THE 1978 SEX RATIO AT BIRTH
(Appendix to Demographic Surveillance System-Matlab, 1978)

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ABSTRACT

The 1978 sex-ratio at birth 100.4 for Matlab appears lower than the usual. The analysis concludes that some male births were not reported in the comparison area in 1978. Deaths in the early neonatal period were reported differently in the comparison area than in the MCH-FP area (zero days vs. one day). It is very likely that some male births which died in the first week of life in the comparison area were not reported as either births or deaths. The idea that some live births which died in the first day were misreported as stillbirths is supported by the indirect evidence of a high stillbirth ratio in the comparison area in 1978 but is not supported by the direct test with data available. None of the above apply to any year except 1978 or any area except comparison area.
INTRODUCTION

The sex ratio calculated from the 3028 male and 3016 female live births recorded in the Matlab Demographic Surveillance System in 1978 was 100.4 giving a proportion of male births of .5010. This figure is below the lower limit reported for any country with relatively complete registration (1). It is generally accepted that the sex ratio at birth lies between 103 and 107.

The tabulations which gave these results were checked three times. In addition the counts of births by sex and village from the computer records were checked against the original birth reports and field records to determine the accuracy of the counts. These checks did not uncover any errors in data processing. In this report we consider the various explanations of this phenomenon.

A RANDOM OCCURRENCE

The sex ratio at birth is known to vary between populations and within populations, according to the age and parity of the mother and frequency and timing of intercourse of the couple. The recorded variation in populations with accurate data is between 103 and 107.

Since all the factors which determine the sex of the fetus are not precisely known, the sex of a newborn can be considered a random variable, following a Bernoulli probability distribution with probability p that the sex will be male. In reality, the parameter p is dependent on the age, parity of the mother and the timing of the act of intercourse which led to conception, and other unknown variables. However, for populations as a whole, such as the Matlab surveillance population, p can be assumed to be constant. With this assumption, it is then possible to consider the births for any given year or area in Matlab as a sample from a population with this
underlying parameter p. In addition, regarding the sex determination as an independent event for each pregnancy and assuming that p is not dependent on time or geographical area within the DSS, the observed sex distribution of births for any given year and area can be considered as a random sample from a binomial distribution with parameters n, representing the number of births and p.

Under these assumptions, it is possible to statistically test if the observed sex ratio of 100 in 1978 is consistent with estimates derived from data for other years in the DSS. To do this the sexes of live births in the DSS area from 1974 to 1977 were tabulated. (1974 is generally agreed to be the year when the surveillance system reached a high level of completeness and accuracy.) These data are shown in Table I. The overall sex ratio for the years 1974-77 was 105 giving a value of p of .5115. Taking this as a constant value for Matlab, the one-way test of the 1978 proportion yields a P value of .103; i.e. the chances of observing a sample with a sex ratio of 100 or less, or, 110 or more in a population with an actual sex ratio of 105 are 1 in 10.

This result can be interpreted two ways: On the one hand, since the probability of the occurrence is low and the ratio is out of line with the series of ratios for previous years it leads one to consider possible non-random explanations for the occurrence. On the other hand, the difference is not insignificant at the customary .05 level.

NON-RANDOM POSSIBILITIES

In 1978, fairly major changes occurred in the DSS. The size of the registration area was changed and the primary data collection personnel were changed. These changes may have had an affect on the quality of the data collected. A second possible non-random explanation is that there were errors in the data processing of the field data. These two possibilities are considered below.
TABLE I--NUMBER OF BIRTHS RECORDED IN DSS AREA, 1974-1978 BY YEAR, SEX AND PROPORTIONS MALE AND SEX RATIO AT BIRTH

<table>
<thead>
<tr>
<th>Year</th>
<th>Sexes</th>
<th>Both</th>
<th>Male</th>
<th>Female</th>
<th>Proportion Male</th>
<th>Sex Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974-1977</td>
<td></td>
<td>42690</td>
<td>21834</td>
<td>20856</td>
<td>.511</td>
<td>104.7</td>
</tr>
<tr>
<td>1974</td>
<td></td>
<td>11315</td>
<td>5756</td>
<td>5559</td>
<td>.509</td>
<td>103.5</td>
</tr>
<tr>
<td>1975</td>
<td></td>
<td>7622</td>
<td>3923</td>
<td>3699</td>
<td>.515</td>
<td>106.1</td>
</tr>
<tr>
<td>1976</td>
<td></td>
<td>11268</td>
<td>5764</td>
<td>5504</td>
<td>.512</td>
<td>104.7</td>
</tr>
<tr>
<td>1977</td>
<td></td>
<td>12485</td>
<td>6391</td>
<td>6094</td>
<td>.512</td>
<td>104.9</td>
</tr>
<tr>
<td>1978</td>
<td></td>
<td>6044</td>
<td>3028</td>
<td>3016</td>
<td>.501</td>
<td>100.4</td>
</tr>
</tbody>
</table>

Data Processing Errors

Live births are recorded in the notebook of the worker responsible for primary data collection. During the monthly visit of the male field assistant, these events are recorded on standard birth report forms. The forms are brought to the Matlab office and the events are entered in the Matlab census volume and the birth registry-book. Then periodically the forms are sent to Dacca where they are coded, punched and verified. After punching, the records are listed sequentially by computer and the list is checked for duplicates and then sent to Matlab for further checking. After these procedures the punch cards are sorted to prepare the tabulations by sex, age of mother, etc.

To check for errors which may have entered in these data processing steps, the following were done. First, the cards were sorted twice to guarantee the accuracy of the tabulation. No errors were found. Second, the birth events by sex were counted from the original records. No error was found. Third, the counts of birth events by village, sex and type of outcome were printed for the year 1978. These were checked with the same tabulations done by hand from the Matlab records.
Thus it appears that data processing errors were not the cause of the low sex ratio in 1978.

Data Collection Errors

Since the DSS underwent quite extensive personnel changes in 1978, the possibility of data collection errors needs careful examination. The specific changes are first reviewed and then the possible type of data collection errors are specified and examined with available data.

In October 1977, an MCH-FP programme was begun in 70 villages. In these villages, Female Village Workers, responsible for both the MCH-FP field work and DSS data collection, replaced the dais who previously had collected demographic data. In the remaining villages the dais remained the primary collectors of demographic data. Then in October 1978, the DSS area was reduced to 149 villages. Simultaneously in the non-MCH/FP villages ('comparison' villages) 30 FVWs replaced the dais in the demographic data collection. In both areas, the Field Assistants remained as supervisors of the work. As the FVWs in the MCH-FP area had many duties besides demographic data collection, the frequency of visiting of households was not the same as in the comparison area. In the former, an FVW visits 1000 households on a fortnightly basis while in the latter an FVW visits 3000 households on a weekly basis.

All these factors might lead us to expect differences in coverage of births by area and time (January-September 1978, October-December 1978). Table II shows that such differential reporting did exist. In the MCH-FP area, the sex ratio was at an acceptable level and quite constant for the whole year. In the comparison area the sex ratio was below the normal range in the first part of the year while the dais were working. Then in the period October - December when FVWs began their work in the comparison area, the ratio fell further below acceptable levels. Because of small sample sizes when cross-classifying by area and period, the observed differences
TABLE II—SEX RATIO AT BIRTH IN MATLAB DSS 1978 BY AREA AND TIME PERIOD

<table>
<thead>
<tr>
<th>Area</th>
<th>Time Period</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Both areas:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex ratio</td>
<td>100.4</td>
<td>101.5</td>
<td>98.4</td>
<td></td>
</tr>
<tr>
<td>Number of births</td>
<td>6044</td>
<td>3947</td>
<td>2097</td>
<td></td>
</tr>
<tr>
<td>MCH - FP:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex ratio</td>
<td>103.6</td>
<td>103.3</td>
<td>104.0</td>
<td></td>
</tr>
<tr>
<td>Number of births</td>
<td>2856</td>
<td>1946</td>
<td>910</td>
<td></td>
</tr>
<tr>
<td>Comparison:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex ratio</td>
<td>97.6</td>
<td>99.7</td>
<td>94.3</td>
<td></td>
</tr>
<tr>
<td>Number of births</td>
<td>3188</td>
<td>2001</td>
<td>1187</td>
<td></td>
</tr>
</tbody>
</table>

In Table II are not statistically significant. Nevertheless, if we compare the proportion male for the comparison area in 1978 with the proportion for the whole DSS for the years 1974-77, the difference is significant at the .05 level.

An abnormally low ratio could arise due to three types of data collection errors. First, if the sex of live births were misreported; second, if male births were missed, and third, if stillbirths were misreported as live births disproportionately for males. Each of these possibilities is considered in turn. It should be noted that any under-enumeration of birth events which was the same for both sexes, would not be detected in any analysis of the sex ratio.
Regarding the first possibility, the misreporting of the sex of live births is very unlikely. How could births be missed? It is unlikely that live births which survived would not be recorded since the field worker would have observed these infants during her next visit. However, it is possible that live births which died in the first minutes, hours or days, were not recorded either as births or deaths. This possibility can be examined indirectly with tabulations from the available 1978 data. Using the data from 1974 to 1977 as the standard, the proportion of recorded deaths which occurred on day 0 are compared in Table III. It is clear (and highly significant statistically) that deaths in the first 24 hours of life

<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
<th>Day of Death</th>
<th>Proportion on day 0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0 - 7</td>
<td>0</td>
</tr>
<tr>
<td>1974-1977</td>
<td>DSS</td>
<td>1141</td>
<td>209</td>
</tr>
<tr>
<td>1974</td>
<td>&quot;</td>
<td>285</td>
<td>31</td>
</tr>
<tr>
<td>1975</td>
<td>&quot;</td>
<td>175</td>
<td>39</td>
</tr>
<tr>
<td>1976</td>
<td>&quot;</td>
<td>311</td>
<td>70</td>
</tr>
<tr>
<td>1977</td>
<td>&quot;</td>
<td>370</td>
<td>69</td>
</tr>
<tr>
<td>1978</td>
<td>Comparison</td>
<td>166</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>MCH - FP</td>
<td>116</td>
<td>27</td>
</tr>
</tbody>
</table>

Z - test for proportion on day 0: Comparison area 1978
Vs 1974-1978 DSS area.

\[ Z = \frac{.183 - .072}{\sqrt{\frac{1}{166} (.183)(.817)}} = 3.69 \text{ (P<.001)} \]
were disproportionately not reported as such in the comparison area in 1978. This may have easily resulted from a misunderstanding on the part of the new workers that any deaths within 24 hours of birth are recorded as occurring on day zero. Indeed, it can be seen in the last column of Table IV that many of these deaths were apparently reported as occurring on day 1. Nevertheless, it is clear from the tables that the data recording procedures were different in the two areas in 1978.

Considering the sex of these deaths, Table V shows that deaths of males in the first week of life in the comparison area in 1978 were significantly lower than expected on the basis of the experience of previous years. The proportion of male early neonatal deaths in the MCH-FP area were also low; however, because the MCH-FP interventions altered neonatal mortality patterns this figure cannot be used as a basis for comparison. Of course, the fact that male births were low would imply, ceteris paribus, that the proportion of male deaths would be lower than usual. Therefore rates are given in Table VI. In both areas in 1978, the rates are much higher than the rates for the 1974-77 period. In addition, in both areas in 1978 the reported female rate is higher than the male rate which is opposite of the pattern for 1974-77. The differential is greatest in the comparison area. These results are consistent with the explanation of missed male early neonatal deaths in the comparison area though a real change in the early neonatal death pattern cannot be ruled out because the same pattern is seen in both the MCH and comparison areas in 1978.

Finally we consider the possibility that some live births were misclassified as stillbirths (Table VII). The stillbirth ratio for the comparison area in 1978 was higher than any ratio in the DSS for the period 1974-77, and higher than the MCH-FP ratio in 1978. The z statistic for difference in stillbirth rates for 1974-77 and the comparison area in 1978 (0.0533 and 0.0533 respectively) is 4.37 giving P<.0001. The rates are used for the test because the z test is not strictly valid for ratios which are not proportions. It is possible therefore that some deaths in the first day of life were reported as stillbirths.
TABLE IV--NUMBER OF EARLY NEONATAL DEATHS RECORDED IN DSS AREA, 1974-1978
BY DAY OF DEATH AND AREA

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 7</td>
<td>Number 1141</td>
<td>282</td>
<td>116</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>Proportion 1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>0 - 1</td>
<td>Number 462</td>
<td>120</td>
<td>54</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>Proportion 0.405</td>
<td>0.426</td>
<td>0.466</td>
<td>0.398</td>
</tr>
<tr>
<td>0</td>
<td>Number 209</td>
<td>39</td>
<td>27</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Proportion 0.183</td>
<td>0.138</td>
<td>0.233</td>
<td>0.072</td>
</tr>
<tr>
<td>1</td>
<td>Number 253</td>
<td>81</td>
<td>27</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>Proportion 0.222</td>
<td>0.287</td>
<td>0.233</td>
<td>0.325</td>
</tr>
<tr>
<td>2 - 7</td>
<td>Number 679</td>
<td>162</td>
<td>62</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Proportion 0.595</td>
<td>0.574</td>
<td>0.534</td>
<td>0.602</td>
</tr>
</tbody>
</table>

TABLE V--NUMBERS OF EARLY NEONATAL DEATHS RECORDED IN MATLAB 1974-1978
BY SEX, AREA AND YEAR

<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
<th>Sexes</th>
<th>Both</th>
<th>Male</th>
<th>Female</th>
<th>Proportion Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974-1977</td>
<td>DSS</td>
<td>Both</td>
<td>1141</td>
<td>655</td>
<td>486</td>
<td>.574</td>
</tr>
<tr>
<td>1974</td>
<td>&quot;</td>
<td>Male</td>
<td>285</td>
<td>168</td>
<td>117</td>
<td>.589</td>
</tr>
<tr>
<td>1975</td>
<td>&quot;</td>
<td>Male</td>
<td>175</td>
<td>91</td>
<td>84</td>
<td>.520</td>
</tr>
<tr>
<td>1976</td>
<td>&quot;</td>
<td>Male</td>
<td>311</td>
<td>184</td>
<td>127</td>
<td>.592</td>
</tr>
<tr>
<td>1977</td>
<td>&quot;</td>
<td>Male</td>
<td>370</td>
<td>212</td>
<td>158</td>
<td>.573</td>
</tr>
<tr>
<td>1978</td>
<td>Comparison</td>
<td>Male</td>
<td>166</td>
<td>79</td>
<td>87</td>
<td>.476</td>
</tr>
<tr>
<td></td>
<td>MCH-FP</td>
<td>Male</td>
<td>116</td>
<td>58</td>
<td>58</td>
<td>.500</td>
</tr>
</tbody>
</table>

Z - test for proportion male early neonatal deaths:
Comparison area 1978 vs. 1974-1978 DSS area.

\[ z = \frac{.574 - .476}{\sqrt{\frac{1}{166} (.574) (.426)}} = 2.55 \ (P<.01) \]
<table>
<thead>
<tr>
<th>Years and Area</th>
<th>Both Sexes</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deaths (days 0-7)</td>
<td>Births</td>
<td>Rate</td>
</tr>
<tr>
<td>1974 - 1977 DSS</td>
<td>1141</td>
<td>42690</td>
<td>.0267</td>
</tr>
<tr>
<td>1978 MCH</td>
<td>116</td>
<td>2856</td>
<td>.0406</td>
</tr>
<tr>
<td>Comparison</td>
<td>166</td>
<td>3168</td>
<td>.0521</td>
</tr>
</tbody>
</table>
TABLE VII--STILLBIRTH RATIOS IN THE MATLAB DSS, 1974 - 1978

<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
<th>Stillbirths per 1000 live births</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974 - 1977</td>
<td>DSS</td>
<td>38</td>
</tr>
<tr>
<td>1974</td>
<td>&quot;</td>
<td>34</td>
</tr>
<tr>
<td>1975</td>
<td>&quot;</td>
<td>33</td>
</tr>
<tr>
<td>1976</td>
<td>&quot;</td>
<td>42</td>
</tr>
<tr>
<td>1977</td>
<td>&quot;</td>
<td>43</td>
</tr>
<tr>
<td>1978</td>
<td>MCH - FP</td>
<td>41</td>
</tr>
<tr>
<td>Comparison</td>
<td></td>
<td>53</td>
</tr>
</tbody>
</table>

To directly examine the possibility of misclassification of male live births followed immediately by death as stillbirths, data from an independent pregnancy history study in the DSS area were used. In 5 villages of the comparison area, 566 detailed pregnancy histories were collected in March 1980. (A scientific report on this study is in preparation). Comparison of reported stillbirths and total losses with the reports of women in the pregnancy history interviews, revealed no such misclassification (Table 8). It should be noted however, that only two stillbirths were available in these data for the five villages.
TABLE VIII--CLASSIFICATION OF 14 STILLBIRTHS OR FETAL LOSSES RECORDED IN THE DSS IN 4 COMPARISON AREA VILLAGES IN 1978 ACCORDING TO PREGNANCY OUTCOME REPORTED BY THE MOTHERS

<table>
<thead>
<tr>
<th>Type</th>
<th>Report in DSS</th>
<th>Report in Pregnancy History</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stillbirth</td>
<td>2</td>
<td>Stillbirth 2</td>
</tr>
<tr>
<td>Fetal loss</td>
<td>12</td>
<td>Fetal loss 8, Stillbirth 1, Missing in pregnancy history 3</td>
</tr>
</tbody>
</table>

AN ACTUAL PHENOMENON

Is it possible that the observed ratio of 100.4 in the comparison area in 1978 indicates that the sex ratio at birth is actually declining?

This supposition can be tested by examining the data for the 1979 calendar year. The data of 7184 live births in 1979 yield sex ratios of 106 in the comparison area and 108 in the MCH-FP area. The 1978 ratio was clearly not an indication of a general decline in the sex ratio at birth.

CONCLUSIONS

The 1978 sex ratio at birth of 100.4 in the DSS area was below the recorded normal level for most human populations and below the level recorded in Matlab in previous years. Since there were major changes in the
surveillance area and staff in 1978, it was hypothesized that problems of data quality may have existed. Indeed, when examined by area, it was found that the sex ratio in the comparison area, where new workers were assigned in late 1978, was only 98.

Direct checks of the available data did not reveal recording or data processing errors. However, indirect checks with the same data indicated that the recording procedures in the comparison area were different from procedures in the MCH-FP area with respect to the recording of deaths in the first days of life. It was hypothesized that births which died in the first hours or day of life may have been missed entirely in this area. Such events may also have been misclassified as stillbirths but the one direct check of this hypothesis revealed no such misclassification.

In contrast to the possibility of data quality problems, the observed sex ratio could be regarded as a random occurrence or as an indication that the sex ratio in Matlab is declining. The latter possibility was ruled out since 1979 data gave a sex ratio of 107. Under assumptions of a binomial distribution, given the number of births and with the probability of male birth fixed at the value calculated from all births in the DSS area 1974-1977, the probability of observing a sex ratio of 100.4 or below in the whole area in 1978 was .051 and the probability of observing a sex ratio of 98 or below in the comparison area in 1978 was .024.
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