

# Epidemiology of Bladder and Cloacal Exstrophies in New York State, 1983–1999

Alissa R. Caton,<sup>1\*</sup> Anna Bloom,<sup>2</sup> Charlotte M. Druschel,<sup>1</sup> and Russell S. Kirby<sup>2</sup>

<sup>1</sup>Congenital Malformations Registry, New York State Department of Health, Troy, New York

<sup>2</sup>Department of Maternal and Child Health, School of Public Health, University of Alabama at Birmingham, Birmingham, Alabama

Received 16 February 2007; Revised 9 April 2007; Accepted 14 June 2007

**BACKGROUND:** Bladder exstrophy (BE) and cloacal exstrophy (CE) are rare birth defects that have been reported to occur in 1:30,000–50,000 and 1:200,000–400,000 live births. Disagreement exists as to whether they comprise two distinct disorders or are part of a spectrum. We examined epidemiologic trends and risk factors for BE and CE in a large population-based dataset. **METHODS:** Potential cases were identified in the New York State (NYS) Congenital Malformations Registry. When nonspecific codes for CE were reported, narrative descriptions were reviewed for classification. Birth certificate data were analyzed with descriptive statistics and Poisson regression was used to calculate crude (PR) and adjusted prevalence ratios (aPR) and 95% confidence intervals (CI). **RESULTS:** In NYS from 1983 through 1999, 95 BE cases and 29 CE cases were identified for a live-birth prevalence of 2.1 and 0.6 per 100,000 live births. BE showed a statistically significant downward linear trend by year. Factors associated with BE included summer conception (vs. winter, aPR 2.46, CI 1.19–5.10), white, non-Hispanic maternal race/ethnicity (vs. black non-Hispanic, aPR 3.20, CI 1.20–8.52), and male sex (female vs. male, aPR 0.53, CI 0.33–0.87). Factors associated with CE included pre-term low birth weight birth (aPR 14.55, CI 5.28–40.07), multiple birth (aPR 6.68, CI 1.19–23.27), non-New York City residence (aPR 3.27, CI 1.04–10.22), and female sex (aPR 2.57, CI 1.00–6.64). Infant mortality was greater in the CE group. **CONCLUSIONS:** The epidemiology suggests different risk factor patterns for BE and CE. Classification of BE and CE is difficult due to the nonspecific coding. *Birth Defects Research (Part A) 79:781–787, 2007.* © 2007 Wiley-Liss, Inc.

**Key words:** bladder exstrophy; cloacal exstrophy; epidemiology; birth defects; surveillance; congenital malformations registry; birth certificates

## INTRODUCTION

Bladder exstrophy (BE) and cloacal exstrophy (CE) are rare congenital anomalies that occur in 1:30,000–50,000 and 1:200,000–400,000 live births, respectively (Stevenson et al., 1993; Jones, 1997; Martinez-Frias et al., 2001). CE also occurs in stillbirths, with a reported prevalence of 1:10,000–50,000 deliveries (Keppler-Noreuil, 2001). In BE, the urinary tract is open anteriorly with the bladder mucosa exposed through a midline defect of the lower abdomen (Stevenson et al., 1993; Jones, 1997). It is accompanied with separation of the pubic symphysis and genital abnormalities, such as epispadias and split phallus. In CE, a common cloacal cavity is exposed. In addition to the defects associated with BE, CE includes imperforate anus and often an omphalocele and spinal defects. The defects are difficult to repair for urinary and/or bowel continence and sexual function.

The etiology of bladder and cloacal exstrophies is not understood (Stevenson et al., 1993; Keppler-Noreuil,

2001; Martinez-Frias et al., 2001; Carey, 2001; Bohring, 2002). BE occurs following urorectal septation, and CE occurs before partitioning of the cloaca by the urorectal septum (Stevenson et al., 1993; Jones, 1997). Thus, the timing of the rupture of the cloacal membrane determines the type of exstrophy. Disagreement exists in the literature as to whether BE and CE comprise two distinct disorders or are part of a spectrum (Carey, 2001; Martinez-Frias et al., 2001; Bohring, 2002). OEIS (omphalocele, exstrophy, imperforate anus, spine abnormalities) complex is another term that has been used synonymously

Presented at the 18th annual meeting of the Society for Paediatric and Perinatal Epidemiology, June 26–27, 2005, Toronto, Canada.

\*Correspondence to: Alissa R. Caton, New York State Department of Health, Bureau of Environmental and Occupational Epidemiology, Flanigan Square, 547 River St., Room 200, Troy, NY 12180-2216. E-mail: arc05@health.state.ny.us  
Published online in Wiley InterScience (www.interscience.wiley.com).

DOI: 10.1002/bdra.20402

with CE; most or all of these components are affected (Carey, 2001; Bohring, 2002).

We identified cases of BE and CE from a 17-year cohort of live births in New York State and examined trends and risk factors associated with these birth defects.

## MATERIALS AND METHODS

The New York State Congenital Malformations Registry has collected population-based malformation reports since 1983 (New York State Department of Health, 1999). New York State law requires medical personnel to report congenital malformations in children under the age of 2 to the Registry. Individual cases are reported to the New York State Department of Health. Trained coders review and code case information, including the narrative description of the malformation. Each case is matched to existing Registry reports for possible duplicates.

Since a change from the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) system (International Classification of Diseases, 1998) to the modified British Paediatric Association (BPA) system (British Paediatric Association, 1979) of malformation coding occurred in 1992, potential cases were selected from the computerized Registry using ICD-9-CM codes for birth years 1983–1991 and BPA codes for years 1992–1999. Potential BE cases were identified using codes specific to exstrophy of the bladder in both coding schemes, ICD-9-CM code 753.5 and BPA code 753.500. Because no specific code exists for CE, an algorithm of diagnosis codes was used to capture records for screening. Using ICD-9-CM codes, records coded with 751.5 (other anomalies of intestine, including persistent cloaca), 759.8 (other specified anomalies), or 759.89 (other specified anomalies, other) were selected. Selected records also containing codes 751.2 (atresia and stenosis of large intestine, rectum and anal canal, including imperforate anus), 756.7 (anomalies of abdominal wall, including omphalocele), or 741 (spina bifida), were flagged as potential CE cases. In the BPA scheme, all records with code 751.550 (persistent cloaca) were flagged as potential CE cases. Records with code 759.8 (other specified anomalies and syndromes) or 759.89 (other specified anomalies) that also contained 751.2 (atresia and stenosis of large intestine, rectum and anal canal, including imperforate anus) were flagged as potential CE cases.

Diagnoses codes and narrative descriptions of potential BE and CE cases were reviewed for classification. Records with the specific BE code (ICD-9-CM 753.5 or BPA 753.500) that also mentioned coexistence of imperforate anus and an additional spinal anomaly or omphalocele were classified as CE cases. The remaining BE cases were categorized into isolated/sequence, multiple, and syndrome groups. BE cases without additionally reported malformations, with a minor unrelated anomaly, or with related urogenital anomalies considered as sequelae of BE (e.g., epispadias or genital ambiguity) were classified as isolated/sequence events. Trisomies and recognized syndromes were categorized as syndromes. The remaining records of BE cases with additional major malformations were classified as multiple anomalies. Narrative descriptions were reviewed for all potential CE cases flagged by the code algorithms. Cases with the term "cloacal exstrophy" recorded were classi-

fied as CE cases. The group of CE cases were not further classified into isolated/sequence, multiple, or syndrome categories.

Identified cases of CE and BE were linked to New York State resident live-birth certificate records and death certificate records by year of birth and birth certificate number. Resident live-birth certificate records for 1983–1999 were used to calculate live-birth prevalence and prevalence ratio estimates. Maternal and infant characteristics were obtained from the birth certificate database and categorized for statistical analysis. Month of conception was estimated using gestational age in weeks and date of birth and categorized into four seasons: winter (December–February), spring (March–May), summer (June–August), and fall (September–November). Distributions of year, season of conception, maternal residence at birth (New York City, other New York State), plurality (singleton, multiple), infant sex, birth weight (<2500 g, 2500 g+), gestational age (<37, 37 weeks+), birth weight for gestational age (<2500 g and <37 weeks, <2500 g and 37 weeks+, 2500 g+ and <37 weeks, 2500 g+ and 37 weeks+), maternal race/ethnicity (white non-Hispanic, black non-Hispanic, Hispanic, other), maternal age (<20, 20–34, 35+ years), maternal education (<12 years, high school, some college), prenatal care (first trimester care, other), principal payment source (Medicaid, other), and total previous live births (0, 1, 2, 3+) were calculated for BE cases restricted to isolated/sequence events, CE cases, and live births. Three-year moving averages of live-birth prevalence were calculated. Chi-square tests were used to compare distributions of maternal and infant characteristics, and Poisson regression analyses were performed to estimate crude (PR) and adjusted live-birth prevalence ratios (aPR) with 95% confidence intervals (CI). Fully adjusted models were created with season of conception, maternal residence at birth, plurality, infant sex, weight for gestational age, maternal age, maternal race/ethnicity, maternal education, prenatal care, and total previous live births. Principal payment source was not included in the multivariable analyses because it was available from 1990 to 1999 only. Linked death certificate data was used to determine infant mortality in the case groups.

## RESULTS

For the 17-year study period, 4,603,747 resident live births were recorded in New York State. One hundred and twenty-three Congenital Malformation Registry records were coded with ICD-9-CM /BPA code 753.5 (bladder exstrophy) which corresponds to a prevalence of 2.7 per 100,000 live births. After manual review of the associated anomalies and case narratives, 28 (23%) of the 123 cases with ICD-9-CM /BPA code 753.5 were reclassified as CE cases. From the remaining 95 BE cases, 2 (2%) were categorized as syndromes, 16 (17%) were categorized as multiples, and 77 (81%) were classified as isolated/sequence events. The birth prevalence of BE was 2.1 per 100,000 live births. Twenty-eight (97%) of the CE cases were captured with ICD-9-CM /BPA code 753.5 (bladder exstrophy), and one additional CE case was identified using the coding algorithm for a total case group of 29 (0.6 per 100,000 live births). Descriptive statistics for BE and CE case groups are shown in Table 1.

Table 1  
Distributions of Maternal and Infant Characteristics among Isolated/Sequence Bladder Exstrophy Cases, Cloacal Exstrophy Cases, and New York State Births, 1983–1999

Maternal and infant characteristics	Live births ( <i>n</i> = 4,603,747) <i>n</i> (%)	Bladder exstrophy ( <i>n</i> = 77)		Cloacal exstrophy ( <i>n</i> = 29)	
		<i>n</i> (%)	<i>P</i> -value <sup>a</sup>	<i>n</i> (%)	<i>P</i> -value <sup>a</sup>
Conception season					
Winter (Dec–Feb)	1,123,943 (24.6)	13 (17.1)	.17	3 (10.3)	.20
Spring (Mar–May)	1,109,348 (24.3)	17 (22.4)		11 (37.9)	
Summer (Jun–Aug)	1,154,332 (25.3)	27 (35.5)		8 (27.6)	
Fall (Sep–Nov)	1,174,856 (25.8)	19 (25.0)		7 (24.1)	
Maternal residence					
Other New York State	2,506,092 (54.4)	51 (66.2)	.04	18 (62.1)	.41
New York City	2,097,655 (45.6)	26 (33.8)		11 (37.9)	
Plurality					
Single	4,481,514 (97.4)	75 (97.4)	.67	24 (82.8)	<.001
Multiple	122,188 (2.7)	2 (2.6)		5 (17.2)	
Infant sex					
Male	2,358,335 (51.2)	49 (63.6)	.03	8 (27.6)	.02
Female	2,245,394 (48.8)	28 (36.4)		21 (72.4)	
Gestational age (weeks)					
<37	386,553 (8.6)	8 (10.5)	.55	12 (44.4)	<.001
37+	4,124,231 (91.4)	68 (89.5)		15 (55.6)	
Birth weight (g)					
<2500	349,304 (7.6)	7 (9.0)	.60	15 (51.7)	<.001
2500+	4,245,952 (92.4)	69 (9.2)		14 (48.3)	
Weight for gestational age					
Preterm LBW	204,099 (4.5)	4 (5.3)		11 (40.7)	
Term NBW	3,986,052 (88.5)	65 (86.7)	.94	13 (48.2)	<.001
Term LBW	133,730 (3.0)	3 (4.0)		2 (7.4)	
Preterm NBW	181,097 (4.0)	3 (4.0)		1 (3.7)	
Maternal age (years)					
<20	433,504 (9.4)	3 (3.9)	.23	5 (17.2)	.34
20–34	3,585,838 (77.9)	65 (84.4)		20 (69.0)	
35+	581,442 (12.6)	9 (11.7)		4 (13.8)	
Maternal race/ethnicity					
White non-Hispanic	2,639,437 (57.7)	60 (77.9)	<.01	16 (55.2)	.97
Black non-Hispanic	897,429 (19.6)	6 (7.8)		6 (20.7)	
Hispanic	819,650 (17.9)	8 (10.4)		6 (20.7)	
Other	221,451 (4.8)	3 (3.9)		1 (3.5)	
Maternal education					
<12 years	879,035 (19.6)	10 (13.3)	.15	14 (53.9)	<.001
High school	1,694,894 (37.9)	24 (32.0)		7 (26.9)	
Some college	1,904,271 (42.5)	39 (54.7)		5 (19.2)	
Prenatal care					
1st trimester	2,963,425 (70.2)	58 (77.3)	<.001	13 (50.0)	.03
Other	1,258,470 (29.8)	17 (22.7)		13 (50.0)	
Primary payor <sup>b</sup>					
Medicaid	1,009,377 (38.1)	7 (15.9)	<.01	8 (50.0)	.33
Other	1,643,388 (62.0)	37 (84.1)		8 (50.0)	
Total previous live births					
0	1,996,047 (44.3)	33 (43.4)	.91	13 (50.0)	<.001
1	1,443,462 (32.0)	26 (34.2)		2 (7.7)	
2	696,592 (15.5)	12 (15.8)		3 (11.5)	
3+	467,122 (8.2)	6 (6.6)		11 (30.8)	

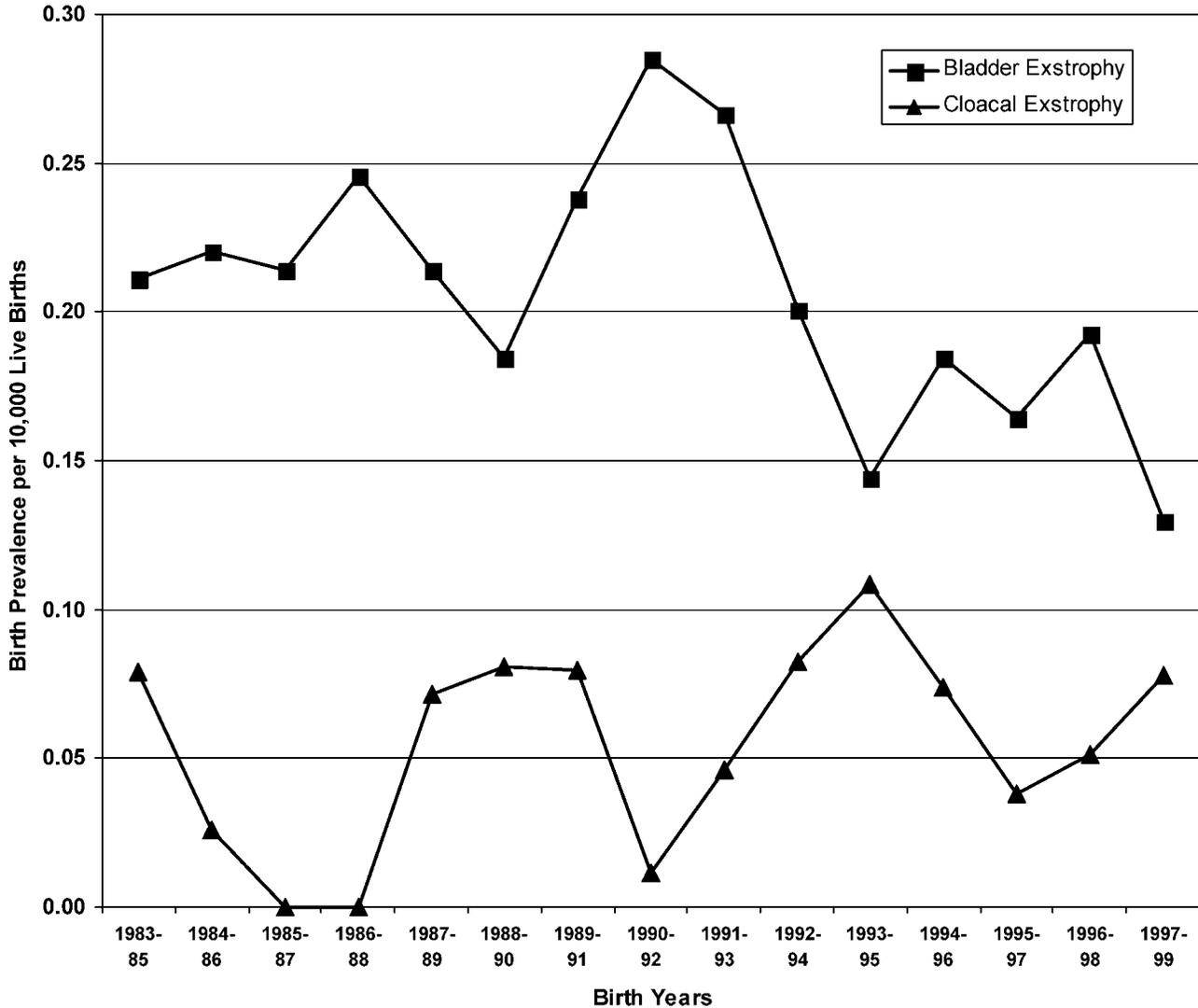
<sup>a</sup>*P*-values are for chi-square comparisons of the distribution for each birth defect to the distribution of live births.

<sup>b</sup>Primary payor information available in birth certificate data from 1990–1999 (2,742,368 live births). LBW, low birth weight; NBW, normal birth weight.

### Bladder Exstrophy

The prevalence of isolated/sequence BE in New York State showed a statistically significant ( $P < .05$ ) downward linear trend by year of birth (Fig. 1). The number of isolated/sequence cases ranged from 2 to 9 per year. There was a significant seasonal variation with the fewest conceptions in winter and the most frequent conceptions in

the summer (Table 1). Compared to winter conceptions, the adjusted birth prevalence ratio for summer conceptions was 2.46 (95% CI 1.19–5.10), as shown in Table 2. In the crude analysis (Table 2), non-New York City resident live births were 64% more likely to be cases than New York City births. However, no pattern remained after controlling for multiple variables in the adjusted analysis.



**Figure 1.** Three-year moving average birth prevalence of isolated/sequence bladder exstrophy and cloacal exstrophy, New York State, 1983–1985 to 1997–1999.

Female infants were less likely to have BE than male infants (Table 1). The adjusted prevalence ratio was 0.53 (95% CI 0.33–0.87) (Table 2). Preterm birth, low birth weight, and plurality were not significantly associated with BE. In multivariable models that excluded terms for gestational age and birth weight, multiple birth was not associated with BE (aPR 1.05, 95% CI 0.26–4.28), and the adjusted estimates for the other covariate relationships were not materially different from those presented in Table 2.

Maternal race/ethnicity and source of primary insurance were significant risk factors for BE in the crude analysis (Table 2). Infants of white non-Hispanic mothers were more than three times as likely to have isolated/sequence BE than infants of black non-Hispanic mothers. Hispanic mothers and mothers of other race/ethnicity also had higher prevalence at birth. In the adjusted analysis, the race/ethnicity association remained. Infants of private/HMO/self-insured mothers were more than three times as likely to have isolated/sequence BE than infants of Medicaid-insured mothers. (Because data were

not available for the entire study period, source of primary insurance was excluded from the multivariable analysis.) Mothers seeking prenatal care after the first trimester, younger mothers, and mothers with less than 12 years of education were less likely to have an infant with BE (Table 1). The relationships with young maternal age and education were attenuated in the multivariable analysis, and timing of prenatal care was no longer associated with BE (Table 2). BE was not associated with total previous live births.

Four (4.2%) infants with BE died within the 1st year: one isolated/sequence, one syndrome, and two multiple cases. Of the deaths, two occurred on the date of birth and the others occurred within 31 days of delivery. One infant was born preterm.

### Cloacal Exstrophy

CE prevalence data did not demonstrate a linear trend by year of birth (Fig. 1). Mothers who conceived in the

Table 2  
Unadjusted (PR) and Multivariable Adjusted Prevalence Ratios (aPR) with 95% Confidence Intervals (95% CI) for Maternal and Infant Characteristics within Isolated/Sequence Bladder Exstrophy and Cloacal Exstrophy Case Groups, New York State, 1983–1999

Maternal and infant characteristics	Bladder exstrophy ( <i>n</i> = 77)		Cloacal exstrophy ( <i>n</i> = 29)	
	PR (95% CI)	aPR (95% CI) <sup>a</sup>	PR (95% CI)	aPR (95% CI) <sup>a</sup>
Conception season				
Winter (Dec–Feb)	Reference	Reference	Reference	Reference
Spring (Mar–May)	1.32 (0.65–2.78)	1.63 (0.74–3.59)	3.72 (1.16–16.42)	4.46 (0.96–20.63)
Summer (Jun–Aug)	2.02 (1.06–4.05)	2.46 (1.19–5.10)	2.60 (0.75–11.85)	3.47 (0.72–16.69)
Fall (Sep–Nov)	1.40 (0.70–2.90)	1.79 (0.83–3.86)	2.23 (0.62–10.36)	1.43 (0.24–8.57)
Maternal residence				
Other New York State	1.64 (1.03–2.67)	1.01 (0.57–1.80)	1.37 (0.66–2.99)	3.27 (1.04–10.22)
New York City	Reference	Reference	Reference	Reference
Plurality				
Single	Reference	Reference	Reference	Reference
Multiple	0.98 (0.16–3.11)	0.76 (0.17–3.37)	7.64 (2.57–18.45)	1.61 (0.42–6.17)
Infant sex				
Male	Reference	Reference	Reference	Reference
Female	0.60 (0.37–0.95)	0.53 (0.33–0.87)	2.76 (1.27–6.63)	2.57 (1.00–6.64)
Weight for gestational age				
Term NBW	Reference	Reference	Reference	Reference
Term LBW	1.38 (0.43–4.38)	2.09 (0.64–6.80)	4.59 (1.03–20.32)	5.13 (1.09–24.09)
Preterm NBW	1.02 (0.32–3.23)	1.29 (0.40–4.15)	1.69 (4.51–12.94)	2.10 (0.27–16.54)
Preterm LBW	1.20 (0.44–3.30)	1.81 (0.63–5.25)	16.53 (7.40–36.88)	14.55 (5.28–40.07)
Maternal age (years)				
<20	0.38 (0.09–1.03)	0.61 (0.17–2.14)	2.07 (0.69–5.11)	1.35 (0.36–5.10)
20–34	Reference	Reference	Reference	Reference
35+	0.85 (0.40–1.63)	0.81 (0.38–1.72)	1.23 (0.36–3.26)	1.28 (0.35–4.65)
Maternal race/ethnicity				
White non-Hispanic	3.40 (1.60–8.81)	3.20 (1.20–8.52)	0.91 (0.37–2.53)	2.74 (0.56–13.48)
Black non-Hispanic	Reference	Reference	Reference	Reference
Hispanic	1.46 (0.51–4.43)	1.82 (0.59–5.62)	1.09 (0.34–3.50)	4.76 (0.93–24.33)
Other	2.03 (0.43–7.68)	1.45 (0.28–7.53)	0.68 (0.04–3.95)	4.61 (0.40–52.64)
Maternal education				
<12 years	Reference	Reference	Reference	Reference
High school	1.24 (0.61–2.73)	1.13 (0.48–2.66)	0.26 (0.10–0.62)	0.51 (0.17–1.52)
Some college	1.89 (0.99–4.00)	1.43 (0.60–3.39)	0.16 (0.05–0.43)	0.34 (0.09–1.24)
Prenatal care				
1st trimester	Reference	Reference	Reference	Reference
Other	0.69 (0.39–1.01)	1.04 (0.57–1.90)	2.35 (1.08–5.13)	1.49 (0.58–3.84)
Primary payor <sup>b</sup>				
Medicaid	Reference		Reference	
Other	3.25 (1.54–7.95)		0.61 (0.23–1.67)	
Total previous live births				
0	Reference	Reference	Reference	Reference
1	1.09 (0.65–1.82)	1.08 (0.63–1.86)	0.21 (0.03–0.77)	0.13 (0.02–1.04)
2	1.04 (0.52–1.96)	1.06 (0.52–2.16)	0.66 (0.15–2.05)	0.74 (0.19–2.86)
3+	0.82 (0.28–1.92)	1.04 (0.39–2.78)	3.33 (1.32–7.90)	2.43 (0.76–7.75)

<sup>a</sup>Adjusted for all other variables in the table except for primary payor.

<sup>b</sup>Primary payor information available in birth certificate data from 1990–1999.  
LBW, low birth weight; NBW, normal birth weight.

winter had the lowest prevalence of infants with CE, and mothers who conceived in the spring had the highest prevalence of children with CE. Compared to winter conceptions, the birth prevalence was 4.46 times as likely (95% CI 0.96–20.63). Adjusting for covariates, non-New York City resident live births were more than three times as likely to be CE cases than New York City births (aPR 3.27, 95% CI 1.04–10.22).

Females were more than twice as likely to have CE (aPR 2.57, 95% CI 1.00–6.64). Preterm birth and low birth weight were associated with CE, with adjusted prevalence ratios of 2.54 (95% CI 0.78–8.30) and 5.71 (95% CI 1.68–18.33), respectively (data not shown). Compared to term,

normal birth weight births, the strongest association was evident in preterm low birth weight infants (aPR 14.55, 95% CI 5.28–40.07), and an association was also found for term low birth weight infants (aPR 5.13, (95% CI 1.09–24.09). CE was approximately eight times more prevalent in multiple births than in singleton births in crude analyses; however, control for preterm birth and low birth weight attenuated the relationship between plurality and CE. Because preterm and low birth weight births may be caused by multiple gestation, a multivariable model that excluded terms for gestational age and birth weight was constructed. Multiple birth was strongly associated with CE (aPR 6.68, 95% CI 1.91–23.27), and the other covariate

effect estimates were not appreciably different than those produced by the full model (data not shown).

There was no association between maternal race/ethnicity and CE. When multivariable analysis was performed, however, black non-Hispanic mothers were the least likely to have an infant with CE, and the highest adjusted prevalence ratio was in Hispanic mothers. Younger mothers, mothers with less than 12 years of education, and mothers insured by Medicaid were more likely to have an infant with CE. Timing of prenatal care and total previous live births demonstrated associations with CE: mothers who initiated prenatal care after the first trimester experienced the highest prevalence of CE births and women with three or more previous live births had a higher birth prevalence of the malformation. Adjusted analyses weakened the associations.

Nine (31.0%) infants with CE died within the 1st year. The infant deaths occurred on the date of delivery (4), day 38 (1), day 92 (1), and days 214–323 (3). Six infants who died were born preterm.

## DISCUSSION

### Epidemiology of BE and CE Is Different

The distributions of maternal and infant characteristics in the case groups differed. BE showed a statistically significant downward linear trend by year of birth, while CE demonstrated no linear trend. After adjusting for covariates, mothers with residences outside of New York City were more than three times as likely to have an infant with CE, while a regional association was not present for BE. Mothers who conceived in the spring had the highest prevalence of children with CE, while mothers who conceived in summer had the highest prevalence of children with BE. Females were more than twice as likely to have CE, as opposed to the male preponderance of BE cases. Preterm birth and low birth weight were more strongly associated with CE than with BE. CE was approximately eight times more common in multiple births than in singleton births in crude analyses, while this association was not evident in the BE group. The weak associations with maternal age, education, and source of primary insurance were in the opposite direction for the CE case group when compared to the BE case group. Late initiation of prenatal care and three or more previous live births were associated with CE. When multivariable analysis was performed, the highest adjusted prevalence ratio was in Hispanic mothers for CE and in white non-Hispanic mothers for BE. Infant mortality was greater in the CE group.

Other studies that compared the two case groups have also found epidemiologic differences. Martinez-Frias et al. (2001) compared the epidemiology of BE and CE using the Spanish Collaborative Study of Congenital Malformations. Birth weight, gestational age, and maternal age were lower in CE infants. CE was more frequent in twins and females, and BE was more common in males. Evans et al. (1985) found a preponderance of males in the BE group, and infants with CE had lower birth weight, shorter gestation, lower maternal age, and higher infant mortality. Our study replicated these findings using larger sample sizes. Boyadjiev et al. (2004) also found a higher preponderance of male infants in the BE

group. However, the rest of the analyses combined case groups.

### BE Studies Based on Codes Are Likely Contaminated with CE Cases

Twenty-eight (23%) of the 122 cases with ICD-9-CM / BPA code 753.5 (bladder exstrophy) were actually CE cases. Thus, published studies of BE may include cases of CE which may inflate the prevalence estimates and distort results due to the heterogeneity of the combined case group (Yang et al., 1994; Nelson et al., 2005). In studies with BE ascertainment based on codes, differences between infants with isolated BE and those with multiple malformations have been observed. Yang et al. (1994) found the malformed group had a higher proportion of low birth weight infants, higher infant mortality, and the isolated group to be predominantly male. Nelson et al. (2005) found the BE group with gastrointestinal anomalies had a preponderance of female infants. Infants with other defects in addition to BE had lower birth weights and higher perinatal mortality than isolated BE cases (International Clearinghouse for Birth Defects Monitoring Systems, 1987). The patterns observed are consistent with our findings, if we assume that those infants with multiple malformations were predominantly CE cases.

### CE Is Likely Underascertained Due to Nonspecific Coding

BE is represented by a specific code on the case report, while CE is usually represented by two or more nonspecific codes, which may include a BE code. Interpretation of these coding combinations and case narrative review is necessary to identify CE cases appropriately. Difficulties associated with the interpretation of nonspecific codes may have resulted in underestimates of the actual birth prevalence of the malformation in our study as well as previous studies.

We found a prevalence of 2.1 and 0.6 per 100,000 live births for BE and CE in New York State from 1983 through 1999. In other studies which distinguished CE from BE, the reported birth prevalence were similar. The prevalence was 2.8 and 0.5 per 100,000 live births for BE and CE from 1976 through 1999 in Spain (Martinez-Frias et al., 2001). The International Clearinghouse for Birth Defects Monitoring Systems (1987) estimated a prevalence of 3.3 and 0.5 per 100,000 live births for BE and CE between 1970 and 1985 from 10 birth defects surveillance systems.

### Limitations and Next Steps

The rare occurrence of BE and CE was a limitation of this study. The sample also did not include early losses, terminations, or stillbirth data, which would have the biggest impact on our CE results, as CE prevalence is reported to occur in 1:10,000–50,000 stillbirths (Keppler-Noreuil, 2001). Therefore, the epidemiology presented here reflects that of live births. Additionally, due to the passive reporting system in New York State, case ascertainment may vary by region and time. To improve case ascertainment with limited resources, the New York State Congenital Malformations Registry has audited the completeness of reported malformations since 1993 by comparing the data with the malformations reported to the

Statewide Planning and Research Cooperative System (SPARCS), a mandatory hospital inpatient and ambulatory surgery database reported to be 99% comprehensive (Wang et al., 2005). Since the exstrophies are obvious at birth and surgical intervention is required within the first days of life, infants with BE and CE are likely to be reported to both SPARCS and the Registry.

In our population-based study of New York State live births, the epidemiology of BE and CE were different. Factors most strongly associated with BE after adjustment for covariates were summer conception, white non-Hispanic maternal race/ethnicity, and male sex. Factors most strongly associated with CE included preterm low birth weight birth, multiple birth, Hispanic maternal race/ethnicity, spring conception, non-New York City residence, maternal education less than 12 years, female sex, and maternal history of three or more previous live births. In future studies, larger sample sizes with improved case ascertainment and narrative review are needed to better understand the epidemiology and risk factors of BE and CE.

#### ACKNOWLEDGMENTS

We thank Tonia Carter, Nancy Mahoney, Mary Anne Giaconia, Cynthia Miller, and Phil Cross of the New York State Congenital Malformations Registry for helping with our case finding mission.

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