DISCUSSION PAPER

Vital Signs for Pediatric Health: Infant Mortality

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June 26, 2023

This paper is part of a series on pediatric vital signs. The other selected measurements in this series include school readiness, chronic absenteeism, and high school graduation. These papers can be found at https://doi.org/10.31478/202306b, https://doi.org/10.31478/202306c, and https://doi.org/10.31478/202306d.

Introduction

In 2015, the Institute of Medicine (now the National Academy of Medicine) released the report *Vital Signs: Core Metrics for Health and Health Care Progress* as a "basic, minimum slate of core metrics for use as sentinel indices of performance at various levels with respect to the key elements of health and health care progress" (IOM, 2015). Although indicators of pediatric health were included in that report as key elements of healthy behaviors, healthy communities, and preventive services, the core measures in the report emphasized indicators of adult health. This series of papers, "Vital Signs for Pediatric Health", describes four metrics across the pediatric life course, each measuring how well the health care system is building the physical, cognitive, and socio-emotional health of the pediatric population, thereby laying the foundation for life-long health and well-being. The metrics—infant mortality, school readiness, chronic absenteeism, and high school graduation—were selected to focus on four different developmental stages of growth. A standardized set of core metrics to assess pediatric health could provide data to support health systems in identifying important areas for attention among their pediatric population and enable them to respond in a timely way. This rapid response is especially important in pediatric health systems as children undergo rapid development within a short time span.

This paper discusses one of those four measures—infant mortality rate (IMR)—as a measure of the early period of life. IMR is used globally as a key indicator of child survival. As a measure, it is sensitive to improvements in care for both women and children, is associated with other well-being indicators in communities, and reflects health inequities in the community (ChildStats, 2021; Ely et al., 2017).

This paper defines IMR and describes why it is a critical pediatric vital sign, then articulates the value of reducing disparities in IMR. Finally, the paper lays out the challenges to using IMR as an indicator for health system accountability.

Defining Infant Mortality

IMR is the number of live-born infants that die before their first birthday per 1,000 live births in a population and is typically calculated from birth and death certificates. Although IMR is expressed as a ratio, it is commonly referred to as a rate. The classification of fetal deaths versus live births may vary somewhat by facility across jurisdictions and can impact the IMR (Woods et al., 2014). However, to the extent that the method of calculation is consistent within a defined geographic area, observed reductions or increases in IMR over time could function well as indicators of change in infant mortality.

Each state in the U.S. shares birth and death records for their state and local areas to the Centers for Disease Control and Prevention (CDC) annually and provisional IMR quarterly, but these reports lag since CDC publishes data only after all states have reported (Driscoll and Ely, 2023; Ely and Driscoll, 2021). Other organizations, such as the March of Dimes (2021), issue annual "report cards" on state indicators, including IMR. IMR is also a core indicator in maps of well-being and population health such as those calculated by the University of Wisconsin's County Health Rankings and Roadmaps projects and is used by every state to track progress for the Title V maternal and child health block grants (University of Wisconsin Population Health Institute,

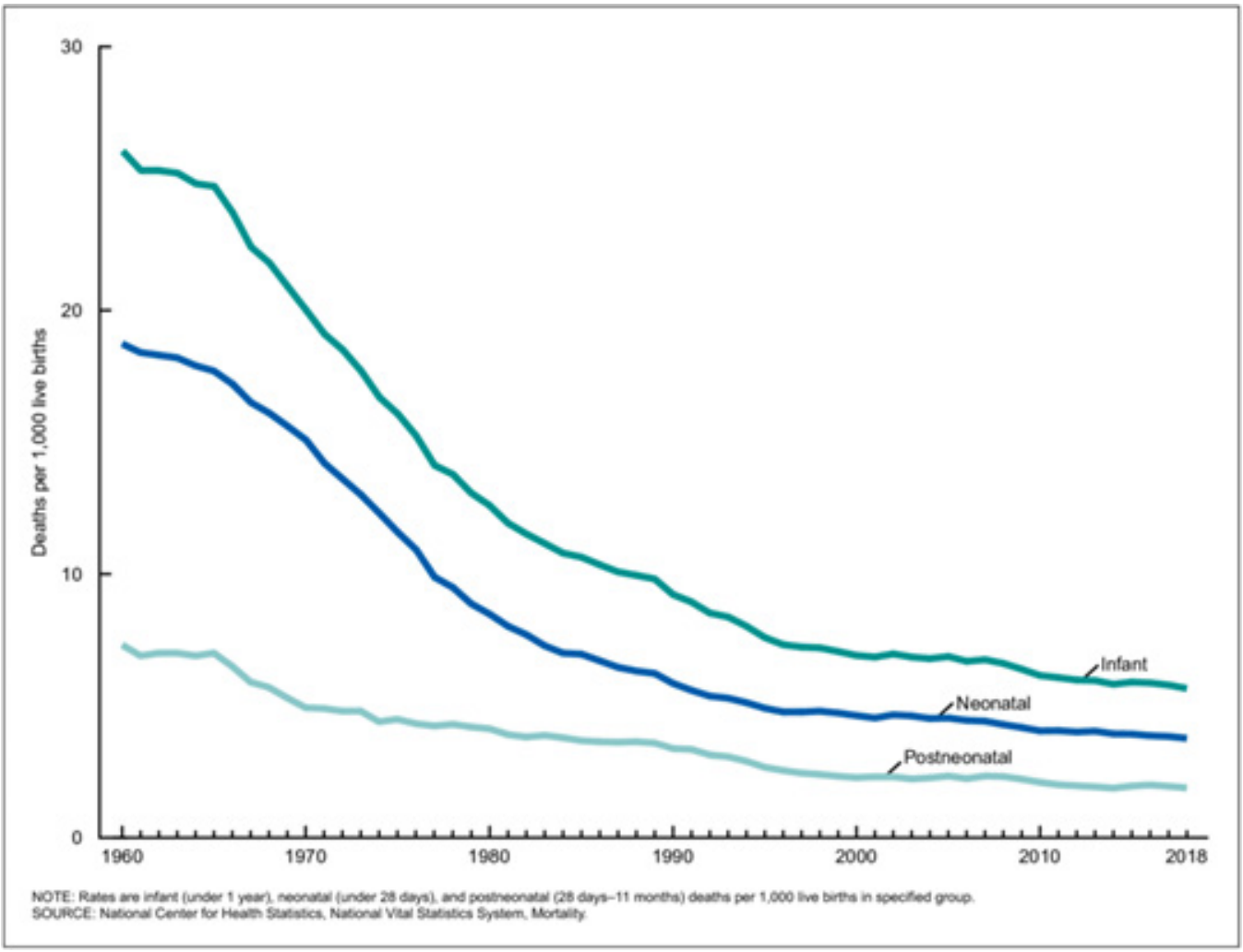
2023; Kogan et al., 2015). Finally, IMR is used as an indicator by the World Health Organization's Global Health Observatory and is one of the 23 Leading Health Indicators for the Healthy People 2030 outcomes measures (Healthy People 2030, n.d.; WHO, n.d.). In short, the authors believe that IMR may be the most widely used measure of overall child health and well-being and therefore is an obvious choice as a pediatric vital sign.

Influences on IMR

No single cause of mortality accounted for even a quarter of infant deaths in the U.S. in 2019 (Ely and Driscoll, 2021). Congenital malformations and disorders related to short gestation and low birthweight accounted for the largest portion of deaths, but maternal complications, sudden infant death syndrome, and unintentional injuries were other leading causes (Ely and Driscoll, 2021). Among the most prominent potential contributing factors to IMR are access to and quality of care for women of reproductive age and for the infant and mother after birth, maternal education and poverty, and structural and individual racism (Dagher and Linares, 2022).

Efforts to improve IMR span health care and other sectors in communities and involve public education; community development; expansion of policies that promote the health, education, and career opportunities of women of reproductive age; and efforts to reduce health disparities (NICHQ, 2017; NIHCM, 2012; Peck et al., 2010). Nationally, diverse players from state and city health departments to hospitals to politicians and women's rights activists have championed efforts to reduce infant mortality. Most improvements come from a systemic, multisector population-based approach, which uses data to inform decisions and accountability. Components of these approaches have included safe sleep campaigns; home visiting programs for high-risk, pri-

FIGURE 1 | Infant, Neonatal, and Post Neonatal Mortality Rates, 1960–2018



SOURCE: Ely, D. M., and A. K. Driscoll. 2020. Infant mortality in the United States, 2018: Data from the period linked birth/death file. National *Vital Statistics Reports* 69(7). Hyattsville, MD: National Center for Health Statistics. Available at: https://www.cdc.gov/nchs/data/nvsr/nvsr69/nvsr-69-7-508.pdf (accessed February 15, 2023).

miparous women; efforts to reduce teenage pregnancies; and regionalization of perinatal services to provide more appropriate levels of neonatal medical care for high-risk infants (Taylor et al., 2019; Ghandour et al., 2017; Barfield et al., 2013; Lasswell et al., 2010).

Selecting Infant Mortality as a Pediatric Vital Sign

IMR is one of the most widely recognized and employed public health measures. While the 2015 *Vital Signs* report identified life expectancy at birth as the first-choice indicator for a population mortality measure, this measure is affected by many factors other than young children's health and is not specific to a pediatric population. As described below, the authors of this paper selected IMR as the preferred indicator of population health for early childhood because it is a significant public health issue in the U.S., it reflects disparities in access to services and resources in communities, it is directly related to child health, and it can be improved through health system and community partnerships.

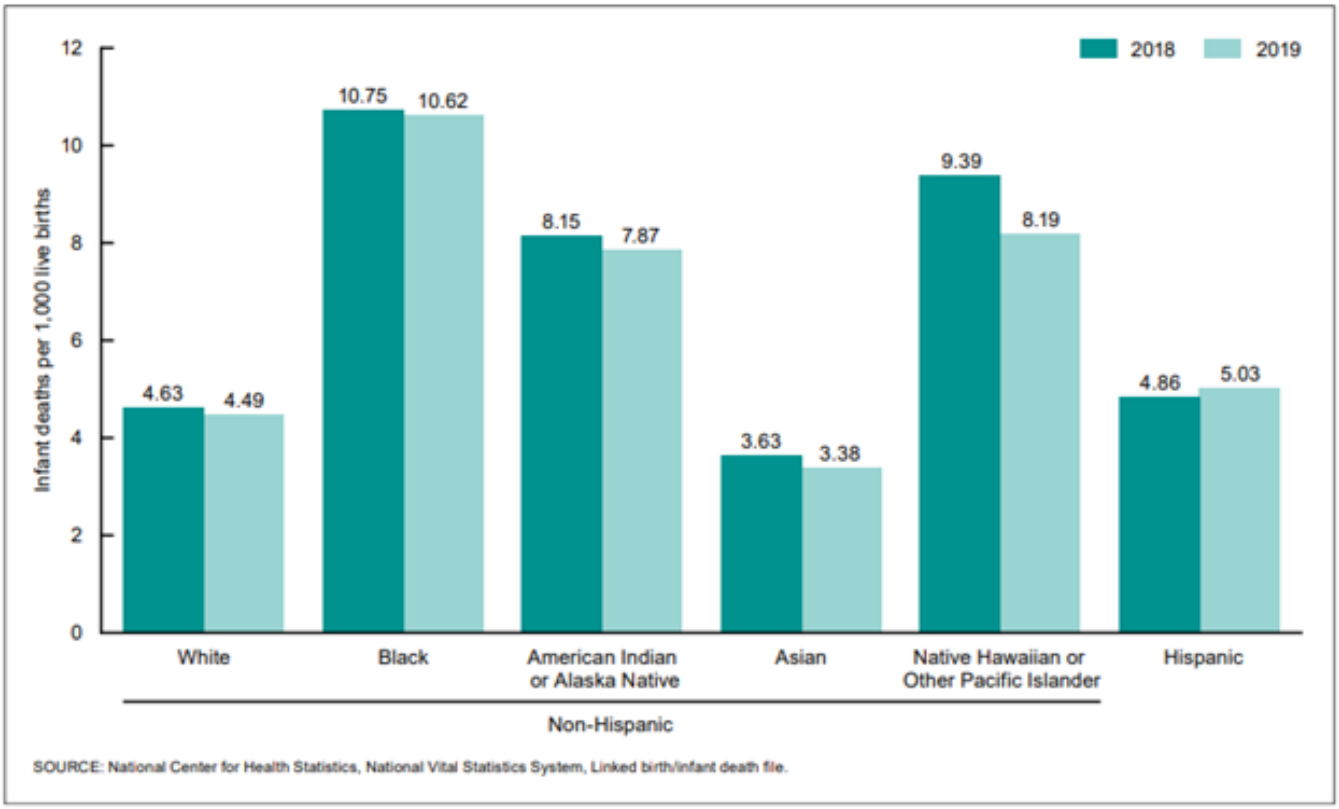
Recent Data and Trends in Infant Mortality

IMR in the U.S. in 2020 was 5.4 deaths per 1,000 live births (Murphy et al., 2021). Although this rate has improved dramatically over the past 60 years (see *Figure 1*) and by roughly 20% over the past two decades, it is higher than in almost every other developed country (Ely and Driscoll, 2020; Kamal et al., 2019; Mathews and Driscoll, 2017). While there are different hypotheses on why the U.S. has an elevated IMR, prematurity-related mortality in the U.S. is higher than most other developed countries (Chen et al., 2016; MacDorman et al., 2014). One possible reason for elevated prematurity-related mortality in the U.S. is a lack of policies that support families of lower socioeconomic status (Chen et al., 2016).

Disparities

IMR can vary by location, level of poverty, and race/ethnicity. IMR differences related to race and ethnicity are not reflective of biological differences, but rather of social constructs that systematically disadvantage and reduce the health status of people of color, as described in previous sections of this paper. For example, *Figure 2* shows that in 2018 and 2019, the highest IMR was for babies born to non-Hispanic Black women, followed by American Indian/Alaska Native women and Native Hawaiian or other Pacific Islander women; and that rates among Asian women were the lowest, below those of Hispanic and White women (Ely and Driscoll, 2021).

FIGURE 2 | Infant Mortality Rate, by Maternal Race and Hispanic Origin: United States, 2018–2019



SOURCE: Ely, D. M. and A. K. Driscoll. 2021. Infant mortality in the United States, 2019: Data from the period linked birth/infant death file. *National Vital Statistics Report 7*(14). Hyattsville, MD: National Center for Health Statistics. https://doi.org/10.15620/cdc:111053.

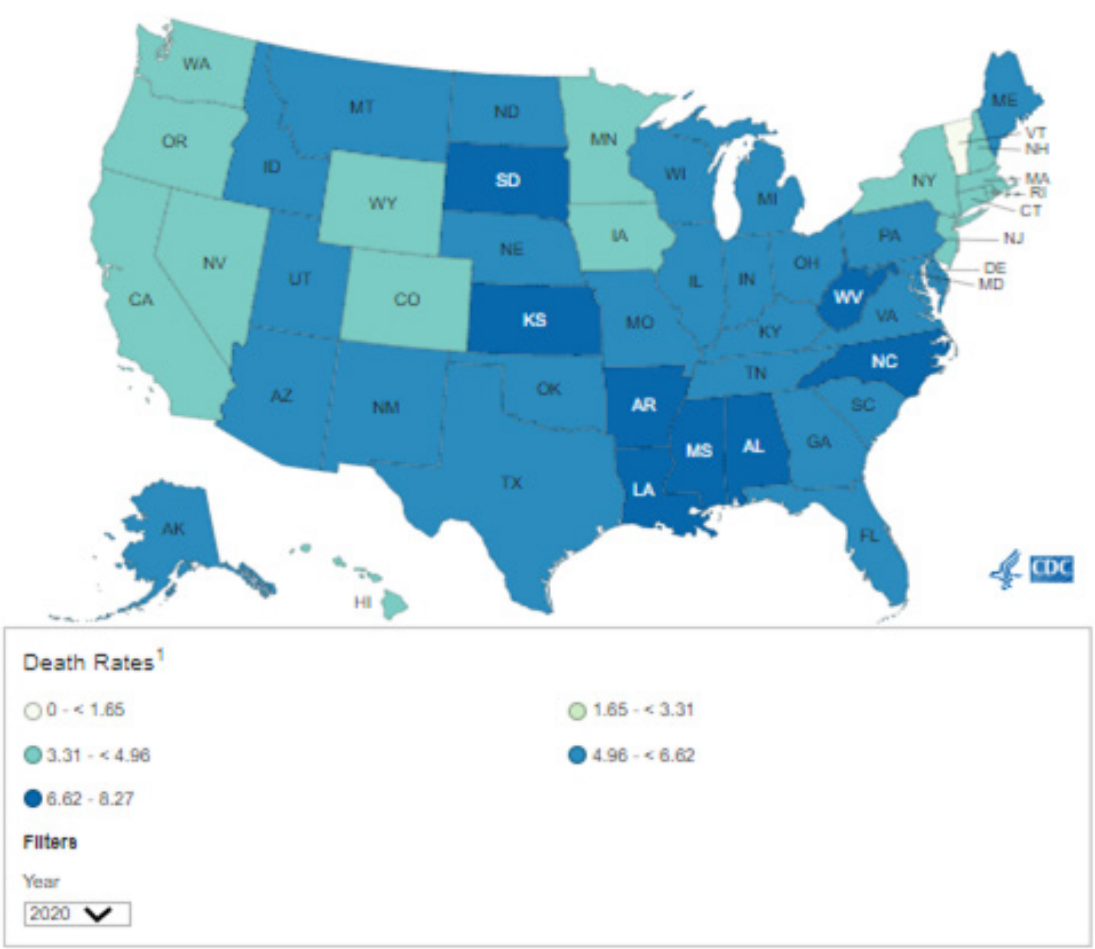
Figure 3 shows that in 2020, U.S. states with the highest IMR had rates that were more than twice those of the lowest states, with the geographically southernmost states showing the highest rates. Although IMRs have been declining in recent years for both Black and White infants, the ratio of Black to White IMR has increased over time (Matoba and Collins, Jr., 2017; Riddell et al., 2017). Between 1950 and 2007, Black infants died at over two times the rate of White infants (Singh and van Dyck, 2010). These differences may be partly attributable to unequal access to high-quality care and the accrual of lifetime risk and allostatic load (e.g., hormonal and biological changes) from social, psychological, and environmental stressors, suggesting a "weathering effect" as described by Matoba and Collins, Jr. (2017) and Geronimus (1992) (Hill et al., 2022; Pabayo et al., 2019). Weathering in this case refers to early biological aging manifested in shortened telomeres or epigenetic changes that occur from chronic stressors like exposure to racism (Geronimus et al., 2010).

Challenges in Measuring Infant Mortality

IMR could serve as a valuable child health and health care system performance metric, but challenges to its use exist. The quality of data provided on birth and death certificates and the erroneous filing of fetal death certificates can vary across jurisdictions (Gonzalez and Gilleskie, 2017). Furthermore, states may use different definitions of "live birth" (CDC, 1997). State health departments might also not share their data until complete certification of all birth and death certificates has occurred, which may delay the release of the IMR up to a year or two due to cases awaiting forensic autopsies (Mathews et al., 2015).

Similarly, even when health systems or agencies and their partners employ IMR as an indicator of child health and well-being, data are usually released by geographic areas, defined by county and city boundaries and zip codes (University of Wisconsin Population Health Institute, 2023; Salahuddin et al., 2022; Ely and Driscoll, 2021). This is problematic because areas with high IMR may not fit precise civic boundaries. Mod-

FIGURE 3 | Infant Mortality Rates by State, 2020



SOURCE: National Center for Health Statistics. n.d. *Infant Mortality Rates by State*. Available at: https://www.cdc.gov/nchs/pressroom/sosmap/infant_mortality_rates/infant_mortality.htm (accessed March 4, 2022).

ern geocoding software can enable communities to map these problems with greater precision if analysts can obtain access to microdata with accurate addresses. However, reporting standards often prevent sharing that level of detail to protect individual privacy by assuring de-identification in the reporting of child deaths.

Choosing a geographic area that is too small for adequate and significant data collection could also be problematic. Infant deaths are currently relatively rare events, and various factors can influence changes from year to year so that population-level shifts in the overall IMR may take time to manifest. Another potential pitfall in the broad use of IMR as a health services indicator is the possibility that higher reported IMR will be interpreted as poorer performance, even where health systems are attempting to improve care in communities with elevated mortality. Since most communities are served by more than one health care provider, data and accountability for a geographic area are shared by several key health stakeholders (IOM, 1997). While it is currently unclear how to best build consensus about the accountability of a health system or group of health systems for IMR across geographic boundaries, several metropolitan areas—including New York City—have been successful in such efforts (Hall and Bayne-Smith, 2011). Risk adjustment methods to control for the effects of different patient characteristics within health system accountability models have been suggested to minimize incentives for health systems to avoid the populations with the poorest health (e.g., the highest IMR) (Pearson and Stecher, 2004).

Importance of Measuring Infant Mortality to Understand Children's Health

IMR and Overall Societal Health

IMR is strongly correlated with child developmental outcomes, school readiness, and early medical and other health-related costs (Owusu et al., 2021; Lejarraga et al., 2018; Gortmaker and Wise, 1997; Lee et al., 1997). IMR is chosen in many communities, states, and countries as a population health indicator because of its simplicity, availability, and, most importantly, utility in describing the performance of the public health system in serving pregnant women (Gonzalez and Gilleskie, 2017). IMR may serve as a proxy indicator of overall societal health because it is strongly associated with fundamental causes of poor maternal health, such as limited resources, structural racism, the social determinants of health, and gaps in care systems in a community (Bishop-Royse et al., 2021; Owusu et al., 2021). High IMR in a community also correlates strongly with socioeconomic disadvantage and concentrated poverty (Bishop-Royse et al., 2021).

Potential Health Systems Benefits

There are several secondary benefits that come with the use of IMR as a community health indicator. First, its use necessitates the incorporation of high-quality health care system data into state or county vital statistics for sharing and analysis. Many communities that have successfully reduced IMR have also developed multisector collaborations of social service agencies, health care systems, and government departments (Gülmezoglu et al., 2016). These collaborations involve intensive data sharing, frequent and effective handoffs of patients among systems, and culturally competent outreach and education involving community partners. Persistent leadership of health care organizations has been critical in seeing these efforts through to completion (NICHQ, 2021).

Similarly, using IMR as an accountability measure in health systems could promote the integration of services for women and children. Coordinated care of mothers and newborns is facilitated by the cooperation of pediatric and obstetric services, along with other health and community services. For example, two essential strategies for reducing preterm births and IMR—safe sleep campaigns and stop smoking campaigns—are primarily conducted as community outreach and education campaigns targeted at the health of both mothers and babies (Gülmezoglu et al., 2016). These initiatives are possible through coordination of common community messaging, cultural adaptations, trusted resident leaders, and continuous engagement of partners to maintain effectiveness over time (de Luca and Hinde, 2016).

IMR improvement work often leads to an increasing focus on the social determinants of health (NICHQ, 2021; Taylor et al., 2019; Reno and Hyder, 2018). Two policies intended to address poverty—increased minimum wage and earned income tax credits—and the receipt of Special Supplemental Nutrition Program for Women, Infants, and Children benefits during pregnancy display evidence of also being associated with lower IMR (Soneji and Beltrán-Sánchez, 2019; Komro et al., 2016; Arno et al., 2009). Although there have been few prospective studies of whether health care organizations can reduce infant mortality through housing, food, transportation, or related interventions, there are some notable examples of success in these efforts, including the Baltimore City Health Department and Family League of Baltimore partnership on the B'more for Healthy Babies initiative to reduce infant mortality in Baltimore County, Maryland. The initiative includes programs that provide health education to Baltimore men and women, a coalition of communities that focus on improving health equity, and home visiting support from a nurse or social worker through the child's third birthday (Baltimore City Health Department, 2021). After the launch of B'more for Healthy Babies, infant mortality decreased 28% from 13.5% in 2009 to 9.7% in 2012. During the same period, the disparity between White and Black infant mortality decreased by almost 40% (Baltimore City Health Department, 2021).

A similar collaborative effort is building connections between parents, community members, and health care professionals in Hamilton County, Ohio to address infant mortality in the community (Cradle Cincinnati, 2021). Other such efforts exist across the country and can serve as examples for other communities.

Furthermore, Healthy Start, a national program of the Health Resources and Services Administration, funds 101 projects that aim to improve health outcomes before, during, and after pregnancy and reduce racial and ethnic differences in rates of infant deaths and negative maternal health outcomes. Each of these projects has a Community Action Network composed of neighborhood residents, community leaders, medical and social service providers, faith-based leaders, and business representatives. Healthy Start projects collaborate with their Community Action Network to address fragmented delivery of services and create culturally and linguistically appropriate services for members of their communities (MCHB, n.d.). Though promising, additional research could provide evidence to guide such interventions.

From a health expenditures perspective, deceased infants have no later life outcomes, so a high IMR does not increase the financial burden of disability on society or a specific health care system. Nonetheless, IMR is highly correlated with disability-adjusted measures of life expectancy and therefore can have value as a proxy for later life population health outcomes (Reidpath and Allotey, 2003).

Conclusion

In summary, IMR could be a valuable foundational measure for health system accountability and population health. IMR may be one of the easiest measures for health systems to adopt, given its widespread use and endorsement as a valuable and reliable indicator of health. IMR reflects health inequities in a community, is associated with other well-being indicators, and is sensitive to improvements in care for both women and children. Additional research and piloting to determine the level of geographic accountability to be assumed by health systems and how inequities in IMR are most accurately represented would allow for data to be comparable across jurisdictions and over time.

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DOI

https://doi.org/10.31478/202306a

Suggested Citation

Kelleher, K. J., K. Hoagwood, D. Klein Walker, J. Kaminski, W. Gardner, and E. G. Fox. 2023. Vital Signs for Pediatric Health: Infant Mortality. *NAM Perspectives*. Discussion Paper, National Academy of Medicine, Washington, DC. https://doi.org/10.31478/202306a.

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Acknowledgments

This manuscript was supported in part by funding (Task Order 200-2011-38807/0070) from the Centers for Disease Control and Prevention.

This paper benefited from the thoughtful input of **Richard Goldstein, MD,** Boston Children's Hospital, and **Courtney D. Lynch, PhD MPH,** The Ohio State University.

Conflict-of-Interest Disclosures

Erin Fox discloses employment by the National Academies of Sciences, Engineering, and Medicine while this paper series was being drafted.

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