

Defining Race/Ethnicity and Explaining Difference in Research Studies on Lung Function

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Abstract

The 2005 guidelines of the American Thoracic Society/European Respiratory Society recommend the use of race and/or ethnic-specific reference standards for spirometry. Yet, definitions of the key variables of race and ethnicity vary worldwide. The purpose of this study was to determine whether researchers defined race and/or ethnicity in studies of lung function and how they explained any observed differences.

Using the methodology of the systematic review, we searched PubMed in July 2008 and screened 10,471 titles and abstracts to identify potentially eligible articles that compared “whites” to “other racial and ethnic groups.”

Of the 226 eligible articles published between 1922 and 2008, race and/or ethnicity was defined in 17.3%, with the proportion increasing to 70% in the 2000s for those using parallel controls. Most articles (83.6%) reported that “other racial and ethnic groups” have a lower lung capacity compared to “whites;” 94% of articles failed to examine socioeconomic status. In the 189 studies that reported lower lung function in “other racial and ethnic groups,” 21.8% and 29.4% of explanations cited inherent factors and anthropometric differences, respectively, whereas 23.1% of explanations cited environmental and social factors.

Even though researchers sought to determine differences in lung function by race/ethnicity, they typically failed to define their terms and frequently assumed inherent (or genetic) differences.

Introduction

Spirometry is used to measure lung capacity in a variety of medical and public health contexts, in addition to specialty clinics. Increasingly, primary care physicians worldwide employ spirometric evaluation in their offices and lung capacity is considered a key indicator of physical health [1]. Lung function values obtained with the spirometer are corrected for age, height, sex, and race according to information on the individual patient provided by the clinician.

Leading medical societies have long incorporated race or ethnic “correction” or “adjustment” of lung capacity measurement into their guidelines, generally for people considered “black”. By 1990, the application of a correction factor (generally 6-12%) or the use of population-specific standards, both of which could be programmed into the spirometer, were commonplace in pulmonary training programs in the United States [2].

The most recent guidelines published in 2005 by the Joint Working Party of the American Thoracic Society/European Respiratory Society (ATS/ERS) recommend the use of race-and ethnic-specific reference standards, rather than an adjustment factor, using self-identification for determining race [3]. In 2006, Kiviranta and Haahtela [4] questioned the racial classification systems employed in the lung capacity literature and proposed that the racial and ethnic groups used be revisited. Yet, race and ethnicity is defined differently in various national contexts [5] and the selection of appropriate reference equations in spirometry and the issue of “race correction” or population-specific norms remain a topic of discussion [6, 7]

To assess the evidence contributing to the ATS/ERS guidelines on race we undertook a systematic review of the biomedical literature that compared lung function in different racial and ethnic groups published prior to and immediately after publications of the guidelines in 2005. Specifically the purpose of this study was to determine 1) whether spirometry researchers have

defined race and/or ethnicity in their studies and 2) how they explained any observed differences among racial and ethnic groups.

Methods

Inclusion Criteria

Eligible articles described the results of primary research that explicitly compared lung function in “other race and ethnic groups” to “white” groups (i.e., used the terms “race” and/or “ethnicity” or “stock,” or terms, such as “Caucasian” or “Mongoloid”). Included articles either made direct comparisons between groups or included comparative statements regarding group difference. We excluded articles that only made within-group comparisons. For example, articles that compared Indians to Europeans and specifically used the terms race and/or ethnicity to refer to these groups were included, whereas articles that compared Indians in different regions of India (e.g. North v. South) were not included. Eligible articles described studies measuring forced vital capacity (FVC), vital capacity (VC), and/or forced expiratory volume in 1 second (FEV1). Excluded articles included review articles, task force statements, and non-English language articles.

For our analyses, we classified the groups studied as “white” or “other race and ethnic groups.” Commonly used terms and groups in this literature that we classified as “white”, by frequency of usage were: white, Caucasian, European or European descent, American, Western, and several UK populations. Additional terms and groups used infrequently specified Italian, occidentals, Scotch-Irish of pre-Revolutionary stock, Anglo, Scandinavian, Danish Caucasian, and foreigners. We intentionally did not classify the wide range of “other race and ethnic groups” into conventional race and/or ethnic categories or continental groupings. Use of the

terms “white” and “other race and ethnic groups” is appropriate for this particular study but does not imply any consistent social, historical, or biological distinctions between or uniformities within either of these categories.

Search strategy and data extraction

With the assistance of a science librarian, we conducted a search of PubMed on July 24, 2008, using the search strategy outlined in Supplementary Table 1 and retrieving 10,471 articles (Figure 1). LB screened the title and abstract of each article. If the title and abstract suggested that the article might meet the above criteria, LB conducted a full text review (422 articles were identified for full text review). MW examined a 10% sample of the 10,471 (first 10 citations in each group of 100 chronologically ordered citations) and identified no additional articles meeting our criteria. After full text review, 165 articles met our inclusion criteria. Through a review of the reference section of the 165 articles, we identified an additional 62 eligible articles. At the time of abstraction, we excluded one additional article because it was not relevant to our analysis. Thus we included 226 articles in our systematic review (see Supplementary Bibliography for full list of papers).

The primary investigator (LB), MW, and two research assistants abstracted key data, including the populations compared and whether investigators included a description of the procedures they employed to assign individuals to a race or ethnic group in the Methods section of the paper; whether FVC, vital capacity (VC), and FEV1 were measured; and whether racial and /or ethnic differences in lung function were observed between study groups. Explanations for any differences observed were extracted word for word. We also recorded year of article publication; country and discipline of the corresponding author, or first author when no

corresponding author was indicated; age and sex of study participants; sample size, defined as the number of people on whom lung function was measured in the study; type of comparison group; use of the term Caucasian; and whether socioeconomic status was assessed in conjunction with race and/or ethnicity.

The identified articles were sorted by publication year. LB and MW used pre-set coding rules to code independently the first 40 articles' explanations for observed difference and compared their results by discussion, resolving any differences. LB and MW then independently coded explanations provided in the remaining 186 articles. The few minor differences were resolved by discussion.

Coding rules for all other abstracted data items were finalized after testing and verification by KD, who examined an approximately 10% sequential random sample of articles from each decade (total n=26). LB independently examined and coded the same 26 articles, KD and LB compared their coding and resolved disagreements regarding the coding rules, and coding rules were finalized. Data items were abstracted by one person (LB or MW) and verified by LB. Once the abstraction and coding process was completed, LB re-reviewed all data for accuracy. Data were initially entered into Microsoft Excel 2004 and subsequently analyzed using SAS software, Version 9.2 (SAS Institute Inc., Cary, NC).

Explanations for difference

Explanations for observed racial/ethnic differences in lung capacity that we abstracted included both explanations provided by the authors and explanations provided by others if they were cited in the Results or Discussion sections of included articles. We coded explanations into one of seven categories: 1) inherent differences between racial/ethnic groups; 2) anthropometric

differences; 3) environmental and social factors; 4) mechanical factors; 5) technical factors; 6) other; or 7) no explanation (Supplementary Table 2). With the exception of anthropometric difference, categories were mutually exclusive. We created category 2, anthropometric differences, because some investigators considered anthropometric difference (e.g., height) as a “fixed” or inherent biological feature of individuals or groups and others as changeable in response to environmental (e.g., nutritional) or social factors.

We categorized the comparison populations as either a “parallel” comparison group (i.e., a population drawn concurrently and compared with the study population by the authors), or as a “historical” comparison group. Historical comparisons included: 1) data collected on a population in a previous study by the same investigators (“cohort from the same investigator”); 2) data from one or more “literature comparison groups with presentation of data” (e.g., one or more studies by different investigators), and displayed in the study article’s figures or tables; and 3) information from one or more “literature comparison groups without presentation of data”, (e.g., information about other populations, presented in the Results or Discussion section of the study article). We subsequently combined the literature comparison groups described in 2) and 3) into one group (“literature comparison group”).

Results

Characteristics of articles identified for systematic review

The 226 eligible articles were published between 1922 and 2008, with a marked increase beginning in the 1960s (Table 1). Corresponding authors were from 39 countries, with the highest proportion from the United States (68/226; 30.1%), followed by India (31/226; 13.7%), and the United Kingdom (26/226; 11.5%).

Only one third (33.2%) of the studies included a parallel comparison group, with about two thirds of the studies comparing the population under study to an historical group from another “cohort from the same investigators” (3.5%), or “from the literature” (63.3%). Study sample sizes ranged from 13 to 65,086, with the majority (59.3%) including 100 to 999 participants (does not include data presented in either of the literature comparison groups). About one quarter of all studies involved children only (23.9%) or males only (27.0%) (Table 2)

Definitions of race and/or ethnicity

We found that 39/226 (17.3%) of the included articles defined race and/or ethnicity and the proportion of articles providing a definition increased over time. In articles published before 1980, 10/87 (11.5%) defined race and/or ethnicity, whereas in articles published in 1980 and after, 29/139 (21%) provided a definition. Considering only studies with stronger study designs (i.e., parallel controls), 7/10 (70%) of articles in the 2000s stated how race was defined as compared to 5/10 (50%) and 4/9 (44%) studies conducted during the 1980s and 1990s, respectively (Figure 2).

In the 39 articles in our study that did define race, methods used to classify a study participant’s race and/or ethnicity varied, including “participant self-identification” (13/39) or “variations on classification by the investigator-observers” (visual inspection, surname, “lineage”, records, language, tribal membership, birthplace, residence, or a combination of participant and observer identification) (26/39). Authors frequently used the terms “race” and “ethnicity” to group individuals with a shared country or region of birth or residence (e.g., northern or southern Indians), a putatively common culture, a common language, and a particular

skin color. In our study sample, the term “Caucasian” was used commonly to represent the “white” or European population (97/226 papers; 42.9%).

By design, our review examined articles that compared at least two populations, one of which was “white.” The “other race and ethnic groups” represented 94 groups from many countries (Supplementary Table 3). Of the 226 articles examined, 189 (83.6%) claimed that “other race and ethnic groups” had lower spirometric values, 13/226 (5.8%) had no difference/similar, 10/226 (4.4%) had higher, and 14/226 (6.2%) had variable spirometric values of lung capacity as compared to “white” groups (Table 3). Only 14/226 (6.1%) of the articles examined socioeconomic status in conjunction with race and/or ethnicity, and we did not observe any meaningful changes over time.

Explaining racial and ethnic difference in lung capacity

We found a wide range of proposed explanations for racial and ethnic differences in lung capacity (Table 4). Of the 189 articles in which “other race and ethnic groups” were reported to have lower lung function than “whites,” the most common explanations suggested were anthropometric differences (93/316; 29.4% of explanations), followed by environmental differences (73/316; 23.1%), and inherent differences (69/316; 21.8%) (authors could provide more than one explanation). In 46/189 (24.3%) articles, investigators provided no explanation for the differences observed (Figure 3.)

Explanations for racial/ethnic differences reported varied over time and place, and included inherent and anthropometric differences, environmental and social factors, technical factors, and others (see Supplementary Table 2 for examples of each). Authors of 4/7 articles published in the 1920s suggested that differences were simply due to “a racial factor” (coded as

inherent difference) (8-11); one article suggested anthropometric difference [12] and another provided no explanation [13]. McCloy [14], on the other hand, found “whites” and Chinese to be similar. McCloy’s explanation for similarity was complex, pointing to changing levels of physical activity among Chinese students and noting that any difference would be eliminated if lung function was interpreted in relation to surface area.

Authors of some articles published between 1930 and 1944 and conducted in India questioned the racial/ethnic paradigm established in the 1920s, providing environmental explanations for difference, such as climate and “modes of life and habits” [15]. By the 1960s, most researchers included a long list of potential explanations, such as “environment” or nutrition, in addition to or in conjunction with biological or genetic factors. Some investigators raised environmental explanations only to rule them out. Schoenberg et al [16], for example, stated that “the lower FVC and FEV1 values among blacks are related to genetic rather than to environmental variables.” On the other hand, Myers of South Africa [17] concluded that “the available evidence does not support a clear thesis of racial or ethnic differences in spirometric lung functions.” Some authors viewed anthropometric difference as a changeable factor over time, yet others viewed it as fixed. The most recently article in our study emphasized anthropometric difference along with social factors. “Differences in upper body segment explained more of the ethnic differences in lung function than SH [standing height], particularly among Black Caribbean/African subjects. Social correlates had a smaller but significant impact” [18]. As indicated in Figure 3, inherent difference remains an explanation for racial/ethnic differences in lung function to the present day.

Discussion

In this paper, we used the methodology of the systematic review to address two questions fundamental to biomedical research on racial/ethnicity and lung function: 1) how was race and/or ethnicity defined in the literature? and 2) how were differences explained and interpreted over time? The interpretation of race and ethnicity in research depends on their appropriate definition in the original research study. Our systematic review found that only 17.3% of articles defined race and/or ethnicity. Over time, there was a clear increase in the proportion of studies defining race and/or ethnicity in the methods section. Yet, even in the 2000s, when the current guidelines regarding “ethnic adjustment” of spirometry data were published, only 29.4% of studies defined race and/or ethnicity.

Despite this lack of definition, 67.2% of the studies reporting lower lung capacity in “other race and ethnic groups” as compared to “whites” suggested inherent or anthropometric characteristics as explanations for difference. This was a consistent finding from the earliest years. For example, in explaining that their “findings suggest a possible racial factor...Poverty, environment and social status, with the ensuring advantages and disadvantages...do not seem to influence of the lung capacity of children,” the earliest paper in our review, published in 1922, laid the foundation for inherent difference [8]. Importantly, studies of all designs and from earlier decades continue to be cited in the contemporary literature as evidence of racial difference [19].

Kiviranta and Haahtela note that “the term Caucasian...is solely a historical term in anthropological science.” [4] In our study, authors' use of the 18th century racial term “Caucasian” was common, even after 1994, when its use was proscribed by the Council of Biology Editors [20]. Our review also found that about two thirds of the articles examining

racial/ethnic differences in lung function used literature comparison groups from different times and places, a weak study design for demonstrating a reliable association.

Over the decades, pulmonologists have discussed extensively the myriad technical and interpretive issues related to proposed racial/ethnic differences in spirometry test results. Yet, until recently few researchers have explicitly considered the underlying assumptions about race and ethnicity that informed pulmonary research. Notable exceptions were South African scientists Myers [17] and White [21] and more recently Kiviranta and Haahtela [4]. Our study is the first to examine the complex history of how race and ethnicity were defined in studies of lung function and how the differences reported were interpreted, both of which have influenced the current policy of “race correction.”

Our objective in this review was not to determine whether the association between race and/or ethnicity and lung function is valid. Indeed, validity is difficult to assess accurately, given the lack of definition of race and ethnicity in the literature and their different meanings in various national contexts. Moreover, selective publication of research findings (reporting biases), or a deliberate selection of a “literature comparison group” which provides the desired contrast, could have influenced our findings. We also recognize that not all aspects of our systematic review follow methodological standards suggested by, for example, the Cochrane Collaboration [22]. We only searched one electronic database, included only English language articles, used a single person to review titles and abstracts and full length articles, and used a single abstractor for most data items. However, we did employ sampling, to check on the reliability of our classifications, and standardized definitions, developed through consultation with all authors. It is possible that we may have missed some studies that would affect our estimates of prevalence. For our findings to be invalidated, however, we would have had to have missed a large number of

articles with parallel comparisons, with definitions of race and/or ethnicity and examination of socioeconomic status, and showing no evidence of association between race and/or ethnicity and lung function, all of which we believe is unlikely based on our findings. We also recognize that by giving each mention of an explanation equal weight in our count of explanation frequency, we may not have captured the full meaning and/or intent of authors' explanations.

Finally, in keeping the classification of anthropometric differences separate from inherent difference, we may have under-estimated the extent to which researchers considered lung function differences among groups to be inherent. In the literature we reviewed, anthropometric measures, such as difference in the sitting height to standing height ratio (a commonly used explanation for racial and ethnic difference), were frequently considered fixed (inherent) characteristics of individuals and groups (Table 4). On the other hand, some investigators were clear in considering anthropometric data, such as height (and thus differences in height), as changeable factors in individuals and populations (e.g., due to improved nutrition) [14]. Other authors' meaning was not possible to discern.

Almost 94% of the studies we examined failed to consider race and/or ethnicity in the context of socioeconomic status, even in recent years. Socioeconomic status has variable meanings within and across time periods, and its examination in the context of a research study is limited by the dataset. Given that lower lung function is associated with lower socioeconomic status [23], descriptors of socioeconomic status should be taken into account when analyzing lung function. Using data from the Third National Health and Nutritional Examination Survey (NHANES III), a recent analysis of the contribution of socioeconomic status to racial difference in lung function found that high school completion was associated with increases in lung function values that were racially patterned [24].

Our study found that since the 1920s and 1930s, some researchers explained racial difference as environmental. Recent studies confirm the view that environmental exposures, such as air pollution affect lung function and respiratory health [25]. Moreover, racial and ethnic minorities are exposed to higher levels of environmental, including respiratory, pollutants. It is thus critical that environmental differences and socioeconomic factors be examined in more detail as possible explanations for difference.

Our data indicate that in the 2000s studies were more rigorously designed and they defined race and/or ethnicity more often. Nevertheless, only some journal editors require that race be defined in articles using the term and there is no consensus on how to do this [26]. We found that most studies in the 2000s that defined race and/or ethnicity used self-identification to assign a participant's race/ethnicity. Self-identification will likely continue to be the norm as long as it is recommended by the ATS/ERS. Self-identification, however, changes over time and place, in part because the categories offered to respondents change. In the United States census, influential in health research, racial categories are fluid, changing every decade since census-taking began in 1790 [5, 27, 28]. The changing nature of race over time provides compelling evidence that race is a social category. While self-identification of race and ethnicity is appropriate for understanding social experiences in certain research contexts, it is inappropriate for genetic causality studies. Thus, there remains a disconnect in the lung function literature between the use of the social definition of self-report and genetic explanations for difference. Nor does the recent turn to racial "ancestry" circumvent the problems associated with defining and interpreting racial and ethnic difference [29]. Ancestry itself is not consistently defined and in the case of lung function the use of ancestry is built on traditional race-based models [30-32].

The concept of race, particularly as it pertains to causal explanations for racial and ethnic difference and disparity in disease, is currently a topic of a vibrant international debate. The debate taking place in the scholarly literature, including arguments for greater emphasis on understanding social determinants of disease, often reflects views of race from the perspective of the US [29, 31-38], even though the issue is broadly relevant. The present study contributes to the debate by showing that the majority of the literature comparing lung function in whites to other racial groups has generally ignored the importance of socioeconomic factors.

The studies we reviewed included 94 groups from very different social contexts. The fact that the key variable of race and/or ethnicity used to frame comparative studies on lung capacity was rarely defined over a period of nearly 90 years should at the very least raise questions about the reliability of research that reports an association between inherent or genetic racial difference and lung function and the scientific evidence that underpins the practice of “race correction.” While the view that races and ethnic groups differ in the capacity of their lungs is widely accepted in pulmonary medicine [39], the continued practice of explaining racial and ethnic difference in lung function as rooted in inherent and fixed anthropometric difference has important health policy implications. Importantly, it could divert attention from much-needed research into the physiological mechanisms by which specific social and physical environments influence lung function. Of note in this regard is recent work by Burney and Hooper [7] which raises questions about the “normality” of lower lung function in African Americans and argues against the use of ethnic-specific norms for prognosis.

There is no simple solution to the problem of an established practice, such as race correction. There is, however, much to be learned about the concept of race, how its historical use in biomedicine shapes current scientific research design, and how white US and European

norms came to be the standard of “normal”. The idea of racial difference in lung capacity stems from the work of US southern plantation physician Samuel Cartwright [40]. This was later affirmed in the work of Benjamin A Gould in an anthropometric study of soldiers in the Union Army at the end of the Civil War [41] and followed up by Frederick Hoffman in *Race Traits and Tendencies of the American Negro* [42]. There are many problems with this early research [39], one of which is its failure to allow for differences between blacks and whites in height, age, or socioeconomic status. Yet, researchers continue to cite Gould’s article uncritically [6].

Despite the challenges, continued dialogue in biomedical journals and at conferences on how underlying assumptions about race and ethnicity shape design and interpretation of research is of great importance. To this end, we suggest that an international workshop comprising pulmonologists who use this technology and historians, anthropologists, and sociologists who study the concepts of race and ethnicity from the global North and South, be convened to assess past research on lung function as it pertains to racial and ethnic disparities, to explore how and why outdated assumptions about race persist in the scientific literature, and to develop methodologies to guide future research. Such a conference would build upon the questions we and others pose about race correction and provide a less Anglo-American perspective on race. For example, while Indian researchers have compared lung function among regional groups within India, Indian researchers have historically drawn more extensively on environmental explanations. Only through continued dialogue will we gain clarity on the relationship of lung function measurements to race, ethnicity, and socioeconomic indicators.

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Figure Legends

Figure 1. Flow chart of search of PubMed and sequence of determination of article eligibility

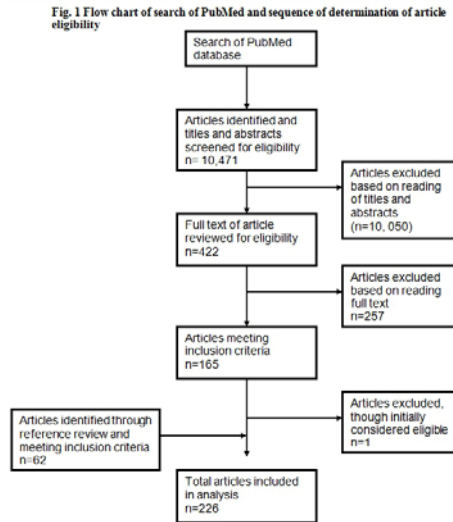


Figure 2. Percent of 226 Articles That Provided Definitions of Race and/or Ethnicity by Type of Comparison Group and Decade of Publication

Figure 2

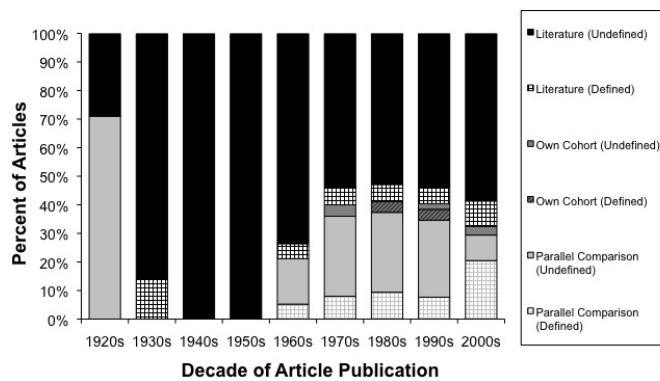


Figure 3. Explanations For Lower Lung Capacity Observed Between “Whites “and “Other Racial and Ethnic Groups” in 189 Articles by Decade of Article Publication. N above each bar refers to the total number of studies in each decade. Articles could include more than one explanation.

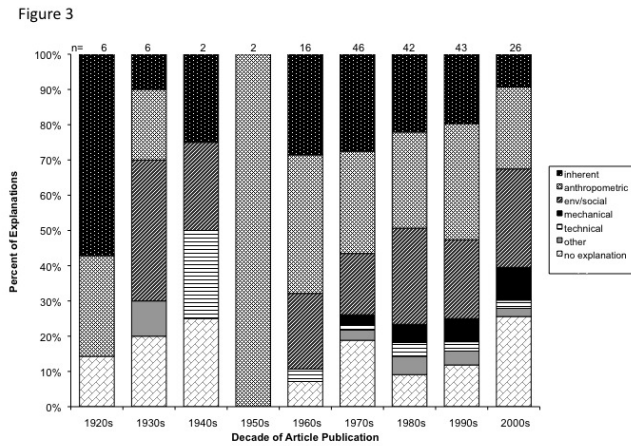


Table 1. Characteristics of Articles by Type of Comparison Group.

		Historical Comparisons			
		Parallel Comparison	Own Cohort	From Literature	Total
		n (%)	n (%)	n (%)	n (%)
Total Studies		75 (33.2)	8 (3.5)	143 (63.3)	226 (100.0)
Decade of Article	1920s	5 (2.2)	0 (0.0)	2 (0.9)	7 (3.1)
	1930s	0 (0.0)	0 (0.0)	7 (3.1)	7 (3.1)
	1940s	0 (0.0)	0 (0.0)	2 (0.9)	2 (0.9)
	1950s	0 (0.0)	0 (0.0)	2 (0.9)	2 (0.9)
	1960s	4 (1.8)	0 (0.0)	15 (6.6)	19 (8.4)
	1970s	18 (8.0)	2 (0.9)	30 (13.3)	50 (22.1)
	1980s	20 (8.9)	2 (0.9)	31 (13.7)	53 (23.5)
	1990s	18 (8.0)	3 (1.3)	31 (13.7)	52 (23.0)
	2000s	10 (4.4)	1 (0.4)	23 (10.2)	34 (15.0)
Country of Corresponding Author	USA	46 (20.4)	4 (1.8)	18 (8.0)	68 (30.1)
	UK	11 (4.9)	1 (0.4)	14 (6.2)	26 (11.5)
	Australia	2 (0.9)	1 (0.4)	6 (2.7)	9 (4.0)
	India	0 (0.0)	0 (0.0)	31 (13.7)	31 (13.7)
	Malaysia	0 (0.0)	0 (0.0)	9 (4.0)	9 (4.0)
	Nigeria	0 (0.0)	0 (0.0)	12 (5.3)	12 (5.3)
	Singapore	0 (0.0)	0 (0.0)	6 (2.7)	6 (2.7)
	South Africa	5 (2.2)	1 (0.4)	6 (2.7)	12 (5.3)
	Other	11 (4.9)	1 (0.4)	41 (18.1)	53 (23.4)

Table 2 Characteristics of Studies in Articles Analyzed.

		No. studies n (%)
Total studies		226 (100.0)
Sample size	1-49	14 (6.2)
	50-99	14 (6.2)
	100-999	134 (59.3)
	1000+	64 (28.3)
Age of participants	Adults	85 (37.6)
	Children	54 (23.9)
	Both	87 (38.5)
Sex of participants	Male only	61 (27.0)
	Female only	6 (2.7)
	Both	159 (70.3)

Table 3. Claims of “White“-“Other Race/Ethnic Group” Difference in Lung Function by Decade of Publication

Decade	Other Higher n (%)	No Difference/ Similar n (%)	Other Lower n (%)	Variable¹ n (%)	Totals n (%)
1920s	0 (0.0)	1 (14.3)	6 (85.7)	0 (0.0)	7 (100.0)
1930s	1 (14.3)	0 (0.0)	6 (85.7)	0 (0.0)	7 (100.0)
1940s	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)	2 (100.0)
1950s	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)	2 (100.0)
1960s	1 (5.3)	0 (0.0)	16 (84.2)	2 (10.5)	19 (100.0)
1970s	2 (4.0)	1 (2.0)	46 (92.0)	1 (2.0)	50 (100.0)
1980s	3 (5.7)	3 (5.7)	42 (79.2)	5 (9.4)	53 (100.0)
1990s	0 (0.0)	5 (9.6)	43 (82.7)	4 (7.7)	52 (100.0)
2000s	3 (8.8)	3 (8.8)	26 (76.5)	2 (5.9)	34 (100.0)
All years	10 (4.4)	13 (5.8)	189 (83.6)	14 (6.2)	226 (100.0)

¹ The difference detected was found to be variable by age, gender, race/ethnicity, equation, spirometry method, or percentage.

Table 4. Sample Explanation by Coding Scheme

Year of Study	Site of Study	Explanation
Inherent Difference		
1922	US	These findings suggest a possible racial factor...Poverty, environment and social status, with the ensuing advantages and disadvantages...do not seem to influence the lung capacity of children.” (8 pp.1109-1110)
1968	Trinidad	Results “underline the relative importance of inherited racial characteristics rather than acquired physical attributes.” (32, p. 279)
1978	US	“The agreement between the two studies suggests that the lower FVC and FEV1 values among blacks are related to genetic rather than to environmental variables.” (16, p. 391)
1999	US	“There are known to be differences in normal lung volumes among various ethnic or racial groups. For example, lung volumes (FVC and FEV1) are about 12% lower in black subjects compared with white subjects. Similarly, normal values for several Asian populations have been shown to be lower than those for white subjects... Various explanation, such as body habitus, have been proposed for these differences, but race or ethnicity itself seems to be the determinant factors.” (33, p. 339)
Anthropometric difference		
1962	Taiwan	“Perhaps the daily habitual posture, especially the sitting habit, of Chinese makes the position of the diaphragm lower, which in turn affects the lung volume. Further studies may be indicated for proper explanation of this theory.” (34, p. 333)
1976	US	“It seems unlikely that differences in socioeconomic status would explain such consistent observations from all locations. It is also unlikely that socioeconomic factors affecting growth influenced the data because there were no significant differences in height or weight between the black and white children...In part, the racial differences in lung size may be explained by the smaller ratio of sitting height to standing height in blacks compared to whites.” (35, p. 957)
2004	US	“The reasons for these racial differences are not well defined. Differences in thoracic height and body stature have been shown to affect spirometric volumes. Orientals have been shown to have smaller lung volumes and larger sitting-to-total-height ratios than whites of the same age and height.” (36, p.1230)
Environmental and social factors		
1969	India	“Milledge et al...attributed the smaller lung volumes in Indians to climatic conditions.” (37, p. 1459)

1984	South Africa	“When subject to scrutiny, the available evidence does not support a clear thesis of racial or ethnic differences in spirometric lung functions. Moreover, fixed percentage discounting from White normal values for Blacks cannot be substantiated. Studies purporting to find ethnic determinants of FVC have generally not controlled for social confounding factors known to be strongly associated with nutritional status, respiratory morbidity and occupational exposures. Predicted values within the same ethnic group vary as widely as predicted values between groups. This variability of FVC values in the different Black populations studies implies that factors other than race are operative.” ^(17, p. 772)
2001	India	“This paper presents evidence to suggest that a well-defined component of ‘racial’ or ‘ethnic’ variation between Caucasian and Asian children may be unrelated to race per se, and could be potentially regulatable by therapeutic (dietary supplementation) or socioeconomic interventions, lending support to the hypothesis that other areas of comparative physiological disadvantage in populations should not be ascribed to racial differences, without the exclusion of poverty or health care-related, potentially treatable, aetiological mechanisms.” ^(38, p. 1303)

Technical factors

1988	US	“With the sample sizes typically available for developing prediction equations, sampling variation will remain an explanation for all but extreme differences.” ^(Coultas et al., p. 1391)
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Other

1993	Israel	“Anthropometric measurements could not explain interethnic variability in spirometric values; could be due to growth velocity.” ^(39,p. 908)
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Mixed explanations

1927	China	“It may prove that there is a larger variability in nationals of one country, caused by climate, activity and bodily build than is found between nations or races.” ^[14, p. 669]
1978	South Africa	"The reasons for ethnic differences in ventilatory function are not clear, but could relate to differences in lung elastic recoil, or to the smaller sitting-to-standing height ratio in Blacks compared with Caucasians. The differences in FEV1 and FVC between

2001 US

Coloureds and Caucasians in this study are considered to be ethnic, despite the difference in physical characteristics between the two groups, since covariance takes such physical characteristics into account....there is no evidence to suggest that malnutrition disproportionately reduces lung growth.” (40, p 546)

“Sitting height accounted for 35-39% of the race difference in both sexes. Poverty index accounted for about 7.5% and 2.5% of the racial difference in men and women, respectively, whereas the effect of education accounted for about 2% in women and 4.7% in men. With further adjustment for BMI, we could account for only about half of the racial difference in FEV1 and FVC. We conclude that the racial difference in lung function is only partially explained by a shorter upper body segment in African-Americans. Although low socioeconomic indicators are related to lower lung function, they explain only a small proportion of this racial difference...The main finding of this analysis is that we can explain only about half of the racial difference in FEV1 and FVC between white individuals and African-Americans by accounting for sitting height, BMI, and socioeconomic indices such as poverty index or education.” (41, p. 1647-1651)