HHS Public Access

Author manuscript

Birth Defects Res. Author manuscript; available in PMC 2022 January 13.

Published in final edited form as:

Birth Defects Res. 2020 November ; 112(18): 1484–1494. doi:10.1002/bdr2.1772.

Trends in prevalence and spatiotemporal distribution of gastroschisis in Arkansas, 1998–2015

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Abstract

Background: Arkansas (AR) had the highest prevalence of gastroschisis in a recent study including 15 U.S. states. Our objective was to evaluate trends in prevalence and the spatiotemporal distribution of gastroschisis in AR.

Methods: Infants with gastroschisis, born 1998–2015, were identified from the Arkansas Reproductive Health Monitoring System. Birth record data were used as denominators for calculations. Maternal residence at delivery was geocoded for spatial analyses. Annual prevalence rates (PRs) were calculated. Joinpoint regression analysis was performed to examine trends in gastroschisis and report the annual percent changes (APCs) in PRs. Spatiotemporal analyses identified counties with unusually high PRs of gastroschisis. Poisson regression, including county, year, and county*year indicators, was fit to evaluate the PRs of gastroschisis, while adjusting for county-level maternal variables.

Results: We identified 401 cases of gastroschisis among 694,459 live births. The overall PR of gastroschisis was 5.8/10,000 live births. The prevalence of gastroschisis had a significant APC of +5.3% ($p < .0001$) between 1998 and 2012, followed by a nonsignificant yearly average decrease of −17% through 2015 ($p = 0.2$). The Emerging Hot Spot Analysis and SaTScan identified an

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CONLICT OF INTEREST

The authors declare no potential conflict of interest.

SUPPORTING INFORMATION

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overlapping five-county cluster from 2006 to 2013. Poisson regression model, including county (inside vs. outside cluster), time (before vs. after 2006), and county*time indicators, was fit to evaluate the PRs of gastroschisis. The model did not confirm the presence of a spatiotemporal cluster, once it adjusted for county-level maternal characteristics ($p = .549$).

Conclusion: Close monitoring of rates of gastroschisis is warranted to determine if the PRs of gastroschisis continue to decline in AR.

Keywords

Arkansas; gastroschisis; prevalence; spatial; spatiotemporal

1 | BACKGROUND

Gastroschisis is a congenital malformation that causes the herniation of the intestines and other abdominal organs outside of the fetal abdominal cavity (Bargy & Beaudoin, 2004; Ledbetter, 2006). The pathophysiology of this defect is not entirely understood and is attributed to a potential developmental disruption of the omphalomesenteric artery (Ledbetter, 2006). Previous epidemiological studies attempted to determine the etiology of this defect. The most consistently identified risk factor is young maternal age (<20 years old) (Rittler et al., 2015; Vo & Langlois, 2015). Additional established risk factors are maternal low education level (Khodr et al., 2013), poverty (Khodr et al., 2013), nulliparity (Benjamin, Ethen, Van Hook, Myers, & Canfield, 2010), and low prepregnancy body mass index (BMI) (Paranjothy et al., 2012). Hence, infants with gastroschisis are typically born to vulnerable young mothers with limited income and education and poor nutritional status. These findings highlight the need to better understand the etiology of this defect.

Reports from multiple birth defects surveillance systems have documented an increase in the prevalence of gastroschisis over the last five decades (Anderson et al., 2018; Bhatt et al., 2018; Brebner, Czuzoj-Shulman, & Abenhaim, 2020; Calderon, Santos, Abreu, & Raimundo, 2019; Given et al., 2017; Jones et al., 2016; Kirby et al. 2013; Loane et al., 2011; MacBird et al., 2009; Werler & Parker, 2017). A recent study from 14 U.S. state surveillance programs described a 30% increase in the prevalence (per 10,000 births) of gastroschisis during the years of 2006–2012 (4.9) compared to 1995–2005 (3.6) and urged public health researchers to determine the etiology of this increase (Jones et al., 2016).

Arkansas (AR) is a key state for investigating these alarming numbers of gastroschisis since it was previously identified as having the highest prevalence of gastroschisis in a national study that included 15 U.S. states (Kirby et al. 2013). Gastroschisis also appears to occur in areas with higher gross agriculture value (Anderson et al., 2018). AR has a distinctive geography since it has an active livestock industry in its Northwestern corridor, a large row crop agriculture in its Eastern areas, and a distinctive Mississippi River Delta area.

Thus, the objective of this analysis was to explore trends in prevalence and the spatiotemporal distribution of gastroschisis in AR over an 18-year period, 1998–2015. This is the first study to examine the characteristics of these infants in a state that steadily reported one of the highest national prevalence of gastroschisis. Our hypothesis, a priori, was

that the prevalence of gastroschisis in AR had significantly increased through the years, and was higher in counties with active livestock or agricultural industry or in areas in proximity to the Mississippi River Delta area.

2 | METHODS

2.1 | Data collection

The study was approved by the Arkansas Department of Health (ADH) Scientific Advisory Committee and the University of Arkansas for Medical Sciences (UAMS) Institutional Review Board.

2.2 | Patient population

Patients with gastroschisis, who were born from January 1, 1998 through December 31, 2015, were identified through the Arkansas Reproductive Health Monitoring System (ARHMS). ARHMS is a statewide, population-based, birth defects surveillance program that monitors all live births, fetal deaths, and termination of pregnancy of congenital anomalies. ARHMS uses active surveillance methods where trained health information management specialists retrieve relevant data from medical records at multiple diagnosing facilities, including all delivering hospitals, the state's only pediatric specialty-care hospital, and the state's primary high-risk pregnancy and prenatal diagnosis center. Eligibility for ARHMS includes AR residence of the mother at delivery and diagnosis of a congenital malformation at any point during pregnancy, after stillbirth or termination of pregnancy, or after live birth and up to 2 years of age. ARHMS staff code all congenital malformations using a modified British Pediatric Association/Centers for Disease Control (CDC) six-digit birth defect coding system. ARHMS maintains a close partnership with the ADH to ensure population-based birth defect counts and prevalence rates (PRs) are complete and accurate for the state population. Data on all live births delivered to AR resident mothers during 1998–2015 were obtained from the Health Statistics Branch at ADH and served as the denominator for prevalence calculations.

Data obtained from ARHMS included maternal, paternal, and infant's demographic characteristics and limited clinical variables. Maternal data included maternal age (<20, 20–24, 25–29, 30–34, 35+ years), ethnicity (non-Hispanic [NH] white, NH black, Hispanic, and other/missing), years of education (<12, 12, >12), and parity defined as the number of previous live births (0, 1, 2+). Paternal data included paternal age (<20, 20–24, 25–29, 30–34, 35+ years) and ethnicity (NH white, NH black, Hispanic, and other/missing). Neonatal data included year of birth, birth weight (grams), sex, plurality (singleton or multiple), any associated chromosomal abnormalities and genetic anomalies, and mortality. Gestational age was occasionally missing and was calculated based on date of maternal last menstrual period and infant's date of birth. The U.S. national standards sex-specific growth curves were used to identify small for gestational age (SGA) and large for gestational age (LGA) infants. SGA and LGA infants were defined as infants with birth weight <10th or >90th percentile, respectively (Olsen, Groveman, Lawson, Clark, & Zemel, 2010). Appropriate for gestational age (AGA) infants had a birth weight ≥10th to ≤90th percentile. The mother's county and zip code of residence at time of delivery were geocoded.

We obtained data on county-level prepregnancy maternal BMI from the AR Pregnancy Risk Assessment Monitoring System (PRAMS; Center for Disease Control, 2019). PRAMS collect, via survey, state-specific, population-based data on maternal experiences before, during, and shortly after pregnancy (Center for Disease Control, 2019). Weighted percent of maternal prepregnancy BMI by county were available for the years of 2003–2015 and were categorized, based on the National Institutes of Health classification, as underweight (<18 kg/m^2), normal weight (18–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (≥30.0 kg/m^2) (Berrington de Gonzalez et al., 2010). BMI for 2003 was used as a proxy for the 1998–2003 time frame.

2.3 | Statistical analysis

Summary statistics including mean and standard deviation for continuous variables, or frequency and percentage for categorical variables, were determined. Prevalence was calculated by dividing the total number of gastroschisis cases by all live births, expressed per 10,000 live births. Annual and category-specific PRs were also calculated. Joinpoint regression analysis, using Joinpoint Regression Program 4.8.01 (www.surveillance.cancer.gov/jointpoint/), was performed to explore trends in gastroschisis in AR (Kim, Fay, Feuer, & Midthune, 2000). This program identified inflection points (called Joinpoints) where a significant change in linear slope occurred, allowing more than one segment to fit PRs trends between 1998 and 2015 (Kim et al., 2017). We chose not to use linear regression analysis to assess time trends since it assumed a constant rate of change over time and chose to use Joinpoint regression analysis since it assumed that the change is only constant over each time partition but varied among different time partitions. Each line segment was characterized with an estimated annual percentage change (APC), reflecting a change in trend within the time horizon of the line segment at a constant percentage of the rate of the previous year (Kim et al., 2000). An associated $p < .05$ represented the likelihood that the APCs were significantly different from zero.

Cluster analyses were performed using purely spatial and spatiotemporal cluster detection methods. The Getis-Ord Gi* (also known as hot spot analysis) was used to perform the spatial cluster detection and was based on the overall prevalence of gastroschisis per county during the entire study period (Getis & Ord, 1992; Kim & Jung, 2017; Kulldorff, 1997). Hot spot analysis assesses the presence of high (or low) value cluster areas, while evaluating a null hypothesis that no spatial autocorrelation is present. We also completed a spatiotemporal cluster detection of elevated gastroschisis prevalence at the county and year scales using Kulldorff's scan statistic (SaTScan v9.6) (Huang, Pickle, & Das, 2008; Root, Meyer, & Emch, 2009). SaTScan uses a discrete scan statistic with a Poisson distribution and places a series of ellipses at the center of each county with radii varying from 0 to a distance large enough to contain half the population. Separate ellipses are also constructed for varying temporal windows, ranging from 1 year to the entire study period. SaTScan calculates for each potential cluster a likelihood ratio test comparing the risk of disease inside to outside of the ellipse. SaTScan then uses a Monte Carlo simulation to determine the maximum likelihood ratio over the entire range of ellipses.

Previous concerns were raised regarding the SaTScan's tendency to overestimate the spatial extent of clusters, partially as a result of its use of an elliptical scanning window that does not allow for irregularly shaped clusters (Huang et al., 2008; Ord & Getis, 1995; Takahashi, Kulldorff, Tango, & Yih, 2008). Thus, we also performed spatiotemporal cluster detection with a newer, more restrictive tool called the Emerging Hot Spot Analysis (EHSA) that is implemented in ArcGIS Pro v2.3.2. EHSA uses the Getis-Ord Gi* for each year of data and applies the Mann–Kendall trend test to identify temporal trends between years (Esri, n.d.; Hamed, 2009; Spataru, 2018). Since EHSA evaluates spatial clustering for each year independently, sample sizes tend to be smaller resulting in smaller clusters compared to SaTScan. We considered any overlap between the clusters detected by SaTScan and EHSA to be a confirmation of a true spatiotemporal cluster of elevated gastroschisis prevalence within the state.

Our cluster analysis was spatiotemporal and thus required spatial units large enough to maintain adequate sample sizes for cluster detection. As such, our unit of analysis was the county. Thus, our multivariable analysis used county-level characteristics. Poisson regression model with repeated county indicator including county, year, and county*year was then fit to evaluate the PRs of gastroschisis, while adjusting for county-level maternal variables. Since we have repeated measurements on each county, compound symmetry was chosen for correlation structure (Kincaid, 2019). Multicollinearity among parental variables (measured at county-level) was examined using variance inflation factors (VIFs). The final model included four variables with VIFs <1.4 and was adjusted for county-level percent of live births born to mothers <20 years old, percent of live births born to NH white mothers, percent of live births born to mothers who completed ≤12 years of education, and weighted percent of mothers with prepregnancy BMI <18 kg/m^2. We also evaluated the time trend of gastroschisis prevalence stratified by the subgroups within each independent parental variable and tested if a significant interaction existed between the subgroup and year (represented as continuous variable), using a Poisson regression model of year, the characteristic, and the year*characteristic interaction term. SAS version 9.4 (SAS Inc., Cary, NC) was used for analysis. *P*-Values <.05 were considered statistically significant.

3 | RESULTS

We identified 401 cases of gastroschisis among 694,459 live births in 75 AR counties during the study period (1998–2015; Table 1). The overall prevalence of gastroschisis in AR for the entire study period was 5.8/10,000 livebirths (95% confidence interval [CI]: 5.2–6.4; Table 1). The statewide prevalence (per 10,000 livebirths) ranged from 3.0 in 2001 to 9.1 in 2012. The crude prevalence ratio was significantly high in 2011 (1.8; 95% CI: 1.0–3.2) and 2012 (1.9; 95% CI: 1.1–3.3) in comparison to the referent year 1998 (Table 1). The prevalence (per 10,000 livebirths) of gastroschisis was highest in the Northwest region of AR (6.5, 95% CI: 5.5–7.6; Table 1). From 1998 through 2012, the PR of gastroschisis had a statistically significant APC of +5.3% (95% CI: 2.6–8.1; $p < .0001$), followed by a yearly nonsignificant average decrease of −17% through 2015 (95% CI: −39.0–13.0; $p = 0.2$; Figure 1). The spatiotemporal trend of gastroschisis rates in AR also varied (Figure 2). Prevalence increased in 44 counties and decreased in 23 counties, while 8 counties had no recorded cases of gastroschisis (Figure 2).

Infants with gastroschisis were typically AGA (59.2%) with an average birth weight of 2,402 g (Table 2). Their mortality rate was approximately 6%. Almost 3% of infants, born with gastroschisis between 1998 and 2013, had associated chromosomal abnormalities, while ~10.0% had genetic anomalies (Table 2). Mothers of infants with gastroschisis were mostly <20 years old (32.9%), primigravida (53.4%), and had ≤12 years of education (63.4%; Table 3). Fathers of infants with gastroschisis were mainly 20–24 years old (35.7%). All the previously listed parental variables showed a statistically significant difference in comparison to their referent group. In addition, NH black mothers had a significantly lower prevalence of children with gastroschisis in comparison to NH white mothers (prevalence ratio = 0.5, 95% CI: 0.4–0.7). On the other hand, NH black fathers had a comparable risk to NH white fathers to have a child with gastroschisis (prevalence ratio = 0.9, 95% CI: 0.7–1.2; Table 3).

When evaluating the time trend of gastroschisis prevalence stratified by the subgroups within each variable, the interaction terms for maternal age, race/ethnicity, and education categories and year had nonsignificant *p*-values (Table S1, Supporting Information). This result suggests that the rate of change in prevalence over time among the subgroups of these three variables is not statistically significant. On the other hand, the interaction terms for parity, paternal age, and paternal race/ethnicity and year were statistically significant. The risk ratios of the different subgroups of these variables to a referent group were calculated and found to be statistically significant in two instances (data not shown). The annual rate of change in the prevalence of gastroschisis was 27% higher among Hispanic compared to NH white fathers ($p = .0016$), while the annual rate of change in the prevalence of gastroschisis among fathers who are younger than 20 years old was 29% higher compared to fathers who are 25–29 years old ($p < .0001$).

Purely spatial cluster analysis failed to detect any clusters present during the entire study period. However, spatiotemporal clusters were detected. SaTScan identified a single elliptical cluster centered in Scott County in the western part of the state, with a radius of 125.42 km, consisting of 18 counties between the years of 2006 and 2013 (Figure 3). The SaTScan cluster contained 85 cases of gastroschisis with a relative risk of 1.9 and a log likelihood ratio of 11.8 ($p = .015$). The temporal analysis of the SaTScan cluster is illustrated in Figure S1. The number of observed cases of gastroschisis is shown by year both inside and outside of the identified cluster, as compared to the number of expected cases in each year estimated from the statewide prevalence of gastroschisis. From 2006 through 2013, the number of observed/expected (O/E) cases of gastroschisis inside the cluster area was significantly higher than the (O/E) ratio outside the cluster. However, in 2014 and 2015, the difference between (O/E) cases of gastroschisis inside and outside the cluster area were no longer significant. EHSA also identified several smaller spatiotemporal clusters across the state, including five counties that were part of the SaTScan cluster (Figure 3).

We considered any overlap between the clusters detected by SaTScan and EHSA to be a strong suggestion of a true spatiotemporal cluster. Thus, we fit a Poisson regression model with repeated county indicator that accounted for county-level maternal age, race/ethnicity, education, and prepregnancy BMI. The model evaluated the PRs of gastroschisis and had

a binary county indicator (inside or outside five county-cluster), binary time frame (before vs. at or after year 2006), and an interaction term between the county and time indicators. The interaction in the model between the temporal and the spatial effect was not statistically significant ($p = .549$). Thus, the Poisson regression model did not confirm the presence of a spatiotemporal cluster, once it adjusted for county-level maternal characteristics ($p = .549$).

4 | DISCUSSION

We evaluated the trends in prevalence and the spatiotemporal distribution of gastroschisis in AR, a state that consistently reported high prevalence of this defect. The overall prevalence of gastroschisis in AR during the study period (1998–2015) was 5.8/10,000 live births. The Joinpoint regression analysis identified one inflection point in trends of gastroschisis during the study period. From 1998 through 2012, the PR of gastroschisis had a statistically significant APC of +5.3% (95% CI: 2.6–8.1; $p < .0001$), followed by a yearly nonsignificant average decrease of −17% through 2015 (95% CI: −39.0–13.0; $p = 0.2$). In addition, two different spatiotemporal analytic techniques, SaTScan and EHSA, initially identified an overlapping five-country area, with unusually high PRs of gastroschisis in the western area of the state. However, the presence of such spatiotemporal cluster was not a significant result based on a Poisson regression model that adjusted for county-level maternal characteristics.

Gastroschisis rates have been widely evaluated. Given et al. (2017) conducted a population-based case malformed control study from 1995 to 2012 and assessed data from 18 EUROmediCAT registries across 14 European countries. The authors determined an average prevalence of 2.0 (95% CI: 1.9–2.1) gastroschisis cases per 10,000 live births across 18 Europeans registries. The prevalence of gastroschisis was reported to be increasing in Brazil (Calderon et al., 2019), Australia (Whitehall, Kandasamy, Stalewski, & Gill, 2010), New Zealand (Srivastava et al., 2009), and Mexico (Salinas-Torres, Salinas-Torres, Cerda-Flores, & Martínez-de-Villarreal, 2018), and decreasing in China (Li et al., 2016; Xu et al., 2011) and Taiwan (Chen, Chen, Chen, Tsai, & Lee, 2019). The variations in gastroschisis rates have been also evaluated in the United States. Kirby et al. (2013) assessed the prevalence (per 10,000 live births) of gastroschisis in 15 states from 1995 to 2005, and noted the lowest rate in New York (1.53) and the highest in AR (5.06). In a follow-up study, the overall gastroschisis prevalence in 14 states (including AR) was estimated to have a significant 30% increase from 3.6 (95% CI: 3.5–3.7) in 1995–2005 to 4.9 (95% CI: 4.7–5.0) in 2006–2012 (Jones et al., 2016). Interestingly, Short et al. (2019) only noted a marginal increase in prevalence of gastroschisis in 20 states (not including AR) between 2006–2010 and 2011–2015 (prevalence ratio = 1.1, 95% CI: 1.0–1.1). Similarly, our study showed that the trends of prevalence of gastroschisis have changed over the years. Although the APC of prevalence of gastroschisis in AR was +5.3% (95% CI: 2.6–8.1; $p < .0001$) from 1998 through 2012, it decreased to a nonsignificant yearly average of −17% (95% CI: −39–13; $p = 0.2$) from 2013 to 2015. The association between young maternal age and gastroschisis have been repetitively reported in the literature (Jones et al., 2016). Recent studies have shown that teen birth rates in the United States have been declining and were additionally down by 8% in 2015 in comparison to 2014 (Hamilton & Mathews, 2016). Perhaps, this decline in teen pregnancies justifies the change in gastroschisis prevalence in the United States. Further

follow-up of rates of gastroschisis is needed to determine if the PRs of gastroschisis continue to decline in AR and other areas of the United States.

Other parental factors have also been correlated with higher risk of gastroschisis. The association of maternal low parity (Benjamin et al., 2010) and limited education (Khodr et al., 2013) with higher risk of gastroschisis was described in the literature and reiterated in our results. On the other hand, epidemiological studies differed on the categorization of maternal ethnicity of infants with gastroschisis. Some studies showed lower risk of gastroschisis among Hispanic mothers compared to NH whites (Vu, Nobuhara, Laurent, & Shaw, 2008), while others had opposite findings (Salemi et al., 2009). In our analysis, the difference in risk of gastroschisis was not statistically different between NH white and Hispanic mothers. The evaluation of the demographic characteristics of fathers of infants with gastroschisis is more limited in the literature. Unlike previous reports that showed that the risk of offspring with gastroschisis was highest among fathers <20 years old (Kazaura et al., 2004), our analysis indicated that the risk was more predominant among 20–24years-old fathers.

The clinical characteristics of patients with gastroschisis have been also described in the literature. (Feldkamp, Botto, Byrne, Krikov, and Carey, 2016) examined the clinical presentation of infants with gastroschisis born in Utah between 1997 and 2011. The authors concluded that 21.6% of patients with gastroschisis were SGA, while ~15% had associated congenital anomalies. On the other hand, (Chen et al., 2011) reported that at least half of infants with gastroschisis, born at a single tertiary center (1990–2010), were SGA. In addition, (Benjamin and Wilson, 2014) reviewed cases from the Texas Birth Defects Registry (1999–2008) and noted that gastroschisis was associated with other congenital anomalies in almost one third of cases. Our study showed that almost 40% of infants with gastroschisis were SGA, while ~10% had associated congenital anomalies.

The role of agricultural exposures in gastroschisis clusters have been formerly explored. Atrazine, an herbicide commonly used in cornfields, was implicated in higher occurrence of gastroschisis (Agopian, Langlois, Cai, Canfield, & Lupo, 2013; Waller, Paul, Peterson, & Hitti, 2010). A recent study evaluating the prevalence of gastroschisis in California noted that the risk was greatest in areas of higher timber value (Paranjothy et al., 2012; Yazdy et al., 2015), based on data from the National Birth Defects Prevention Study (NBDPS; 1997–2007), previously completed a spatial analysis of gastroschisis in the states of AR, California, and Utah. The authors noted elevated crude odd ratios of gastroschisis in the southwest areas of AR (Yazdy et al., 2015). Interestingly, the southwest areas of AR include the Ouachita Mountains Natural Division, an area that is mostly covered by forests and timber trees (Ecoregions/Natural Divisions of Arkansas, n.d.). Although our analysis initially indicated high numbers of gastroschisis in the southwest of AR (Table 2) and identified possible clusters in that area, the Poisson regression models could not confirm the presence of such significant clusters, once it adjusted for county-level maternal characteristics.

Our study has multiple strengths. It evaluated the trends in prevalence and the spatiotemporal distribution gastroschisis in AR over 18 years and used multi-ethnic,

population-based data that was collected prospectively via active surveillance methods. Additionally, the study applied two different techniques to evaluate the spatiotemporal distribution of this defect in AR. Some limitations, however, remained. We were unable to assess maternal behavioral or life style factors such as smoking or illicit drug use and/or illnesses. In addition, we were only able to include county-level rather than individual-level maternal characteristics in our modeling. However, our cluster analysis was spatiotemporal and required larger spatial units (county-level rather than individual-level characteristics) to maintain adequate sample sizes for cluster detection. We also had some missing data on maternal and paternal characteristics. However, the data appear to be missing at random and complete case analysis is typically valid in such instances.

5 | CONCLUSION

The increase in gastroschisis prevalence and its disproportionate higher occurrence among offspring of young mothers stressed the urgency of public health research in this defect. We leveraged the availability of an 18-year data on gastroschisis in AR, a state that has an established birth defect registry and consistently reports high occurrence of this defect. Our analysis revealed that although the APC of prevalence of gastroschisis in AR significantly increased from 1998 through 2012, it stopped rising and even became negative from 2013 through 2015. Our findings seem to indicate a change in trends of gastroschisis in AR. Further follow-up of rates of gastroschisis is warranted to determine if the PRs of gastroschisis continue to decline in AR and other areas of the United States.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Funding information

Centers for Disease Control and Prevention (CDC) National Center for Birth Defects and Developmental Disabilities, Grant/Award Number: #5U01DD000491

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request

Abbreviations:

APC	annual percent change
ADH	Arkansas Department of Health
AGA	appropriate for gestational age
AR	Arkansas
ARHMS	Arkansas Reproductive Health Monitoring System
BMI	body mass index

CDC	Centers for Disease Control
CI	confidence interval
CNS	central nervous system
EHSA	Emerging Hot Spot Analysis
LGA	large for gestational age
NBDPS	National Birth Defects Prevention Study
NH	non-Hispanic
O/E	observed/expected
PR	prevalence rate
PRAMS	Pregnancy Risk Assessment Monitoring System
SGA	small for gestational age
UAMS	University of Arkansas for Medical Sciences
VIFs	variance inflation factors

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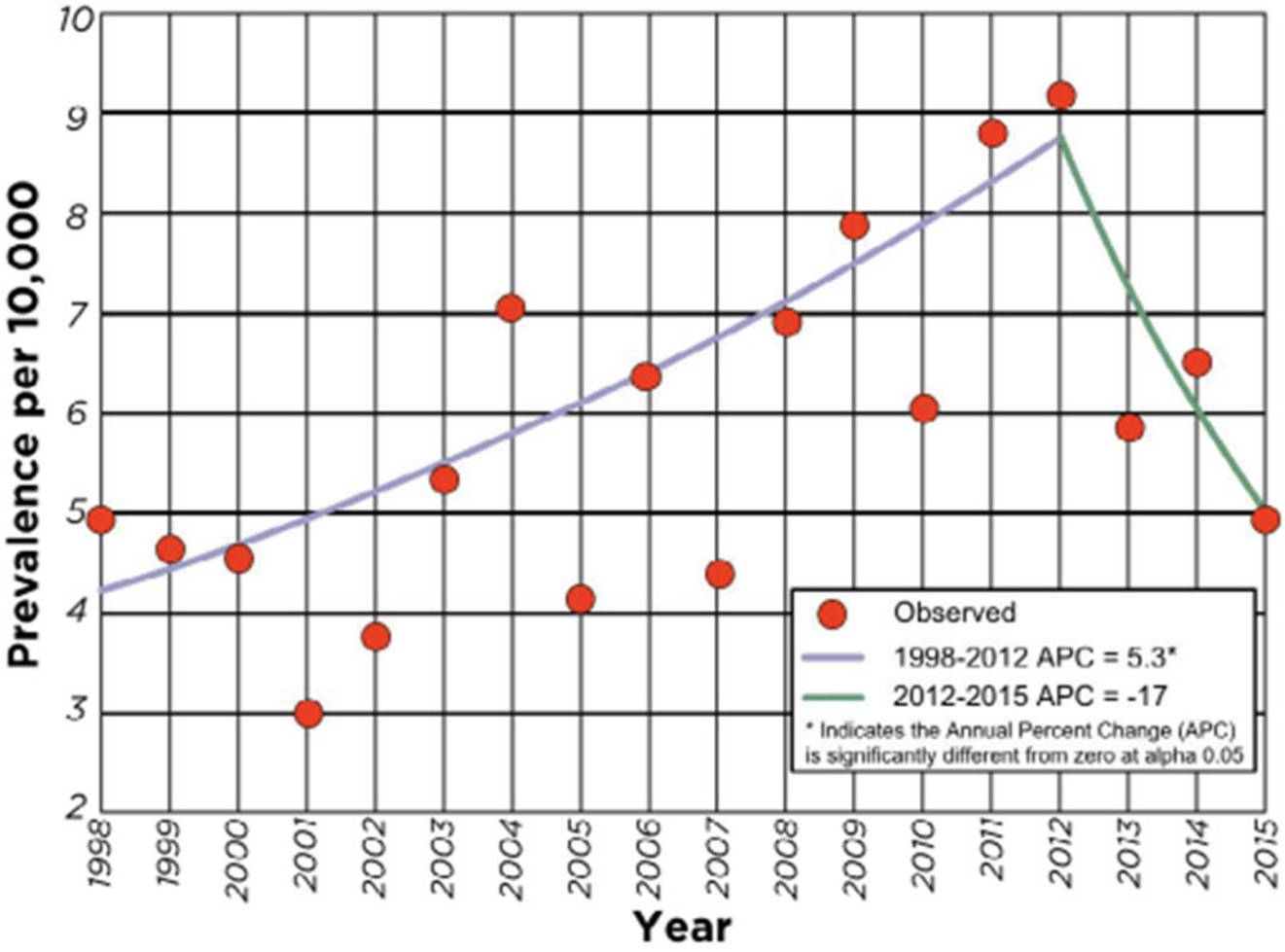

FIGURE 1.
Joinpoint graph of prevalence of gastroschisis in AR per year, 1998–2015

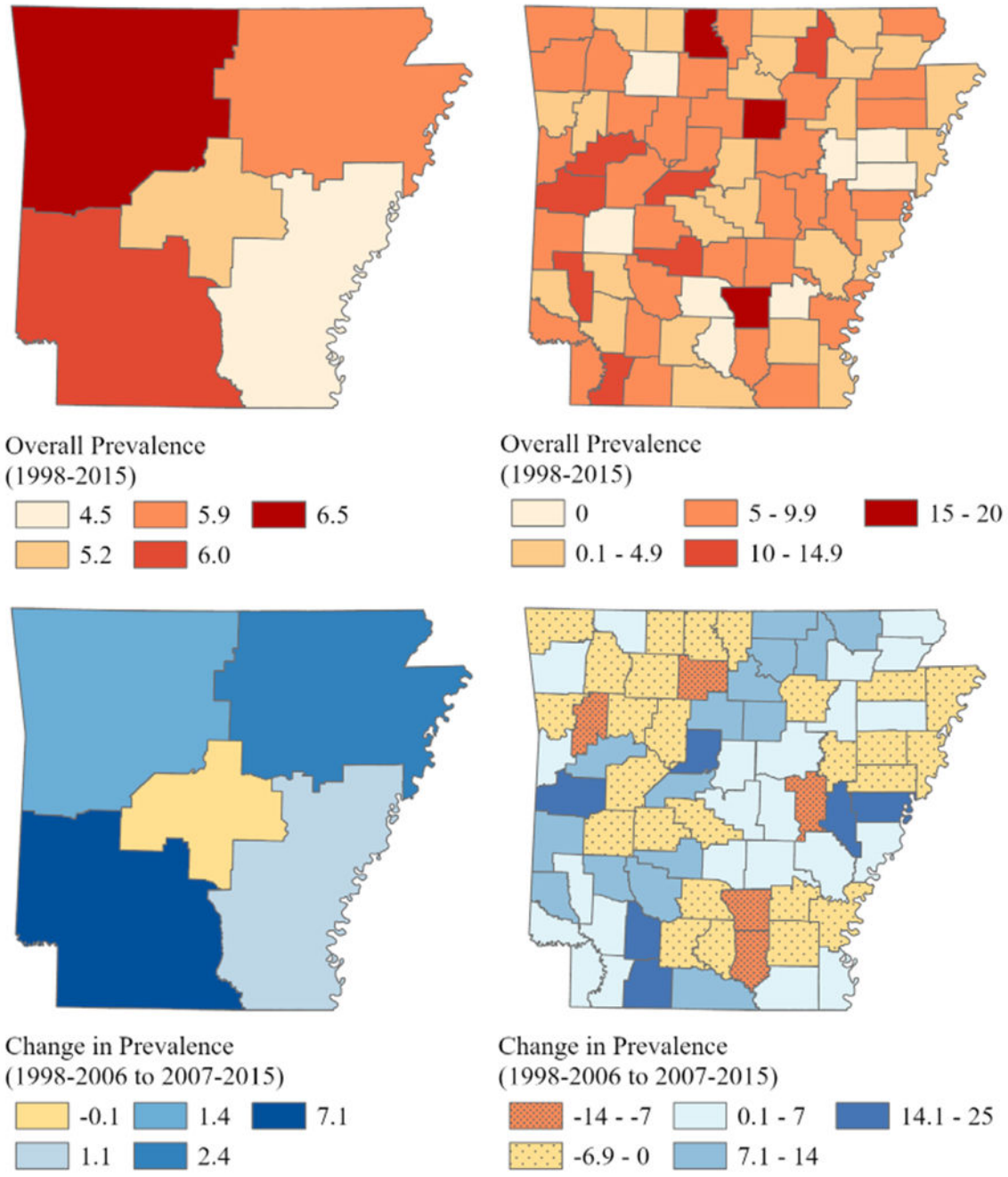

FIGURE 2.
Prevalence of gastroschisis in AR (1998–2015) by region and county

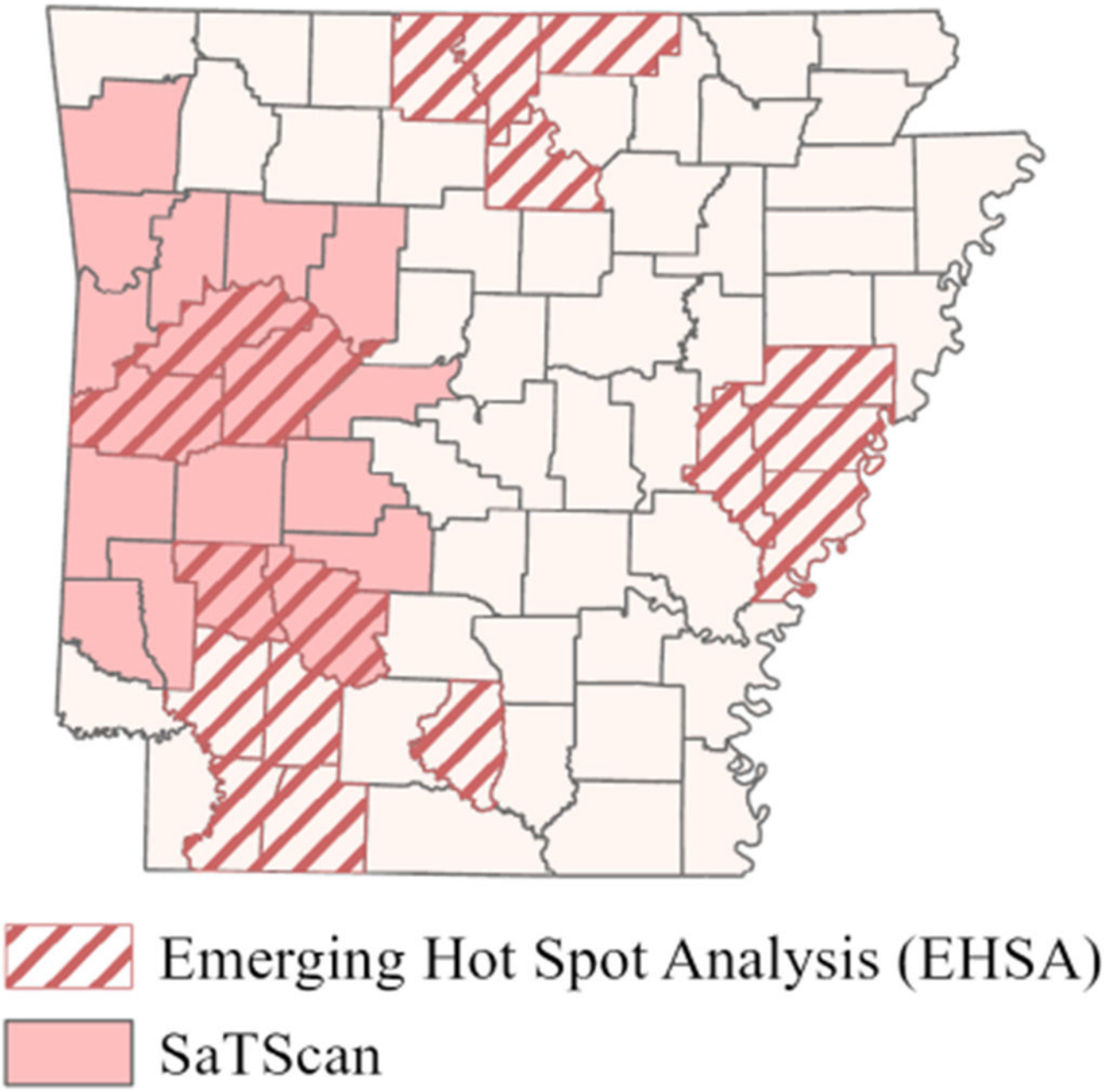

FIGURE 3.
Cluster of gastroschisis cases in AR, 1998–2015

TABLE 1

Prevalence and crude prevalence ratios for gastroschisis in AR, 1998–2015

	Cases		Total births			
Characteristic	**No.**	**%**	**No.**	**%**	**Prevalence[a] (95% CI)**	**Crude prevalence ratio (95% CI)**
Overall	401	100.0	694,459	100.0	5.8 (5.2–6.4)	
Year of birth						
1998	18	4.5	36,831	5.3	4.9 (3.1–7.8)	Referent
1999	17	4.2	36,672	5.3	4.6 (2.9–7.5)	1.0 (0.5–1.8)
2000	17	4.2	37,790	5.4	4.5 (2.8–7.2)	0.9 (0.5–1.8)
2001	11	2.7	36,983	5.3	3.0 (1.7–5.4)	0.6 (0.3–1.3)
2002	14	3.5	37,457	5.4	3.7 (2.2–6.3)	0.8 (0.4–1.5)
2003	20	5.0	37,794	5.4	5.3 (3.4–8.2)	1.1 (0.6–2.1)
2004	27	6.7	38,564	5.6	7.0 (4.8–10.2)	1.4 (0.8–2.6)
2005	16	4.0	39,218	5.7	4.1 (2.5–6.7)	0.8 (0.4–1.6)
2006	26	6.5	40,967	5.9	6.4 (4.3–9.3)	1.3 (0.7–2.4)
2007	18	4.5	41,361	6.0	4.4 (2.7–6.9)	0.9 (0.5–1.7)
2008	28	7.0	40,662	5.9	6.9 (4.8–10.0)	1.4 (0.8–2.6)
2009	31	7.7	39,679	5.7	7.8 (5.5–11.1)	1.6 (0.9–2.9)
2010	23	5.7	38,525	5.6	6.0 (4.0–9.0)	1.2 (0.7–2.3)
2011	34	8.5	38,763	5.6	8.8 (6.3–12.3)	1.8 (1.0–3.2)
2012	35	8.7	38,300	5.5	9.1 (6.6–12.7)	**1.9 (1.1–3.3)**
2013	22	5.5	37,838	5.5	5.8 (3.8–8.8)	1.2 (0.6–2.2)
2014	25	6.2	38,411	5.5	6.5 (4.4–9.6)	1.3 (0.7–2.4)
2015	19	4.7	38,644	5.6	4.9 (3.1–7.7)	1.0 (0.5–1.9)
Region						
Central	99	24.7	190,091	27.4	5.2 (4.3–6.3)	1.2 (0.9–1.6)
Northeast	76	19.0	129,731	18.7	5.9 (4.7–7.3)	1.3 (0.9–2.0)
Northwest	149	37.2	229,231	33.0	6.5 (5.5–7.6)	1.4 (1.0–1.9)
Southeast	31	7.7	68,355	9.8	4.6 (3.2–6.5)	Referent
Southwest	46	11.5	77,051	11.1	6.0 (4.5–8.0)	1.3 (0.8–2.1)

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Note: In bold are associations for which the 95% CI excludes 1.00.

[a]Cases per 10,000 live births.

TABLE 2

Neonatal characteristics of infants born with gastroschisis in AR, 1998–2015

Variable	Number
Birth weight (g)	
Mean (*SD*)	2,402 (595)
Range	465–4,450
Sex, n (%)	
Male	210 (52.4%)
Female	191 (47.6%)
Gestational age (weeks)	
Mean (*SD*)	35.5 (4.8)
Range	13.0–45.0
Size for gestational age, n (%)	
SGA	129 (36.0%)
AGA	212 (59.2%)
LGA	17 (4.8%)
Plurality, n (%)	
Single	386 (96.3%)
Plural	8 (2.0%)
Not stated/unknown	7 (1.7%)
Genetic anomalies, n (%)[a,b]	34 (9.5%)
Multiple congenital anomalies (Cardiac, CNS, and limb)	21 (5.0%)
Cardiac anomalies	2 (0.6%)
CNS anomalies	3 (0.8%)
Limb anomalies	4 (1.1%)
Cleft lip and palate	3 (0.8%)
Hypospadia	1 (0.3%)
Chromosomal abnormalities, n (%)[a]	10 (2.8%)
Trisomy 13	3 (0.8%)
Trisomy 18	3 (0.8%)
Chromosomal deletions, duplication, and rearrangement with no known clinical significance	4 (1.1%)
Mortality, n (%)	
Deceased	23 (5.7%)
Living	378 (94.3%)

Abbreviations: AGA, appropriate for gestational age; CNS, central nervous system; LGA, large for gestational age; *SD*, standard deviation; SGA, small for gestational age.

[a]The complete review of chromosomal abnormalities and genetic anomalies was only available for the years of 1998–2013. The total number of infants with gastroschisis was 357 during that timeline.

[b]A total of 14 patients had associated chromosomal abnormalities (Trisomy 13 or 18) or died shortly after delivery.

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TABLE 3

Prevalence and crude prevalence ratios for gastroschisis by parental characteristics in AR, 1998–2015

Maternal variables	**Cases**		**Total births**		**Prevalence[a] (95% CI)**	**Crude prevalence ratio (95% CI)**
Maternal age (years)						
<20	132	32.9	98,971	14.3	13.3 (11.3–15.8)	**4.6 (3.4–6.3)**
20–24	187	46.6	228,230	32.9	8.2 (7.1–9.5)	**2.8 (2.1–3.8)**
25–29	56	14.0	193,427	27.9	2.9 (2.2–3.8)	Referent
30–34	18	4.5	117,609	16.9	1.5 (1.0–2.4)	**0.5 (0.3–0.9)**
35+	7	1.8	55,975	8.1	1.3 (0.6–2.6)	**0.4 (0.2–1.0)**
Missing	1	0.3	247	0.0		
Maternal race/ethnicity						
NH white	301	75.1	474,341	68.3	6.4 (5.7–7.1)	Referent
NH black	46	11.5	135,431	19.5	3.4 (2.5–4.5)	**0.5 (0.4–0.7)**
Hispanic	30	7.6	63,462	9.1	4.7 (3.3–6.8)	0.7 (0.5–1.1)
Other or missing	24	6.0	21,225	3.1	11.3 (7.6–16.9)	**1.8 (1.2–2.7)**
Maternal education						
<12 years	80	20.0	138,581	20.0	5.8 (4.6–7.2)	**1.9 (1.4–2.6)**
12 years	174	43.4	269,583	38.8	6.5 (5.6–7.5)	**2.1 (1.7–2.8)**
13+ years	84	21.0	278,980	40.2	3.0 (2.4–3.7)	Referent
Missing	63	15.7	7,315	1.1		
Parity						
0	214	53.4	242,021	34.9	8.8 (7.7–10.1)	**8.0 (5.4–11.9)**
1	59	14.7	198,066	28.5	3.0 (2.3–3.8)	**2.7 (1.7–4.2)**
2 or more	28	7.0	253,213	36.5	1.1 (0.8–1.6)	Referent
Missing	100	24.9	1,159	0.2		
Paternal variables	**Cases**		**Total births**		**Prevalence (95% CI)**	**Crude prevalence ratio (95% CI)**
Paternal age (years)						
<20	38	9.5	103,624	14.9	3.7 (2.7–5.0)	0.8 (0.6–1.2)
20–24	143	35.7	132,539	19.1	10.8 (9.2–12.7)	**2.4 (1.8–3.2)**

Maternal variables	Cases		Total births		Prevalence[a] (95% CI)	Crude prevalence ratio (95% CI)
25–29	76	19.0	167,795	24.2	4.5 (3.6–5.7)	Referent
30–34	36	9.0	130,833	18.8	2.8 (2.0–3.8)	**0.6 (0.4–0.9)**
35+	14	3.5	109,795	15.8	1.3 (0.8–2.1)	**0.3 (0.2–0.5)**
Missing	94	23.4	49,873	7.2		
Paternal race/ethnicity						
NH white	258	64.3	395,609	57.0	6.5 (5.8–7.4)	Referent
NH black	48	12.0	83,666	12.1	5.7 (4.3–7.6)	0.9 (0.7–1.2)
Hispanic	18	4.5	58,694	8.5	3.1(1.9–4.9)	**0.5 (0.3–0.8)**
Other, missing	77	19.2	156,490	22.5		

Note: In bold are associations for which the 95% CI excludes 1.00.

Abbreviations: CI, confidence interval.

[a]Cases per 10,000 live births.