Evaluating False Positives in Two Hospital Discharge Data Sets of the Birth Defects Monitoring Program

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Synopsis

The principal goal in this study was to quantify false positives in the hospital discharge data of the Birth Defects Monitoring Program conducted by the Centers for Disease Control and Prevention. The two hospital data processing agencies which contribute data to the Birth Defects Monitoring Program, the Commission on Professional and Hospital Activities and the McDonnell Douglas Health Information Systems, had respective levels of false positives of 13.2 percent and 8.5 percent, levels which were statistically different from each other. These false positive levels should be considered minimal because these data bases do not include information on sick babies who may be transferred into or out of member hospitals, and who may have their initial diagnoses significantly modified.

Potential correlates of false positives were evaluated, including hospital size, diagnostic certainty, race, sex, and insurance source. Two-thirds of all false positives were due to the miscoding of correctly diagnosed anomalies, and another quarter were clearly contradicted in notes easily available before the patients were discharged. The authors hope that this study of false positives will enhance the interpretation of the Birth Defects Monitoring Program data and lead to improved understanding of data collection and processing.

THE BIRTH DEFECTS MONITORING PROGRAM (BDMP), begun in 1974 and operated by the Centers for Disease Control and Prevention (CDC), provides systematic surveillance for congenital anomalies within the United States. The primary purpose of the BDMP is to detect changes in the incidence of birth defects, changes that could be related to teratogenic exposures, demographic variability, or other parameters. Additional goals of the BDMP are to understand the natural history of individual congenital defects, to provide a systematic data base for epidemiologic research, and to project the need for special services for the mentally and physically handicapped (*1–3*).

The BDMP obtains data on birth defects from two hospital data processing agencies: the Commission on Professional and Hospital Activities (CPHA) and the McDonnell Douglas Health Information Systems (MDHIS). Data are available through CPHA from 1970 to the present and through MDHIS from 1982 to the present. Member hospitals send hospital discharge data, including demographic variables and congenital anomaly codes of the International Classification of Diseases, Ninth Revision (ICD-9-CM) to CPHA and MDHIS on a regular basis. Participating hospitals send newborn discharge abstracts to CPHA on a monthly basis and to MDHIS twice annually (*1,4*).

The CPHA and MDHIS both obtain hospital data through discharge abstracts, but there are three differences between them: CPHA includes data on stillbirths and MDHIS does not, the hospitals in CPHA are notably larger than those in MDHIS, and the two data bases are derived from geographically different populations. CPHA has more hospitals in the north central United States, whereas MDHIS has more in the western part of the country (*4*).

Hospitals do not usually belong to more than one of the two abstracting agencies in a given year, and infants who are transferred into a member hospital are excluded from analysis. Thus, no overlap of cases is expected in the data sets. Although data from all

hospitals utilizing MDHIS are sent to the CDC for use in the BDMP, only 80 percent of CPHA hospitals have agreed to participate. The BDMP obtains data on 21 percent of the nation's births through CPHA and on 15 percent through MDHIS, so that more than one-third of the births in the United States are represented (*4*). Although this sample is large and representative of all parts of the country, it is neither random nor population-based, since data come only from hospitals that choose to use one of these data processing agencies and (for CPHA hospitals) to participate in the BDMP.

The accuracy of the BDMP data for a few individual congenital defects was evaluated recently. The program was assessed by members of the CDC staff, using the CDC Morbidity and Mortality Weekly Report Supplement, "Guidelines for Evaluating Surveillance Systems" (*5*). In this qualitative evaluation, they computed the levels of false positives and false negatives for renal agenesis-dysgenesis by comparing BDMP data with the Metropolitan Atlanta Congenital Defects Program (MACDP) data. The levels of false positives for this defect were 23.7 percent and for false negatives it was 71.7 percent.

Similarly, the BDMP data for Down's syndrome were compared by another set of researchers to an Ohio Down's syndrome data base for the years 1970 through 1985 (*6*). During these years, data for the BDMP were obtained through CPHA only. The researchers found the levels of false positives by comparing the BDMP and Ohio Down's syndrome data set with each other, and computed the levels of false negatives by comparing the incidence rate of Down's syndrome in each data set with the expected incidence rates for mothers of specified ages. The BDMP data set had a false positive rate of 7.1 percent and a level of ascertainment of 60.2 percent for Down's syndrome (*6*).

In the current study, the accuracy of the BDMP data for 38 congenital defects is evaluated. Our objectives were to (*a*) estimate and compare the levels of false positives for CPHA and MDHIS, (*b*) estimate and compare the levels of false positives for 10 anomaly categories, (*c*) determine the reasons for false positives, and (*d*) determine potential correlates of false positives.

Methods

We evaluated the medical records of infants with 1 or more of 38 specified congenital anomalies for 15 CPHA and 11 MDHIS hospitals. Sample periods were January 1986 through June 1987 for CPHA and January 1984 through December 1986 for MDHIS. These distinct overlapping periods were chosen because detailed line-by-line case listings were available to CDC for those years. We computer generated a sample of hospitals, stratified by hospital size, from the list of all hospitals in Ohio that send data to either CPHA or MDHIS. Hospital size was defined as follows: small (less than 600 births per year); medium (600–1,499 births per year) and large (more than 1,500 births per year). A priori sample size calculations indicated that at least 400 records of infants with at least 1 of the 38 sampled anomalies from each data base needed to be reviewed. Out of 56 available Ohio CPHA hospitals, 15 participated in the study (6 small, 5 medium, and 4 large) and provided 485 records for review out of a total number of 31,789 births. Out of 26 available Ohio MDHIS hospitals, 11 participated in the study (1 small, 7 medium, and 3 large) and provided 390 records for review out of a total of 40,623 births.

We excluded 41 records of infants from 4 of the 15 CPHA hospitals from the sample, 36 because the infants were born in other hospitals and transferred to the sampled hospital, 2 because the records belonged to infants already included in the sample, and 3 because they were records of fetuses that were therapeutically aborted. There were no exclusions in the MDHIS sample. Of the 444 remaining CPHA records, we reviewed 431 or 97 percent. Of the 390 MDHIS charts in the sample, we analyzed 382 or 98 percent. The remaining records could not be retrieved by medical records personnel.

The abstracting team consisted of seven persons from a laboratory at the University of Cincinnati who were experienced in the epidemiology of birth defects. The members included research staff, graduate students, and faculty who were under contract with the CDC to carry out the study. A member of the abstracting team reviewed each birth record for evidence substantiating or refuting the diagnoses of the 38 congenital anomalies. The entire medical record of each infant in the sample was systematically reviewed, including the physician's discharge summary, physical assessment reports, physician's notes, consultation reports, labor and delivery records, laboratory test results, nurses' notes, and autopsy reports.

If the BDMP record contained a code indicating that a baby had a particular malformation and if in our review we found that the record provided support for this claim, we considered it to be a "true case." Alternatively, if in our review of the medical record we found no evidence for or found evidence against a diagnosis that was coded on the BDMP abstract, this was considered a "false positive." After reviewing

Table 1. True cases and false positives in all records and anomalies for Ohio hospitals participating in the Commission on Professional and Hospital Activities and McDonnell Douglas Health Information Systems hospitals during sample periods

	Records		Anomalies	
Category	Number	Percent	Number	Percent
True cases	714	87.8	805	89.0
False positives.....	99	12.2	99	11.0
Total	814	100.0	904	100.00

Table 2. Comparison of true cases and false positives between Commission on Professional and Hospital Activities (CPHA) and McDonnell Douglas Health Information Systems (MDHIS) data sets during sample periods

	CPHA		MDHIS	
Anomaly	Number	Percent	Number	Percent
True cases	415	86.8	390	91.5
False positives.....	63	13.2	36	8.5
Total	478	100.0	426	100.0

records of a hospital, discussion of each false positive recorded was carried out by the entire abstracting team to assure uniformity among the abstractors.

Two types of statistical tests were carried out on the data. A chi square test for homogeneity was used to compare overall differences between the two observed data sets. A log linear odds ratio chi square test was used to test for homogeneity and association for false positive rates among the 10 anomaly categories into which the 38 sampled defects were included in the two data sets. The homogeneous component tests whether the false positive rates for the anomaly categories are statistically similar between the data sets, and the association component tests the average difference between the data sets for all anomaly categories.

Results

False positives in CPHA and MDHIS data bases. Table 1 shows the false positives and true cases per record and per anomaly within the sampled area. The overall false-positive level per record was 12.2 percent, whereas the false-positive level per anomaly was 11.0 percent. We computed the false-positive level per record by dividing the number of records with a false-positive defect by the total number of records in the sample and multiplying by 100. Similarly, we obtained the false-positive level per anomaly by dividing the number of false positives by the total number of anomalies in the records and multiplying by 100. This calculation was needed because some records contained more than one of the sampled anomalies. Table 1 shows that the percentages of false positives per record and per anomaly were similar. Moreover, the total number of false positives was the same in both calculations, as no record contained more than one false positive. The false positive level per anomaly is used in all subsequent comparisons.

In Table 2 we compared the false-positive levels of the CPHA and MDHIS data bases for the 38 sampled defects. Of the 478 coded defects for babies in the CPHA hospitals, 63 (13.2 percent) were false positives. In comparison, 36 (8.5 percent) of the 426 coded defects on MDHIS hospital records were false positives. The false-positive levels for the two data bases differed significantly ($\chi^2 = 5.17$, $0.05 > P > 0.025$).

Reasons for false positives. For the combined sample we found that the most frequent reason for false positives (64.6 percent) was that someone had miscoded the defect on the face sheet of the medical record. In these cases the anomaly listed on the face sheet had been diagnosed correctly, but its accompanying ICD-9-CM code was incorrect. For another 26.3 percent of the false positives, evidence which was available in the medical records before the infants' dismissals disproved the diagnoses. Another 6.1 percent of the false positives were diagnoses that were contradicted by data that may not have been available until after the infant was discharged from the hospital. These data included information from autopsy and chromosome reports. For 1 percent of the false positives (one case), we found no documenting evidence of the defect in the record. Finally, for 2 percent of the false-positive anomalies, we found that the codes had been transposed or inverted when transferred from the face sheet to the CPHA and MDHIS abstracts.

False positives among anomaly categories. Tables 3 and 4 illustrate the variation in the false-positive levels with 95 percent confidence intervals for the 38 sampled anomalies in the CPHA and MDHIS data sets. In both data sets, central nervous system and heart defects were among those defects that were most likely to be false positives. Limb, orofacial, and chromosome anomalies were more likely to be correctly included in both data sets. For many individual defects the number sampled was small leading to wide confidence limits for false positives.

Table 3. False positive levels with 95 percent confidence intervals for sampled anomalies in the data base of the Commission on Professional and Hospital Activities

Anomaly	Total number	False positives		95 percent confidence intervals
		Number	Percent	
Nervous system	85	26	30.6	20.8, 40.4
Anencephaly	6	0	0.0	0, 0
Spina bifida	12	1	8.3	0, 23.9
Encephalocele	6	2	33.3	0, 71.0
Microcephaly	16	3	18.8	0, 29.8
Hydrocephaly	45	20	44.4	28.8, 60.0
Eye	7	1	14.3	0, 40.2
Anophthalmus	2	0	0.0	0, 0
Congenital cataract	3	0	0.0	0, 0
Coloboma	2	1	50.0	0, 100.0
Aniridia	0	0	0.0	0, 0
Cardiovascular	125	19	15.2	8.9, 21.5
Common truncus	1	0	0.0	0, 0
Transposition of great vessels	4	0	0.0	0, 0
Tetralogy of Fallot	6	0	0.0	0, 0
Ventricular septal defect	64	1	1.6	0, 4.6
Atrial septal defect	13	6	46.2	19.1, 73.3
Endocardial cushion defect	2	1	50.0	0, 100.0
Pulmonary valve anomalies	14	6	42.9	17.0, 68.8
Tricuspid valve anomalies	2	1	50.0	0, 100.0
Aortic valve anomalies	4	0	0.0	0, 0
Hypoplastic left heart syndrome	3	0	0.0	0, 0
Coarctation of aorta	5	0	0.0	0, 0
Pulmonary artery defects	7	4	57.1	20.4, 93.8
Lung agenesis or hypoplasia	18	3	16.7	0, 33.9
Orofacial	52	3	5.8	0, 12.2
Cleft palate	27	2	7.4	0, 17.3
Cleft lip with or without cleft palate	25	1	4.0	0, 11.7
Gastrointestinal	17	2	11.8	0, 27.1
Tracheo-esophageal fistula, atresia	4	0	0.0	0, 0
Intestinal or rectal atresia	13	2	15.4	0, 35.0
Genitourinary	29	4	13.8	1.2, 26.4
Renal agenesis and hypoplasia	4	0	0.0	0, 0
Exstrophy of the bladder	1	0	0.0	0, 0
Cystic kidneys	7	1	14.3	0, 40.2
Hydronephrosis	17	3	17.6	0, 35.7
Musculoskeletal	107	2	1.9	0, 4.5
Clubfoot	96	1	1.0	0, 3.0
Upper limb reductions	5	0	0.0	0, 0
Lower limb reductions	0	0	0.0	0, 0
Arthrogryposis	6	1	16.7	0, 46.5
Chromosomal	33	2	6.1	0, 14.3
Trisomy 21	30	1	3.3	0, 9.7
Trisomy 13	2	0	0.0	0, 0
Trisomy 18	1	1	100.0	100.0, 100.0
Fetal alcohol syndrome	5	1	20.0	0, 55.1

The chi square test for homogeneity was used to compare the the two data sets with respect to the 38 sampled defects grouped into 10 anomaly categories and showed no statistical difference between them (χ^2_{homog} = 6.83 at 9 df, $0.70 > P > 0.50$). The χ^2_{assoc}, was equal to 1.83 at 1 df ($0.20 > P > 0.10$). The log linear comparison for these 10 anomaly categories shows that any statistical difference between the two data sets is not due to variation in false positive rates among the 10 anomaly categories. We concluded from this analysis that random differences in numbers of heart defects and CNS defects, which had relatively high false positive levels, contributed to the overall difference in false positives between the MDHIS and CPHA data bases and not any real difference in the accuracy of their data.

Potential correlates of false positives. Standard regression analyses for MDHIS and CPHA hospitals showed no correlation between hospital size and false-positive levels in the data bases. Similarly, once differences in number and types of anomalies were accounted for in the data bases, there was no dif-

Table 4. False positive levels with 95 percent confidence intervals for sampled anomalies in the data base of the McDonnell Douglas Health Information Systems

Anomaly	Total Number	False positives		95 percent confidence interval
		Number	Percent	
Nervous system	67	14	20.9	11.2, 30.6
Anencephaly	9	0	0.0	0, 0
Spina bifida	26	3	11.5	0, 23.8
Encephalocele	3	1	33.3	0, 86.6
Microcephaly	6	0	0.0	0, 0
Hydrocephaly	23	10	43.5	23.2, 63.8
Eye	7	0	0.0	0, 0
Anophthalmus	6	0	0.0	0, 0
Congenital cataract	1	0	0.0	0, 0
Coloboma	0	0	0.0	0, 0
Aniridia	0	0	0.0	0, 0
Cardiovascular	83	11	13.3	6.0, 20.6
Common truncus	2	1	50.0	0, 100.0
Transposition of great vessels	1	0	0.0	0, 0
Tetralogy of Fallot	4	1	25.0	0, 67.4
Ventricular septal defect	52	3	5.8	0, 12.2
Atrial septal defect	3	0	0.0	0, 0
Endocardial cushion defect	3	0	0.0	0, 0
Pulmonary valve anomalies	6	2	33.3	0, 71.0
Tricuspid valve anomalies	1	0	0.0	0, 0
Aortic valve anomalies	3	0	0.0	0, 0
Hypoplastic left heart syndrome	1	0	0.0	0, 0
Coarctation of aorta	1	0	0.0	0, 0
Pulmonary artery defects	6	4	66.7	29.0, 100.0
Lung agenesis or hypoplasia	20	0	0.0	0, 0
Orofacial	55	0	0.0	0, 0
Cleft palate	12	0	0.0	0, 0
Cleft lip with or without cleft palate	43	0	0.0	0, 0
Gastrointestinal	16	1	6.3	0, 18.2
Tracheo-esophageal fistula, atresia	9	0	0.0	0, 0
Intestinal or rectal atresia	7	1	14.3	0, 40.2
Genitourinary	25	2	8.0	0, 18.6
Renal agenesis and hypoplasia	7	1	14.3	0, 40.2
Exstrophy of the bladder	0	0	0.0	0, 0
Cystic kidneys	5	0	0.0	0, 0
Hydronephrosis	13	1	7.7	0, 22.2
Musculoskeletal	117	6	5.1	1.1, 9.1
Clubfoot	97	2	2.1	0, 5.0
Upper limb reductions	8	0	0.0	0, 0
Lower limb reductions	5	0	0.0	0, 0
Arthrogryposis	7	4	57.1	20.4, 93.8
Chromosomal	32	2	6.3	0, 14.7
Trisomy 21	26	0	0.0	0, 0
Trisomy 13	2	0	0.0	0, 0
Trisomy 18	4	2	50.0	1.0, 99.0
Fetal alcohol syndrome	4	0	0.0	0, 0

ference in false positive levels among races. False positive rates were also similar by sex within the data bases. For CPHA, the false-positive levels were 13.9 percent for male infants and 12.4 percent for females; for MDHIS, they were 8.0 percent for males and 9.1 percent for females.

For MDHIS hospitals, data were available on insurance coverage for individual infants within the sample. A chi-square analysis of seven insurance categories showed no relationship between false positives and insurance source ($\chi^2 = 4.35$, $0.70 > P > 0.50$ at 6 df). By partitioning the chi square, we found no statistical difference between false-positive proportions for babies covered by Medicaid and those covered by other or no insurance plans ($\chi^2_{diff} = 0.37$, $0.70 > P > 0.50$ at 1 df).

Several anomalies in the sample had been tentatively diagnosed. The listings of these diagnoses on the discharge sheets were prefaced with such disclaimers as "rule out," "probable," and "possible." Of the 99 false positives in the combined sample, 13 were provisionally diagnosed, 9 in MDHIS (25 percent of false positives) and 4 in CPHA (6.3 percent of false positives). Of all tentatively diag-

nosed defects in MDHIS and CPHA data bases, 12.7 percent (9 ÷ 71) and 5.2 percent (4 ÷ 76), respectively, were false positives. Thus, the tentatively diagnosed cases were no more likely to be false positives than those with no provisional terminology in the diagnosis.

Discussion

False positives are not unexpected in a system like BDMP. Indeed, they have been reported for this (*5,6*) and for other surveillance systems (*7–9*). Our aim, however, was to quantify these values for a broad range of birth defects, so that the BDMP data might be better interpreted and its limitations understood.

The overall false-positive levels were 13.2 percent for CPHA and 8.5 percent for MDHIS, values that were significantly different from each other. This was not expected, since both data bases were built from similarly gathered discharge data. Though the CPHA data set included stillbirths and the MDHIS data set did not, this created no evident bias for false positives, since only four records of stillborn infants containing seven anomalies with one false positive were included in the CPHA sample. The chance inclusion of more heart and central nervous system defects in CPHA, defects with greater propensities for false positives, adequately provides the basis of the higher false-positive level in CPHA.

It is important to realize that the levels of false positives found in this study are minimal estimates of the true false positive levels in the data sets because only newborn data are included and because data on babies transferred into and and out of member hospitals are not included in the surveillance. Transferred babies are likely to be the sickest babies and may have their initial diagnoses modified through subsequent study, thus leading to more false positives in the system.

Hospital size (on the average larger for CPHA) was evaluated as a plausible source of variation in false-positive levels. We know that larger hospitals deliver more infants with birth defects, both because they have more births and because they are often the high-risk obstetrical or tertiary care facilities in their areas, but our findings suggest that defects diagnosed in these hospitals are no more likely to be false positives than those diagnosed in other hospitals.

Other potential correlates of false positives, including sex, race, insurance status, and diagnostic certainty were evaluated. At the time of our sampling, Medicaid and Medicare participated in the Diagnosis Related Groups system, which pays a fixed reimbursement to hospitals for each diagnosis and treatment regardless of the actual costs incurred (*10*). In a study of northeastern hospitals receiving Medicare reimbursements for adult diagnoses and procedures, researchers concluded that "creep," a tendency to make coding and diagnostic errors that increase reimbursement for hospital services, exists within hospitals participating in that system (*11*). However, our analysis of the records of newborn Medicaid recipients did not show any such "creep."

Diagnoses of defects with disclaimers like "possible," "probable," and "rule out" were no more likely to be false positives than were other anomalies in these data sets. A study by Hexter and coworkers (*12*), however, suggests that many of the provisionally diagnosed anomalies could be disproved through subsequent admissions or procedures (for example, cardiac catheterization or echocardiogram). In their study of the California Birth Defects Monitoring Defect Program data, they attributed the higher false-positive levels they found to the ascertainment time of 1 year and the multiple ascertainment sources used, and to the inclusion of tentatively diagnosed anomalies in the discharge index data.

Hexter and coworkers (*12*) reported a high false-positive level for central nervous system anomalies but reported the highest false-positive levels for heart defects and lung agenesis. Chromosome anomalies, clefts, and gastrointestinal defects had the lowest false positive levels in the Hexter study. These levels were higher than those found in CPHA and MDHIS, but the trend was similar. Knox and coworkers (*8*) found in a study of a birth defect notification system in England that the data were most accurate for clefts, tracheoesophageal fistulas, anal atresias, and Down's syndrome.

Most (64.6 percent) of the false positives in our study were miscodes. Various medical records staffs responsible for coding sometimes confused similar terms. For example, cephalohematoma, macrocephaly, and hydrocele were given the codes for encephalocele, microcephaly, and hydrocephalus.

For 26.3 percent of the false positives, there was information in the medical record contradicting a diagnosis on the face sheet. In some cases two diagnoses were being considered at the same time, and one of them was clearly preferred. In other cases, just one diagnosis was offered, but evidence in a specialist's report ruled it out. These errors may reflect policies requiring coding of all diagnoses considered, regardless of validation, or they may represent mistakes that persons made in completing the discharge sheet.

This study was designed to evaluate false positives in the BDMP. Clearly, however, false negatives are

another important concern in birth defects surveillance systems and have been reported for the BDMP and for other systems. For instance, Calle and Khoury (*13*) found in a national study of children of U.S. veterans that 38 percent of the diagnoses of major anomalies were missing from newborns' face sheets even though the diagnoses were clearly stated within the newborns' records. Such underreporting of birth defects may underestimate the incidence of birth defects and undermine a system's ability to detect significant environmental hazards.

What are the consequences of false positives in the BDMP and similar systems? False positives could increase the number of defects in a category, thereby resulting in a false alarm. Though most monitoring programs have expeditious and systematic means for ruling out artificial increases in incidence, money and time could potentially be wasted on an investigation of a statistical increase that was caused by false positives.

In the present study, false positives within the BDMP have been quantified for a sample of participating hospitals within the State of Ohio. Assuming these error rates are similar for other States contributing data to the BDMP, this information should allow all users of BDMP to better interpret the BDMP data base. With the increased understanding of the reasons for these false positives, the opportunity is presented to reduce them by improving methods of coding correctly diagnosed anomalies and more carefully evaluating the data available in the medical records at the time of discharge.

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