Appendix B: Technical notes - formulas

GENERAL:

$$PERCENT\ CHANGE = \frac{New\ Data - Old\ Data}{Old\ Data} \times 100$$

Birth rate, Oregon, 1993 = 13.7
Birth rate, Oregon, 1994 = 13.6

$$Percent\ change = \frac{13.6 - 13.7}{13.7} \times 100 = -0.7\%$$

PREGNANCY:

1. $(CRUDE)\ BIRTH\ RATE = \frac{Resident\ Births}{Population} \times 1{,}000$

$$Oregon,\ 1994 = \frac{41{,}832}{3{,}082{,}800} \times 1{,}000 = 13.6$$

2. $AGE\text{-}SPECIFIC\ BIRTH\ RATE = \frac{Resident\ Births\ To\ Mothers\ in\ Age\ Category}{Female\ Population\ in\ Age\ Category} \times 1{,}000$

$$Oregon,\ 1994,\ Age\ 20\text{-}24 = \frac{10{,}999}{104{,}718} \times 1{,}000 = 105.0$$

3. $FERTILITY\ RATE = \frac{Resident\ Births\ to\ Mothers\ Aged\ 15\text{-}44}{Female\ Population\ Aged\ 15\text{-}44} \times 1{,}000$

NOTE: *Some publications use the following*: $\frac{All\ Resident\ Births}{Female\ Population\ Aged\ 15\text{-}44}$

$$Oregon,\ 1994 = \frac{41{,}659}{682{,}428} \times 1{,}000 = 61.0$$

4. $TOTAL\ FERTILITY\ RATE = \left(\begin{array}{c} The\ Sum\ of\ Age\ Specific\ Birth\ Rates\ in \\ 5\text{-}Year\ Categories\ between\ 15\ and\ 44 \end{array} \right) \times 5$

$$Oregon,\ 1994 = 5\ (51.3 + 105.0 + 115.4 + 78.5 + 30.2 + 6.0) = 1{,}932.0$$

5. *FETAL DEATH RATIO* $= \dfrac{\text{Resident Fetal Deaths (350+ grams Birthweight)}}{\text{Resident Live Births}} \times 1{,}000$

$$\text{Oregon, 1994} = \frac{224}{41{,}832} \times 1{,}000 = 5.4$$

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6. *FETAL DEATH RATE* $= \dfrac{\text{Resident Fetal Deaths (350+ grams Birthweight)}}{\text{Resident Live Births + Resident Fetal Deaths}} \times 1{,}000$

$$\text{Oregon, 1994} = \frac{224}{43{,}591 + 224} \times 1{,}000 = 5.1$$

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7. *PERINATAL DEATH RATE* $= \dfrac{\text{Resident Neonatal Deaths + Resident Fetal Deaths (350+ grams Birthweight)}}{\text{Resident Live Births + Resident Fetal Deaths}} \times 1{,}000$

$$\text{Oregon, 1994} = \frac{148 + 203}{41{,}566 + 203} \times 1{,}000 = 8.4$$

Note: Publications vary in the definition of fetal deaths. In addition, some measures employ gestational age in place of birthweight. Fetal and perinatal death rates are based on year of birth.

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8. *ABORTION RATIO* $= \dfrac{\text{Resident Abortions}}{\text{Resident Births}} \times 1{,}000$ *or* $\dfrac{\text{Occurrence Abortions}}{\text{Occurrence Births}} \times 1{,}000$

$$\text{Oregon, 1994, Occurrence} = \frac{13{,}392}{43{,}591} \times 1{,}000 = 307.2$$

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9. *ABORTION RATE* $= \dfrac{\text{Resident Abortions or Occurrence Abortions}}{\text{Female Resident Population Aged 15–44}} \times 1{,}000$

$$\text{Oregon 1994, Occurrence with total adjusted for unknown ages} = \frac{13{,}300}{682{,}428} \times 1{,}000 = 19.5$$

DEATHS:

10. (*CRUDE*) *DEATH RATE* $= \frac{\text{Resident Deaths}}{\text{Population}} \times 1{,}000$

$$\text{Oregon, 1994} = \frac{27{,}361}{3{,}082{,}000} \times 1{,}000 = 8.9$$

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11. *INFANT DEATH RATE* $= \frac{\text{Resident Infant Deaths}}{\text{Resident Births}} \times 1{,}000$

$$\text{Oregon, 1994} = \frac{295}{41{,}832} \times 1{,}000 = 7.1$$

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12. *NEONATAL DEATH RATE* $= \frac{\text{Resident Neonatal Deaths}}{\text{Resident Births}} \times 1{,}000$

$$\text{Oregon, 1994} = \frac{164}{41{,}832} \times 1{,}000 = 3.9$$

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13. *POSTNEONATAL DEATH RATE* $= \frac{\text{Resident Postneonatal Deaths}}{\text{Resident Births}} \times 1{,}000$

$$\text{Oregon, 1994} = \frac{131}{41{,}832} \times 1{,}000 = 3.1$$

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14. *CAUSE-SPECIFIC DEATH RATE* $= \frac{\text{Resident Deaths Due to Specific Cause}}{\text{Population}} \times 100{,}000$

$$\text{Oregon, 1994, Heart Disease} = \frac{7{,}417}{3{,}082{,}000} \times 100{,}000 = 240.7$$

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15. *AGE AND SEX-SPECIFIC DEATH RATE* $= \frac{\text{Resident Deaths in Age-Sex Category}}{\text{Population in Age-Sex Population}} \times 1{,}000$

$$\text{Oregon, 1994, Males Aged 5-14} = \frac{63}{225{,}880} \times 100{,}000 = 27.9$$

MARRIAGE AND DIVORCE:

$$16.\ \mathit{MARRIAGE\ RATE} = \frac{\mathit{Marriages}}{\mathit{Population}}\ X\ 1{,}000$$

$$\mathit{Oregon},\ 1994 = \frac{25{,}194}{3{,}082{,}000}\ X\ 1{,}000 = 8.2$$

$$17.\ \mathit{DIVORCE\ RATE} = \frac{\mathit{Divorces}}{\mathit{Population}}\ X\ 1{,}000$$

$$\mathit{Oregon},\ 1994 = \frac{15{,}844}{3{,}082{,}000}\ X\ 1{,}000 = 5.1$$

Beginning with 1998 data, the following methodology is being used for calculating confidence intervals and statistical significance. This explanation is paraphrased from *"Public Health Data: Our Silent Partner"*, a training manual from the Public Health Practice Program Office of the National Center for Health Statistics.[1]

CALCULATING CONFIDENCE INTERVALS FOR RATES:

Confidence limits for rates based on less than 100 events

When the number of events in the numerator is less than 100, the confidence interval for a rate can be estimated using the two formulas which follow and the values in Table B-1.
Lower Limit = R x L
Upper Limit = R x U
where:
R = the rate
L = the value in Table B-1 that corresponds to the number N in the numerator of the rate
U = the value in Table B-1 that corresponds to the number N in the numerator of the rate

Example: Confidence limits for rates based on less than 100 events

In Baker County, the teen pregnancy rate for 10- to 17-year-old teens in 1998 was 13.0 per thousand, based on 12 live births in the numerator. Using Table B-1:

Lower Limit = 13.0 x 0.51671 = 6.7
Upper Limit = 13.0 x 1.7468 = 22.7

This means that the chances are 95 out of 100 that the pregnancy rate in Baker County for teens 10-17 lies between 6.7 and 22.7 per 1,000. So if there were 100 counties like Baker County, the teen pregnancy rate would be expected to lie between 6.7 and 22.7 per 1,000 in 95 of these counties.

TABLE B-1.
Values of L and U for calculating 95% confidence limits for the numbers of events and rates when the number of events is less than 100.

N	L	U	N	L	U	N	L	U
1	0.02532	5.57164	34	0.69253	1.3974	67	0.77499	1.26996
2	0.1211	3.61234	35	0.69654	1.39076	68	0.77654	1.26774
3	0.20622	2.92242	36	0.70039	1.38442	69	0.77806	1.26556
4	0.27247	2.5604	37	0.70409	1.37837	70	0.77955	1.26344
5	0.3247	2.33367	38	0.70766	1.37258	71	0.78101	1.26136
6	0.36698	2.17658	39	0.7111	1.36703	72	0.78244	1.25933
7	0.40205	2.06038	40	0.71441	1.36172	73	0.78384	1.25735
8	0.43173	1.9704	41	0.71762	1.35661	74	0.78522	1.25541
9	0.45726	1.89831	42	0.72071	1.35171	75	0.78656	1.25351
10	0.47954	1.83904	43	0.7237	1.34699	76	0.78789	1.25165
11	0.4992	1.78928	44	0.7266	1.34245	77	0.78918	1.24983
12	0.51671	1.7468	45	0.72941	1.33808	78	0.79046	1.24805
13	0.53246	1.71003	46	0.73213	1.33386	79	0.79171	1.2463
14	0.54671	1.67783	47	0.73476	1.32979	80	0.79294	1.24459
15	0.55969	1.64935	48	0.73732	1.32585	81	0.79414	1.24291
16	0.57159	1.62394	49	0.73981	1.32205	82	0.79533	1.24126
17	0.58254	1.6011	50	0.74222	1.31838	83	0.79649	1.23965
18	0.59266	1.58043	51	0.74457	1.31482	84	0.79764	1.23807
19	0.60207	1.56162	52	0.74685	1.31137	85	0.79876	1.23652
20	0.61083	1.54442	53	0.74907	1.30802	86	0.79987	1.23499
21	0.61902	1.52861	54	0.75123	1.30478	87	0.80096	1.2335
22	0.62669	1.51401	55	0.75334	1.30164	88	0.80203	1.23203
23	0.63391	1.50049	56	0.75539	1.29858	89	0.80308	1.23059
24	0.64072	1.48792	57	0.75739	1.29562	90	0.80412	1.22917
25	0.64715	1.4762	58	0.75934	1.29273	91	0.80514	1.22778
26	0.65323	1.46523	59	0.76125	1.28993	92	0.80614	1.22641
27	0.65901	1.45495	60	0.76311	1.2872	93	0.80713	1.22507
28	0.66449	1.44528	61	0.76492	1.28454	94	0.8081	1.22375
29	0.66972	1.43617	62	0.76669	1.28195	95	0.80906	1.22245
30	0.6747	1.42756	63	0.76843	1.27943	96	0.81	1.22117
31	0.67945	1.41942	64	0.77012	1.27698	97	0.81093	1.21992
32	0.684	1.4117	65	0.77178	1.27458	98	0.81185	1.21868
33	0.68835	1.40437	66	0.7734	1.27225	99	0.81275	1.21746

Confidence limits for rates based on 100 or more events

In this case, use the following formula for the rate (R) based on the number of events (N):

$$\text{Upper Limit} = R + [1.96 \;\; x \;\; R / \sqrt{N}]$$

where:
R = the rate (birth rate, mortality rate, teen pregnancy rate, etc.)
N = the number of events (births, deaths, teen pregnancy, etc.)

Example: Confidence limits for rates based on 100 or more events

In Jackson County, the teen pregnancy rate for teens 10-17 was 13.7 in 1998 based on 143 pregnancies. Therefore, the confidence interval would be:

$$\text{Lower Limit} = 13.7 - [1.96 \;\; x \;\; (13.7 / \sqrt{143})]$$

= 13.7 - [1.96 x (13.7 / 11.96)]
= 13.7 - [1.96 x 1.15]
= 13.7 - 2.25
= 11.5

$$\text{Upper Limit} = 13.7 + [1.96 \;\; x \;\; (13.7 \;\; / \sqrt{143})]$$

= 13.7 + [1.96 x (13.7 / 11.96)]
= 13.7 + [1.96 x 1.15]
= 13.7 + 2.25
= 16.0

So if there were 100 counties like Jackson County with similar populations, the teen pregnancy rate would be expected to lie between 11.5 and 16.0 per 1,000 in 95 of these counties.

DETERMINING STATISTICAL SIGNIFICANCE FOR RATES:

If the difference between two rates would occur due to random variability less than 5 times out of 100, then we say that the difference is statistically significant at the 95% level. Otherwise the difference is not statistically significant.

Computing statistical significance when at least one of the rates is based on fewer than 100 events

To compare two rates, when one or both rates are based on fewer than 100 events, compute the confidence intervals for both rates. If the intervals overlap, the difference is not statistically significant.

Example: comparing rates when one is based on fewer than 100 events

Baker County teen pregnancy rate for age 10-17
Lower Limit = 6.7
Upper Limit = 22.7
Jackson County teen pregnancy rate for age 10-17
Lower Limit = 11.5
Upper Limit = 16.0

The confidence intervals overlap - the interval for Jackson County is entirely within the range of the interval for Baker County. Therefore, the difference between the teen pregnancy rate for age 10-17 in Baker County and the rate for Jackson County is not statistically significant.

Computing statistical significance when both rates are based on 100 or more events

When both rates are based on 100 or more events, calculate the difference between the two rates by subtracting the lower rate from the higher rate. The difference is considered statistically significant if it exceeds 1.96 times the standard error for the difference between the two rates.

$$1.96\sqrt{\frac{R_1^2}{N_1}+\frac{R_2^2}{N_2}}$$

where:
R_1 = the first rate
R_2 = the second rate
N_1 = the first number
N_2 = the second number

If the difference is greater than the statistic, the difference would occur by chance less than 5 times out of 100. The difference is statistically significant at the 95 percent confidence level.

If the difference is less than the statistic, the difference might occur by chance more than 5 times out of 100. The difference is not statistically significant at the 95 percent confidence level.

Example: comparing rates when both are based on 100 or more events
The teen pregnancy rate for Oregon teens age 10-17 in 1997 was 18.0 and the comparable rate for 1998 was 17.2. Both rates are based on more than 100 pregnancies (3,197 in 1997 and 3,176 in 1998). The difference between the rates is 18.0 - 17.2 = 0.8. The statistic is calculated as follows:

$$1.96\sqrt{\frac{18.0^2}{3,197}+\frac{17.2^2}{3,176}}$$

$$1.96\sqrt{(\frac{324}{3,197}+\frac{295.84}{3,176})}$$

$$1.96\sqrt{(0.101+0.093)}$$

$$1.96\sqrt{0.194}$$

= 1.96 x .44
= 0.86

The difference between the rates (0.8) is less than this statistic (0.9). Therefore, the difference is not statistically significant. A difference of 0.8 between these two rates might occur by chance more than 5 times out of 100.

CALCULATING RATES ADJUSTED FOR SEX/AGE/RACE:

When comparing rates and ratios, the influences of sex, age, and race differences in the populations must be taken into account. Comparing many different age-sex-race specific rates can be cumbersome. The following techniques are used by vital statisticians to summarize these rates into one number.

The *direct adjusted rate* applies each of the specific rates for a particular population (such as a county or a Health Service Area) to a standard population distribution (such as the state).

The *standard mortality ratio* compares the number of deaths for a particular population (such as a county or a Health Service Area) to the number of deaths which would be expected if some standard set of rates (such as the state or the U.S. rates) had occurred.[2]

Both of these techniques have their advantages and disadvantages. The easiest to calculate is the direct adjusted rate. The following example shows how to adjust a county's death rate for sex so that it may be compared to the state rate.

$$\frac{\left[\frac{\text{county male deaths}}{\text{county male population}} \times \text{state male population}\right] + \left[\frac{\text{county female deaths}}{\text{county female population}} \times \text{state female population}\right]}{\text{TOTAL STATE POPULATION}} \times 1{,}000$$

The same logic can be used to adjust for age and/or race.