Chronic Obstructive Pulmonary Disease in Hispanics A 9-Year Update

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Chronic obstructive pulmonary disease (COPD) is a major public health problem in the United States (1) and Latin America (2). In the United States, approximately 28.9 million people are estimated to have COPD (1). Nine years ago, we reviewed the burden of COPD in Hispanics (3) and emphasized the importance of research and public health policy focused on Hispanic subgroups, with the ultimate goal of improving the prevention, diagnosis, and treatment of COPD among Hispanics in the United States and Latin America (3).

In this Pulmonary Perspective, we first discuss the demographic characteristics and social determinants of health in the Hispanic population. We then examine lung function measures and COPD burden and recent studies of risk factors, diagnosis, and management of COPD in Hispanics. Finally, we discuss future directions in this field.

The Hispanic Population

A Hispanic or Latino is an individual whose ancestry can be traced to Spain or territories previously under Spanish control, including Mexico, large parts of Central and South America, and some Caribbean islands (Cuba, Puerto Rico, and the Dominican Republic). Hispanics are very diverse with regard to racial ancestry, country of origin, nativity, and area of residence. Most Hispanics are racially admixed, having various proportions of European, Native

American, and African ancestry (4). Thus, Hispanic is an ethnicity and not a race.

Hispanics are the largest, youngest, and fastest-growing minority in the United States, now numbering 57.5 million people or 17.8% of the country's population (5). Whereas the non-Hispanic white (NHW) population grew by 1.2% from 2000 to 2010, the Hispanic population increased by 54% over the same period. The proportion of each subgroup within the U.S. Hispanic population is as follows: Mexican Americans (~63%), Puerto Ricans (~9.2%), others (e.g., Spaniards and Spanish Americans, ~8.1%), Central Americans (~7.9%), South Americans (~5.5%), Cuban Americans (~3.5%), and Dominicans (~2.8%) (5). By 2060, Hispanics are expected to compose 28.6% of the U.S. population.

Social Determinants of Health

Compared with other ethnic groups in the United States, Hispanics have lower educational attainment and income and lower health insurance rates and English proficiency, all of which can affect healthcare access (6). Among U.S. adults 25 years and older in 2015, Hispanics were less likely to have at least a bachelor's degree (15.0%) than NHWs (34.2%) or Asians (52.6%). In 2015, the proportion of Hispanics in poverty (21.9%) was higher than that for NHWs (9.8%) or the national

average (14.2%). An analysis of four U.S. surveys found that the percentage of individuals aged 18 to 64 years who lacked health insurance was substantially higher in Hispanics (41.5%) than in NHWs (15.1%), with an even higher proportion of uninsured individuals among Hispanic immigrants (54.7%) (8). In 2014, the percentages of all Hispanics and foreign-born Hispanics who reported speaking English very well were 68.4 and 33.4%, respectively (7).

In Latin America, social determinants of health—such as gross domestic product and healthcare spending—showed marked variations across countries (Table 1). Although Honduras had a gross domestic product per capita of \$2,361 and allocated \$212 for health care per capita, Uruguay had corresponding figures of \$15,200 and \$1,442. Some variation is also seen in average school attendance, with some countries averaging approximately 5 years of schooling and others more than 8 years.

Lung Function

Until recently, spirometry reference equations were available for Mexican Americans but not for other U.S. Hispanic subgroups. Using data from more than 16,000 subjects, the HCHS/SOL (Hispanic Community Health Study/Study of Latinos) generated spirometry reference equations for specific Hispanic subgroups (9), including Mexicans, Puerto Ricans, Cubans,

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Table 1. Selected Demographic, Healthcare, and Education Data for Some Latin American Countries

Country	GDP per Capita (US\$)*	Healthcare Expenditure (US\$)†	Schooling Years‡	Smoking Prevalence§ (%)		Solid Fuel Use (%)
				Male	Female	
Argentina	12,449.20	605	7.2	29.5	18.4	<5
Chile	13,792.90	1,137	—	40	36	7
Colombia	5,805.60	569	—	16	6.2	14
Costa Rica	11,824.60	970	8.4	18.5	8.3	5
Cuba		817	—	52.7	17.8	7
Dominican Republic	6,722.20	269	7.5	18.8	9.4	9
El Salvador	4,223.60	280	6.5	—	—	19
Guatemala	4,146.70	233	4.7	—	—	64
Honduras	2,361.20	212	5.5	33.3	2.1	50
Mexico	8,201.30	677	8.5	20.8	6.6	15
Peru	6,045.70	359	—	—	5.9	34
Uruguay	15,220.60	1,442	8.5	26.7	19.4	<5

Definition of abbreviation: GDP = gross domestic product.

*GDP, 2016. GDP per capita is GDP divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data from Reference 61.

†Healthcare expenditure, 2014. Total health expenditure is the sum of public and private health expenditures as a ratio of total population. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation. Data from Reference 62.

‡Schooling years, 2012. Schooling years is the average number of completed years of education of a population aged 25 years or older. Data from Reference 63.

§Prevalence of smoking, 2015. Prevalence of smoking of any tobacco product among persons aged 15 years or older (as percentage). Data from Reference 64.

||Solid fuels use, 2013. The indicator solid fuels is the percentage of the population that relies on solid fuels as the primary source of domestic energy for cooking and heating. The indicator is calculated as the number of people using solid fuels divided by total population, expressed as percentage. When no solid fuel use information was available for the country (in this table, Argentina, Chile, Cuba, and Uruguay), the regional population-weighted mean was used. Examples of solid fuels are wood, charcoal, crops or other agricultural waste, dung, shrubs and straw, and coal. Data from Reference 65.

and Dominicans (9). Of interest, Dominicans and Puerto Ricans had lower predicted values and lower limit of normal values for FEV₁ and FVC than members of other subgroups, which may be partly explained by their higher average proportion of African ancestry (10, 11). In Latin America, the PLATINO (Proyecto Latinoamericano para la Investigación de la Obstrucción Pulmonar) study used data from subjects representative of the general population of five major cities (Mexico City, Mexico; Caracas, Venezuela; Santiago, Chile; Sao Paulo, Brazil; and Montevideo, Uruguay) to generate spirometric reference equations for specific subgroups.

Subgroup-specific reference equations should reduce inaccuracies in lung function measures and COPD diagnoses among Hispanics in the United States and Latin America (3).

COPD Burden

Among U.S. adults aged 40 to 79 years between 2007 and 2010, estimates of the prevalence of COPD (defined by spirometric measures of airflow obstruction) were: 5.4%

in Hispanics, 14.1% in African Americans, and 15% in NHWs (12). More recently, the HCHS/SOL demonstrated striking differences in age- and sex-adjusted COPD prevalence (assessed by spirometry) among Hispanic subgroups, with Puerto Ricans (14.1%) and Cubans (9.8%) being more likely to be affected than Mexicans (4.6%) (13). However, subgroup differences in COPD prevalence became nonstatistically significant after the analysis was adjusted for asthma onset before age 45 years (Figure 1), suggesting potential misclassification of asthma as COPD or high frequency of asthma-COPD overlap syndrome (ACOS) in some groups.

Certain Hispanic subgroups may be at lower risk of COPD. A longitudinal study of smokers in New Mexico showed that Hispanics had lower decline in lung function and lower risk of developing COPD than NHWs (14, 15). In that study, Hispanics were 45% less likely to develop COPD than NHWs after 5.9 years of follow-up (15). In contrast to studies of New Mexico Hispanics, studies of Mexican Americans have yielded conflicting results, with some showing reduced COPD risk (16) and others demonstrating no risk

difference with other ethnic groups (17, 18). Variable sampling methodology and smoking exposure might explain discrepant findings across studies.

Disparities in COPD prevalence across U.S. Hispanic subgroups may be partly explained by differences in racial ancestry: Puerto Ricans have (on average) a greater proportion of African ancestry but a lower proportion of Native American ancestry than New Mexican Hispanics. Although Native American ancestry is associated with higher FEV₁ and reduced COPD risk among New Mexican Hispanics (14) and Costa Ricans (4), African ancestry (more prominent in Puerto Ricans) has been associated with reduced FEV₁ and faster decline in lung function among African Americans (19).

The PUMA (Prevalence Study and Regular Practice, Diagnosis, and Treatment among General Practitioners in Populations at Risk of COPD in Latin America) study of COPD in primary care settings in four countries (Argentina, Colombia, Venezuela, and Uruguay) included adults aged 40 years or older who were current/former smokers or were exposed to biomass (20). PUMA reported an estimated overall COPD

Figure 1. Prevalence of chronic obstructive pulmonary disease (COPD) among U.S. Hispanics 45 years or older in the Hispanic Community Health Study/Study of Latinos, by country or region of origin. COPD was defined by a post-bronchodilator FEV₁/FVC ratio less than 0.7. The estimates are percentages from a multivariable analysis adjusted for age, sex, educational attainment, age at immigration, residing 10 or more years in the United States, smoking status, pack-years of smoking, and asthma onset before age 45 years. *P* value is for the difference in prevalence across subgroups.

prevalence (defined by FEV₁/FVC < 0.7) of 20.1%, ranging from 11% in Venezuela to 29.6% in Argentina.

COPD is the third leading cause of death in the United States. In 2013, the age-adjusted death rates (per 100,000 people) from COPD among U.S. Hispanics were highest in Cubans (28.0) and Puerto Ricans (26.9) and lowest in Mexican Americans (18.3) (8). Compared with NHWs, Hispanics from San Luis Valley (Colorado) had lower COPD mortality, even after adjusting for smoking and other covariates (21). Although some studies have shown COPD mortality to be lower in Mexican Americans, recent findings suggest that the risk of death from COPD in Mexican Americans is similar to that of members of other racial or ethnic groups (16).

Patients with COPD may die from nonrespiratory causes. In PLATINO, the main causes of death were cardiovascular conditions, cancer, and respiratory disease. The age-standardized mortality rates (per 1,000 persons/yr) for cardiovascular causes were higher in men than in women living in three PLATINO sites (Santiago, Montevideo, and Sao Paulo), varying from 11.9 in Brazilian men to 1.6 in Uruguayan women. A similar male-predominant pattern was also observed for respiratory causes, but the total number of deaths in this group was small (*N* = 28) (22). Cancer deaths showed less variability by sex or site (23).

Risk Factors

Tobacco Use

Current smoking was lower in U.S. Hispanics (13.1%) than in NHWs (17.2%) in 2015 (24). However, this broad comparison obscures marked variability in smoking habits among Hispanic subgroups. In HCHS/SOL, current smoking was highest in Puerto Ricans (men, 35.0%; women, 32.6%) and Cubans (men, 31.3%; women, 21.9%) and lowest in Dominicans (men, 11.0%; women, 11.7%), with intermediate estimates for Mexican Americans (men, 23.4%; women, 10.4%), Central Americans (men, 20.5%; women, 8.5%), and South Americans (men, 15.8%; women, 11.7%) (25). In that study, birth in the United States or greater acculturation was associated with current smoking among U.S. Hispanics, with stronger effects in women than in men. In HCHS/SOL, immigration before age 16 years was linked to current smoking, perhaps through acculturation of women (13), who are generally less likely to smoke in their countries of origin (25). Male sex, age 60 years or younger, low education, and low income are also risk factors for current smoking in U.S. Hispanics (25).

Smoking rates remain high in some Latin American countries, varying markedly between countries and sexes (Table 1).

In 2016, smoking was more common in Cuban men (52.7%) and women (17.8%) than in Colombian men (16%) and women (6.2%). In Honduras, the prevalence of smoking was approximately 15 times higher in men than in women. Sex differences in current smoking are also observed among subjects with COPD (26), which may be due to lower social acceptance of smoking among Latin American women.

Smoking intensity also varies among U.S. Hispanics. Although half of Cuban men and more than one-third of Cuban women smoke 20 or more cigarettes per day, 7.1% of Mexicans and 9.4% of Dominican groups smoke that much (25). Intermittent or nondaily smoking is common among Hispanics, particularly among men of Mexican (15.5%), Central American (9.8%), and Puerto Rican (9.0%) descent (25). Hispanics also report cigar and pipe smoking, particularly among men (25).

Electronic (e-) cigarette use has increased in the United States, particularly in youth. Among high school students, e-cigarette use increased from 1.5% in 2011 to 16.0% in 2015, with a corresponding increment among Hispanics of 16.4% (27). Although NHWs were more likely to use e-cigarettes than Hispanics in studies of adolescents (28) and adults (29, 30), such ethnic differences were not found among college students (31). A community-based study showed that, among Hispanic ever smokers, lifetime and current use of e-cigarettes were 71 and 35%, respectively (32). Compared with other groups, Hispanics are less likely to use e-cigarettes as a smoking cessation aid or to save money, and thus a pleasant experience, perceived harm reduction, or circumventing ban policies may be motivating Hispanics to use these products. Dual use of traditional cigarettes and e-cigarettes might challenge culturally sensitive efforts to reduce tobacco use among Hispanics.

Second-hand smoke (SHS) is associated with increased risk of COPD among nonsmokers (33). During 2011 to 2012, SHS among U.S. adults 40 to 59 years of age was more common in Mexican Americans (24.9%) than in NHWs (16.3%) (34). However, little is known about SHS and COPD in Hispanics.

Genetics

Recent studies have identified potential susceptibility loci for COPD in Hispanics. Severe alpha-1 antitrypsin deficiency, a genetic risk factor for COPD, is more common in NHWs than in Hispanics. Hispanic carriers of a genetic mutation at one of the alpha-mannosidase genes (*MAN2B1*, which degrades AAT) were found to have high levels of alpha-1 antitrypsin and may thus be protected against high levels of elastase and, ultimately, COPD (35). Moreover, four potential susceptibility loci for FEV₁ (in *ZSWIM7*) and COPD (in or near the genes *KLHL7/NUPL2*, *DLG2*, and *PDZD2*) (36) have been identified in genome-wide association studies of Hispanic populations, with further replication of findings for *ZSWIM7* and *PDZD2* in European populations. *ZSWIM7* mutations might increase COPD susceptibility through mechanisms including oxidative stress, cell senescence, and apoptosis.

Air Pollution

In the United States, 28.3% of Hispanics live near a major highway and are thus exposed to traffic-related air pollution, which has been linked to COPD. In a U.S. study, Hispanic Medicare beneficiaries exposed to fine particulate matter (<2.5 μm [$\text{PM}_{2.5}$]) had higher risk of all-cause mortality than the general population (37). In that study, the effect of ozone exposure on mortality was lower than that of $\text{PM}_{2.5}$, and Hispanics exposed to ozone had lower risk of death than those in the general population (37). Among Hispanics in another U.S. study with limited phenotypic data, $\text{PM}_{2.5}$ exposure was associated with hospitalizations for asthma, but not for COPD (38).

Biomass

Exposure to biomass (i.e., cooking or heating with wood and coal) is common in Latin America. In 2013, at least 19% of the population of El Salvador, Guatemala, and Honduras was using solid fuels (Table 1). In the PUMA study, 40% of subjects with COPD reported exposure to biomass, and biomass exposure for at least 10 years was associated with approximately 2.3 times increased risk of COPD, independently of cigarette smoking (39).

Diagnosis

HCHS/SOL has shown substantial differences in respiratory symptoms among

Hispanic subgroups (13). For example, Puerto Ricans reported dyspnea (24.1%) more frequently than Dominicans (16.5%), Cubans (13.1%), Central Americans (12.7%), South Americans (12.6%), or Mexican Americans (12.1%). Similarly, wheeze was reported more frequently by Puerto Ricans than by members of other subgroups. In HCHS/SOL, dyspnea was more frequently reported by those migrating to the United States before age 16 years than by those born in the United States (15.9 vs. 12.4%). In a Latin American study, women with COPD report more dyspnea than men with COPD (60.5 vs. 41.9%), but there were no sex differences in other symptoms (26). Although the causes of sex differences in dyspnea perception are unclear, they may include hormonal effects or psychological factors (26).

In a small U.S. study, Hispanic smokers had threefold increased odds of dyspnea compared with NHWs, regardless of an asthma or COPD diagnosis (40). An examination of word descriptors for breathing discomfort among subjects undergoing methacholine-induced bronchoconstriction demonstrated that NWHs only used word descriptors for lower airway symptoms ("can't get air in," "chest heavy," and "wheezing"), whereas Mexican Americans used word descriptors for both upper airway ("voice tight," "itchy throat," and "itchy inside throat and chest") and lower airway ("sore lung," "wheezing," and "hurts to breathe") symptoms (41). This is important, as healthcare professionals may not associate upper airway symptoms with dyspnea among Mexican Americans.

Among subjects with COPD, daily dyspnea is common and may lead to exercise limitation. A study of Chileans with mild COPD reported that the main contributor to dyspnea intensity during a 6-minute-walk was a drop in inspiratory capacity, which—together with low thigh muscle mass—was associated with exercise limitation (42). Physical activity is an intervention that helps increase exercise capacity and quality of life in patients with COPD. In a Chilean clinical trial in subjects with COPD, wearing a pedometer was associated with higher daily steps than counseling alone (3,080 vs. 138.3 steps per day) (43). This intervention was also associated with an improved 6-minute-walk test and better disease-specific quality of life.

Underdiagnosis of COPD is a major problem around the globe. In the United

States, 72% of adults with airflow obstruction did not report physician-diagnosed COPD or asthma in the 2007 to 2012 period (44). In Latin America, the PUMA study showed that 77% of cases of COPD were missed in primary care settings (45). In this study, obesity, dark skin, and mild airflow obstruction were predictors of undiagnosed COPD. Furthermore, among subjects with self-reported physician-diagnosed COPD, 30% had an incorrect diagnosis (e.g., an FEV₁/FVC > 0.7). Thus, making spirometry available in primary care settings may improve the diagnosis of COPD in Latin America.

Little is known about ACOS among Hispanics. In the PUMA Study, the prevalence of ACOS ranged between 2.3 and 5.3% (depending on the definition used), and subjects with ACOS were more likely to report symptoms (dyspnea, cough, and phlegm) and to have exacerbations than those with COPD (46).

Three studies have reported on lung imaging and COPD in U.S. Hispanics. Powell and colleagues did not find racial or ethnic differences in the effect of smoking on emphysema in cardiac computed tomography (CT) scans (17), and other studies found no racial-ethnic differences in CT measures of airways (wall thickness, lumen area), vascular morphology, or extrapulmonary manifestations of COPD (i.e., muscle and fat mass) (40, 47). In a Chilean COPD cohort, greater burden of emphysema on CT and low DL_{CO} at baseline were both associated with reduced exercise capacity 2 years later (48).

Management

Health insurance is a key determinant of health care. In a U.S. study of 24 emergency rooms, Hispanics with COPD were less likely to have a primary care provider or to have insurance than NHWs with COPD, suggesting that Hispanics use the emergency department to care for their chronic condition (49). In that study, Hispanics were 80% less likely to have arterial blood gas measurements than NHWs, but no significant ethnic differences were found in other care indicators (e.g., receiving systemic corticosteroids).

COPD is associated with reduced health-related quality of life (HRQL) in all racial-ethnic groups. Compared with NHWs, Hispanics with obstructive airway

diseases experience worse HRQL (50), which may be partly explained by limited education and lack of health insurance. In another study using a generic questionnaire and the disease-specific St. George's Respiratory Questionnaire, New Mexican Hispanic smokers had worse HRQL than their NHW counterparts (51), particularly for physical impairment. Among PLATINO subjects with COPD, however, mental health was an important factor for quality of life, as a higher mental health score was associated with good to excellent health status (52).

Therapeutic options for COPD include smoking cessation, immunizations, rehabilitation, pharmacologic therapy, and surgical interventions such as lung transplant. Although smoking cessation improves survival in patients with COPD, only 5.5% of U.S. Hispanic smokers with health insurance were prescribed smoking cessation aids (25). U.S. Hispanics are also less likely to use nicotine replacement therapy than NHWs (53, 54). Among Medicaid and Veterans Affairs Healthcare System beneficiaries with COPD, Hispanics were less likely to be vaccinated against influenza than NHWs (55–57).

In Latin America, bronchodilator use differs markedly among subjects with health insurance and medication coverage (75.7%),

health insurance but not medication coverage (18.8%), and no health insurance (5%) (58). On the other hand, inappropriate use of respiratory medications was common in the PLATINO study, with more than one-half of subjects using bronchodilators or corticosteroids despite no evidence of airflow obstruction (59).

Nonadherence to therapy is common in patients with COPD. In a U.S. study of inner-city residents, non-Hispanic black individuals and Hispanics were more likely to be nonadherent to treatment than NHWs (60), with nonadherent participants reporting greater concern about medication effectiveness and being more emotionally affected by COPD. Thus, adequate discussion of side effects and expected efficacy of medications, along with emotional support, may improve adherence among Hispanics with COPD.

In summary, our knowledge of COPD in Hispanics has improved over the last 9 years, because of a better understanding of genetics and differences in COPD burden and risk factors across Hispanic subgroups, development of group-specific spirometry reference equations, and improved knowledge about barriers and needs in the diagnosis and management of COPD in Hispanics. Despite this progress, much remains to be done.

Future Directions

The ongoing HCHS/SOL study, combined with future observational studies and clinical trials including sufficient numbers of well-characterized Hispanic subjects, are needed to draw firm conclusions about the etiology and management of COPD in Hispanic subgroups. Such Hispanic-focused studies should improve our understanding of the “omics” of COPD, the impact of variables correlated with racial ancestry (i.e., genetic variants, environmental exposures) on COPD and lung function (e.g., spirometry reference equations that account for racial ancestry proportions superior to those developed for self-reported members of Hispanic subgroups?), the burden of ACOS, the use of nontobacco products, and effective smoking cessation interventions in this ethnic group. Increasing health insurance coverage, together with culturally sensitive policies to address healthcare barriers (i.e., language proficiency, low health literacy, nonadherence to therapy, patient beliefs, and cultural competency of healthcare providers), should help improve the care of Hispanic patients with COPD. ■

Author disclosures are available with the text of this article at www.atsjournals.org.

References

- Ford ES, Mannino DM, Wheaton AG, Giles WH, Presley-Cantrell L, Croft JB. Trends in the prevalence of obstructive and restrictive lung function among adults in the United States: findings from the National Health and Nutrition Examination surveys from 1988-1994 to 2007-2010. *Chest* 2013;143:1395-1406.
- Menezes AM, Perez-Padilla R, Jardim JR, Muñio A, Lopez MV, Valdivia G, et al.; PLATINO Team. Chronic obstructive pulmonary disease in five Latin American cities (the PLATINO study): a prevalence study. *Lancet* 2005;366:1875-1881.
- Brehm JM, Celedón JC. Chronic obstructive pulmonary disease in Hispanics. *Am J Respir Crit Care Med* 2008;177:473-478.
- Chen W, Brehm JM, Boutaoui N, Soto-Quiros M, Avila L, Celli BR, et al. Native American ancestry, lung function, and COPD in Costa Ricans. *Chest* 2014;145:704-710.
- United States Census Bureau. Quick facts United States [accessed 2017 Nov 27]. Available from: <https://www.census.gov/quickfacts/fact/table/US/PST045216#qf-headnote-b>.
- Velasco-Mondragon E, Jimenez A, Palladino-Davis AG, Dawn D, Escamilla-Cejudo JA. Hispanic health in the U.S.A: a scoping review of the literature. *Public Health Rev* 2016;37.
- Flores A, López G, Radford J. Facts on U.S. Latinos, 2015: statistical portrait of Hispanics in the United States. Washington, DC: Pew Research Center [accessed 2017 Nov 27]. Available from: <http://www.pewhispanic.org/2017/09/18/facts-on-u-s-latino-current-data/>.
- Dominguez K, Penman-Aguilar A, Chang MH, Moonesinghe R, Castellanos T, Rodriguez-Lainz A, et al.; Centers for Disease Control and Prevention (CDC). Vital signs: leading causes of death, prevalence of diseases and risk factors, and use of health services among Hispanics in the United States - 2009-2013. *MMWR Morb Mortal Wkly Rep* 2015;64:469-478.
- LaVange L, Davis SM, Hankinson J, Enright P, Wilson R, Barr RG, et al. Spirometry reference equations from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). *Am J Respir Crit Care Med* 2017;196:993-1003.
- Conomos MP, Laurie CA, Stilp AM, Gogarten SM, McHugh CP, Nelson SC, et al. Genetic diversity and association studies in U.S. Hispanic/Latino Populations: applications in the Hispanic Community Health Study/Study of Latinos. *Am J Hum Genet* 2016;98:165-184.
- Kumar R, Seibold MA, Aldrich MC, Williams LK, Reiner AP, Colangelo L, et al. Genetic ancestry in lung-function predictions. *N Engl J Med* 2010;363:321-330.
- Tilert T, Dillon C, Paulose-Ram R, Hnizdo E, Doney B. Estimating the U.S. prevalence of chronic obstructive pulmonary disease using pre- and post-bronchodilator spirometry: the National Health and Nutrition Examination Survey (NHANES) 2007-2010. *Respir Res* 2013;14:103.
- Barr RG, Avilés-Santa L, Davis SM, Aldrich TK, Gonzalez F II, Henderson AG, et al. pulmonary disease and age at immigration among Hispanics: results from the Hispanic Community Health Study/Study of Latinos. *Am J Respir Crit Care Med* 2016;193:386-395.
- Bruse S, Sood A, Petersen H, Liu Y, Leng S, Celedón JC, et al. New Mexican Hispanic smokers have lower odds of chronic obstructive pulmonary disease and less decline in lung function than non-Hispanic whites. *Am J Respir Crit Care Med* 2011;184:1254-1260.
- Petersen H, Sood A, Meek PM, Shen X, Cheng Y, Belinsky SA, et al. Rapid lung function decline in smokers is a risk factor for COPD and is attenuated by angiotensin-converting enzyme inhibitor use. *Chest* 2014;145:695-703.

16. Diaz AA, Come CE, Mannino DM, Pinto-Plata V, Divo MJ, Bigelow C, *et al.* Obstructive lung disease in Mexican Americans and non-Hispanic whites: an analysis of diagnosis and survival in the National Health and Nutritional Examination Survey III follow-up study. *Chest* 2014;145:282–289.
17. Powell R, Davidson D, Divers J, Manichaikul A, Carr JJ, Detrano R, *et al.* Genetic ancestry and the relationship of cigarette smoking to lung function and per cent emphysema in four race/ethnic groups: a cross-sectional study. *Thorax* 2013;68:634–642.
18. Powell R, Barr RG. Response letter to: the Hispanic paradox further unraveled? *Thorax* 2014;69:185–186.
19. Aldrich MC, Kumar R, Colangelo LA, Williams LK, Sen S, Kritchevsky SB, *et al.*; Health ABC and CARDIA Studies Groups. Genetic ancestry-smoking interactions and lung function in African Americans: a cohort study. *Plos One* 2012;7:e39541.
20. López Varela MV, Montes de Oca M, Rey A, Casas A, Stirbulov R, Di Boscio V, PUMA Team. Development of a simple screening tool for opportunistic COPD case finding in primary care in Latin America: the PUMA study. *Respirology* 2016;21:1227–1234.
21. Kinney GL, Thomas DS, Cicutto L, Newman LS, Lutz S, Hokanson JE. The protective effect of Hispanic ethnicity on chronic obstructive pulmonary disease mortality is mitigated by smoking behavior. *J Pulm Respir Med* 2014;4:220.
22. Menezes AM, Wehrmeister FC, Perez-Padilla R, Viana KP, Soares C, Müllerova H, *et al.* The PLATINO study: description of the distribution, stability, and mortality according to the Global Initiative for Chronic Obstructive Lung Disease classification from 2007 to 2017. *Int J Chron Obstruct Pulmon Dis* 2017;12:1491–1501.
23. Menezes AM, Pérez-Padilla R, Wehrmeister FC, Lopez-Varela MV, Muñoz A, Valdivia G, *et al.*; PLATINO team. FEV1 is a better predictor of mortality than FVC: the PLATINO cohort study. *Plos One* 2014;9:e109732.
24. Jamal A, King BA, Neff LJ, Whitmill J, Babb SD, Graffunder CM. Current cigarette smoking among adults - United States, 2005-2015. *MMWR Morb Mortal Wkly Rep* 2016;65:1205–1211.
25. Kaplan RC, Bangdiwala SI, Barnhart JM, Castañeda SF, Gellman MD, Lee DJ, *et al.* Smoking among U.S. Hispanic/Latino adults: the Hispanic community health study/study of Latinos. *Am J Prev Med* 2014;46:496–506.
26. Lopez Varela MV, Montes de Oca M, Halbert RJ, Muñoz A, Perez-Padilla R, Tálamo C, *et al.*; PLATINO Team. Sex-related differences in COPD in five Latin American cities: the PLATINO study. *Eur Respir J* 2010;36:1034–1041.
27. Singh T, Arrazola RA, Corey CG, Husten CG, Neff LJ, Homa DM, *et al.* Tobacco use among middle and high school students—United States, 2011-2015. *MMWR Morb Mortal Wkly Rep* 2016;65:361–367.
28. Anand V, McGinty KL, O'Brien K, Guenther G, Hahn E, Martin CA. E-cigarette use and beliefs among urban public high school students in North Carolina. *J Adolesc Health* 2015;57:46–51.
29. Schoenborn CA, Gindi RM. Electronic cigarette use among adults: United States, 2014. *NCHS Data Brief* 2015;217:1–8.
30. Saddleson ML, Kozlowski LT, Giovino GA, Hawk LW, Murphy JM, MacLean MG, *et al.* Risky behaviors, e-cigarette use and susceptibility of use among college students. *Drug Alcohol Depend* 2015;149:25–30.
31. Littlefield AK, Gottlieb JC, Cohen LM, Trotter DR. Electronic cigarette use among college students: links to gender, race/ethnicity, smoking, and heavy drinking. *J Am Coll Health* 2015;63:523–529.
32. Webb Hooper M, Kolar SK. Racial/ethnic differences in electronic cigarette use and reasons for use among current and former smokers: findings from a community-based sample. *Int J Environ Res Public Health* 2016;13:E1009.
33. Eisner MD, Anthonisen N, Coultas D, Kuenzli N, Perez-Padilla R, Postma D, *et al.*; Committee on Nonsmoking COPD, Environmental and Occupational Health Assembly. An official American Thoracic Society public policy statement: novel risk factors and the global burden of chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2010;182:693–718.
34. Homa DM, Neff LJ, King BA, Caraballo RS, Bunnell RE, Babb SD, *et al.*; Centers for Disease Control and Prevention (CDC). Vital signs: disparities in nonsmokers' exposure to secondhand smoke—United States, 1999-2012. *MMWR Morb Mortal Wkly Rep* 2015;64:103–108.
35. Manichaikul A, Hoffman EA, Smolonska J, Gao W, Cho MH, Baumhauer H, *et al.* Genome-wide study of percent emphysema on computed tomography in the general population: the Multi-Ethnic Study of Atherosclerosis Lung/SNP Health Association Resource Study. *Am J Respir Crit Care Med* 2014;189:408–418.
36. Chen W, Brehm JM, Manichaikul A, Cho MH, Boutaoui N, Yan Q, *et al.* A genome-wide association study of chronic obstructive pulmonary disease in Hispanics. *Ann Am Thorac Soc* 2015;12:340–348.
37. Di Q, Wang Y, Zanobetti A, Wang Y, Koutrakis P, Choirat C, *et al.* Air pollution and mortality in the medicare population. *N Engl J Med* 2017;376:2513–2522.
38. Grineski SE, Herrera JM, Bulathsinhala P, Staniswalis JG. Is there a Hispanic health paradox in sensitivity to air pollution? Hospital admissions for asthma, chronic obstructive pulmonary disease and congestive heart failure associated with NO2 and PM2.5 in El Paso, TX, 2005-2010. *Atmos Environ* (1994) 2015;119:314–321.
39. Montes de Oca M, Zabert G, Moreno D, Lauchó-Contreras ME, Lopez Varela MV, Surmont F. Smoke, biomass exposure, and COPD risk in the primary care setting: the PUMA study. *Respir Care* 2017;62:1058–1066.
40. Diaz AA, Rahaghi FN, Doyle TJ, Young TP, Maclean ES, Martinez CH, *et al.* Differences in respiratory symptoms and lung structure between Hispanic and non-Hispanic white smokers: a comparative study. *Chronic Obstr Pulm Dis* 2017;4:297–304.
41. Hardie G, Liu R, Darden J, Gold WM. Ethnic differences in methacholine responsiveness and word descriptors in African Americans, Hispanic-Mexican Americans, Asian-Pacific Islanders, and Whites with mild asthma. *J Asthma* 2010;47:388–396.
42. Diaz AA, Morales A, Diaz JC, Ramos C, Klaassen J, Saldías F, *et al.* CT and physiologic determinants of dyspnea and exercise capacity during the six-minute walk test in mild COPD. *Respir Med* 2013;107:570–579.
43. Mendoza L, Horta P, Espinoza J, Aguilera M, Balmaceda N, Castro A, *et al.* Pedometers to enhance physical activity in COPD: a randomised controlled trial. *Eur Respir J* 2015;45:347–354.
44. Martinez CH, Mannino DM, Jaimes FA, Curtis JL, Han MK, Hansel NN, *et al.* Undiagnosed obstructive lung disease in the United States: associated factors and long-term mortality. *Ann Am Thorac Soc* 2015;12:1788–1795.
45. Casas Herrera A, Montes de Oca M, López Varela MV, Aguirre C, Schiavi E, Jardim JR; PUMA Team. COPD underdiagnosis and misdiagnosis in a high-risk primary care population in four Latin American countries: a key to enhance disease diagnosis: the PUMA study. *Plos One* 2016;11:e0152266.
46. Montes de Oca M, Victorina Lopez Varela M, Lauchó-Contreras ME, Casas A, Schiavi E, Mora JC. Asthma-COPD overlap syndrome (ACOS) in primary care of four Latin America countries: the PUMA study. *BMC Pulm Med* 2017;17:69.
47. Donohue KM, Hoffman EA, Baumhauer H, Guo J, Budoff M, Austin JH, *et al.* Cigarette smoking and airway wall thickness on CT scan in a multi-ethnic cohort: the MESA Lung Study. *Respir Med* 2012;106:1655–1664.
48. Diaz AA, Pinto-Plata V, Hernández C, Peña J, Ramos C, Diaz JC, *et al.* Emphysema and DLCO predict a clinically important difference for 6MWD decline in COPD. *Respir Med* 2015;109:882–889.
49. Tsai CL, Camargo CA Jr. Racial and ethnic differences in emergency care for acute exacerbation of chronic obstructive pulmonary disease. *Acad Emerg Med* 2009;16:108–115.
50. Martinez CH, Mannino DM, Curtis JL, Han MK, Diaz AA. Socioeconomic characteristics are major contributors to ethnic differences in health status in obstructive lung disease: an analysis of the National Health and Nutrition Examination Survey 2007-2010. *Chest* 2015;148:151–158.
51. Diaz AA, Petersen H, Meek P, Sood A, Celli B, Tesfayigz Y. Differences in health-related quality of life between New Mexican Hispanic and Non-Hispanic white smokers. *Chest* 2016;150:869–876.
52. Montes de Oca M, Tálamo C, Halbert RJ, Perez-Padilla R, Lopez MV, Muñoz A, *et al.*; PLATINO Team. Health status perception and airflow obstruction in five Latin American cities: the PLATINO study. *Respir Med* 2009;103:1376–1382.
53. Trinidad DR, Pérez-Stable EJ, White MM, Emery SL, Messer K. A nationwide analysis of U.S. racial/ethnic disparities in smoking behaviors, smoking cessation, and cessation-related factors. *Am J Public Health* 2011;101:699–706.

54. Levinson AH, Pérez-Stable EJ, Espinoza P, Flores ET, Byers TE. Latinos report less use of pharmaceutical aids when trying to quit smoking. *Am J Prev Med* 2004;26:105–111.
55. Straits-Tröster KA, Kahwati LC, Kinsinger LS, Orelie J, Burdick MB, Yevich SJ. Racial/ethnic differences in influenza vaccination in the Veterans Affairs Healthcare System. *Am J Prev Med* 2006;31:375–382.
56. Yoo BK, Hasebe T, Szilagyi PG. Decomposing racial/ethnic disparities in influenza vaccination among the elderly. *Vaccine* 2015;33:2997–3002.
57. Egede LE, Zheng D. Racial/ethnic differences in influenza vaccination coverage in high-risk adults. *Am J Public Health* 2003;93:2074–2078.
58. Montes de Oca M, Lopez Varela MV, Jardim J, Stirvulov R, Surmont F. Bronchodilator treatment for COPD in primary care of four Latin America countries: the multinational, cross-sectional, non-interventional PUMA study. *Pulm Pharmacol Ther* 2016;38:10–16.
59. Montes de Oca M, Tálamo C, Perez-Padilla R, Lopez MV, Muiño A, Jardim JR, *et al.*; PLATINO Team. Use of respiratory medication in five Latin American cities: the PLATINO study. *Pulm Pharmacol Ther* 2008;21:788–793.
60. Krauskopf K, Federman AD, Kale MS, Sigel KM, Martynenko M, O'Connor R, *et al.* Chronic obstructive pulmonary disease illness and medication beliefs are associated with medication adherence. *COPD* 2015;12:151–164.
61. The World Bank. GDP per capita (current US\$) [accessed 2017 Nov 27]. Available from: <http://data.worldbank.org/indicator/NY.GDP.PCAP>. CD.
62. The World Bank. Health expenditure per capita (current US\$) [accessed 2017 Nov 27]. Available from: <http://data.worldbank.org/indicator/SH.XPD.PCAP>.
63. Pan American Health Organization. Schooling mean years [accessed 2017 Nov 27]. Available from: <http://www.paho.org/data/index.php/en/indicators/demographics-core/357-schooling-en.html>.
64. World Health Organization. Global Health Observatory data repository: tobacco use data by country [accessed 2017 Nov 27]. Available from: <http://apps.who.int/gho/data/node.main.65>.
65. World Health Organization. Global Health Observatory indicator views: population using solid fuels [accessed 2017 Nov 27]. Available from: http://apps.who.int/gho/data/node.imr.WHS5_512?lang=en.