

- Establish controls for pesticides posing greater human health and environmental hazard through: prohibition of pesticides in their countries of origin, prohibition of substances belonging to persistent organic pollutants, homogeneity of pesticides prohibited in all the countries of the subregion, strictest controls for the sale of products that have produced the greatest number of APP, adequate elimination of residues and containers, prohibition of application by women and children, and selection of pesticides based on molecules found in fungi, bacteria, and plants that act on the pest organism and induce resistance of the same.
- Better controls on compliance using existing legislation.
- One of the biggest problems in the subregion is the standardization in all the countries of the list of prohibited pesticides. This standardization is required in order to improve controls at customs, in the field, at the points of sale, and generally in the enforcement of existing legislation.
- Improve the conditions of hygiene and safety for farm workers and their families, who are the population with greater exposure to these substances.

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Standardization: A Classic Epidemiological Method for the Comparison of Rates

Introduction

One of the fundamentals of health situation analysis (HSA) is the comparison of basic health indicators. Among other objectives of HSA, this allows to identify risk areas, define needs, and document inequalities in health, in two or more populations, in subgroups of a population, or else in a single population at different points in time. Crude rates, whether they represent mortality, morbidity or other health events, are summary measures of the experience of populations that facilitate this comparative analysis. However, the comparison of crude rates can sometimes be inadequate, particularly when the population structures are not comparable for factors such as age, sex or socioeconomic level. Indeed, these and other factors influence the magnitude of crude rates and may distort their interpretation in an effect called confounding (box 1).^{1,2,3}

The calculation of specific rates in well defined subgroups of a population is a way of avoiding certain confounding factors. For example, specific rates calculated by age groups are often used to examine how diseases affect people differently depending on their age. However, although this uncovers the patterns of health events in the population and allows for more rigorous comparison of rates, it can sometimes be impractical to work with a large number of subgroups.⁴ Furthermore, if the subgroups consist of small pop-

Box 1: Definition of Confounding

A *confounding effect* appears when the measurement of the effect of an exposure on a risk is distorted by the relation between the exposure and other factor(s) that also influence(s) the outcome under study.¹

Similarly, a *confounding factor* (or confounder) must meet three criteria: 1) to be a known risk factor for the result of interest,² 2) to be a factor associated with exposure but not a result of exposure² and 3) to be a factor that is not an intermediate variable between them.

An example is that of smoking as a confounder in the study of coffee consumption as risk factor for ischemic heart disease. The association between coffee consumption and ischemic heart disease may be confounded by smoking. Indeed, smoking is a known risk factor for ischemic heart disease. It is associated with coffee consumption as smokers are usually consumers of coffee, but it is not a result of drinking coffee. Smoking is not an intermediate variable between coffee consumption and ischemic heart disease. Schematically:



Smoking is a *confounder* of the association between coffee consumption and ischemic heart disease.

Sources:

(1) Last J. *A Dictionary of Epidemiology*. Fourth Edition. New York, New York: Oxford University Press. 2001
 (2) Gordis L. *Epidemiology*. Second Edition. Philadelphia, PA: W.B. Saunders Company. 2000

ulations, the specific rates can be very imprecise. The process of standardization (or adjustment) of rates is a classic epidemiological method that removes the confounding effect of variables that we know — or think — differ in populations we wish to compare. It provides an easy to use summary measure that can be useful for information users, such as decision-makers, who prefer to use synthetic health indices in their activities.

In practice, age is the factor that is most frequently adjusted for. Age-standardization is particularly used in comparative mortality studies, since the age structure has an important impact on a population's overall mortality. For example, in situations with levels of moderate mortality, as in the majority of the countries of the Americas, an older population structure will always present higher crude rates than a younger population.

There are two main standardization methods, characterized by whether the standard used is a population distribution (direct method) or a set of specific rates (indirect method). The two methods are presented below.

Direct method

In the direct standardization method, the rate that we would expect to find in the populations under study if they

all had the same composition according to the variable which effect we wish to adjust or control (such as age, socioeconomic group, or other characteristics) is calculated. We use the structure of a population called “standard”, stratified according to the control variable, and to which we apply the specific rates of the corresponding strata in the population under study. We thus obtain the number of cases “expected” in each stratum if the populations had the same composition. The adjusted or “standardized” rate is obtained by dividing the total of expected cases by the standard population. An example is presented in box 2.

An important step in the direct standardization method is the selection of a standard population.³ The value of the adjusted rate depends on the standard population used, but to a certain extent this population can be chosen arbitrarily, because there is no significance in the calculated value itself. Indeed adjusted rates are products of a hypothetical calculation and do not represent the exact values of the rates. They serve only for comparisons between groups, not as a measure of absolute magnitude.³ However, some aspects should be taken into account in the selection of the standard population. The standard population may come from the study population (sum or average for example). In this case howev-

Box 2: Comparison of general age-standardized mortality rates in Mexico and the United States, using the direct method, 1995-1997

In this example, the standard population that was used is the so-called “old” world standard population defined by Waterhouse (see Box 3). The crude mortality rate for all ages in the United States for 1995-1997 is 8.7 per 1,000 population. In Mexico it is much lower: 4.7 per 1,000 population. We can conjecture that the higher rate in the United States may be due to an older population structure than in Mexico. Therefore, we wish to study the rates of the two countries when controlling for the effect of the age structure difference.

In this example, to use the direct method we need:

- The specific mortality rates by stratum of the characteristic we want to control, in this case age, in each population (i.e. Mexico and the United States)
- A standard population, stratified in the same way

First we calculate the expected number of deaths in both countries, applying the rate of each country to the standard population (columns (4) and (5)). The sum of all the groups gives us the total of expected deaths.

To calculate the adjusted rate, we divide this number by the total standard population.

	Standard Population (1)	Age-specific mortality rate per 100,000 population, 1995-1997		Expected number of deaths	
		Mexico (2)	United States (3)	Mexico (4) = (1)x(2)/100,000	United States (5) = (1)x(3)/100,000
<1	2,400	1,693.2	737.8	41	18
1-4	9,600	112.5	38.5	11	4
5-14	19,000	36.2	21.7	7	4
15-24	17,000	102.9	90.3	17	15
25-44	26,000	209.6	176.4	55	46
45-64	19,000	841.1	702.3	160	133
65+	7,000	4,967.4	5,062.6	348	354
	100,000			639	574

Age-adjusted mortality rate_{Mexico} = 6.4 per 1,000 pop. and Age-adjusted mortality rate_{United States} = 5.7 per 1,000 pop.

When eliminating the effect of the difference in the age structure in both countries, we obtain a rate that is higher in Mexico than in the United States. The conclusion of the comparison of the rates is inverted when using adjusted rates rather than crude rates.

Source of the data: Pan American Health Organization. *Perfiles de mortalidad de las comunidades hermanas fronterizas México - Estados Unidos Edición 2000 / Mortality profiles of the Sister Communities on the United States-Mexico border 2000 Edition*. Washington, D.C.: OPS. 2000

Box 3: "Old" Standard Populations (World and European)

Age groups (Years)	World	European
0	2,400	1,600
1-4	9,600	6,400
5-9	10,000	7,000
10-14	9,000	7,000
15-19	9,000	7,000
20-24	8,000	7,000
25-29	8,000	7,000
30-34	6,000	7,000
35-39	6,000	7,000
40-44	6,000	7,000
45-49	6,000	7,000
50-54	5,000	7,000
55-59	4,000	6,000
60-64	4,000	5,000
65-69	3,000	4,000
70-74	2,000	3,000
75-79	1,000	2,000
80-84	500	1,000
85+	500	1,000
Total	100,000	100,000

Source: Waterhouse J. y Col. (Eds.). Cancer incidence in five continents. Lyon, IARC, 1976.

er, it is important to ensure that the populations do not differ in size, since a larger population may unduly influence the adjusted rates.⁵ The standard population may also be a population without any relation to the data under study, but in general, its distribution with regard to the adjustment factor should not be radically different from the populations we wish to compare.

The comparative study of adjusted rates may be carried out in different ways: we can calculate the absolute difference between the rates, their ratio, or the percentage difference between them. Obviously, this comparison is valid only when the same standard was used to calculate the adjusted rates. When the national standards change (as in the United States in 1999 for example, when a new standard was adopted based on the 2000 population instead of the 1940 standard), the time series have to be recalculated at all levels. Updating the standard populations provides a more current common standard. For comparison of rates from different countries, the standard population used by WHO and PAHO is the so-called "old" standard population defined by Waterhouse.⁶ The age distribution of this population is shown in Box 3.

The direct method is most often used. However, it requires rates specific to population strata corresponding to the variable of interest in all the populations we wish to compare, which are sometimes not available. Even when these specific rates are available for all the subgroups, they are sometimes calculated from very small numbers and can be very imprecise. In this case, the indirect standardization method is recommended.³

Indirect method

Indirect standardization is different in both method and interpretation. An example of adjustment using the indirect method is presented in box 4. Instead of using the structure of the standard population, we utilize its specific rates and

apply them to the populations under comparison, previously stratified by the variable to be controlled. The total of expected cases is obtained this way. The Standardized Mortality Ratio (SMR) is then calculated by dividing the total of observed cases by the total of expected cases. This ratio allows to compare each population under study to the standard population. A conclusion can be reached by simply calculating and looking at the SMR. A SMR higher than one (or 100 if expressed in percentage) indicates that the risk of dying in the observed population is higher than what would be expected if it had the same experience or risk than the standard population. On the other hand, a SMR lower than one (or 100) indicates that the risk of dying is lower in the observed population than expected if its distribution were the same as the reference population. The actual adjusted rates can also be calculated using the indirect method by multiplying the crude rate of every population by its SMR.⁴ Just like in the direct method, a single value is obtained for every population which, even though it only represents an artificial number, takes into account the differences in the compositions of the populations.

Standardized Mortality Ratios are frequently used in epidemiology to compare different study groups, because they are easy to calculate and also because they provide an estimate of the relative risk between the standard population and the population under study. However, it is important to know that there are instances when this comparison is not adequate, like for example when the ratios of the rates in the groups under study and in the population of reference are not homogeneous in the different strata.⁷ However, the comparison between each group and the population of reference is always relevant. The SMRs of different causes in a population may also be calculated using a single standard.

Conclusion

As with any summary measure, adjusted rates may hide great differences between groups, which can be of importance to explain changes in the rates due to or associated with the variable that we wish to adjust for, for example. Nevertheless, whenever possible it is important to analyze the specific rates along with the adjusted rates. The two methods used in a single population should lead to the same conclusions. If it were not the case, the situation in the different population strata requires more in-depth research.⁴

One of the reasons for sometimes limited use of these methods is the lack of tools or instruments that simplify it. To respond to this need, the General Direction of Public Health of the Xunta de Galicia and PAHO's Special Program for Health Analysis have developed the "EpiDat" computer package for analysis of tabulated data. EpiDat is distributed free of charge via the Internet at: <http://www.paho.org/Spanish/SHA/epidat.htm>. A newer version of this package will be issued soon. The software SIGEpi (see http://www.paho.org/English/sha/be_v22n3-SIGEpi.htm), which combines the capacity of a geographic information system with epidemiological tools, also allows to generate adjusted rates.

In short, adjusted rates allow for more exact comparisons between populations. This is important because it can be used in setting priorities between groups. Nevertheless, the crude rates are the only indicators of the real dimension or magnitude of a problem and hence remain valuable public health tools.

Box 4: Use of indirect standardization to compare mortality in the Colombian department of Vichada and mortality in Colombia in general, 1999

The crude mortality rate in Colombia in 1999 was 4.4 per 1,000 population, with variations between 1.8 per 1,000 population in the department of Vichada and 6.9 per 1,000 in Quindío.¹ We would like to study the possible significant differences in the observed mortality (or in the risk of dying) in the country and in its departments. The case of the state of Vichada is presented in this example.

In this case, in order to use the indirect method we need:

- The age-specific mortality rates by age group in Colombia
- The population of the state of Vichada stratified by age
- The total number of deaths observed in the department of Vichada

The first step is to calculate the expected number of deaths in Vichada by applying the standard rates to the population of the department (column (3) = (1) x (2)). Then the calculated deaths are summed up and the SMR is calculated by dividing the total number of observed deaths by the expected deaths.

	Age-specific mortality rates, per 100,000 pop. Colombia, 1999 ¹ (1)	Population of the Department of Vichada ¹ (2)	Observed deaths in Vichada, 1999 ¹	Expected deaths in Vichada (3)
0-4	339	2,364	61	39
5-14	34	4,390	5	7
15-44	219	10,002	27	27
45-64	752	2,503	22	53
65 and more	4,573	513	27	84
		19,772	142	267

$$SMR_{\text{vichada}} (\%) = \frac{142}{267} \times 100 = 53\%$$

The SMR of 53% indicates that in the population of Vichada the risk of dying is 47% less than expected according to the mortality standards of all of Colombia, controlling for the age variable.

NOTE: Confidence interval for SMRs

The confidence interval provides the range of values within which we expect to find the real value of the indicator under study, with a given probability. That way, it gives an estimate of the potential difference between what is observed and what is really happening in the population, which helps in interpreting the value of the observed indicator. The 95% confidence interval is the most used. As mentioned previously, it indicates the range of values within which we expect to find the real value of the indicator, with a probability of 95%.

In the case of the SMR, the calculation of the confidence interval can be carried out in the following way:

1) First, the Standard Error (SE) for the SMR is calculated using the following formula: $SE = \frac{SMR}{\sqrt{\text{observed deaths}}}$

2) The 95% Confidence Interval (CI) is calculated as follows: $CI (95\%) \Rightarrow SMR \pm (1.96 \times SE)$ where 1.96 is the value of the Z distribution with a level of confidence of 95%. It is assumed that the values follow a normal distribution.

In this example: $SE_{\text{Vichada}} = 15.9$ and $CI_{\text{Vichada}} (95\%) = [174.1 ; 205.9]$

The confidence interval indicates that we know with a probability of 95% that the SMR's value is between 174.1 and 205.9.

Source of the data:

- (1) Ministerio de Salud de Colombia, Instituto Nacional de Salud de Colombia, PAHO/WHO Representation in Colombia. *Situación de Salud en Colombia, Indicadores Básicos 2002*. Bogotá, Colombia: Ministerio de Salud, PAHO; 2002.
- (2) Ministerio de Salud de Colombia. *La Salud en Colombia - Diez años de información*. Santafé de Bogotá, Colombia. 1994

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Source: Prepared by the Analysis Group of PAHO's Special Program for Health Analysis (SHA)