; [2]There were 251 linked deaths with a missing gestation week on the birth record.

Table 2: Infant mortality rates and rankings by state, 2007-2017.

State	Deaths (21 weeks gestation or less)	Births (21 weeks gestation or less)	Births (all gestational ages)	Deaths (All gestational ages)	Births less than 22 weeks/1000 births[1]	% of deaths less than 22 weeks	IMR < 22 weeks[1]	IMR total[1]	IMR Rank	IMR (total - < 22 weeks)	Modified IMR Rank	Rank Change[2]
Massachusetts	658	746	805682	3550	0.926	18.535	0.817	4.406	1	3.590	1	0
New Hampshire	73	81	140819	626	0.575	11.661	0.518	4.445	2	3.927	2	0
Vermont	42	45	66691	310	0.675	13.548	0.630	4.648	3	4.019	3	0
California	3551	4063	5611128	26170	0.724	13.569	0.633	4.664	4	4.031	4	0
Washington	547	640	971809	4563	0.659	11.988	0.563	4.695	5	4.132	7	2 worse
New Jersey	851	1043	1169043	5567	0.892	15.287	0.728	4.762	6	4.034	5	1 better
New York	1995	2274	2655595	13285	0.856	15.017	0.751	5.003	7	4.251	8	1 worse
Iowa	267	362	432542	2173	0.837	12.287	0.617	5.024	8	4.407	11	3 worse
Minnesota	614	717	769834	3895	0.931	15.764	0.798	5.060	9	4.262	9	0
Oregon	337	367	506900	2573	0.724	13.098	0.665	5.076	10	4.411	12	2 worse
Utah	419	448	571535	2934	0.784	14.281	0.733	5.134	11	4.400	10	1 better
Colorado	602	641	734478	3909	0.873	15.400	0.820	5.322	12	4.503	13	1 worse
Connecticut	506	569	411835	2199	1.382	23.010	1.229	5.340	13	4.111	6	7 better
Idaho	198	213	255120	1381	0.835	14.337	0.776	5.413	14	4.637	14	0
Nebraska	224	252	290417	1603	0.868	13.974	0.771	5.520	15	4.748	17	2 worse
Nevada	274	348	403645	2251	0.862	12.172	0.679	5.577	16	4.898	18	2 worse
Alaska	60	71	123706	700	0.574	8.571	0.485	5.659	17	5.174	24	7 worse
Hawaii	210	230	205962	1171	1.117	17.933	1.020	5.686	18	4.666	15	3 better
New Mexico	185	223	298677	1701	0.747	10.876	0.619	5.695	19	5.076	20	1 worse
Texas	3329	4736	4332267	25619	1.093	12.994	0.768	5.914	20	5.145	22	2 worse
Arizona	852	981	978912	5790	1.002	14.715	0.870	5.915	21	5.044	19	2 better
Wyoming	52	54	83733	498	0.645	10.442	0.621	5.947	22	5.326	27	5 worse
Montana	70	80	135010	810	0.593	8.642	0.518	6.000	23	5.481	32	9 worse
Wisconsin	755	825	751921	4622	1.097	16.335	1.004	6.147	24	5.143	21	3 better
Rhode Island	182	193	122990	758	1.569	24.011	1.480	6.163	25	4.683	16	9 better
North Dakota	86	95	110908	687	0.857	12.518	0.775	6.194	26	5.419	31	5 worse
Maine	151	157	142755	888	1.100	17.005	1.058	6.220	27	5.163	23	4 better
Florida	2606	2954	2441475	15799	1.210	16.495	1.067	6.471	28	5.404	29	1 worse

Virginia	1367	1611	1140897	7410	1.412	18.448	1.198	6.495	29	5.297	25	4 better
Illinois	2237	2648	1791906	11740	1.478	19.055	1.248	6.552	30	5.303	26	4 better
Kansas	444	472	437653	2868	1.078	15.481	1.015	6.553	31	5.539	33	2 worse
Missouri	844	1021	843576	5617	1.210	15.026	1.001	6.659	32	5.658	34	2 worse
Pennsylvania	2155	2411	1576823	10582	1.529	20.365	1.367	6.711	33	5.344	28	5 better
Kentucky	474	691	620235	4200	1.114	11.286	0.764	6.772	34	6.007	37	3 worse
South Dakota	124	140	133304	907	1.050	13.671	0.930	6.804	35	5.874	36	1 worse
Maryland	1220	1345	814487	5630	1.651	21.670	1.498	6.912	36	5.414	30	6 better
Michigan	1611	1985	1271229	8889	1.561	18.124	1.267	6.992	37	5.725	35	2 better
South Carolina	665	781	646388	4681	1.208	14.206	1.029	7.242	38	6.213	42	4 worse
West Virginia	136	171	225462	1633	0.758	8.328	0.603	7.243	39	6.640	44	5 worse
Georgia	1567	2133	1486136	10793	1.435	14.519	1.054	7.262	40	6.208	41	1 worse
Indiana	975	1195	932630	6821	1.281	14.294	1.045	7.314	41	6.268	43	2 worse
North Carolina	1849	2085	1353015	10124	1.541	18.264	1.367	7.483	42	6.116	40	2 better
Tennessee	728	859	899038	6731	0.955	10.816	0.810	7.487	43	6.677	45	2 worse
Ohio	2138	2410	1552654	11631	1.552	18.382	1.377	7.491	44	6.114	39	5 better
Oklahoma	525	679	585296	4435	1.160	11.838	0.897	7.577	45	6.680	46	1 worse
Arkansas	338	432	428480	3255	1.008	10.384	0.789	7.597	46	6.808	47	1 worse
Delaware	205	225	124279	954	1.810	21.488	1.650	7.676	47	6.027	38	9 better
Louisiana	784	1208	700039	5718	1.726	13.711	1.120	8.168	48	7.048	49	1 worse
District of Columbia	181	211	102686	890	2.055	20.337	1.763	8.667	49	6.905	48	1 better
Alabama	811	986	665015	5784	1.483	14.021	1.220	8.698	50	7.478	50	0
Mississippi	454	580	443953	4149	1.306	10.942	1.023	9.346	51	8.323	51	0

[1]10 highest rates in this column are shaded; [2]Rank changes in this column are shaded light if they improved and dark if they got worse.

al age accounted for 0.57/1000 live births in Alaska, the rate in Washington DC was more than three times as high at 2.05/1000 [6]. (Ohio's rate was 1.59/1000). These differences seem to correspond with overall infant mortality rates in these states. Of the 10 states with the highest proportion of pre-viable live births, 6 were in the top 10 highest rates of infant mortality in this database. If the infant mortality rate from those with pre-viable births and deaths is subtracted from the infant mortality rate, the calculated infant mortality rate decreases for all states. For the states with the highest rate of pre-viable live births, this decrease is disproportionately large.

If states were ranked based on these CDC WONDER data, the change in rank by removing pre-viable live births would change Ohio's ranking by 5 spots, from 44 to 39. Of those states with the 10 highest rates of pre-viable live births reported, 8 would have improvements in rank, while the 10 with the lowest rates of pre-viable live births would all decrease or stay the same in rank.

Discussion

Ohio-specific data show that pre-viable births have a large impact of the infant mortality rate. Subsequent analysis of CDC Wonder data shows that the proportion of pre-viable live births and their effect on the infant mortality rate differs substantially among states. These findings are supported by the work of Goyal and DeFranco [7]. Using the US National Center for Health Statistics data from > 2000 US counties, Goyal and colleagues found variation by US region in the proportion of early gestation births (17-20 weeks of gestation) categorized as fetal deaths versus live births with a subsequent death [7]. They found that for every 1 point increase in the fetal death percentage, there was an associated 0.02 point decrease in a county's infant mortality rate; they concluded that the variability in reporting requirements makes county-to-county comparisons challenging. In another study, DeFranco and colleagues found racial disparity in the infant mortality rates of pre-viable infants in Ohio [8]. Births at gestational ages between 16 and 22 weeks accounted for 45% of Non-Hispanic Black infant mortality and thus may explain part of the racial disparity in infant mortality in Ohio [8]. These researchers also raised the concern that this phenomenon can be obscured when pre-viable infants are included in state rates instead of separately examining these rates.

When one considers the implications of infant mortality rates on strategic priorities within each state, between states, and internationally, it becomes increasingly important that data enable an apples-to-apples comparison [9,10]. When comparing the United States to countries in Europe, often births at pre-viable gestational ages are excluded and the disparity between the United States and other European countries decreases [10]. We submit that the national surveillance definition of infant mortality should be changed to exclude pre-viable live births. We acknowledge that picking a specific gestational age cutoff is difficult as there is no clear cutoff that determines viability, and with improvements in neonatal intensive care, this is a moving target. However, for a surveillance definition to be accurate and allow for reasonable comparisons between states, it is vital that state-to-state variability in measurement and documentation be minimized. In addition, the reporting of fetal deaths should be standardized across states and adjusted to avoid a documentation gap. As state definitions have not been collected and documented since 1997, these definitions should be standardized, updated, and disseminated. We note that we are not proposing that doctors cease collecting pre-viable birth data, rather we submit that post-hoc analysis of data on infant mortality should be focused on those cases where medical technology exists to intervene.

Additionally, this approach would allow for the ongoing and expanded collection of pre- and peri-viable infant mortality data, which could offer important insights into contributing factors and the health of the community. More clearly differentiating the infant mortality rate, fetal death rate, and pre-viable infant birth rate will allow intervention programs to be properly tailored to both populations and regional challenges. Areas with high rates of pre-viable births and fetal deaths may have very different risk factors and educational needs than those with high infant mortality rates. Interventions in regions with rising infant mortality rates could focus on improving perinatal and postnatal care while in areas with rising rates of fetal death and pre-viable births, interventions intended to prolong pregnancy might need to be a stronger focus. As infant mortality rates are frequently compared among states, further standardization of infant mortality rate calculations would make such comparisons much more appropriate as policy-makers continue their efforts to reduce infant mortality in the United States.

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Author Contribution

All authors contributed to the design, analysis or interpretation, writing and editing of this work.

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