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Methods of linking mothers and infants using health plan data for studies of pregnancy outcomes

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Abstract

Purpose—Research on medication safety in pregnancy often utilizes health plan and birth certificate records. This study discusses methods used to link mothers with infants, a crucial step in such research.

Methods—We describe how 8 sites participating in the Medication Exposure in Pregnancy Risk Evaluation Program created linkages between deliveries, infants and birth certificates for the 2001–2007 birth cohorts. We describe linkage rates across sites and, for two sites, we compare the characteristics of populations linked using different methods.

Results—Of 299,260 deliveries, 256,563 (86%; range by site, 74–99%) could be linked to infants using a deterministic algorithm. At two sites, using birth certificate data to augment mother-infant linkage increased the representation of mothers who were Hispanic or non-white,

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younger, Medicaid recipients, or had low educational level. A total of 236,460 (92%; range by site, 82–100%) deliveries could be linked to a birth certificate.

Conclusions—Tailored approaches enabled linking most deliveries to infants and to birth certificates, even when data systems differed. The methods used may affect the composition of the population identified. Linkages established with such methods can support sound pharmacoepidemiology studies of maternal drug exposure outside the context of a formal registry.

Keywords

Birth Certificates; Medicaid; Pregnancy Outcome/epidemiology; Medical Record Linkage

Introduction

There is little information about medication safety during pregnancy. Medication use during pregnancy is common (in one study, 64% of deliveries [1]). It often occurs before a woman knows she is pregnant and may also occur as a result of new medical conditions that arise during pregnancy [2]. For most medications, little is known about their effect on congenital anomalies and other birth outcomes. Evidence from randomized clinical trials is lacking due to the ethical challenges of conducting human trials for medications with unknown effects on birth outcomes. For many medications, the only available data come from animal studies and sources with limited generalizability such as case reports and pregnancy registries. Consequently, postmarketing research and surveillance are important strategies to study the effects of medication exposure during pregnancy on maternal and neonatal outcomes [3].

In response to the need for better information about medication safety in pregnancy, the U.S. Food and Drug Administration (FDA) developed the Medication Exposure in Pregnancy Risk Evaluation Program (MEPREP). As detailed elsewhere [4], MEPREP is a collaborative research program between the FDA and researchers at 11 health plans (Table 1) with 12 million enrollees (about 4% of the U.S. population). Health plan data offer opportunities for studying medication safety in pregnancy because they provide comprehensive demographic, medication use, diagnosis, and procedure information for a defined population. They can provide large and diverse populations that are more representative of the general population than drug- or disease- specific registries. These data can be enriched by linkage to state birth certificates, which contain information that may not be readily available from health plan data, such as gestational age; parental race, ethnicity, and education; birth weight; and maternal tobacco use.

A crucial step in utilizing health plan data to study medication safety in pregnancy is to identify valid linkages between mothers and their infants. Approaches to linking individuals across health care datasets in the United States vary widely and include use of a single reliable key (e.g., social security number) or the incorporation of several characteristics using deterministic or probabilistic matching [5, 6]. In deterministic matching, logical rules are applied that define whether a match exists. For example, if an individual has the same name and birth date in two files, the link would be considered true. In probabilistic matching, researchers apply algorithms that assign a probability score to a match; matches that exceed a predefined threshold are considered true. In either case, the linking process can affect the final population available for study. For example, the rate of linkage error may differ according to race and ethnicity [7, 8]. This has implications for study interpretation, including internal validity and generalizability.

There has been little published description of approaches to link mothers to infants using health plan data or other data sources for pregnancy outcome studies. While individual studies have briefly described their own methods, to our knowledge no prior publication has

provided a comprehensive algorithm that can be tailored to specific data sources or health plans. This paper describes an approach that 8 MEPREP health plans used to link mothers to infants, including establishing linkages to birth certificates. We also explored how using different linking methods affected the composition of the final study population at two plans, particularly related to race, ethnicity and socioeconomic status.

Methods

Overview of MEPREP

The goal of MEPREP is to facilitate and conduct studies of medication safety in pregnancy. A description of MEPREP has been previously published [4]. In brief, 11 sites identified cohorts of mother-infant pairs and then created standardized datasets formatted according to shared standards. Variables include health plan data (e.g., enrollment, utilization, diagnoses, and prescription dispensing) as well as birth certificate variables. To protect patient privacy, all individual-level data remain within the health plan, using a distributed data model [4, 9, 10]. Because of standardized data formatting, a computer program written at one site can be run at other sites, facilitating cross-site analyses. MEPREP currently includes 1.2 million infants delivered to 933,917 mothers from 2001 through 2008. The current analyses focus on the 2001–2007 birth cohorts, which include about 1 million infants born to about 830,000 mothers, because 2008 linkages had not been completed at the time this work was conducted. IRB approval was obtained at all participating sites and from state departments of public health where required.

Three of the 11 MEPREP sites already had well-established procedures in place for linking mothers to infants, and so their procedures are not described in detail in this paper. Kaiser Permanente Northern and Southern California have established birth registries through their health plan affiliated hospitals. Since nearly all of their enrollees deliver at a hospital owned and operated by the plan, these registries are believed to capture over 99% of their deliveries, and thus these plans did not need to use any additional methods to identify deliveries or create mother-infant linkages. Vanderbilt University researchers working with Tennessee Medicaid data use a previously described probabilistic algorithm [6] to link newly enrolled infants with both birth certificates and Medicaid data for women delivering infants. For the other 8 sites (Table 1), MEPREP needed to develop an algorithm that applied standard procedures and definitions, to ensure cross-site consistency, but also recognized and took advantage of the sites' varying data resources. This paper describes our experience with linkage at those 8 sites, all members of the HMO Research Network. Overall, these sites provided about one-fourth of the final MEPREP cohort.

Linkage of mothers and infants using health plan data

Each of the 8 sites started by identifying deliveries from women's health plan utilization data. These were linked to infant enrollees using a deterministic algorithm (referred to in the rest of the paper as the "MEPREP hierarchical algorithm") (Figure 1). To identify *deliveries*, the algorithm selected female members aged 10–55 years with least one International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) diagnosis code or an ICD-9 CM or Current Procedural Terminologies (CPT) procedure code indicating infant delivery (Appendix). This list was originally developed by manual review of ICD-9-CM and CPT code books to identify all codes that indicated delivery. Although the MEPREP cohort is currently limited to live births, codes for stillbirths were included to maximize capture of deliveries, for instance to capture multiple gestations where a stillbirth occurred but one or more infants survived. The investigators used these codes in prior studies (e.g., [1, 11–15]). One participating site found that, compared to a perinatal database, the diagnosis and procedure codes had sensitivity and positive predictive value (PPV) of

98% for identifying deliveries [16]. For the present study, investigators updated the list of codes to include a few (<20) that did not exist originally.

After a delivery-related diagnosis or procedure code was identified, any additional codes in the following 120 days were considered to represent the same delivery since it is not plausible that a woman could have more than one delivery in this time period. To identify *infants*, the algorithm selected all members born within the study time period who had at least one day of health plan enrollment. The delivery and infant datasets were *linked* using the following steps, in order of preference:

1. A birth registry, if available;
2. Health plan subscriber number;
3. Last name and address of the mother and infant; or
4. Other resources, as available.

Two sites were able to use state birth records to identify additional pairs. To do so, these sites linked deliveries to birth certificates and infants to birth certificates independently, based on first and last names, dates of birth for the woman and infant, and date of delivery (from the woman's records). Then they identified as new matches those women and infants who were previously unmatched who linked to the same birth certificate. Some of the infants identified in this process had not been previously identified in the health plan data and were added to the MEPREP cohort.

In order to increase linkage rates and accuracy, sites could implement additional provisions to address site-specific nuances. When linking is done using resources other than a birth registry, the exact date of delivery is not available; instead, plans have information about the admission and discharge dates for the delivery hospitalization. To improve standardization, it was recommended that the infant date of birth fall in the time period between three days prior to the mother's admission date and her discharge date for the delivery hospitalization. The three-day window before admission allows for out-of-hospital births. Sites using name/address matching double-checked potential linkages by checking whether the infant birth fell within the specified time period. They also used computerized or manual review to allow for misspellings and variability in address formatting. We excluded uncertain matches made using this method (for example, 501 First Street vs. 501 First Avenue in a city where both addresses exist).

Linkage of health plan records to birth certificates

Each site worked with their state department of health to develop procedures to link health plan records to birth certificates for this study. At one site, the health plan catchment area spans two states, so the site worked with two departments of health. In all, the 8 sites worked with 8 state departments of health.

Four sites sent information about the delivery to the state health department, who performed the linking to birth certificates and returned birth certificate data to the researcher. At the other four sites, MEPREP researchers did the linking. The keys used to establish linkages to birth certificates included all or several of the following: parent names, infant name and sex, mother's birth date, delivery date, infant birth date, ZIP code and hospital code. Social security number was used as a key in only one state. In two states, the matching process included variations on the mother's name (alternate spellings or names that sound alike). One state maintains a data enclave, which allows the researchers to access relevant information directly via controlled on-site access.

Statistical analysis

We calculated the proportion of deliveries identified from health plan data that could be linked to an infant using the MEPREP hierarchical algorithm, overall and for individual sites and calendar years. We also calculated the proportion of linked pairs that could be linked to a birth certificate. Finally, at two sites that used both birth certificate and health plan records to establish mother-infant linkages, we examined whether characteristics of the population differed by linking method within each site. Statistical significance was assessed using the chi-square test. All tests were two-tailed, with alpha of 0.05.

Results

We identified 299,260 deliveries at 8 health plans from 2001–2007. Of these, 256,563 (86%) could be linked to an infant (range by site, 74% to 99%; Figure 3). This proportion declined from 87% in 2001 to 82% in 2007. Seven of eight sites primarily used one data source to link deliveries to infants. However, the primary key varied by site. About half of linkages were made using subscriber number or family unit identifier. Birth registry information was available at three sites and captured 4% to 95% of identified deliveries at these sites. Two sites identified additional matches using name and address matching.

At the two sites that used birth certificates to enhance linkages, incorporating this additional step increased the linkage rate for deliveries from 12 to 82% at one site and from 71 to 84% at the other (Figure 2). This process identified an additional 25,201 mother-infant pairs, beyond those identified using other methods. There were 6,018 infants matched to deliveries in this process who were not identified as having any health plan enrollment, accounting for about 10% of deliveries at each site.

We were able to link 236,460 (92%) of the 256,563 linked pairs to birth certificates. This proportion ranged from 82% to 100% by site and was similar across years. We did not detect any pattern in terms of which procedures produced a higher linking rate (e.g., which key was used or which entity did the linking).

At the two sites that augmented linkages using birth certificates, we analyzed characteristics of mothers who were linked to infants via birth certificates versus health plan records alone (Table 2). Compared to women linked to infants by health plan records, women linked only through birth certificate data were more likely to be Hispanic (64% vs. 42%) at one site and more likely to be nonwhite at the other (28% vs. 19%). At both sites, these women were younger and more likely to have Medicaid insurance and not to have completed high school.

Discussion

Health plan data offer great potential for supporting research on medication safety in pregnancy because of the large and diverse populations included, but such research requires the ability to link health records of mothers with those of their infants. These linkages are not readily available for most health plans. Using the hierarchical algorithm described above, we were able to create a large cohort of mothers and infants for future studies. Additionally, the sites were able to obtain birth certificate records for the majority of these linked pairs. The MEPREP experience illustrates the potential for sound pharmacoepidemiologic studies of maternal drug exposure to be conducted outside the context of a formal registry. The algorithm we describe supports standardization, while also providing flexibility which allows tailoring to the needs and data resources of individual health plans.

Multiple linking approaches were needed because different data are available at different sites, partly due to the fact that participating health plans vary in terms of clinical integration. Some plans are part of systems that provide both care and coverage to all subscribers. In such a system, a birth registry can be created by recording data uniformly at the point of care. In contrast, other plans primarily provide health insurance to members who receive most or all care from external providers. When many different external providers participate, it is not feasible to create a birth registry. Even within plans that provide both care and coverage, some have their own hospitals while others have few or no hospitals. In our experience, linkages are the most straightforward to establish in systems where a birth registry exists and the research group has access to that data. However, even in less integrated systems, high linkage rates can be achieved using the algorithms and approaches described here. Our success at identifying linkages at 8 health plans–which differ considerably in terms of their degree of integration and the data resources available– indirectly supports the generalizability and relevance of the algorithm beyond these 8 plans.

The MEPREP cohort is designed to maximize capture of information about medication exposure and outcomes and to minimize the biases (e.g., recall bias, referral bias, self-selection in studies of volunteers) that can arise in studies of medication safety in pregnancy. Previous studies have suggested that data quality improves when health plan and birth certificate data are used in combination, rather than alone [17, 18]. At the two sites that used birth certificates to enhance linkages, incorporating the additional data source increased the linkage rate for deliveries considerably at one site (from 12 to 82%) and moderately at the other (from 71 to 84%). Furthermore, adding this data source substantially increased the diversity of the cohort at those sites. This should enhance generalizability of findings from future studies. The infants that were linked to birth certificate but not health plan data were retained in the final cohort because their data can support studies of certain outcomes, particularly those that are readily identified during the birth hospitalization (e.g., preterm birth, low birth weight, neonatal intensive care unit admission or certain major congenital anomalies). Because all of these infants have birth certificate data available, some outcomes of interest can be identified from the birth certificate. Alternatively, for some states, ICD-9 codes for the hospital stay are available linked to birth certificate data, and these can allow the identification of certain conditions noted during the birth hospitalization.

We were not able to match all deliveries to an infant. This may arise when an infant is adopted or is not enrolled in the health plan after the birth, e.g., if a parent's healthcare coverage changes or if the infant is covered under the insurance plan of a family member other than the mother. A particular challenge arises when linking mothers and infants insured by Medicaid. This difficulty is illustrated by our experience at the MEPREP site that could only link 12% of deliveries using health plan records but increased the linkage rate to 82% using birth certificates. The low initial number arose because 80% of mothers and infants receiving care at that site are insured by Medicaid. After birth, if the mother does not specifically enroll her infant in that site's Medicaid plan, the infant is automatically enrolled in the state's default Medicaid administering plan – in which case the MEPREP health plan does not receive utilization information. Thus, at this site, linked pairs could only be identified from name and address matching using birth certificate information. In our experience, when we conducted name and address matching using birth certificates, linkage rates were lower if the mother and infant had different last names or if there had been frequent address changes around the time of the birth. Additional possible reasons for missing linkages to birth certificates include a child being born out of state or having a name change after birth [6].

Several additional limitations should be noted. First, we do not know whether MEPREP algorithms capture all deliveries. As noted above, a previous study at one site found high

sensitivity of claims data for identifying deliveries [16]. Our linkage rates compare favorably with one previously published approach: in a Georgia study of 89 hospitals, 85% of hospital discharge records could be linked to birth certificates [19]. Second, we favored accuracy of matches rather than completeness because of the need to measure medication exposure accurately in future studies. Future studies with validation components could further refine the matching criteria. Third, we did not have resources to validate linkages through other means, such as chart review. These limitations are likely to omit only a small percentage of the population; however, future analyses using this cohort should consider potential selection biases.

We focused on health plans in the United States, but the challenges we faced and the procedures we developed may be relevant in other settings. Conducting linkages across multiple health plans or data sets requires local knowledge about each system's data resources, as well as careful consideration of optimal matching algorithms to achieve both a high linkage rate and high accuracy while minimizing the potential for systematic biases. Representation from each data partner is important to ensure that data linkages are maximized, limitations are adequately expressed, and interpretations are sound.

In conclusion, linking mother-infant pairs within multiple health systems provides a mechanism for establishing large and diverse birth cohorts, which is especially valuable for studies of rare exposures or outcomes. This work demonstrates the potential for sound pharmacoepidemiologic studies of maternal drug exposures to be conducted using electronic health data. Such data offer expanding opportunities to improve knowledge about medication safety and ultimately the health of women and infants.

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Appendix: Codes used to identify deliveries at the 8 MEPREP sites included in these analyses*

ICD-9-CM diagnosis codes	Abbreviated Description
641.01	PLACENTA PREVIA WITHOUT HEMORRHAGE, DELIVERED
641.11	HEMORRHAGE FROM PLACENTA PREVIA, DELIVERED
641.21	PREMATURE SEPARATION OF PLACENTA, DELIVERED

ICD-9-CM diagnosis codes	Abbreviated Description
641.31	ANTEPARTUM HEMORRHAGE ASSOC WITH COAG DEFECT, DELIVERED
641.81	OTHER ANTEPARTUM HEMORRHAGE, DELIVERED
641.91	UNSPECIFIED ANTEPARTUM HEMORRHAGE, DELIVERED
642.01	BENIGN ESSENTIAL HYPERTENSION WITH DELIVERY
642.02	BENIGN ESSENTIAL HYPERTENSION, WITH DELIVERY WITH POSTPARTUM COMPLICATION
642.11	HYPERTENSION SECONDARY TO RENAL DISEASE, WITH DELIVERY
642.12	HYPERTENSION SECONDARY TO RENAL DISEASE, WITH DELIVERY WITH POSTPARTUM COMPLICATION
642.21	OTHER PRE-EXISTING HYPERTENSION, WITH DELIVERY
642.22	OTHER PRE-EXISTING HYPERTENSION, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
642.31	TRANSIENT HYPERTENSION OF PREGNANCY, WITH DELIVERY
642.32	TRANSIENT HYPERTENSION OF PREGNANCY, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
642.41	MILD OR UNSPECIFIED PRE-ECLAMPSIA, WITH DELIVERY
642.42	MILD OR UNSPECIFIED PRE-ECLAMPSIA, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
642.51	SEVERE PRE-ECLAMPSIA, WITH DELIVERY
642.52	SEVERE PRE-ECLAMPSIA, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
642.61	ECLAMPSIA, WITH DELIVERY
642.62	ECLAMPSIA, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
642.71	PRE-ECLAMPSIA OR ECLAMPSIA SUPERIMPOSED ON PRE-EXISTING HYPERTENSION, WITH DELIVERY
642.72	PRE-ECLAMPSIA OR ECLAMPSIA SUPERIMPOSED ON PRE-EXISTING HYPERTENSION, WITH DELIVERY, WITH CURRENT POSTPARTUM COMPLICATION
642.91	UNSPECIFIED HYPERTENSION, WITH DELIVERY
642.92	UNSPECIFIED HYPERTENSION, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
643.01	MILD HYPEREMESIS GRAVIDARUM, DELIVERED
643.11	HYPEREMESIS GRAVIDARUM WITH METABOLIC DISTURBANCE, DELIVERED
643.21	LATE VOMITING OF PREGNANCY, DELIVERED
643.81	OTHER VOMITING COMPLICATING PREGNANCY, DELIVERED
643.91	UNSPECIFIED VOMITING OF PREGNANCY, DELIVERED
644.2	EARLY ONSET OF DELIVERY
644.20	EARLY ONSET OF DELIVERY, UNSPECIFIED AS TO EPISODE OF CARE
644.21	EARLY ONSET OF DELIVERY, DELIVERED
645.01	PROLONGED PREGNANCY, WITH DELIVERY
645.11	POST TERM PREGNANCY, DELIVERED
645.21	PROLONGED PREGNANCY, DELIVERED
645.22	PROLONGED PREGNANCY, DELIVERED, ANTEPARTUM CONDITION OR COMPLICATION
646.01	PAPYRACEOUS FETUS, DELIVERED
646.11	EDEMA OR EXCESSIVE WEIGHT GAIN IN PREGNANCY, DELIVERED

ICD-9-CM diagnosis codes	Abbreviated Description
646.12	EDEMA OR EXCESSIVE WEIGHT GAIN IN PREGNANCY, WITH MENTION OF POSTPARTUM COMPLICATION
646.21	UNSPECIFIED RENAL DISEASE IN PREGNANCY, WITH DELIVERY
646.22	UNSPECIFIED RENAL DISEASE IN PREGNANCY, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
646.31	HABITUAL ABORTER, DELIVERED
646.41	PERIPHERAL NEURITIS IN PREGNANCY, WITH DELIVERY
646.42	PERIPHERAL NEURITIS IN PREGNANCY, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
646.51	ASYMPTOMATIC BACTERIURIA IN PREGNANCY, WITH DELIVERY
646.52	ASYMPTOMATIC BACTERIURIA IN PREGNANCY, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
646.61	INFECTIONS OF GENITOURINARY TRACT IN PREGNANCY, WITH DELIVERY
646.62	INFECTIONS OF GENITOURINARY TRACT IN PREGNANCY, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
646.71	LIVER DISORDERS IN PREGNANCY, WITH DELIVERY
646.81	OTHER SPECIFIED COMPLICATIONS OF PREGNANCY, WITH DELIVERY
646.82	OTHER SPECIFIED COMPLICATIONS OF PREGNANCY, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
646.91	UNSPECIFIED COMPLICATION OF PREGNANCY, WITH DELIVERY
647.01	SYPHILIS OF MOTHER, COMPLICATING PREGNANCY, WITH DELIVERY
647.02	SYPHILIS OF MOTHER, COMPLICATING PREGNANCY, WITH DELIVERY WITH MENTION OF POSTPARTUM COMPLICATION
647.11	GONORRHEA OF MOTHER, WITH DELIVERY
647.12	GONORRHEA OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
647.21	OTHER VENEREAL DISEASES OF MOTHER, WITH DELIVERY
647.22	OTHER VENEREAL DISEASES OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
647.31	TUBERCULOSIS OF MOTHER, WITH DELIVERY
647.32	TUBERCULOSIS OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
647.41	MALARIA OF MOTHER, WITH DELIVERY
647.42	MALARIA OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
647.51	RUBELLA OF MOTHER, WITH DELIVERY
647.52	RUBELLA OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
647.61	OTHER VIRAL DISEASES OF MOTHER, WITH DELIVERY
647.62	OTHER VIRAL DISEASES OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
647.81	OTHER SPECIFIED INFECTIOUS AND PARASITIC DISEASES OF MOTHER, DELIVERED
647.82	OTHER SPECIFIED INFECTIOUS AND PARASITIC DISEASES OF MOTHER, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
647.91	UNSPECIFIED INFECTION OR INFESTATION OF MOTHER, WITH DELIVERY
647.92	UNSPECIFIED INFECTION OR INFESTATION OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
648.01	DIABETES MELLITUS OF MOTHER, WITH DELIVERY

ICD-9-CM diagnosis codes	Abbreviated Description
648.02	DIABETES MELLITUS OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
648.11	THYROID DYSFUNCTION OF MOTHER, WITH DELIVERY
648.12	THYROID DYSFUNCTION OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
648.21	ANEMIA OF MOTHER, WITH DELIVERY
648.22	ANEMIA OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
648.31	DRUG DEPENDENCE OF MOTHER, WITH DELIVERY
648.32	DRUG DEPENDENCE OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
648.41	MENTAL DISORDERS OF MOTHER, WITH DELIVERY
648.42	MENTAL DISORDERS OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
648.51	CONGENITAL CARDIOVASCULAR DISORDERS OF MOTHER, WITH DELIVERY
648.52	CONGENITAL CARDIOVASCULAR DISORDERS OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
648.61	OTHER CARDIOVASCULAR DISEASES OF MOTHER, WITH DELIVERY
648.62	OTHER CARDIOVASCULAR DISEASES OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
648.71	BONE AND JOINT DISORDERS OF BACK, PELVIS, AND LOWER LIMBS, DELIVERED
648.72	BONE AND JOINT DISORDERS OF BACK, PELVIS, AND LOWER LIMBS, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
648.81	ABNORMAL GLUCOSE TOLERANCE OF MOTHER, WITH DELIVERY
648.82	ABNORMAL GLUCOSE TOLERANCE OF MOTHER, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
648.91	OTHER CURRENT CONDITIONS CLASSIFIABLE ELSEWHERE OF MOTHER, DELIVERED
648.92	OTHER CURRENT CONDITIONS CLASSIFIABLE ELSEWHERE OF MOTHER, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
650	NORMAL DELIVERY
651.01	TWIN PREGNANCY, DELIVERED
651.11	TRIPLET PREGNANCY, DELIVERED
651.21	QUADRUPLET PREGNANCY, DELIVERED
651.31	TWIN PREGNANCY WITH FETAL LOSS AND RETENTION OF ONE FETUS
651.41	TRIPLET PREGNANCY WITH FETAL LOSS AND RETENTION OF ONE OR MORE FETUS(ES)
651.51	QUADRUPLET PREGNANCY WITH FETAL LOSS AND RETENTION OF ONE OR MORE FETUS(ES)
651.61	OTHER MULTIPLE PREGNANCY WITH FETAL LOSS AND RETENTION OF ONE OR MORE FETUS(ES)
651.81	OTHER SPECIFIED MULTIPLE GESTATION, DELIVERED
651.91	UNSPECIFIED MULTIPLE GESTATION, DELIVERED
652.01	UNSTABLE LIE, DELIVERED
652.11	BREECH OR OTHER MALPRESENTATION SUCCESSFULLY CONVERTED TO CEPHALIC PRESENTATION
652.21	BREECH PRESENTATION WITHOUT MENTION OF VERSION, DELIVERED

ICD-9-CM diagnosis codes	Abbreviated Description
652.31	TRANSVERSE OR OBLIQUE PRESENTATION, DELIVERED
652.41	FACE OR BROW PRESENTATION, DELIVERED
652.51	HIGH HEAD AT TERM, DELIVERED
652.61	MULTIPLE GESTATION WITH MALPRESENTATION OF ONE FETUS OR MORE, DELIVERED
652.71	PROLAPSED ARM OF FETUS, DELIVERED
652.81	OTHER SPECIFIED MALPOSITION OR MALPRESENTATION, DELIVERED
652.91	UNSPECIFIED MALPOSITION OR MALPRESENTATION, DELIVERED
653.01	MAJOR ABNORMALITY OF BONY PELVIS, NOT FURTHER SPECIFIED, DELIVERED
653.11	GENERALLY CONTRACTED PELVIS, DELIVERED
653.21	INLET CONTRACTION OF PELVIS, DELIVERED
653.31	OUTLET CONTRACTION OF PELVIS, DELIVERED
653.41	FETOPELVIC DISPROPORTION, DELIVERED
653.51	UNUSUALLY LARGE FETUS CAUSING DISPROPORTION, DELIVERED
653.61	HYDROCEPHALIC FETUS CAUSING DISPROPORTION, DELIVERED
653.71	OTHER FETAL ABNORMALITY CAUSING DISPROPORTION, DELIVERED
653.81	DISPROPORTION OF OTHER ORIGIN, DELIVERED
653.91	UNSPECIFIED DISPROPORTION, DELIVERED
654.01	CONGENITAL ABNORMALITIES OF UTERUS, WITH DELIVERY
654.02	CONGENITAL ABNORMALITIES OF UTERUS, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
654.11	TUMORS OF BODY OF UTERUS, WITH DELIVERY
654.12	TUMORS OF BODY OF UTERUS, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
654.21	PREVIOUS CESAREAN DELIVERY, DELIVERED
654.31	RETROVERTED AND INCARCERATED GRAVID UTERUS, DELIVERED
654.32	RETROVERTED AND INCARCERATED GRAVID UTERUS, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
654.41	OTHER ABNORMALITIES IN SHAPE OR POSITION OF GRAVID UTERUS
654.42	OTHER ABNORMALITIES IN SHAPE OR POSITION OF GRAVID UTERUS, WITH MENTION OF POSTPARTUM COMPLICATION
654.51	CERVICAL INCOMPETENCE, WITH DELIVERY
654.52	CERVICAL INCOMPETENCE, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
654.61	OTHER CONGENITAL OR ACQUIRED ABNORMALITY OF CERVIX, DELIVERED
654.62	OTHER CONGENITAL OR ACQUIRED ABNORMALITY OF CERVIX, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
654.71	CONGENITAL OR ACQUIRED ABNORMALITY OF VAGINA, DELIVERED
654.72	CONGENITAL OR ACQUIRED ABNORMALITY OF VAGINA, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
654.81	CONGENITAL OR ACQUIRED ABNORMALITY OF VULVA, DELIVERED
654.82	CONGENITAL OR ACQUIRED ABNORMALITY OF VULVA, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
654.91	OTHER AND UNSPECIFIED ABNORMALITY OF ORGANS AND SOFT TISSUE WITH DELIVERY

ICD-9-CM diagnosis codes	Abbreviated Description
654.92	OTHER AND UNSPECIFIED ABNORMALITY OF ORGANS AND SOFT TISSUE WITH DELIVERY WITH MENTION OF POSTPARTUM COMPLICATION
655.01	CENTRAL NERVOUS SYSTEM MALFORMATION IN FETUS, DELIVERED
655.11	CHROMOSOMAL ABNORMALITY IN FETUS, AFFECTING MANAGEMENT OF MOTHER
655.21	HEREDITARY DISEASE IN FAMILY POSSIBLY AFFECTING FETUS, AFFECTING MANAGEMENT OF MOTHER, DELIVERED
655.31	SUSPECTED DAMAGE TO FETUS FROM VIRAL DISEASE IN THE MOTHER
655.41	SUSPECTED DAMAGE TO FETUS FROM OTHER DISEASE IN THE MOTHER
655.51	SUSPECTED DAMAGE TO FETUS FROM DRUGS, AFFECTING MANAGEMENT OF MOTHER
655.61	SUSPECTED DAMAGE TO FETUS FROM RADIATION, AFFECTING MANAGEMENT OF MOTHER
655.71	DECREASED FETAL MOVEMENTS, DELIVERED
655.81	OTHER KNOWN OR SUSPECTED FETAL ABNORMALITY
655.91	UNSPECIFIED SUSPECTED FETAL ABNORMALITY, AFFECTING MANAGENT OF MOTHER
656.01	FETAL-MATERNAL HEMORRHAGE, WITH DELIVERY
656.11	RHESUS ISOIMMUNIZATION, AFFECTING MANAGEMENT OF MOTHER
656.21	ISOIMMUNIZATION FROM OTHER AND UNSPECIFIED BLOOD-GROUP
656.31	FETAL DISTRESS, AFFECTING MANAGEMENT OF MOTHER, DELIVERED
656.41	INTRAUTERINE DEATH, AFFECTING MANAGEMENT OF MOTHER, DELIVED
656.51	POOR FETAL GROWTH, AFFECTING MANAGEMENT OF MOTHER, DELIVE
656.61	EXCESSIVE FETAL GROWTH, AFFECTING MANAGEMENT OF MOTHER, DELIVERED
656.71	OTHER PLACENTAL CONDITIONS, AFFECTING MANAGEMENT OF MOTHER
656.81	OTHER SPECIFIED FETAL AND PLACENTAL PROBLEMS, AFFECTING MANAGEMENT OF MOTHER
656.91	UNSPECIFIED FETAL AND PLACENTAL PROBLEM, AFFECTING MANAGENT OF MOTHER
657.01	POLYHYDRAMNIOS, WITH DELIVERY
658.01	OLIGOHYDRAMNIOS, DELIVERED
658.11	PREMATURE RUPTURE OF MEMBRANES, DELIVERED
658.2	DELAYED DELIVERY AFTER SPONTANEOUS OR UNSPECIFIED RUPTURE
658.20	DELAYED DELIVERY AFTER SPONTANEOUS OR UNSPECIFIED RUPTURE
658.21	DELAYED DELIVERY AFTER SPONTANEOUS OR UNSPECIFIED RUPTURE
658.23	DELAYED DELIVERY AFTER SPONTANEOUS OR UNSPECIFIED RUPTURE
658.3	DELAYED DELIVERY AFTER ARTIFICIAL RUPTURE OF MEMBRANES
658.30	DELAYED DELIVERY AFTER ARTIFICIAL RUPTURE OF MEMBRANES
658.31	DELAYED DELIVERY AFTER ARTIFICIAL RUPTURE OF MEMBRANES
658.33	DELAYED DELIVERY AFTER ARTIFICIAL RUPTURE OF MEMBRANES
658.41	INFECTION OF AMNIOTIC CAVITY, DELIVERED
658.81	OTHER PROBLEMS ASSOCIATED WITH AMNIOTIC CAVITY AND MEMBRANES
658.91	UNSPECIFIED PROBLEM ASSOCIATED WITH AMNIOTIC CAVITY AND MEMBRANES
659.01	FAILED MECHANICAL INDUCTION OF LABOR, DELIVERED

ICD-9-CM diagnosis codes	Abbreviated Description
659.11	FAILED MEDICAL OR UNSPECIFIED INDUCTION OF LABOR, DELIVERED
659.21	UNSPECIFIED TYPE MATERNAL PYREXIA DURING LABOR, DELIVERED
659.31	GENERALIZED INFECTION DURING LABOR, DELIVERED
659.41	GRAND MULTIPARITY, WITH CURRENT PREGNANCY, DELIVERED
659.51	ELDERLY PRIMIGRAVIDA, DELIVERED
659.61	ELDERLY MULTIGRAVIDA, DELIVERED
659.71	ABNORMALITY IN FETAL HEART RATE/RHYTHM, DELIVERED
659.81	OTHER SPECIFIED INDICATIONS FOR CARE OR INTERVENTION RELATED TO LABOR AND DELIVERY, DELIVERED
659.91	UNSPECIFIED INDICATION FOR CARE OR INTERVENTION RELATED TO LABOR AND DELIVERY, DELIVERED
660.01	OBSTRUCTION CAUSED BY MALPOSITION OF FETUS AT ONSET OF LABOR
660.11	OBSTRUCTION BY BONY PELVIS DURING LABOR, WITH DELIVERY
660.21	OBSTRUCTION BY ABNORMAL PELVIC SOFT TISSUES DURING LABOR
660.31	DEEP TRANSVERSE ARREST AND PERSISTENT OCCIPITOPOSTERIOR POSTERIOR
660.41	SHOULDER (GIRDLE) DYSTOCIA, WITH DELIVERY
660.51	LOCKED TWINS, WITH DELIVERY
660.61	FAILED TRIAL OF LABOR, UNSPECIFIED, WITH DELIVERY
660.71	FAILED FORCEPS OR VACUUM EXTRACTOR, UNSPECIFIED, WITH DELIVERY
660.81	OTHER CAUSES OF OBSTRUCTED LABOR, WITH DELIVERY
660.91	UNSPECIFIED OBSTRUCTED LABOR, WITH DELIVERY
661.01	PRIMARY UTERINE INERTIA, WITH DELIVERY
661.11	SECONDARY UTERINE INERTIA, WITH DELIVERY
661.21	OTHER AND UNSPECIFIED UTERINE INERTIA, WITH DELIVERY
661.31	PRECIPITATE LABOR, WITH DELIVERY
661.41	HYPERTONIC, INCOORDINATE, OR PROLONGED UTERINE CONTRACTIONS, DELIVERED
661.91	UNSPECIFIED ABNORMALITY OF LABOR, WITH DELIVERY
662.01	PROLONGED FIRST STAGE OF LABOR, DELIVERED
662.11	PROLONGED LABOR, UNSPECIFIED TYPE, DELIVERED
662.21	PROLONGED SECOND STAGE OF LABOR, DELIVERED
662.31	DELAYED DELIVERY OF SECOND TWIN, TRIPLET, ETC., DELIVERED
663.01	PROLAPSE OF CORD COMPLICATING LABOR AND DELIVERY, DELIVERERED
663.11	CORD AROUND NECK, WITH COMPRESSION, COMPLICATING LABOR AND DELIVERY, DELIVERED
663.21	OTHER AND UNSPECIFIED CORD ENTANGLEMENT, WITH COMPRESSION
663.31	OTHER AND UNSPECIFIED CORD ENTANGLEMENT
663.41	SHORT CORD COMPLICATING LABOR AND DELIVERY, DELIVERED
663.51	VASA PREVIA COMPLICATING LABOR AND DELIVERY, DELIVERED
663.61	VASCULAR LESIONS OF CORD COMPLICATING LABOR AND DELIVERY
663.81	OTHER UMBILICAL CORD COMPLICATIONS DURING LABOR AND DELIVERY

ICD-9-CM diagnosis codes	Abbreviated Description
663.91	UNSPECIFIED UMBILICAL CORD COMPLICATION DURING LABOR AND DELIVERY
664.01	FIRST-DEGREE PERINEAL LACERATION, WITH DELIVERY
664.11	SECOND-DEGREE PERINEAL LACERATION, WITH DELIVERY
664.21	THIRD-DEGREE PERINEAL LACERATION, WITH DELIVERY
664.31	FOURTH-DEGREE PERINEAL LACERATION, WITH DELIVERY
664.41	UNSPECIFIED PERINEAL LACERATION, WITH DELIVERY
664.51	VULVAR AND PERINEAL HEMATOMA, WITH DELIVERY
664.81	OTHER SPECIFIED TRAUMA TO PERINEUM AND VULVA, WITH DELIVERY
664.91	UNSPECIFIED TRAUMA TO PERINEUM AND VULVA, WITH DELIVERY
665.01	RUPTURE OF UTERUS BEFORE ONSET OF LABOR, WITH DELIVERY
665.11	RUPTURE OF UTERUS DURING LABOR, DELIVERED
665.22	INVERSION OF UTERUS, DELIVERED WITH POSTPARTUM COMPLICATIONS
665.31	LACERATION OF CERVIX, WITH DELIVERY
665.41	HIGH VAGINAL LACERATION, WITH DELIVERY
665.51	OTHER INJURY TO PELVIC ORGANS, WITH DELIVERY
665.61	DAMAGE TO PELVIC JOINTS AND LIGAMENTS, WITH DELIVERY
665.71	PELVIC HEMATOMA, WITH DELIVERY
665.72	PELVIC HEMATOMA, DELIVERED WITH POSTPARTUM COMPLICATION
665.81	OTHER SPECIFIED OBSTETRICAL TRAUMA, WITH DELIVERY
665.82	OTHER SPECIFIED OBSTETRICAL TRAUMA, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
665.91	UNSPECIFIED OBSTETRICAL TRAUMA, WITH DELIVERY
665.92	UNSPECIFIED OBSTETRICAL TRAUMA, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
666.02	THIRD-STAGE POSTPARTUM HEMORRHAGE, WITH DELIVERY
666.12	OTHER IMMEDIATE POSTPARTUM HEMORRHAGE, WITH DELIVERY
666.22	DELAYED AND SECONDARY POSTPARTUM HEMORRHAGE, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
666.32	POSTPARTUM COAGULATION DEFECTS, WITH DELIVERY
667.02	RETAINED PLACENTA WITHOUT HEMORRHAGE, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
667.12	RETAINED PORTIONS OF PLACENTA OR MEMBRANES, WITHOUT HEMORRHAGE, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
668.01	PULMONARY COMPLICATIONS OF ANESTHESIA OR OTHER SEDATION IN LABOR AND DELIVERY
668.02	PULMONARY COMPLICATIONS OF ANESTHESIA OR OTHER SEDATION IN LABOR AND DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
668.11	CARDIAC COMPLICATIONS OF ANESTHESIA OR OTHER SEDATION IN LABOR AND DELIVERY
668.12	CARDIAC COMPLICATIONS OF ANESTHESIA OR OTHER SEDATION IN LABOR AND DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
668.21	CENTRAL NERVOUS SYSTEM COMPLICATIONS OF ANESTHESIA OR OTHER SEDATION IN LABOR AND DELIVERY
668.22	CENTRAL NERVOUS SYSTEM COMPLICATIONS OF ANESTHESIA OR OTHER SEDATION IN LABOR AND DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION

ICD-9-CM diagnosis codes	Abbreviated Description
668.81	OTHER COMPLICATIONS OF ANESTHESIA OR OTHER SEDATION IN LABOR AND DELIVERY
668.82	OTHER COMPLICATIONS OF ANESTHESIA OR OTHER SEDATION IN LABOR AND DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
668.91	UNSPECIFIED COMPLICATION OF ANESTHESIA OR OTHER SEDATION
668.92	UNSPECIFIED COMPLICATION OF ANESTHESIA OR OTHER SEDATION, WITH MENTION OF POSTPARTUM COMPLICATION
669.01	MATERNAL DISTRESS, WITH DELIVERY
669.02	MATERNAL DISTRESS, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
669.11	SHOCK DURING OR FOLLOWING LABOR AND DELIVERY
669.12	SHOCK DURING OR FOLLOWING LABOR AND DELIVERY WITH MENTION OF POSTPARTUM COMPLICATION
669.21	MATERNAL HYPOTENSION SYNDROME, WITH DELIVERY
669.22	MATERNAL HYPOTENSION SYNDROME, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
669.32	ACUTE RENAL FAILURE WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
669.41	OTHER COMPLICATIONS OF OBSTETRICAL SURGERY AND PROCEDURES
669.42	OTHER COMPLICATIONS OF OBSTETRICAL SURGERY AND PROCEDURES
669.5	FORCEPS OR VACUUM EXTRACTOR DELIVERY
669.50	FORCEPS OR VACUUM EXTRACTOR DELIVERY
669.51	FORCEPS OR VACUUM EXTRACTOR DELIVERY
669.6	FORCEPS OR VACUUM EXTRACTOR DELIVERY
669.60	BREECH EXTRACTION, WITHOUT MENTION OF INDICATION
669.61	BREECH EXTRACTION, WITHOUT MENTION OF INDICATION
669.7	FORCEPS OR VACUUM EXTRACTOR DELIVERY WITHOUT MENTION OF INDICATION
669.70	CESAREAN DELIVERY, WITHOUT MENTION OF INDICATION
669.71	CESAREAN DELIVERY, WITHOUT MENTION OF INDICATION
669.81	OTHER COMPLICATIONS OF LABOR AND DELIVERY, DELIVERED
669.82	OTHER COMPLICATION OF LABOR AND DELIVERY, DELIVERED, WITH MENTION OF POSTPARTUM COMPLICATION
669.91	UNSPECIFIED COMPLICATION OF LABOR AND DELIVERY
669.92	UNSPECIFIED COMPLICATION OF LABOR AND DELIVERY
670.02	MAJOR PUERPERAL INFECTION, DELIVERED
671.01	VARICOSE VEINS OF LEGS, WITH DELIVERY
671.02	VARICOSE VEINS OF LEGS, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
671.11	VARICOSE VEINS OF VULVA AND PERINEUM, WITH DELIVERY
671.12	VARICOSE VEINS OF VULVA AND PERINEUM, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
671.21	SUPERFICIAL THROMBOPHLEBITIS WITH DELIVERY
671.22	SUPERFICIAL THROMBOPHLEBITIS WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
671.31	DEEP PHLEBOTHROMBOSIS, ANTEPARTUM, WITH DELIVERY
671.42	DEEP PHLEBOTHROMBOSIS, POSTPARTUM, WITH DELIVERY

ICD-9-CM diagnosis codes	Abbreviated Description
671.51	OTHER PHLEBITIS AND THROMBOSIS WITH DELIVERY
671.52	OTHER PHLEBITIS AND THROMBOSIS WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
671.81	OTHER VENOUS COMPLICATIONS, WITH DELIVERY
671.82	OTHER VENOUS COMPLICATIONS, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
671.91	UNSPECIFIED VENOUS COMPLICATION, WITH DELIVERY
671.92	UNSPECIFIED VENOUS COMPLICATION, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
672.02	PYREXIA OF UNKNOWN ORIGIN, WITH DELIVERY
673.01	OBSTETRICAL AIR EMBOLISM, WITH DELIVERY
673.02	OBSTETRICAL AIR EMBOLISM, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
673.11	AMNIOTIC FLUID EMBOLISM, WITH DELIVERY
673.12	AMNIOTIC FLUID EMBOLISM, WITH DELIVERY WITH MENTION OF POSTPARTUM COMPLICATION
673.21	OBSTETRICAL BLOOD-CLOT EMBOLISM, WITH DELIVERY
673.31	OBSTETRICAL PYEMIC AND SEPTIC EMBOLISM, WITH DELIVERY
673.32	OBSTETRICAL PYEMIC AND SEPTIC EMBOLISM, WITH DELIVERY WITH MENTION OF POSTPARTUM COMPLICATION
673.81	OTHER OBSTETRICAL PULMONARY EMBOLISM, WITH DELIVERY
673.82	OTHER OBSTETRICAL PULMONARY EMBOLISM, WITH DELIVERY WITH MENTION OF POSTPARTUM COMPLICATION
674.01	CEREBROVASCULAR DISORDERS, WITH DELIVERY
674.02	CEREBROVASCULAR DISORDERS, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
674.12	DISRUPTION OF CESAREAN WOUND, WITH DELIVERY
674.22	DISRUPTION OF PERINEAL WOUND, WITH DELIVERY
674.32	OTHER COMPLIC OF OBSTET SURG WOUNDS, WITH DELIVERY
674.42	PLACENTAL POLYP, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
674.51	PERIPARTUM CARDIOMYOPATHY, DELIVERED
674.52	PERIPARTUM CARDIOMYOPATHY, DELIVERED, WITH MENTION OF POSTPARTUM CONDITION
674.82	OTHER COMPLICATIONS OF PUERPERIUM, WITH DELIVERY
674.92	UNSPECIFIED COMPLICATIONS OF PUERPERIUM, WITH DELIVERY
675.01	INFECTION OF NIPPLE, WITH DELIVERY
675.02	INFECTION OF NIPPLE, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
675.11	ABSCESS OF BREAST, WITH DELIVERY
675.12	ABSCESS OF BREAST, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
675.21	NONPURULENT MASTITIS, WITH DELIVERY
675.22	NONPURULENT MASTITIS, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
675.81	OTHER SPEC INFECT OF BREAST, WITH DELIVERY
675.82	OTHER SPEC INFECT OF BREAST, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION

ICD-9-CM diagnosis codes	Abbreviated Description
675.91	UNSPEC INFECT OF BREAST, WITH DELIVERY
675.92	UNSPEC INFECT OF BREAST, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
676.01	RETRACTED NIPPLE, WITH DELIVERY
676.02	RETRACTED NIPPLE, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
676.11	CRACKED NIPPLE, WITH DELIVERY
676.12	CRACKED NIPPLE, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
676.21	ENGORGEMENT OF BREASTS, WITH DELIVERY
676.22	ENGORGEMENT OF BREASTS, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
676.31	OTHER DISORDER OF BREASTS, WITH DELIVERY
676.32	OTHER DISORDER OF BREASTS, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
676.41	FAILURE OF LACTATION, WITH DELIVERY
676.42	FAILURE OF LACTATION, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
676.51	SUPPRESSED LACTATION, WITH DELIVERY
676.52	SUPPRESSED LACTATION, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
676.61	GALACTORRHEA, WITH DELIVERY
676.62	GALACTORRHEA, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
676.81	OTHER DISORDERS OF LACTATION, WITH DELIVERY
676.82	OTHER DISORDERS OF LACTATION, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
676.91	UNSPECIFIED DISORDER OF LACTATION, WITH DELIVERY
676.92	UNSPECIFIED DISORDER OF LACTATION, WITH DELIVERY, WITH MENTION OF POSTPARTUM COMPLICATION
763	BREECH DELIVERY AND EXTRACTION AFFECTING FETUS OR NEWBORN
763.2	FORCEPS DELIVERY AFFECTING FETUS OR NEWBORN
763.3	DELIVERY BY VACUUM EXTRACTOR AFFECTING FETUS OR NEWBORN
763.4	CESAREAN DELIVERY AFFECTING FETUS OR NEWBORN
763.6	PRECIPITATE DELIVERY AFFECTING FETUS OR NEWBORN
V27	OUTCOME OF DELIVERY
V27.0	SINGLE NEWBORN
V27.1	SINGLE STILLBORN
V27.2	TWINS, BOTH LIVEBORN
V27.3	TWINS, ONE LIVEBORN
V27.4	TWINS, STILLBORN
V27.5	OTHER MULTIPLE BIRTH, ALL LIVEBORN
V27.6	OTHER MULTIPLE BIRTH, SOME LIVEBORN
V27.7	OTHER MULTIPLE BIRTH, ALL STILLBORN
V27.9	MOTHER WITH UNSPECIFIED OUTCOME OF DELIVERY
V30.0	SINGLE NEWBORN, BORN IN HOSPITAL

ICD-9-CM diagnosis codes	Abbreviated Description
V30.00	SINGLE NEWBORN, BORN IN HOSPITAL
V30.01	SINGLE NEWBORN, BORN IN HOSPITAL, CESAREAN
V30.1	SINGLE LIVEBORN, BORN BEFORE ADMISSION TO HOSPITAL
V31.0	TWIN, BORN IN HOSPITAL
V31.00	TWIN, BORN IN HOSPITAL
V31.01	TWIN, BORN IN HOSPITAL, CESAREAN
V31.1	TWIN BIRTH, MATE LIVEBORN, BORN BEFORE ADMISSION TO HOSPITAL
V31.2	TWIN BIRTH, MATE LIVEBORN, BORN OUTSIDE HOSPITAL AND NOT HOSPITALIZED
V32.0	TWIN, BORN IN HOSPITAL, MATE STILLBORN
V32.01	TWIN, BORN IN HOSPITAL, CESAREAN, MATE STILLBORN
V32.1	TWIN BIRTH, MATE STILLBORN, BORN BEFORE ADMISSION TO HOSPITAL
V32.2	TWIN BIRTH, MATE STILLBORN, BORN OUTSIDE HOSPITAL AND NOT HOSPITALIZED
V33.0	TWIN, BORN IN HOSPITAL
V33.01	TWIN, BORN IN HOSPITAL, CESAREAN
V33.1	TWIN BIRTH, UNSPECIFIED WHETHER MATE LIVEBORN OR STILLBORN, BORN BEFORE ADMISSION TO HOSPITAL
V34.0	OTHER MULTIPLE, BORN IN HOSPITAL
V34.00	OTHER MULTIPLE, BORN IN HOSPITAL
V34.01	OTHER MULTIPLE, BORN IN HOSPITAL, CESAREAN
V34.1	OTHER MULTIPLE BIRTH (THREE OR MORE), MATES ALL LIVEBORN, BORN BEFORE ADMISSION TO HOSPITAL
V35.0	OTHER MULTIPLE, BORN IN HOSPITAL
V35.00	OTHER MULTIPLE, BORN IN HOSPITAL
V35.01	OTHER MULTIPLE, BORN IN HOSPITAL, CESAREAN
V35.1	OTHER MULTIPLE BIRTH (THREE OR MORE), MATES ALL STILLBORN, BORN BEFORE ADMISSION TO HOSPITAL
V36.0	OTHER MULTIPLE, BORN IN HOSPITAL
V36.00	OTHER MULTIPLE, BORN IN HOSPITAL
V36.01	OTHER MULTIPLE, BORN IN HOSPITAL, CESAREAN
V36.1	OTHER MULTIPLE BIRTH (THREE OR MORE), MATES LIVEBORN AND STILLBORN, BORN BEFORE ADMISSION TO HOSPITAL
V37.0	OTHER MULTIPLE, BORN IN HOSPITAL
V37.00	OTHER MULTIPLE, BORN IN HOSPITAL
V37.01	OTHER MULTIPLE, BORN IN HOSPITAL, CESAREAN
V37.1	OTHER MULTIPLE BIRTH (THREE OR MORE), UNSPECIFIED WHETHER MATES LIVEBORN OR STILLBORN, BORN BEFORE ADMISSION TO HOSPITAL
V39.0	UNSPEC, BORN IN HOSPITAL
V39.00	UNSPEC, BORN IN HOSPITAL
V39.01	UNSPEC, BORN IN HOSPITAL, CESAREAN
V39.1	LIVEBORN, UNSPECIFIED WHETHER SINGLE, TWIN OR MULTIPLE, BORN BEFORE ADMISSION TO HOSPITAL

ICD-9-CM Procedure Codes	Description
72	FORCEPS, VACUUM, AND BREECH DELIVERY
72.0	FORCEPS, VACUUM, AND BREECH DELIVERY
72.1	FORCEPS, VACUUM, AND BREECH DELIVERY
72.2	FORCEPS, VACUUM, AND BREECH DELIVERY
72.21	FORCEPS, VACUUM, AND BREECH DELIVERY
72.29	FORCEPS, VACUUM, AND BREECH DELIVERY
72.3	FORCEPS, VACUUM, AND BREECH DELIVERY
72.31	FORCEPS, VACUUM, AND BREECH DELIVERY
72.39	FORCEPS, VACUUM, AND BREECH DELIVERY
72.4	FORCEPS, VACUUM, AND BREECH DELIVERY
72.5	FORCEPS, VACUUM, AND BREECH DELIVERY
72.51	FORCEPS, VACUUM, AND BREECH DELIVERY
72.52	FORCEPS, VACUUM, AND BREECH DELIVERY
72.53	FORCEPS, VACUUM, AND BREECH DELIVERY
72.54	FORCEPS, VACUUM, AND BREECH DELIVERY
72.6	FORCEPS, VACUUM, AND BREECH DELIVERY
72.7	FORCEPS, VACUUM, AND BREECH DELIVERY
72.71	FORCEPS, VACUUM, AND BREECH DELIVERY
72.79	FORCEPS, VACUUM, AND BREECH DELIVERY
72.8	FORCEPS, VACUUM, AND BREECH DELIVERY
72.9	FORCEPS, VACUUM, AND BREECH DELIVERY
73	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.0	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.01	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.09	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.1	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.2	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.21	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.22	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.3	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.4	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.5	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.51	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.59	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.6	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.8	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.9	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.91	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.92	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.93	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.94	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
73.99	OTHER PROCEDURES INDUCING OR ASSISTING DELIVERY
74	CESAREAN SECTION AND REMOVAL OF FETUS

ICD-9-CM Procedure Codes	Description
74.1	CESAREAN SECTION AND REMOVAL OF FETUS
74.2	CESAREAN SECTION AND REMOVAL OF FETUS
74.4	CESAREAN SECTION AND REMOVAL OF FETUS
74.9	CESAREAN SECTION AND REMOVAL OF FETUS
74.99	CESAREAN SECTION AND REMOVAL OF FETUS

CPT Procedure Codes	Description
59400	ROUTINE OB CARE INCL ANTEPARTUM CAR, VAGINAL DELIVER, POSTPARTUM CARE
59409	VAGINAL DELIVERY ONLY
59410	VAGINAL DELIVERY INCL POSTPARTUM CARE
59510	ROUTINE OB CARE INCL ANTEPARTUM CAR, CESAREAN DELIVER, POSTPARTUM CARE
59514	CESAREAN DELIVERY ONLY
59515	CESAREAN DELIVERY, INCL POSTPARTUM CARE
59610	OB CARE INCL ANTEPARTUM CAR, VAG DELIVER, POSTPART CARE. AFTER PREV C-SECT
59612	VAG DELIVERY ONLY AFTER PREV C-SECT
59614	VAG DELIVERY AFTER PREV C-SECT, INCL POSTPARTUM CARE
59618	OB CARE INCL ANTEPARTUM CAR, CES DELIVER, POSTPART CARE. AFTER PREV C-SECT
59620	CESAREAN DELIVERY ONLY AFTER PREV C-SECT
59622	CESAREAN DELIVERY AFTER PREV C-SECT, INCL POSTPARTUM CARE

Take-home messages

- Health plan data offer great potential for studying medication safety in pregnancy because they include large, diverse, and defined populations. A crucial step is identifying linkages between mothers and infants.
- The Medication Exposure in Pregnancy Risk Evaluation Program (MEPREP) developed a hierarchical linking algorithm used at 8 different health plans. This algorithm supports standardization yet allows tailoring to each plan's data resources, such as birth registries and individual or family subscriber numbers.
- With this approach, 8 MEPREP sites were able to link 86% of 299,260 deliveries to infants (range, 74–99% across plans) for the years 2001–2007.
- Using birth certificates to identify additional mother-infant pairs substantially increased linkage rates at 2 sites and identified a more diverse population, including more Hispanic or non-white individuals.
- Linkages created using these tools can support sound pharmacoepidemiologic studies of maternal drug exposures outside the context of a formal registry.

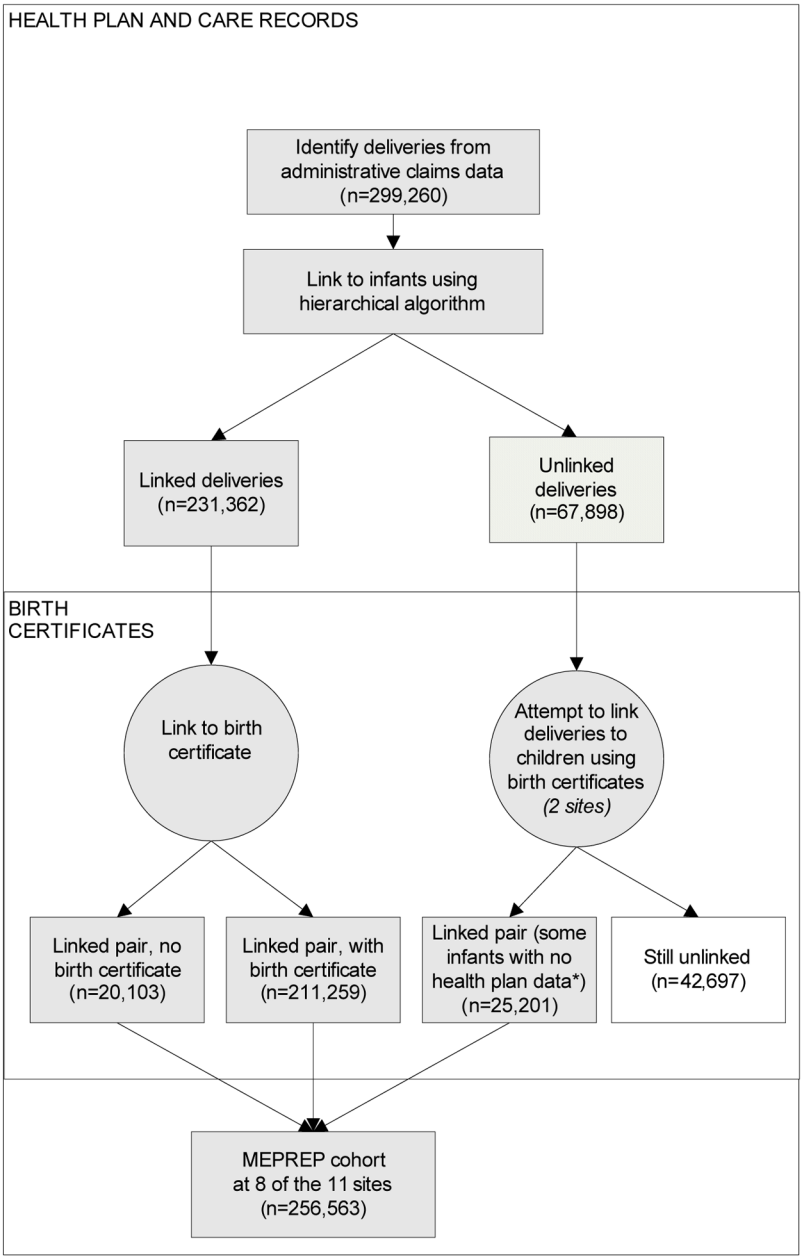

Fig. 1.

Process used to link deliveries to infants within health plans and to link health plan data to birth certificates at 8 sites, 2001–2007

*Includes 6,018 infants not linked to health plan records. Because birth certificates include data on some outcomes identified around the time of birth, this subset is still useful for some MEPREP activities but may not be included in all studies.

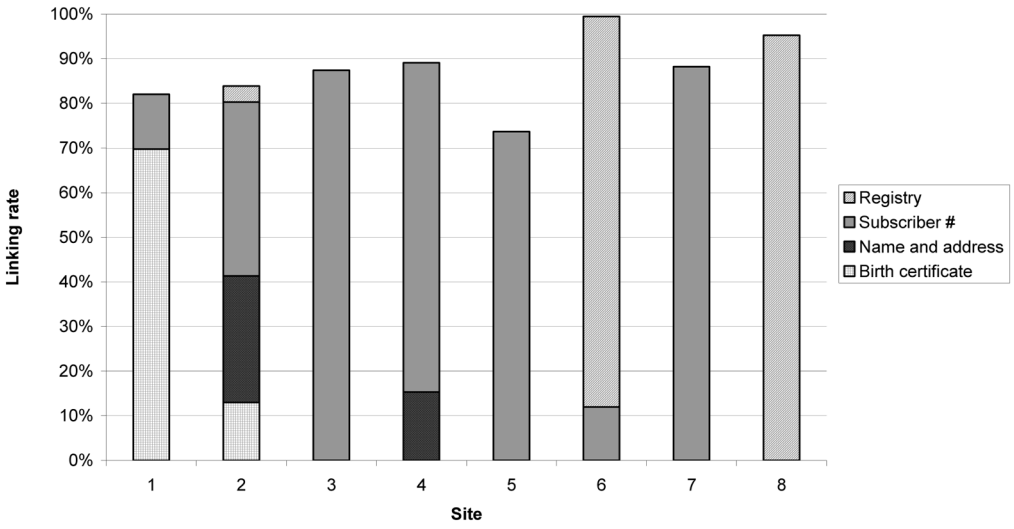

Fig. 2.
Proportion of deliveries linked to an infant, by linkage method and site, 2001–2007

Table 1

MEPREP sites, 2001–2007

	Number of infants (%)
HMO Research Network sites using the MEPREP hierarchical algorithm Fallon Community Health Plan (Worcester, MA) Group Health Cooperative (Seattle, WA) Harvard Pilgrim Health Care (Boston, MA) HealthPartners (Minneapolis, MN) Kaiser Permanente Colorado (Denver, CO) Kaiser Permanente Georgia (Atlanta, GA) Kaiser Permanente Northwest (Portland, OR) LCF Research (Albuquerque, NM)	257,268 (24.2%)
Vanderbilt University/Tennessee State Medicaid	350,522 (33.0%)
Kaiser Permanente Northern California and Southern California	453,369 (42.7%)

Table 2

Comparison of women linked to infants using different methods at two sites which augmented linkage using birth certificate data*

	SITE 1		SITE 2	
	Links from birth certificates (60% of pairs)	**Links from health plan records alone (40% of pairs)**	**Links from birth certificates (13% of pairs)**	**Links from health plan records alone (87% of pairs)**
Hispanic (%)	64.3	41.5	7.4	5.6
Race (%)				
White	91.7	92.1	72.3	81.1
Black	2.3	1.2	11.0	4.6
Asian American	0.1	0.5	10.6	9.1
Pacific Islander	1.1	3.2	2.3	2.6
Native American	3.9	3.0	2.0	1.1
Education: < high school graduate (%)	30.3	4.1	16.5	3.7
Age (%)				
<18	8.1	0.7	4.0	1.0
18–39	91.0	95.4	83.3	76.8
40+	0.9	3.9	2.3	4.1
Medicaid insurance (%)	73.8	6.6	32.0	6.0
Smoking status (%)				
Smoker	12.5	4.1	4.0	1.0
Nonsmoker	85.9	94.2	18.0	20.0
Unknown	1.6	1.7	78.0	79.0
Nulliparous (%)	71.4	73.9	48.0	42.0

* Limited to the two sites which identified additional linked mother-infant pairs from the public record portion of state birth certificate files. Characteristics included in the table are derived from birth certificate data. All comparisons between groups linked using different methods within each site are statistically significant ($p<0.01$).