Technical Notes — Formulas

GENERAL:

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

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

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

PREGNANCY:

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

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

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

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

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

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

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

4. $$\text{TOTAL FERTILITY RATE} = \text{The Sum of Age-Specific Birth Rates in 5-Year Categories between 15 and 44} \times 5$$

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

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

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

$$FETAL\ DEATH\ RATE = \frac{Resident\ Fetal\ Deaths\ (350+\ grams\ Birthweight)}{Resident\ Live\ Births + Resident\ Fetal\ Deaths} \times 1{,}000$$

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

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

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

Note: *Publications vary in the gestation cutoff for fetal deaths. In addition, some measures employ weeks of gestation in place of birthweight. Fetal and perinatal death rates are based on year of birth.*

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6. $$ABORTION\ RATIO = \frac{Resident\ Abortions}{Resident\ Births} \times 1{,}000 \ or\ \frac{Occurrence\ Abortions}{Occurrence\ Births} \times 1{,}000$$

$$Oregon,\ 1994,\ Occurrence = \frac{13{,}391}{43{,}591} \times 1{,}000 = 307.2$$

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7. $$ABORTION\ RATE = \frac{Resident\ Abortions\ or\ Occurrence\ Abortions}{Female\ Resident\ Population\ Aged\ 15\text{-}44} \times 1{,}000$$

Oregon 1994, *Occurrence with total adjusted for not stated ages* $= \frac{13{,}300}{682{,}428} \times 1{,}000 = 19.5$

DEATHS:

8. $(CRUDE)\ DEATH\ RATE = \dfrac{Resident\ Deaths}{Population}\ X\ 1{,}000$

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

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9. $INFANT\ DEATH\ RATE = \dfrac{Resident\ Infant\ Deaths}{Resident\ Births}\ X\ 1{,}000$

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

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10. $NEONATAL\ DEATH\ RATE = \dfrac{Resident\ Neonatal\ Deaths}{Resident\ Births}\ X\ 1{,}000$

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

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11. $POSTNEONATAL\ DEATH\ RATE = \dfrac{Resident\ Postneonatal\ Deaths}{Resident\ Births}\ X\ 1{,}000$

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

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12. $CAUSE\text{-}SPECIFIC\ DEATH\ RATE = \dfrac{Resident\ Deaths\ Due\ to\ Specific\ Cause}{Population}\ X\ 100{,}000$

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

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13. $AGE\ AND\ SEX\ SPECIFIC\ DEATH\ RATE = \dfrac{Resident\ Deaths\ in\ Age\text{-}Sex\ Category}{Population\ in\ Age\ Sex\ Population}\ X\ 1{,}000$

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

MARRIAGE AND DIVORCE:

14. $MARRIAGE\ RATE = \dfrac{Marriages}{Population} \ X\ 1{,}000$

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

15. $DIVORCE\ RATE = \dfrac{Divorces}{Population} \ X\ 1{,}000$

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

CALCULATING CONFIDENCE INTERVALS FOR RATES:

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]

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

<u>Example: Confidence limits for rates based on less than 100 events</u>

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.

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):

$$\text{Lower Limit} = R - [1.96 \times R / \sqrt{N}]$$

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

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

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

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:

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

$= 13.7 - [1.96 \times (13.7 / 11.96)]$

$= 13.7 - [1.96 \times 1.15]$
$= 13.7 - 2.25$
$= 11.5$

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

$= 13.7 + [1.96 \times (13.7 / 11.96)]$

$= 13.7 + [1.96 \times 1.15]$
$= 13.7 + 2.25$
$= 16.0$

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.

<u>Example: comparing rates when both are based on 100 or more events</u>

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 AGE-ADJUSTED DEATH RATES

To avoid false conclusions regarding mortality risks, caution must be used in comparing groups in terms of crude death rates. While these are accurate measures of the number of deaths per unit of population, they can be affected by the age distribution within subsets (e.g., counties). An apparent difference could simply be the result of different age compositions. One solution is to make comparisons based on individual age-specific rates for each subset, however, this can be time-consuming. A less cumbersome method of making comparisons is the age-adjusted death rate, a summary measure based on all of the age-specific death rates of a subset.[2] Age-adjusted rates are useful in comparing relative risks over time, across geographic areas, or among other subsets (e.g., race) of the population that have different age compositions. Age-adjusted death rates eliminate differences that would be caused because one population is older relative to another. It is a hypothetical rate for a subset as if it's age composition was that of the standard population.

Beginning with mortality data for 1999, the standard population used by the National Center for Health Statistics (NCHS), and Oregon Center for Health Statistics (OCHS), to calculate age-adjusted death rates is based on the Year 2000 estimated population distribution, replacing that of 1940, used previously. When subsets with small populations are compared, it is preferable to base rates on multiple years to reduce the random statistical variation that can occur with annual rates. In this report, age-adjusted death rates for counties are based on three-year periods. Age-adjusting results in theoretical rates that should be compared only to rates calculated using the same age groups and standard population. Rates may also be adjusted for other factors (e.g., sex, race) using the same methodology shown below.

The age-adjusted death rates in this annual report were computed using the direct method, that is, by applying age-specific death rates to the Year 2000 U.S. Standard Population.[3,4] These rates may differ slightly from federally published age-adjusted rates due to different population estimate sources, different cut-off dates employed in determining the number of

Counties	Age Groups						
	<1	1-4	5-14	15-24	25-34	35-44	45-54
Standard Proportion	0.013818	0.055317	0.145565	0.138646	0.135573	0.162613	0.134834
Josephine County							
Deaths	20	2	5	16	26	89	163
Population	2,242	9,680	31,211	24,718	22,159	31,412	35,312
Age-specific Rate	892.1	20.7	16.0	64.7	117.3	283.3	461.6
Multnomah County							
Deaths	148	24	36	151	327	694	1,353
Population	28,061	107,767	244,468	276,591	349,078	324,477	295,029
Age-specific Rate	527.4	22.3	14.7	54.6	93.7	213.9	458.6

deaths for a particular year, and correction of miscoded underlying causes of death. The formula used to calculate age-adjusted death rates using the direct method is as follows:

$$AADR = 3w_i \times ((d_i/p_i) \times 100{,}000) = 3w_i \times R_i$$

where

w_i = proportion of each age group of the standard population (see below).

d_i = the number of deaths in the subset.

p_i = the (estimated) population of the subset.

R_i = age-specific death rate, usually expressed per 100,000 population.

An Example

Assessing the risk of death using crude death rates for residents of Josephine County and Multnomah County would indicate that the former were at an elevated risk of death relative to the latter. The crude death rate for Josephine County during 2000-2002 was 1,289.1 per 100,000 population while the rate for Multnomah County was 866.4, a 48.8 percent difference. But it would be a mistake to conclude that the risk of death was greater for Josephine County residents than for Multnomah County residents. Calculation of age-adjusted rates show that the risk was actually greater for Multnomah County residents (with a rate of 908.0) than for Josephine County residents (with a rate of 882.3), so that instead of being 48.8 percent more likely to die during the three-year period, Josephine residents actually enjoyed a 2.8 percent lower risk.

The age-adjusted death rates controlled for the age distribution of residents within each county and reflected the age-specific death rates of those groups. Josephine County residents were far more likely to be 55 or older (32.0 percent of the population) than were Multnomah County residents (18.7 percent) while age-specific rates were higher for Multnomah County residents ages 55-84 (54.2 percent of the deaths) than for their counterparts living in Josephine County.

Age Groups				Crude Rate	Age-adjusted Rate	Counties
55-64	65-74	75-84	85+			
0.087247	0.066037	0.044842	0.015508	-	-	Standard Proportion
						Josephine County
272	538	949	892	2,972	-	Deaths
27,593	23,454	17,213	5,565	230,559	-	Population
985.8	2,293.9	5,513.3	16,028.8	1,289.1	882.3	Age-specific Rate
						Multnomah County
1,617	2,717	5,059	5,194	17,320	-	Deaths
152,171	103,760	85,178	32,420	1,999,000	-	Population
1,062.6	2,618.5	5,939.3	16,021.0	866.4	908.0	Age-specific Rate

The following shows how the rates were calculated using the data in the table on the previous two pages:

Josephine County

AADR = (0.013818 x 892.1) + (0.055317 x 20.7) + (0.145565 x 16.0) + (0.138646 x 64.7) + (0.135573 x 117.3) + (0.162613 x 283.3) + (0.134834 x 461.6) + (0.087247 x 985.6) + (0.066037 x 2293.9) + (0.044842 x 5513.3) + (0.015508 x 16,028.8) = 882.3

Multnomah County

AADR = (0.013818 x 527.4) + (0.055317 x 22.3) + (0.145565 x 14.7) + (0.138646 x 54.6) + (0.135573 x 93.7) + (0.162613 x 213.9) + (0.134834 x 458.6) + (0.087247 x 1062.6) + (0.066037 x 2618.5) + (0.044842 x 5939.3) + (0.015508 x 16021.0) = 908.0

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3. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Center for Health Statistics: "Direct Standardization (Age-adjusted Death Rates)," by L.R. Curtin and R.J. Klein. Healthy People 2000 Statistical Notes, No. 6. Hyattsville, Maryland. March 1995. (http://www.cdc.gov/nchs/data/statnt/statnt06rv.pdf)

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