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Public health priorities for gastroschisis: Summary of a meeting sponsored by the Centers for Disease Control and Prevention and the March of Dimes

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Abstract

Background: Gastroschisis has increased worldwide over several decades; however, there are significant gaps in understanding risk factors for development of the defect, particularly those that might be modifiable. Despite advances in survival, little is known about longer-term outcomes for affected individuals.

Methods: On April 27– and 28, 2023, the National Center on Birth Defects and Developmental Disabilities at the Centers for Disease Control and Prevention (CDC) and March of Dimes sponsored a meeting entitled “Public Health Priorities for Gastroschisis”. The meeting goals were to review current knowledge on gastroschisis, discuss research gaps, and identify future priorities for public health surveillance, research, and action related to gastroschisis. Meeting participants encompassed a broad range of expertise and experience, including public health, clinical care of individuals with gastroschisis, affected individuals and families, and representatives from professional organizations and federal agencies.

Results: Several goals were identified for future public health surveillance and research, including focused theory-driven research on risk factors and increased study of longer-term effects of gastroschisis through improved surveillance. Certain public health actions were identified, that which could improve the care of affected individuals, including increased education of providers and enhanced resources for patients and families.

Conclusions: These efforts may lead to an improved understanding of pathogenesis, risk factors, and outcomes and to improved care throughout the lifespan.

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Keywords

gastroschisis; research; surveillance

1 | INTRODUCTION

Gastroschisis is a birth defect in which a portion of the intestines extrude through a defect in the abdominal wall. The incidence of gastroschisis has increased in the U.S. and worldwide over several decades (Jones et al., 2016), although the reason for the increase remains unknown. It occurs most frequently among infants of younger mothers and the reason for this inverse association has been studied extensively but, similar to the temporal trend, remains unknown. Many risk factors have been examined for possible associations with gastroschisis, with variable findings, and none appears to explain either the increasing occurrence over time or increasing risk with younger maternal age. Advances in treatment have improved survival among infants with gastroschisis (Suominen & Rintala, 2018) and have highlighted a need for better understanding of the clinical course of disease and longer-term morbidity and outcomes. On April 27–28, 2023, the National Center on Birth Defects and Developmental Disabilities at the Centers for Disease Control and Prevention (CDC) and March of Dimes sponsored a meeting entitled “Public Health Priorities for Gastroschisis”. The 45 participants represented public health, clinical care, patient advocacy, professional organizations, and federal agencies. Specific expertise included epidemiology, birth defect surveillance and research, general pediatrics, pediatric surgery, pediatric gastroenterology, adolescent pediatrics, neonatology, obstetrics and gynecology, maternal-fetal medicine, and patient and family education and advocacy. Participants reviewed current knowledge on gastroschisis pathogenesis, risk factors, and longer-term outcomes and research gaps related to these areas. Discussions focused on identifying priorities for future surveillance, research, and public health actions to address key gaps.

2 | REVIEW OF CURRENT KNOWLEDGE

To frame the meeting discussions a series of presentations was given, which included two virtual webinars in March 2023 and five presentations at the meeting in April 2023. Information was presented on the current state of knowledge about gastroschisis and gaps in understanding.

The mechanism of gastroschisis development is not fully understood. The diagnosis is considered only after 12 weeks’ gestation, due to physiologic umbilical herniation of the midgut before that time which then resolves (Bargy & Beaudoin, 2014). Although there are several theories for the development of gastroschisis, the pathogenesis remains unknown (Haddock & Skarsgard, 2018). Intrauterine bowel injury is variable and is potentially related to exposure to amniotic fluid or vascular mesenteric impairment (Beaudoin, 2018). The severity of bowel injury is an important determinant of prognosis, with infants who have severe bowel injury at birth having higher risk for neonatal death, sepsis, short bowel syndrome, and prolonged mechanical ventilation and parenteral nutrition needs (Haddock & Skarsgard, 2018). Studies continue to examine the optimal management of gastroschisis

during pregnancy and after delivery, including timing of delivery, post-delivery management, and defect closure mechanism ([ClinicalTrials.gov](https://www.clinicaltrials.gov), 2023; Haddock & Skarsgard, 2018; Mowrer et al., 2022).

Studies have consistently found that the incidence of gastroschisis has increased worldwide since the 1970s (Beaudoin, 2018; Loane et al., 2007; St Louis et al., 2017). The National Birth Defects Prevention Network (NBDPN) examines select birth defects in surveillance programs in the U.S. The NBDPN found that the national prevalence of gastroschisis was estimated to be 4.3 per 10,000 live births in 2012–2016, with an estimated 5349 cases during this period (Stallings et al., 2019). This estimate was derived from 30 state programs, with estimates differing between those programs that ascertained cases actively (prevalence 4.7/10,000 live births) versus passively (prevalence 3.9/10,000 live births). The differences in estimates underscore the importance of considering case ascertainment methods, such as data sources used and pregnancy outcomes included, in birth defect surveillance and research.

Young maternal age has consistently been associated with gastroschisis among infants. The NBDPN found that the highest prevalence was observed among infants of mothers ages <20 years (15.5/10,000 live births) and 20–24 years (8.5/10,000 live births), with prevalence declining sharply with increasing age (0.7/10,000 live births among those 40 years) (Stallings et al., 2019). However, the reason for the association with young maternal age is not known. The NBDPN found that prevalence differed by maternal race/ethnicity, with prevalence highest among infants of American Indian or Alaska Native (7.2/10,000 live births) and Hispanic (5.0/10,000 live births) versus white (4.3/10,000 live births) mothers (Stallings et al., 2019). Infants of black mothers had a lower prevalence of gastroschisis (3.2/10,000 live births). In analyses adjusted for maternal age, the risk of gastroschisis was lower in infants of non-Hispanic black mothers than in infants of non-Hispanic white mothers. The risk was not statistically significantly different in infants of Hispanic mothers and infants of non-Hispanic white mothers (Baldacci et al., 2020).

Additional risk factors have been found to be independently associated with gastroschisis after adjusting for maternal age. Maternal smoking, alcohol, and illicit drug use have been associated with gastroschisis (Baldacci et al., 2020). Maternal body mass index (BMI) has been found to have an inverse relationship with gastroschisis, with lower BMI associated with a higher risk for gastroschisis among infants (Baldacci et al., 2020). Other studies have found associations between gastroschisis and certain maternal infections (e.g., urinary tract infections) (Yazdy et al., 2014), medical conditions (e.g., depression) (Given et al., 2017), medications (e.g., nonsteroidal anti-inflammatory drugs) (Interrante et al., 2017; Werler et al., 2009), and stress (Carmichael et al., 2017). Some studies have found associations with perinatal exposure to certain environmental agents, such as pesticides and atrazine, but these findings have not been consistent (Brender & Weyer, 2016; Souther et al., 2017). Although gastroschisis usually occurs without other birth defects, a certain proportion of cases are found to have cooccurring birth defects, with cardiovascular defects being the most common, found among 11.9% of gastroschisis cases (Stallings et al., 2019). While gastroschisis is not generally associated with chromosomal abnormalities, some studies have found associations with gene variants (Padula et al., 2016) and researchers

have hypothesized potential interactions between genetic and environmental factors in the development of gastroschisis.

Advances in treatment have led to improved short-term outcomes and long-term survival (88%–94% at 1 year of life, 86%–94% at 5 years of life, 82% at 25 years of life) (Glinianaia et al., 2020; Wang et al., 2011). However, less research has focused on longer-term outcomes of gastroschisis, including gastrointestinal, neurodevelopmental, physical growth, and quality of life parameters. Gastrointestinal issues are prevalent, with one study finding that 84% of individuals followed through 8 years of life experienced gastrointestinal complications, for example, small bowel obstruction, perforation, and atresia bowel dysmotility; necrotizing enterocolitis; enteric fistulas; and short bowel syndrome (Durfee et al., 2013). In another study, approximately 30% of individuals with gastroschisis followed through a median of 7 years of life experienced chronic abdominal pain and constipation and 37% experienced small bowel obstruction by 10 years of life (van Eijck et al., 2008). Some studies found that individuals with gastroschisis experienced motor function delays, visual and hearing impairments, and diminished cognitive and behavioral function (Hijkoop et al., 2018; Lap et al., 2017; van Manen et al., 2013). Because the optimal gestational age for delivery of infants with gastroschisis is not known, some infants are delivered early and these complications may be attributable to prematurity (Mowrer et al., 2022). One study found that despite early growth delays, the majority showed improvement in growth, particularly in those with a less complicated disease course (Harris et al., 2014). One study found that quality of life was generally positive and comparable to published controls (Arnold et al., 2018). Nonetheless, interpretation of these results is limited by study design issues, including small numbers of individuals with gastroschisis, lack of population base, and non-standardized measurements of outcomes; therefore, these results may not be generalizable to the larger population.

A study of individuals with short bowel syndrome found that specific surveys, rather than generic quality of life measures, are needed to examine quality of life related to the condition and that 40% of caregivers report that the condition has a high impact on the child's overall wellbeing (Neumann et al., 2022). Communication from patients and families highlights that research findings do not always adequately reflect lived experiences and stressed the importance of including those with lived experience in research development. One anecdotal concern is that the healthcare community's focus on immediate surgical outcomes minimizes the profound longer-term challenges and traumas faced by patients and families that have likely contributed to morbidity and mortality. In addition, individuals experience a lack of attention to chronic symptoms and challenges in finding caregivers with knowledge about the specific issues after repaired gastroschisis and/or short gut. Misdiagnosed pain and inadequate pain management among adolescents and adults with repaired gastroschisis further diminish the quality of life. Individuals may not be aware that they had gastroschisis because the family may be informed that the condition was resolved with the repair. As a result, patients who experience complications later in life may not know to inform their healthcare provider that gastroschisis could be a contributing factor, and that could impact the care received (personal communication, Meghan Rauen).

3 | PRIORITIES FOR PUBLIC HEALTH RESEARCH ON GASTROSCHISIS

The meeting discussion was framed by asking participants to identify key gaps in knowledge of gastroschisis risk factors, epidemiology, and longer-term outcomes and to highlight public health surveillance and research approaches to address these gaps. Participants identified several activities that might improve understanding and awareness of the disease.

3.1 | Focus research on potentially modifiable risk factors

Studies that have examined risk factors for the development of gastroschisis have focused on many varied maternal factors including demographics, behaviors, medical conditions and medications, environmental exposures, and genetics. The association with young maternal age has been consistently found; however, the pathogenesis of this association is not understood. Other risk factors have been less consistently associated across studies (Baldacci et al., 2020), and there could be potential interactions. Although complex and likely multifactorial, the etiology of gastroschisis may be better understood by focusing on common underlying risk factors. Accurate exposure assessment is critical with regard to the timing, amount, and duration of exposure. A focus on potentially modifiable risk factors, such as social determinants of health, might translate to more actionable results and future preventive measures.

3.2 | Improve understanding of impact throughout lifespan

While the abdominal wall defect is often repaired soon after birth, the impact of the intra-uterine environment and the treatment can extend beyond infancy and can impact survival, growth, development, and quality of life into adulthood. Clinical research has largely focused on management and outcomes during infancy and the first few years of life. As survival has increased, it has become increasingly important to understand how gastroschisis affects the health and well-being of affected individuals and families throughout their lifespan.

Meeting participants discussed the range of impacts gastroschisis can have throughout the lifespan, including negative effects on the gastrointestinal system (e.g., abdominal pain, bowel motility), quality of life, and mental health. Meeting participants identified some gaps in information about certain critical outcomes, including the following:

- What is overall survival of affected individuals?
- What proportion of affected individuals have chronic abdominal pain?
- What proportion of affected individuals have other comorbidities?
- What proportion of affected individuals have reduced quality of life, related to chronic pain, school performance, feeding difficulties, and other concerns?
- What proportion of affected individuals have mental health issues?

In order to address the long-term impacts of gastroschisis on families and patients, several approaches were proposed to enhance the scientific community's understanding of the condition and to improve how the healthcare system communicates about the condition.

3.3 | Improve approaches to long-term surveillance

To better examine long-term outcomes, it is important to use and improve upon existing data as well as consider the potential to conduct new studies. Administrative datasets may present opportunities to identify individuals with gastroschisis nationwide and to examine medical encounters, hospitalizations, mortality, and comorbidities. Leveraging existing databases may be preferable with respect to cost, data availability, and timeliness of results. However, it is important to note that administrative datasets are likely limited by potential underascertainment of affected individuals if the original diagnosis is not included beyond infancy and early childhood. Assessment of the prevalence of gastroschisis among all ages and associated outcomes hinges on accurately identifying individuals in a population-based approach, which relies on improving recognition of the condition by healthcare providers when an affected individual presents for care later in life. Existing studies with identified patients such as the Gastroschisis Outcomes of Delivery (GOOD) study ([ClinicalTrials.gov](https://clinicaltrials.gov), 2023) may present opportunities to follow affected individuals prospectively and gather additional information on the disease course, quality of life, and access to care.

3.4 | Improve educational materials for healthcare community

Meeting participants discussed concerns that individuals who present for medical care may not be recognized by care providers as having had gastroschisis, particularly when seen beyond early childhood. Educational efforts can be focused on improved identification of individuals with gastroschisis, so healthcare providers might better understand that symptoms later in life, such as chronic abdominal pain, may be related to their gastroschisis. In addition, it is important that healthcare providers become informed about the possibility of longer-term outcomes of gastroschisis, which might occur despite the defect being repaired. The onus of informing clinicians about gastroschisis sometimes falls on the patient and their family, which could be facilitated with an easily accessible online source that would provide state-of-the-art information about gastroschisis. However, a multipronged approach to education would likely be most effective, including publications and online information, continuing education activities, and materials from professional organizations. Future gatherings of specialists and key stakeholders could serve to advance understanding of the condition and develop educational materials for the healthcare community.

3.5 | Improve information for affected individuals and families

Affected individuals and families may not have access to educational information including disease course, self-advocacy, and navigating the healthcare system. It is particularly important to ensure that affected individuals have continuity and quality of care throughout the lifespan. Creation and dissemination of resources for individuals and families may improve their ability to engage with the healthcare system and maximize their care.

4 | CONCLUSIONS

Significant gaps exist in the understanding of etiology and risk factors for gastroschisis. Research efforts aimed at examining modifiable risk factors would improve understanding of the etiology and potentially identify opportunities for prevention. The incidence of gastroschisis has increased and, with improvements in treatment and survival, there

is a critical need for enhanced understanding of the natural course and longer-term effects after the initial repair. Surveillance and research examining longer-term outcomes, including mortality, pain, quality of life, and mental health, may lead to targeted efforts to improve these outcomes. Enhanced education and resources for healthcare providers, affected individuals, and families could improve recognition of the defect during healthcare encounters, identify challenges in access to care, and improve continuity and quality of care for individuals throughout their lifespan.

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DATA AVAILABILITY STATEMENT

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REFERENCES

- Arnold HE, Baxter KJ, Short HL, Travers C, Bhatia A, Durham MM, & Raval MV (2018). Short-term and family-reported long-term outcomes of simple versus complicated gastroschisis. *The Journal of Surgical Research*, 224, 79–88. 10.1016/j.jss.2017.11.054 [PubMed: 29506856]
- Baldacci S, Santoro M, Coi A, Mezzasalma L, Bianchi F, & Pierini A. (2020). Lifestyle and sociodemographic risk factors for gastroschisis: A systematic review and meta-analysis. *Archives of Disease in Childhood*, 105(8), 756–764. 10.1136/archdischild-2019-318412 [PubMed: 32051127]
- Bargy F, & Beaudoin S. (2014). Comprehensive developmental mechanisms in gastroschisis. *Fetal Diagnosis and Therapy*, 36(3), 223–230. 10.1159/000360080 [PubMed: 25171094]
- Beaudoin S. (2018). Insights into the etiology and embryology of gastroschisis. *Seminars in Pediatric Surgery*, 27(5), 283–288. 10.1053/j.sempedsurg.2018.08.005 [PubMed: 30413258]

- Brender JD, & Weyer PJ (2016). Agricultural compounds in water and birth defects. *Current Environmental Health Reports*, 3(2), 144–152. 10.1007/s40572-016-0085-0 [PubMed: 27007730]
- Carmichael SL, Ma C, Tinker S, Shaw GM, for the National Birth Defects Prevention Study. (2017). Maternal stressors and social support and risks of delivering babies with gastroschisis or hypospadias. *American Journal of Epidemiology*, 185(12), 1240–1246. 10.1093/aje/kww121 [PubMed: 28505275]
- ClinicalTrials.gov. (2023). Gastroschisis Outcomes of Delivery (GOOD) Study. <https://clinicaltrials.gov/study/NCT02774746>
- Durfee SM, Benson CB, Adams SR, Ecker J, House M, Jennings R, Katz D, Pettigrew C, & Wolfberg A. (2013). Postnatal outcome of fetuses with the prenatal diagnosis of gastroschisis. *Journal of Ultrasound in Medicine*, 32(3), 407–412. 10.7863/jum.2013.32.3.407 [PubMed: 23443180]
- Given JE, Loane M, Garne E, Nelen V, Barisic I, Randrianaivo H, Khoshnood B, Wiesel A, Rissmann A, Lynch C, Neville AJ, Pierini A, Bakker M, Klungsoyr K, Latos Bielenska A, Cavero-Carbonell C, Addor MC, Zymak-Zakutnya N, Tucker D, & Dolk H. (2017). Gastroschisis in Europe - a case-malformed-control study of medication and maternal illness during pregnancy as risk factors. *Paediatric and Perinatal Epidemiology*, 31(6), 549–559. 10.1111/ppe.12401 [PubMed: 28841756]
- Glinianaia SV, Morris JK, Best KE, Santoro M, Coi A, Armaroli A, & Rankin J. (2020). Long-term survival of children born with congenital anomalies: A systematic review and meta-analysis of population-based studies. *PLoS Medicine*, 17(9), e1003356. 10.1371/journal.pmed.1003356
- Haddock C, & Skarsgard ED (2018). Understanding gastroschisis and its clinical management: Where are we? *Expert Review of Gastroenterology & Hepatology*, 12(4), 405–415. 10.1080/17474124.2018.1438890 [PubMed: 29419329]
- Harris EL, Minutillo C, Hart S, Warner TM, Ravikumara M, Nathan EA, & Dickinson JE (2014). The long term physical consequences of gastroschisis. *Journal of Pediatric Surgery*, 49(10), 1466–1470. 10.1016/j.jpedsurg.2014.03.008 [PubMed: 25280647]
- Hijkoop A, Ijsselstijn H, Wijnen RMH, Tibboel D, Rosmalen JV, & Cohen-Overbeek TE (2018). Prenatal markers and longitudinal follow-up in simple and complex gastroschisis. *Archives of Disease in Childhood. Fetal and Neonatal Edition*, 103(2), F126–F131. 10.1136/archdischild-2016-312417 [PubMed: 28615305]
- Interrante JD, Ailes EC, Lind JN, Anderka M, Feldkamp ML, Werler MM, Taylor LG, Trinidad J, Gilboa SM, Broussard CS, The National Birth Defects Prevention Study. (2017). Risk comparison for prenatal use of analgesics and selected birth defects, National Birth Defects Prevention Study 1997–2011. *Annals of Epidemiology*, 27(10), 645–653.e642. 10.1016/j.annepidem.2017.09.003 [PubMed: 28993061]
- Jones AM, Isenburg J, Salemi JL, Arnold KE, Mai CT, Aggarwal D, Arias W, Carrino GE, Ferrell E, Folorunso O, Ibe B, Kirby RS, Krapfl HR, Marengo LK, Mosley BS, Nance AE, Romitti PA, Spadafino J, Stock J, & Honein MA (2016). Increasing prevalence of gastroschisis—14 states, 1995–2012. *Morbidity and Mortality Weekly Report*, 65(2), 23–26. 10.15585/mmwr.mm6502a2 [PubMed: 26796490]
- Lap CC, Bolhuis SW, Van Braeckel KN, Reijneveld SA, Manten GT, Bos AF, & Hulscher JB (2017). Functional outcome at school age of children born with gastroschisis. *Early Human Development*, 106–107, 47–52. 10.1016/j.earlhumdev.2017.01.005
- Loane M, Dolk H, Bradbury I, & Group EW (2007). Increasing prevalence of gastroschisis in Europe 1980–2002: A phenomenon restricted to younger mothers? *Paediatric and Perinatal Epidemiology*, 21(4), 363–369. 10.1111/j.13653016.2007.00820.x [PubMed: 17564594]
- Mowrer AR, DeUgarte DA, & Wagner AJ (2022). Abdominal Wall defects: A review of current practice guidelines. *Clinics in Perinatology*, 49(4), 943–953. 10.1016/j.clp.2022.07.004 [PubMed: 36328609]
- Neumann ML, Allen JY, Kakani S, Ladner A, Rauen MH, Weaver MS, & Mercer DF (2022). A beautiful struggle: Parent-perceived impact of short bowel syndrome on child and family wellbeing. *Journal of Pediatric Surgery*, 57(9), 149–157. 10.1016/j.jpedsurg.2021.09.039 [PubMed: 34702565]
- Padula AM, Yang W, Schultz K, Tom L, Lin B, Carmichael SL, Lammer EJ, & Shaw GM (2016). Gene variants as risk factors for gastroschisis. *American Journal of Medical Genetics Part A*, 170(11), 2788–2802. 10.1002/ajmg.a.37883 [PubMed: 27616475]

- Souther C, Puapong DP, Woo R, & Johnson SM (2017). Possible etiologies of increased incidence of gastroschisis. *Pediatric Surgery International*, 33(11), 1209–1213. 10.1007/s00383-017-4166-4 [PubMed: 28952022]
- St Louis AM, Kim K, Browne ML, Liu G, Liberman RF, Nembhard WN, Canfield MA, Copeland G, Fornoff J, Kirby RS, for the National Birth Defects Prevention Network. (2017). Prevalence trends of selected major birth defects: A multi-state population-based retrospective study, United States, 1999 to 2007. *Birth Defects Research*, 109(18), 1442–1450. 10.1002/bdr2.1113 [PubMed: 28905502]
- Stallings EB, Isenburg JL, Short TD, Heinke D, Kirby RS, Romitti PA, Canfield MA, O’Leary LA, Liberman RF, Forestieri NE, Nembhard WN, Sandidge T, Nestoridi E, Salemi JL, Nance AE, Duckett K, Ramirez GM, Shan X, Shi J, & Lupo PJ (2019). Population-based birth defects data in the United States, 2012–2016: A focus on abdominal wall defects. *Birth Defects Research*, 111(18), 1436–1447. 10.1002/bdr2.1607 [PubMed: 31642616]
- Suominen J, & Rintala R. (2018). Medium and long-term outcomes of gastroschisis. *Seminars in Pediatric Surgery*, 27(5), 327–329. 10.1053/j.sempedsurg.2018.08.008 [PubMed: 30413265]
- van Eijck FC, Wijnen RM, & van Goor H. (2008). The incidence and morbidity of adhesions after treatment of neonates with gastroschisis and omphalocele: A 30-year review. *Journal of Pediatric Surgery*, 43(3), 479–483. 10.1016/j.jpedsurg.2007.10.027 [PubMed: 18358285]
- van Manen M, Hendson L, Wiley M, Evans M, Taghaddos S, & Dinu I. (2013). Early childhood outcomes of infants born with gastroschisis. *Journal of Pediatric Surgery*, 48(8), 1682–1687. 10.1016/j.jpedsurg.2013.01.021 [PubMed: 23932607]
- Wang Y, Hu J, Druschel CM, & Kirby RS (2011). Twentyfive-year survival of children with birth defects in New York state: A population-based study. *Birth Defects Research. Part A, Clinical and Molecular Teratology*, 91(12), 995–1003. 10.1002/bdra.22858
- Werler MM, Mitchell AA, Moore CA, Honein MA, & the National Birth Defects Prevention Study. (2009). Is there epidemiologic evidence to support vascular disruption as a pathogenesis of gastroschisis? *American Journal of Medical Genetics. Part A*, 149A(7), 1399–1406. 10.1002/ajmg.a.32897 [PubMed: 19533769]
- Yazdy MM, Mitchell AA, & Werler MM (2014). Maternal genitourinary infections and the risk of gastroschisis. *American Journal of Epidemiology*, 180(5), 518–525. 10.1093/aje/kwu157 [PubMed: 25073472]