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## The Latin American Consortium of Studies in Obesity (LASO)

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### Summary

Current, high-quality data are needed to evaluate the health impact of the epidemic of obesity in Latin America. The Latin American Consortium of Studies of Obesity (LASO) has been

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Conflict of Interest Statement

None.

established, with the objectives of (i) Accurately estimating the prevalence of obesity and its distribution by sociodemographic characteristics; (ii) Identifying ethnic, socioeconomic and behavioural determinants of obesity; (iii) Estimating the association between various anthropometric indicators or obesity and major cardiovascular risk factors and (iv) Quantifying the validity of standard definitions of the various indexes of obesity in Latin American population. To achieve these objectives, LASO makes use of individual data from existing studies. To date, the LASO consortium includes data from 11 studies from eight countries (Argentina, Chile, Colombia, Costa Rica, Dominican Republic, Peru, Puerto Rico and Venezuela), including a total of 32 462 subjects. This article describes the overall organization of LASO, the individual studies involved and the overall strategy for data analysis. LASO will foster the development of collaborative obesity research among Latin American investigators. More important, results from LASO will be instrumental to inform health policies aiming to curtail the epidemic of obesity in the region.

## Keywords

Consortium; health surveys; Latin America; obesity; risk factors

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## Introduction

The parallel processes of economic growth, migration and urbanization in Latin America have shaped the epidemiological transition by increasing life expectancy and modifying lifestyles (1-3). In fact, the increase in the consumption of high-energy-density foods and the reduction in the levels of physical activity have been recognized as the main factors associated with the accelerated epidemic of obesity in the region (4,5). This epidemic is a matter of great concern because obesity constitutes a major modifiable risk factor for most of the leading causes of disability and mortality in Latin American countries, particularly cardiovascular diseases (CVD), diabetes mellitus, osteoarthritis and certain types of cancers (6,7).

Although existing evidence suggests a parallel increment in total energy and fat consumption, the prevalence of sedentary behaviours and the prevalence of obesity (8-10), there are limited reliable data on the magnitude and consequences of the epidemic of obesity in the region. Furthermore, the association of behavioural and environmental factors with obesity, as well as the relationship between obesity and other chronic diseases, might be more complex in Latin America than in more homogeneous populations. In fact, the current definition of obesity, primarily derived from White populations from Europe and the United States (6), might not be optimal to identify individuals at high risk of CVD or of diabetes mellitus (11,12).

Estimates of the prevalence of obesity have shown a great variability in Latin American populations, ranging from 9.9% to 35.7% (13). Women and individuals living in urban areas have been identified as the groups predominantly affected (14). In addition, obesity has been independently associated to low socioeconomic status and poorer educational level (15,16), and contributes to the accentuation of health inequalities in the region (17). There is also evidence of a secular trend towards the increase in levels of obesity among the most economically developed Latin American countries during the past three decades (14,18); however, similar data are not available for more disadvantaged populations. Moreover, most of the information on obesity has been obtained from nutritional surveys conducted during the first half of the nineties in adult women, mostly in urban settings, and little is known about adult men or the growing elderly population as well as rural obesity profiles.

In order to compose a comprehensive and updated picture of the impact of obesity in Latin America, we have established a multi-country consortium of obesity-related epidemiological studies conducted in the region. This initiative constitutes a strategy aimed to efficiently identify individual and population determinants of obesity, as well as to assess the role of obesity on the burden of CVD. We have chosen to focus on CVD for several reasons. First, CVD is the leading cause of non-traumatic mortality in Latin America (3,7); second, the projected burden of CVD will double during the following 20 years in the region (19,20); and third, there is a well-established association between obesity and the incidence of major cardiovascular risk factors and clinical cardiovascular events (21).

The specific objectives of the Latin American Consortium of Studies of Obesity (LASO) are (i) To accurately estimate the prevalence of obesity and its distribution by sociodemographic characteristics in Latin American; (ii) To identify ethnic, socioeconomic and behavioural factors (nutritional and physical activity patterns) associated to the prevalence of obesity; (iii) To estimate the association between various anthropometric indicators of obesity and classic cardiovascular risk factors and (iv) To quantify the validity of standard definitions of obesity in this population. Along with the accomplishment of these objectives, it is expected that the consolidation of LASO will foster the development of collaborative, harmonized studies on the association between obesity and other relevant chronic diseases in the region. LASO will help understand the obesity epidemic and develop future studies to evaluate the determinants and the impact of obesity in Latin America.

The aim of this manuscript is to present the protocol for LASO, describe the use of standardized methodologies for the pooling of data from individual studies and provide a general description of participating studies and their methodologies.

## Materials and methodology

### Identification and selection of studies

Studies included in LASO are cross-sectional or prospective population-based cohort studies, based on random samples of a defined free-living population. All studies have individual data on demographic and socioeconomic indicators and anthropometric indicators of obesity collected through physical examination. Moreover, they have at least one of the following (i) Direct measurement of major cardiovascular risk factors; (ii) Determination of levels of physical activity and (iii) Determination of nutritional patterns. The search for potential participant studies is based on computer-assisted literature searches of health-related databases; hand-searching of obesity, cardiology, epidemiology and other relevant journals; and personal communications with cardiovascular and obesity researchers from the region.

### Ethical approval, informed consent and confidentiality of the data

All studies have been approved by their respective local Institutional Review Board, and all participants provided their informed consent. The investigators of the original studies provide written consent for the use of their data before transferring and inclusion into the Consortium's central database at the University of Wisconsin at Madison. The data remain the property of the principal investigators of each participant study and are securely stored in study-dedicated computers. The central database does not include codes or data that may directly or indirectly allow the identification of individuals participating in the original studies.

## Consortium management and coordination

The LASO Steering Committee includes the principal investigators from all original studies. The tasks of this committee include (i) Coordinating the recruitment of new studies; (ii) Developing and prioritizing research questions to be addressed by the analysis of pooled data; (iii) Identifying and securing funds for the study; (iv) Producing and disseminating scientific reports of the ongoing research projects among members of the Consortium and (v) Acting as a publication committee. Parallel to the Steering Committee, a statistical centre has been constituted as an external academic instance responsible for the creation and management of the Consortium's central database, as well as for data analysis and generation of preliminary reports. This centre is based at Department of Population Health Sciences, University of Wisconsin at Madison.

## Study variables

Individual data collected in each study are categorized in five domains (Table 1) (i) Demographics, including age, gender, race or ethnic group; (ii) Indicators of socioeconomic status, including socioeconomic stratification, educational attainment, income, occupation and area of residency; (iii) Anthropometric indicators of total and regional obesity, measured by physical examination; (iv) Classic cardiovascular risk factors, including measurements of blood pressure and the laboratory assessment of glucose and lipid fractions and (v) Behavioural risk factors, including smoking status, alcohol consumption, physical activity and nutritional intake. Continuous variables such as anthropometric measures, blood pressure, glucose and lipid fractions are categorized according to current standard definitions. Whenever possible, categorical variables are recoded following standard procedures to maximize comparability among studies. Data on study-specific procedures are used to assess heterogeneity among studies.

## Data transfer and checking

Password-protected data files are transferred from the individual studies to the Consortium's statistical centre using electronic mailing. A codebook and a transference form containing a list of parameters directly estimated from the original datasets are included as part of the transference protocol. For security purposes, the datasets and accompanying files are encrypted before transference using keywords known only to the coordinator of the Consortium and the principal investigators of each study. Specific parameters calculated from each study after data transfer are compared with those obtained by the study investigators before data transfer. In the case of inconsistencies, the data are back-transferred to ensure identical results are obtained with both datasets. The data are then converted to a standard format and incorporated to the Consortium's central database.

## Statistical analysis

Specific data analysis strategies are used for each specific study using LASO data. However, some statistical procedures are applied for all analyses. We use multivariate imputation by chained equations to fill out missing values within studies in order to minimize selection bias because of missing data (22). Multiple imputed datasets are generated and the parameters of interest are averaged across datasets, using Rubin's formula (23). In addition, we use post-stratification by the age and gender distribution of the whole population in the countries included in the specific analysis as a way to minimize bias as a result of non-response and sampling frame under-coverage (24). Post-strata are constructed using the population totals by country, gender and age group (20-29, 30-39, 40-49, 50-59, 60-69, 70-79 and 80 years and older). Population distribution data are obtained from the U.S. Census Bureau (<http://www.census.gov>) for Puerto Rico and from the Centro

Latinoamericano y Caribeño de Demografía - CELADE (<http://www.cepal.org.ar/Celade>) for all other countries.

Multiple weighted linear and logistic regression are implemented in order to (i) Compare the distribution of anthropometric indicators and the prevalence of obesity and cardiovascular risk factors in groups defined by demographic and socioeconomic characteristics; (ii) Predict the prevalence of total and regional obesity in these groups and (iii) Quantify the independent effect of total and regional obesity on the distribution of individual cardiovascular risk factors and coronary heart disease risk. In order to determine which anthropometric indicator of obesity better identifies individuals with specific cardiovascular risk factors or who are at high risk of coronary heart disease, we estimate and compare the areas under the receiver operator characteristic (ROC) curves using the method of placement values (25,26). Finally, optimal cut-points for the anthropometric indicators of obesity are also determined on the basis of the ROC analysis by estimating the values of the indicator that minimize the cost of misclassifying individuals according to the presence of specific cardiovascular risk factors or the risk of coronary heart disease (27).

### Publication policy

Manuscripts derived from the analysis of aggregated data undergo an internal peer-review process. Manuscripts circulate among the members of the Steering Committee, who provide comments and generate a feedback report to the main authors. The main author addresses and responds to the comments and prepares a final revised version. LASO's Steering Committee approves the final manuscript before submission. Finally, as part of a strategy of communication and recruitment, the Consortium has developed a website (<http://www.pophealth.wisc.edu/laso>), which contains general information on the participant studies, the principal investigators and their groups, and links to the all the publications derived from the analysis of pooled data.

### Results

Eleven studies (28-38) from eight countries in Latin American and the Caribbean (Argentina, Chile, Colombia, Costa Rica, Dominican Republic, Peru, Puerto Rico and Venezuela) are currently included in the LASO, including a total of 32 462 subjects (Table 2). The overall mean age is 45.8 years (standard deviation 18.6 years; range: 15-109 years) and the male proportion is 40.6%, ranging from 31.0% to 50%. Four studies are national health surveys (29,32-34), but one of them is restricted to urban population (33). In addition, one study was conducted at the state level (38), five exclusively targeted urban populations from single cities (28,30,31,36,37) and other sampled an urban and a rural population (35).

Data on demographic and socioeconomic characteristics, smoking, medical history and current treatment of hypertension and diabetes were collected by trained interviewers using similar questionnaires (available to the members of the statistical centre) in all studies. Standing height and weight were measured in all surveys with the participants wearing light clothing and no shoes. Waist circumference was measured at the umbilical level in five studies (28,31,32,36,38), at the midpoint between the lowest rib and the iliac crest in four studies (29,30,34,35), at the high point of the iliac crest in one study (37), and was not measured in one study (33). Hip circumference was measured at the maximum extension of the buttocks. Blood pressure measurements were conducted at least twice in all but one study (34), following standard recommendations (39). Blood samples were obtained in all studies, after 8 h of fast, blood glucose, total cholesterol and high-density lipoprotein cholesterol were measured enzymatically by automated methods. Low-density lipoprotein (LDL) cholesterol was directly measured in two studies (36,38) and was calculated using the Friedewald equation (40) otherwise.

For effects of statistical analyses, hypertension is defined as a systolic blood pressure  $\geq 140$  mmHg, or as a diastolic blood pressure  $\geq 90$  mm Hg, or as current anti-hypertensive treatment, and participants are considered diabetics if their fasting glucose is  $\geq 7.0$  mmol L<sup>-1</sup> (126 mg dL<sup>-1</sup>) or if they report current pharmacological treatment for diabetes (either insulin or oral agents). High total cholesterol is defined as a total cholesterol  $\geq 6.15$  mmol L<sup>-1</sup> (240 mg dL<sup>-1</sup>). High LDL cholesterol and low high-density lipoprotein cholesterol are deemed present if the corresponding cholesterol levels are  $\geq 4.10$  (160 mg dL<sup>-1</sup>) and  $<1.03$  mmol L<sup>-1</sup> ( $<40$  mg dL<sup>-1</sup>), respectively. Hypertriglyceridemia is defined as a level of triglycerides  $\geq 2.25$  mmol L<sup>-1</sup> (200 mg dL<sup>-1</sup>). Also, participants are classified as current smokers if they report to have smoked at least 100 cigarettes in their lives and have smoked during the previous 1-6 months in two studies (30,35) or if they were smoking at least one cigarette per day at the moment of the evaluation in the remaining studies. Overall, obesity is defined as body mass index  $\geq 30$  kg m<sup>-2</sup> and abdominal obesity as a waist circumference  $\geq 88$  cm in women and  $\geq 102$  cm in men, following the recommendations of the World Health Organization (6).

Finally, as a strategy to summarize the cardiovascular risk, the expected 10-year risk of coronary heart disease is estimated in men and women 30-74 years old by using the Framingham equation (41). Considering that the equation may overestimate the absolute risk of coronary heart disease (CHD) in Latin Americans (42), we use the population-specific mean values for the risk factors in order to minimize such effect. Participants with an estimated 10-year risk of CHD  $\geq 20\%$  are considered at 'high risk', because current standards of care recommend aggressive risk reduction and selective use of proven drug therapies in these individuals (43,44).

## Conclusion

The LASO constitutes a multinational initiative to efficiently assess the public health problem of obesity, its sociodemographic and behavioural determinants, and its impact on the risk of CVD in the region. The strategy of combining data captured at individual level from population-based studies will allow not only to increase precision in estimating the prevalence of obesity, but also to capture the heterogeneity of the effect of this condition on the health of the Latin American population. Finally, the Consortium, which currently includes data from 11 studies involving approximately 33 000 participants, will serve as framework for the interchange of observational data, discussion and interpretation of regional epidemiological evidence, and ultimately the formulation of high-quality, standardized, collaborative proposals on obesity and other prevalent chronic diseases.

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**Table 1**

Variables available in the Latin American Consortium of Studies in Obesity (LASO)

| <b>Domain</b>                              | <b>Variable (description)</b>  |
|--|--|
| Demographic                                | Age (years); gender (male/female)<br>Ethnicity (Amerindian/Black/White/other)  |
| Socioeconomic                              | Education attainment (highest level or total years)<br>Income (individual or household)<br>Occupation (occupational categories)<br>Area of residency (urban/rural)   |
| Anthropometry*                             | Body weight (kg)/height (m)<br>Waist circumference (cm)<br>Hip circumference (cm)  |
| Cardiovascular and metabolic risk factors* | Systolic/diastolic blood pressure (mmHg)<br>Glucose (mmol L <sup>-1</sup> )<br>Total, HDL and LDL cholesterol (mmol L <sup>-1</sup> )<br>Triglycerides (mmol L <sup>-1</sup> )   |
| Behavioural risk factors                   | Smoking status (never, past or current; cigarettes per day)<br>Alcohol consumption (type of beverage, frequency and quantity)<br>Physical activity (type of activity, frequency and duration)<br>Foods/nutrients' intake (food frequency questionnaires) |

HDL, high-density lipoprotein; LDL, low-density lipoprotein.

\* Measured by physical examination or laboratory analysis.

**Table 2**  
 Characteristics of the studies from the Latin American Consortium of Studies in Obesity (LASO)

| Study                               | Location                          | Year      | Target           | Sample | Age    | Male |
|-------------------------------------|-----------------------------------|-----------|------------------|--------|--------|------|
| Encuesta de Factores de Riesgo (28) | Argentina, Ushuaia/<br>Rio Grande | 2003-2004 | City             | 1135   | 18-65  | 48%  |
| Encuesta Nacional de Salud (29)     | Chile                             | 2003      | National         | 3619   | 16-97  | 45%  |
| CARMEN (30)                         | Colombia, Bogotá                  | 2001      | City             | 2962   | 15-69  | 43%  |
| CARMEN (31)                         | Colombia, Bucaramanga             | 2001      | City             | 2994   | 15-66  | 36%  |
| CRELES (32)                         | Costa Rica                        | 2004-2006 | National         | 2826   | 60-109 | 46%  |
| EFRICARD (33)                       | Dominican Republic                | 1998      | National (urban) | 6184   | 18-75  | 34%  |
| ENINBSC-ECNT (34)                   | Peru                              | 2005      | National         | 4209   | 20-95  | 50%  |
| PERU/MIGRANT (35)                   | Peru, Lima/Ayacucho               | 2007-2008 | Urban/rural      | 990    | 29-92  | 47%  |
| PREVENCIÓN (36)                     | Peru, Arequipa                    | 2004-2006 | City             | 1878   | 20-80  | 46%  |
| Metabolic syndrome in San Juan (37) | Puerto Rico                       | 2005-2007 | City             | 865    | 21-79  | 35%  |
| The Zulia CHD Factor Study (38)     | Venezuela, Zulia                  | 1999-2001 | State            | 4800   | 20-97  | 31%  |

CHD, coronary heart disease.