Impact of Prenatal Diagnosis and Elective Termination on the Prevalence of Selected Birth Defects in Hawaii

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This study examined the effect of prenatal diagnosis and elective termination on the prevalence of neural tube defects, oral clefts, abdominal wall defects, and chromosomal anomalies in Hawaii by using actively ascertained surveillance data collected between 1987 and 1996 by the Hawaii Birth Defects Program. Because the Program has nearly universal access to prenatal diagnostic information and to follow-up data on elective terminations, Hawaii is an ideal setting in which to study their effects on prevalence rates of birth defects. Except for oral clefts, a large proportion of the defects studied were prenatally diagnosed: anencephaly (87%), spina bifida (62%), encephalocele (83%), cleft palate (0%), cleft lip with or without cleft palate (14%), omphalocele (60%), gastroschisis (76%), Down syndrome (43%), trisomy 18 (61%), and trisomy 13 (40%). The effect of elective terminations on the birth prevalence rates for most of these birth defects was significant. Including electively terminated cases in the calculations of birth prevalence rates increased the rates by more than 50% for five of the 10 birth defects studied. Am J Epidemiol 1998;148:1206-11.

A number of studies have noted a decline in the birth prevalence of certain birth defects over the last several decades, particularly neural tube defects (NTDs) (anencephaly, spina bifida, and encephalocele) (1–11) and Down syndrome (12–16). At the same time, increasingly sophisticated prenatal diagnostic procedures have been developed to detect birth defects in utero. These include, but are not limited to, maternal serum screening for alpha-fetoprotein, human chorionic gonadotropin, and unconjugated estriol (17–20); amniocentesis (21); chorionic villus sampling (22); and ultrasonography (23). The detection of serious birth defects earlier in pregnancy and with more accuracy has led to a corresponding increase in elective terminations of affected pregnancies (24, 25).

It is unclear whether changes in the observed prevalence of birth defects are solely due to prenatal diagnosis and elective terminations or whether other factors, such as changes in environmental exposures, health behaviors, and demographic characteristics of the population, have played a role. For example, the increase in elective terminations of pregnancies in which fetuses were found to have Down syndrome may be counteracting the expected increase in the birth prevalence of Down syndrome due to more older women having children (12). Since 1992, women of childbearing age have been encouraged to increase their intake of folic acid to reduce their risk of having a baby with a NTD (26). In 1996, the Food and Drug Administration approved the fortification of enriched flour and grain products with folic acid to reduce the number of NTDs in the United States (27). To measure the impact of these public health interventions on rates of NTDs in specific populations, the effect of prenatal diagnosis and elective terminations will have to be taken into account when estimating changes in prevalence rates. The relative importance of prenatal diagnosis versus public health interventions on the prevalence of birth defects could have tremendous implications for the planning and allocation of health resources.

Previous studies that examined the impact of prenatal diagnosis on NTD prevalence rates may have been limited by incomplete ascertainment of prenatal screening and/or restricted access to termination data (2, 4, 24). This study examines the effect of prenatal diagnoses and elective terminations on the prevalence of NTDs, oral clefts, abdominal wall defects, and chromosomal anomalies in Hawaii by using surveillance data collected by the Hawaii Birth Defects Program (HBDP). The HBDP uses multiple sources of case ascertainment and has nearly universal access to
prenatal diagnostic information and follow-up data on elective terminations, making Hawaii an ideal setting in which to study their effects on the prevalence rates of birth defects.

MATERIALS AND METHODS

The HBDP, which uses multiple ascertainment sources, is a population-based, active surveillance system for birth defects and other adverse pregnancy outcomes for the entire state of Hawaii. All pregnancies are included regardless of outcome (livebirth, fetal demise, or elective termination) or the gestational age of the fetus at the end of the pregnancy. The following are the eligibility criteria for the registry: 1) the pregnancy must be affected by one or more moderate-to-severe birth defects or other adverse conditions, such as antenatal maternal substance abuse, neoplasms, and congenital infections; 2) the end of the pregnancy must occur in Hawaii; and 3) the diagnosis must be made prenatally or within 1 year after delivery.

Affected pregnancies are identified by examining lists of medical record diagnostic codes and other reports provided by hospitals where births and second-trimester terminations occur, tertiary care facilities, and clinics and laboratories that perform prenatal diagnostic screening, testing, or follow-up counseling. Terminations due to fetal anomalies are identified by 1) discharge lists of patients with International Classification of Diseases, Ninth Revision, code 655 (known or suspected fetal abnormality affecting management of the mother), provided by participating hospitals, and 2) follow-up of patients reported by clinics and laboratories performing prenatal screening, diagnosis, and genetic counseling to have a fetus with anomalies. The data do not include elective terminations that were performed for reasons other than the prenatal diagnosis of a birth defect.

The current analysis includes 10 years of data collected from 1987 through 1996 on all reported cases of anencephaly, spina bifida, encephalocele, cleft palate, cleft lip with or without cleft palate, omphalocele, gastrochisis, Down syndrome, trisomy 18, and trisomy 13. For each of the 10 birth defects, the frequencies and percentages of cases prenatally diagnosed, cases identified after elective termination, and cases electively terminated are reported. No attempt was made to adjust the calendar year for pregnancies that ended in stillbirths and elective terminations when the expected completion of the pregnancy would have occurred in the following calendar year. The 19 (1.6 percent of all cases) instances in which a prenatal diagnosis was made but the outcome of the pregnancy could not be determined were excluded from this analysis. These included pregnancies involving 10 military families, who probably left the state for elective terminations or were transferred before the end of the pregnancies, and those of two families who lived outside Hawaii and probably returned home for the end of their pregnancies. An extensive search of the Department of Health birth and fetal death certificates and likely health care facilities failed to locate the seven remaining cases, which meant that the pregnancies probably did not end in Hawaii.

Birth prevalence rates for each of the birth defect categories were calculated by using as denominators livebirth and stillbirth data provided by the Hawaii State Department of Health, Office of Health Status Monitoring, as derived from birth and fetal death certificates. Both crude and adjusted prevalence rates, as well as the difference between the two, were also calculated. The crude rate is defined as:

\[
\frac{\text{livebirths} + \text{stillbirths} \times X_{1987-1996}}{\text{livebirths} + \text{stillbirths}}
\]

The adjusted prevalence rate is defined as:

\[
\frac{\text{livebirths} + \text{stillbirths} + \text{elective terminations} \times X_{1987-1996}}{\text{livebirths} + \text{stillbirths}}
\]

The data are presented per defect category, the usual procedure for reporting rates. Infants or fetuses with multiple anomalies may be counted in more than one defect category. For example, an infant with Down syndrome and cleft palate will be counted in both of those categories.

RESULTS

The frequencies by pregnancy outcome for each of the 10 birth defects studied are listed in table 1. During the 10-year period from 1987 through 1996, the HBDP ascertained 211 infants or fetuses with NTDs, 376 with oral clefts, 117 with abdominal wall defects, and 449 chromosomal anomalies of the trisomic type. The percentages of these birth defects that were prenatally diagnosed varied from zero percent for cleft palates to 87 percent for anencephalies. Most of the NTDs were identified prenatally, whereas very few of the oral clefts were. For the abdominal wall defects, 60 percent of the omphalocele cases were diagnosed prenatally, whereas nearly 76 percent of the gastrochisis cases were. Trisomy 18 was more likely to be diagnosed prenatally than was Down syndrome or trisomy 13. A few of the defects were identified after elective termination (table 1). This occurred when an elective termination was performed because of an accompanying defect. For example, in a pregnancy that was electively...
terminated because of trisomy 13, the fetus may also have had an oral cleft, or in a pregnancy that was electively terminated because of holoprosencephaly, the fetus may have had trisomy 13. Oral clefts and chromosomal anomalies were the most likely birth defects to be identified after an elective termination occurred. The identification of these defects was usually made through a review of autopsy and cytogenetic reports. The percentage of affected pregnancies that were electively terminated after a birth defect diagnosis was highest for anencephaly (83 percent) and Down syndrome (84 percent) diagnoses (table 1).

The impact of prenatal diagnosis and elective terminations on the prevalence rates of the 10 birth defects is shown in table 2. Elective pregnancy terminations had the greatest effect on rates of NTDs and the chromosomal anomalies. Including the electively terminated cases in the rate calculations increased the anencephaly prevalence rate by 260 percent, the encephalocele rate by 82 percent, and the spina bifida rate by 41 percent. The change in the rate for the chromosomal anomalies varied from 58 percent for trisomy 13 to 100 percent for trisomy 18. The inclusion of electively terminated cases increased the rates of oral clefts and gastroschisis very little (5 and 11 percent, respectively).

For some of the birth defects, there was evidence of a trend in the percentage of cases prenatally diagnosed over the 10-year period. Table 3 shows the percentage of each birth defect that was prenatally diagnosed in 2-year increments from 1987 through 1996. All of the birth defects except cleft palate were more likely to have been prenatally diagnosed in the period 1995–

### Table 1. Frequencies of selected birth defects by pregnancy outcome and frequencies and percentages of pregnancies electively terminated after the diagnosis of selected birth defects, Hawaii, 1987–1996

<table>
<thead>
<tr>
<th>Birth defect</th>
<th>No. of livebirths</th>
<th>No. of stillbirths</th>
<th>No. of elective terminations*</th>
<th>Total</th>
<th>Prenatally diagnosed</th>
<th>No. identified after elective termination*</th>
<th>%</th>
<th>Pretermatal terminations after prenatal diagnosis</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neural tube defects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Anencephaly</td>
<td>9</td>
<td>12</td>
<td>54</td>
<td>75</td>
<td>65</td>
<td>65</td>
<td>86.7</td>
<td>54</td>
<td>83.1</td>
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<tr>
<td>Spina bifida</td>
<td>65</td>
<td>1</td>
<td>28</td>
<td>94</td>
<td>58</td>
<td>58</td>
<td>61.7</td>
<td>28</td>
<td>48.3</td>
</tr>
<tr>
<td>Encephalocele</td>
<td>19</td>
<td>4</td>
<td>19</td>
<td>42</td>
<td>35</td>
<td>35</td>
<td>83.3</td>
<td>19</td>
<td>54.3</td>
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<tr>
<td>Oral clefts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleft palate</td>
<td>130</td>
<td>6</td>
<td>5</td>
<td>141</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>28.1</td>
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<td>Cleft lip with or without cleft palate</td>
<td>216</td>
<td>8</td>
<td>11</td>
<td>235</td>
<td>32</td>
<td>32</td>
<td>13.6</td>
<td>9</td>
<td>28.1</td>
</tr>
<tr>
<td>Abdominal wall defects</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Omphalocele</td>
<td>33</td>
<td>6</td>
<td>16</td>
<td>55</td>
<td>33</td>
<td>33</td>
<td>60.0</td>
<td>14</td>
<td>42.4</td>
</tr>
<tr>
<td>Gastroschisis</td>
<td>50</td>
<td>6</td>
<td>6</td>
<td>62</td>
<td>47</td>
<td>47</td>
<td>75.8</td>
<td>6</td>
<td>12.8</td>
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<tr>
<td>Chromosomal anomalies</td>
<td></td>
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<td></td>
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<tr>
<td>Down's syndrome</td>
<td>165</td>
<td>26</td>
<td>114</td>
<td>306†</td>
<td>131</td>
<td>131</td>
<td>42.8</td>
<td>110</td>
<td>84.0</td>
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<tr>
<td>Trisomy 18</td>
<td>30</td>
<td>22</td>
<td>51</td>
<td>104†</td>
<td>63</td>
<td>63</td>
<td>60.6</td>
<td>43</td>
<td>68.3</td>
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<tr>
<td>Trisomy 13</td>
<td>17</td>
<td>7</td>
<td>16</td>
<td>40</td>
<td>16</td>
<td>16</td>
<td>40.0</td>
<td>10</td>
<td>62.5</td>
</tr>
</tbody>
</table>

* Reason for elective termination may be for other prenatally diagnosed conditions.
† Includes one case in which it was not certain whether the pregnancy ended in a stillbirth or an elective termination.

### Table 2. Prevalence rates for selected birth defects, Hawaii, 1987–1996

<table>
<thead>
<tr>
<th>Birth defect</th>
<th>Crude rate* (per 10,000)</th>
<th>Adjusted rate† (per 10,000)</th>
<th>Percentage of rate increase with adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neural tube defects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anencephaly</td>
<td>1.0</td>
<td>3.6†</td>
<td>260</td>
</tr>
<tr>
<td>Spina bifida</td>
<td>3.2</td>
<td>4.5†</td>
<td>41</td>
</tr>
<tr>
<td>Encephalocele</td>
<td>1.1</td>
<td>2.0†</td>
<td>82</td>
</tr>
<tr>
<td>Oral clefts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleft palate</td>
<td>6.5</td>
<td>6.8</td>
<td>5</td>
</tr>
<tr>
<td>Cleft lip with or without cleft palate</td>
<td>10.8</td>
<td>11.3</td>
<td>5</td>
</tr>
<tr>
<td>Abdominal wall defects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omphalocele</td>
<td>1.9</td>
<td>2.6</td>
<td>37</td>
</tr>
<tr>
<td>Gastroschisis</td>
<td>2.7</td>
<td>3.0</td>
<td>11</td>
</tr>
<tr>
<td>Chromosomal anomalies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Down's syndrome</td>
<td>9.2</td>
<td>14.7†</td>
<td>60§</td>
</tr>
<tr>
<td>Trisomy 18</td>
<td>2.5</td>
<td>5.0§</td>
<td>100§</td>
</tr>
<tr>
<td>Trisomy 13</td>
<td>1.2</td>
<td>1.9§</td>
<td>58</td>
</tr>
</tbody>
</table>

* Crude rate = (livebirths + stillbirths with defect X)/(livebirths + stillbirths).
† Adjusted rate = (livebirths + stillbirths + elective terminations with effect X)/(livebirths + stillbirths).
‡ Adjusted rate is significantly different from the crude rate at p < 0.05 based on chi-square test of proportions.
§ Includes one case in which it was not certain whether the pregnancy ended in a stillbirth or an elective termination.
1996 than in the period 1987–1988. A trend for increasing prenatal diagnosis over the study period is evident for spina bifida, cleft lip with or without cleft palate, omphalocele, and gastrochisis. There is less of a trend for other defects, such as encephalocele and Down syndrome. Table 3 also shows, in 2-year increments, the increases in prevalence rates when elective terminations are included in the numerators of the rate calculations. Birth defects such as spina bifida, omphalocele, and trisomies 13 and 18 show an increasing trend in the effect that elective terminations have on birth prevalence rates. For other birth defects, there is no trend, and for a few, such as encephalocele and gastrochisis, the inclusion of elective terminations had less of an impact on the rates over time.

**DISCUSSION**

This study of birth defects ascertained by the HBDP shows that prenatal diagnoses and elective terminations can have a significant impact on the birth prevalence rates of selected birth defects. Including electively terminated cases in the calculations of birth prevalence rates increased the rates in Hawaii by more than 50 percent for five of 10 of the birth defects studied.

The effect that prenatal diagnoses have on prevalence rates varies by birth defect because elective termination rates vary by defect. As might be expected, the birth defects that were more likely to be a cause for elective termination were those, such as anencephaly and trisomy 18, that have poor prognoses after delivery and those, such as Down syndrome, that result in substantial disability or require tremendous health care interventions (surgery, intensive long-term therapy, etc.). The prenatal diagnoses of abdominal wall defects and oral clefts, which generally have a positive prognosis and can often be treated or corrected after delivery, resulted in a lower percentage of elective terminations. This observation has been noted in other studies as well (28). The high rate of elective terminations for cleft lip with or without cleft palate in this study (28 percent) can be accounted for by the fact that these defects were found in association with NTDs, hydrocephaly, limb-reduction deformities, renal dysplasia, and chromosomal defects.

It is not clear how the rates of prenatal birth defect diagnoses and subsequent pregnancy terminations observed in Hawaii compare with those in other states. Several researchers who investigated the termination of anencephaly- and spina bifida-affected pregnancies found that in all six states examined anencephaly-affected pregnancies were more likely to be terminated than were those that were affected by spina bifida (11, 29, 30), a finding that agrees with this study. However, these previous studies also showed that the percentages of anencephaly- and spina bifida-affected pregnancies that were terminated varied widely among the six states, with Hawaii exhibiting the highest rate of termination for pregnancies affected by anencephaly and by both defects combined. Likewise, this study also observed a higher termination rate for Down syndrome-affected pregnancies in Hawaii than was found in metropolitan Atlanta, Georgia, and Ohio (13) or in California (14). These higher rates in Hawaii could be due to greater access to prenatal tests, long-term cultural and statutory openness to elective terminations, more willingness on the part of women to...
electively terminate an affected pregnancy, and/or differences in the time periods of the studies.

Several studies have noted variation in access to and utilization of prenatal tests among the states (31, 32). As a result of Hawaii’s campaign to provide health care coverage to its entire populace, few pregnant women do not have access to prenatal diagnostic tests. Of the pregnancies included in this study in which defects were diagnosed prenatally, 94 percent were covered by some form of insurance or Medicaid, and of those in which defects were not prenatally diagnosed, 96 percent were covered. The few women who did not have prenatal diagnostic tests performed appear to be those who refused the tests or started prenatal care late in their pregnancy.

With the exception of cleft palate, all of the birth defects in this study were more likely to be prenatally diagnosed at the end of the 10-year period than at the beginning. This may be a reflection of improved prenatal diagnostic technology as well as of efforts to make these tests available to more women. The improved ability to detect cleft lip, the abdominal wall defects, and trisomies 13 and 18 are likely due to improved ultrasound technologies. The prenatal diagnosis of the abdominal wall defects has also benefited from improvements in maternal serum screening, as have the diagnoses of NTDs. At the rate at which Down syndrome was diagnosed prenatally changed little over the 10-year period. Down syndrome is difficult to diagnose by ultrasound, and maternal serum alpha-fetoprotein screening is not a very sensitive test for this syndrome. Although the triple screen, which includes tests for human chorionic gonadotropin and unconjugated estriol in addition to alpha-fetoprotein, is more sensitive, these tests are relatively new and are less widely used.

Identifying the causes of increases in the prevalence rate for specific birth defects is more complex. These rates are affected by changes in prenatal diagnosis, willingness of women to electively terminate an affected pregnancy, and changes in medical technology or practices for treating specific birth defects. For example, the prenatal diagnosis of gastroschisis increased from 50 to 94 percent from 1987 to 1996, yet there does not appear to be a corresponding increase in the rate of elective terminations. This may be due to an improvement in the prognosis for infants with gastroschisis because of improved antenatal testing and surgical techniques (33, 34). The increase in prevalence may also have occurred by chance. There were not very many cases of encephalocele, abdominal wall defects, or trisomy 13 over the 10-year period. Dividing the cases into five time periods may have led to rates that were not very stable for these defect categories.

Although the number of birth defect cases included in this study was not large, the ascertainment of birth defects in Hawaii is thought to be as complete as possible, given the multiple sources of ascertainment, strict quality control procedures, and the unrestricted access of the HBDP to data on prenatal diagnoses and elective terminations (35). The birth defect surveillance program in Hawaii, which monitors about 20,000 births per year, would not be the best place in which to evaluate the effectiveness of specific birth defect prevention programs. An evaluation of the effectiveness of folic acid use for preventing NTDs, for example, would require a much larger population, probably involving a number of states. Despite the small numbers in Hawaii, findings from this study have important implications for other birth defect surveillance programs: When rates are used to monitor changes in the prevalence of selected birth defects or when they are used to evaluate the effectiveness of prevention programs, the effect that prenatal diagnoses and elective terminations may have on these rates should be taken into account.

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