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Measuring Respiratory Health in Longitudinal Social Science Surveys

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Objectively assessing respiratory health in longitudinal social science surveys would involve collecting pulmonary function measures on research participants, either in clinic settings or at home. These measures include indicators of volume (e.g., maximal amount of air blown in the first second of a forced exhalation) and air flow (maximal speed air is exhaled during a forced exhalation). Equipment options include office spirometry, portable spirometry, or home peak flow monitoring. Each option has different equipment and personnel costs. The types of research questions that could be answered using pulmonary function measures in longitudinal household surveys are quite broad, ranging from effects of socioeconomic status and race/ethnicity on respiratory health to social/environmental factors that contribute to respiratory health to the long-term social and economic consequences of respiratory health problems. Currently, such data are lacking. Given the potential payoffs in scientific knowledge, adding these measures to population-based surveys merits serious consideration.

Respiratory diseases refer to diseases of the lung and airways and range from chronic conditions such as asthma and chronic obstructive pulmonary disease (COPD) to acute conditions such as influenza and pneumonia. These diseases represent serious health problems in the United States. For example, asthma is the most common chronic illness in childhood. Approximately 9 million American youth under the age of 18 (12.5%) have had asthma during their lifetime (Dey and Bloom 2005). Furthermore, approximately 4 million American youth under 18 have experienced an asthma attack during the past 12 months (Dey and Bloom). COPD is the fourth leading cause of death in the United States (Murray and Lopez 1997). Approximately 12 million Americans are diagnosed with COPD, with a prevalence rate among adults of 6.9 percent (American Thoracic Society 2004). Furthermore, over 120,000 Americans are dying each year from COPD (<http://www.nhlbi.nih.gov/health/public/lung/copd/what-is-copd/index.htm>).

Moreover, these diseases have significant public health and economic consequences. In the United States, asthma is the third-ranking cause of hospitalizations among youth 15 years and younger (Popovic 2001), resulting in close to 200,000 hospitalizations a year (Akinbami 2006). It has been estimated that the economic impact of asthma, in terms of the annual cost of asthma care for children under 18 in the United States, lies at around \$3.2 billion (K. B. Weiss, Sullivan, and Lyttle 2000). Asthma is also one of the leading causes of school absenteeism, resulting in 12.8 million missed school days a year (Akinbami).

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COPD also has high costs, with an estimated \$38 billion in annual COPD-related medical expenses in the United States (Foster, Miller, Marton, Caloyeras, Russell, and Menzin 2006). In this article, we focus on asthma as one example of a respiratory disease with serious social and economic consequences and seek to illustrate the potential scientific knowledge that could be gained by incorporating objective respiratory health measures into longitudinal population-based surveys. Throughout the article, we will use the Panel Study of Income Dynamics (PSID) as an example to show the scientific value of collecting objective respiratory health measures in a longitudinal social science survey.

What Types of Scientific Knowledge Could Be Generated by Including Respiratory Health Measures in Social Science Surveys?

The opportunities for contributing to scientific knowledge by incorporating objective respiratory health measures into surveys that assess social and economic characteristics of respondents is four-fold. First, there is a pressing need to better understand relationships between socioeconomic background and prevalence as well as severity of respiratory diseases. Though low socioeconomic status (SES) is well known to increase risk for a variety of diseases, its relationship with respiratory diseases such as asthma has remained less clear. A number of studies find the traditional relationship, for example, of low SES or poverty being related to greater asthma (Miller 2000; Cesaroni, Farchi, Davoli, Forastiere, and Perucci 2003; Simon, Zeng, Wold, Haddock, and Fielding 2003); however, there are some studies that find the opposite, that higher SES families are more likely to have asthma (Shankardass et al., 2007). Whether this is due to differences in the types or timing of SES measures used across studies, differential access to health care, the selective nature of the samples, a lack of adequate control variables, or to differences in objective disease versus the perception of symptoms are issues that social science surveys like the PSID could help to resolve.

Second, there is the question of how social environments get translated into physical health status of an individual. The existing literature suggests that there is much clearer evidence that individuals from lower SES backgrounds have worse asthma outcomes. Lower SES children are more likely to be hospitalized for asthma, to have greater asthma symptoms, and to have more severe asthma episodes compared to higher SES children with asthma (Miller 2000; Amre, Infante-Rivard, Gautrin, and Malo 2002; Simon et al. 2003; Wood, Smith, Romero, Bradshaw, Wise, and Chavkin 2002). This is also true at the neighborhood level, such that neighborhoods with lower income levels and higher unemployment rates have higher rates of pediatric asthma hospitalizations (Goodman, Stukel, and Chang 1998; Castro, Schechtman, Halstead, and Bloomberg 2001; Claudio, Stingone, and Godbold 2006). What is still needed, however, is to develop a better understanding of the mechanisms through which SES affects asthma severity; that is, what toxic components of SES influence asthma progression. For example, SES might relate to respiratory outcomes because of neighborhood/housing conditions (e.g., air pollution), adverse family psychosocial characteristics (e.g., frequent conflicts), psychosocial stress, and/or detrimental health behaviors (e.g., smoking). Studies such as the PSID would be able to provide data to help determine which of these or other similar factors are most critical, as well as which factors interact, in explaining how SES comes to affect respiratory health outcomes.

Third, longitudinal social surveys such as the PSID provide a unique opportunity to document how environmental and social factors over time affect trajectories of pulmonary function. Researchers could also begin to ask intergenerational questions related to the predictors of respiratory health. For example, are the associations between social factors and respiratory health similar across generations? What role does genetics play in explaining

cross-generational associations? Can factors in one generation affect health in subsequent generations? What is the link between respiratory health in one generation and that of the next generation?

Fourth, another pressing issue is to better understand the social consequences of health problems such as respiratory diseases. Previous reviews have found some evidence that asthma impacts mental health outcomes as well as later employment opportunities (Milton, Whitehead, Holland, and Hamilton 2004; Chida, Hamer, and Steptoe 2008); however, conclusions from a number of studies were based on cross-sectional designs. Hence, studies like the PSID with lengthy follow-up periods could potentially be utilized to answer long-range impact questions related to the effects of respiratory diseases on educational attainment, earnings, and marriage and childbearing in adults, as well as on cognitive, social-emotional, and behavioral outcomes in children.

In the section below on research synergies, we elaborate on some of the above types of research questions that social science surveys could potentially answer with the addition of respiratory health measures; however, first we discuss measures of respiratory health and their advantages and disadvantages.

How Can Respiratory Health Be Measured?

Respiratory health can be measured subjectively (e.g., probing for symptoms) or objectively (e.g., assessing pulmonary functioning). The gold standard for assessing pulmonary function is spirometry, a test that provides an indication of both air volume and air speed during forced exhalations and inhalations (American Thoracic Society 2004). Spirometry provides an objective indication of airway obstruction and the reversibility of this obstruction (both of which are necessary for the diagnosis of asthma). Spirometry forms one important component of assessing lung impairment and is used in combination with medical histories and physical exams to diagnosis asthma and other respiratory conditions. Spirometry, in combination with symptom reports, is also used to determine severity of asthma. For more detailed information, see the report by the National Heart Lung and Blood Institute (2007).

Participants performing a spirometry assessment are asked to inhale as deeply as possible and then to exhale into a mouthpiece as hard and fast as they possibly can until the end of the test (6 seconds) or as long as possible, if they cannot reach the end of the test. Several exhalations are usually completed and saved during one spirometry session, and the best spirometry result is selected. Spirometry is typically performed by trained technicians in a clinic or hospital setting. Spirometry provides indications of the amount of air an individual is able to blow out in the first second of exhalation (forced expiratory volume in 1 second, or FEV_1). Higher numbers indicate better pulmonary functioning, because airway obstruction can decrease the amount of air one can rapidly exhale. Spirometry also provides another volume-based measure of total lung capacity during the exhalation (forced vital capacity, or FVC). In addition, it provides speed-based measures, such as the maximal speed with which air is exhaled during the maneuver (peak expiratory flow, or PEF). As well, it provides indicators such as forced expiratory mean Flow (FEF_{25-75} and FEF_{75} , which are measures of the smaller airways. As with FEV_1 , higher numbers for FVC and PEF also indicate better pulmonary functioning. Volume-based measures such as FEV_1 are considered the gold standard in pulmonary function assessment and are utilized in making a diagnosis of respiratory conditions such as asthma. Flow-based measures such as PEF are indicators of pulmonary function that can also be measured by research participants themselves but are considered a less reliable indicator.

Not surprisingly, lung properties and, hence, maximal possible air volume and speed vary with age. For example, lung capacity increases with a child's age (as the size of the lung increases; Hankinson, Odencrantz, and Fedan 1999). In order to facilitate comparison of lung function measures across people, excellent normative data have been acquired for spirometry (Morris, Koski, and Johnson, 1971; Wang, Dockery, Wypij, Fay, and Ferris, 1993). These norms provide predicted values of lung function based on age, gender, ethnicity, and height. This allows one to calculate percentage of predicted values for each individual, and it is typically these percentiles (rather than absolute values) that form the basis for comparisons.

Spirometry also allows for the possibility of assessing airway responsiveness, in addition to testing basal pulmonary functioning, as described above. Airway responsiveness or lability is a hallmark characteristic of asthma. For example, airway lability can be measured by administering a bronchodilator in between two spirometry assessments. A baseline spirometry session is conducted, followed immediately by bronchodilator administration, and after 15 minutes, a second spirometry session is conducted. Airway lability is measured as the increase in FEV₁ from pre-bronchodilator to post-bronchodilator. Individuals with asthma will often display heightened reactivity to bronchodilators. In addition, methacholine challenge tests can be used to create a laboratory model of airway responsiveness or how a participant responds to stimuli that restrict the airways. Methacholine is a drug that induces bronchoconstriction. Methacholine challenge involves a participant inhaling increasing doses of methacholine (starting from a baseline administration of saline up to a maximal dose, often 25 mg/mL methacholine) until the participant reaches the point at which methacholine produces a 20 percent decrease in FEV₁ compared to baseline (known as *provocative concentration* that reduced FEV₁ by 20%, or PC₂₀), or until he or she reaches the maximal dose. Existing protocols provide standardized procedures for methacholine challenge testing (Childhood Asthma Management Program Research Group 1999). A higher PC₂₀ indicates less bronchial reactivity, in the sense that it takes a higher dose of methacholine to produce a drop in pulmonary function. However, methacholine challenge tests need to be conducted with trained specialists and hence are not feasible in survey settings.

As an alternative to spirometry, sometimes clinicians or researchers might want to gain a better sense of a participant's pulmonary function during daily life. Peak flow meters were developed to allow for such assessments. These are portable devices that participants can use at home. Participants are coached on how to perform exhalations (similar to during spirometry), and the device displays peak expiratory flow rates following each exhalation. Typically participants are asked to perform three exhalations, and the best of the three readings is kept. Participants might be asked to record peak flows upon awakening and before bed every day for a period of weeks or months. One can examine average PEF percentage (calculated as a percentage of one's best value, with higher being better) or variability across the day in PEF percentage (higher is worse, because it indicates less stable lung functioning across the day).

Pros and Cons of Spirometry versus Peak Flow Assessment

Though both are useful for measuring pulmonary functioning, spirometry and peak flow assessment have different types of advantages and disadvantages. Spirometry is considered the most accurate method for assessing pulmonary function. This is because trained technicians are coaching participants in performing exhalation maneuvers, checking that exhalations are appropriate, editing out any bad flow-volume results, and hence insuring

that the best reading is a valid one. In addition, spirometry allows for multiple measures of pulmonary function, such as FEV₁, FVC, and FEF. The disadvantages to spirometry are that it typically has to be performed in a clinic setting, meaning that in the context of a research study, spirometers would have to be set up within close proximity to all research participants. Because participants would have to be willing and able to go to the clinic setting, this might result in selective survey samples. Furthermore, costs for spirometry are high. Equipment typically costs over \$10,000 for a single machine, and one would also need to support salary costs for pulmonary function technicians.

Peak flow assessment is considered more feasible in many circumstances. Peak flow meters range in price, but the least expensive ones typically cost \$20–\$50. Basic models provide an immediate peak flow reading after exhalation but do not have the ability to store readings. More expensive versions have the ability to store readings, as well as to query about recent medication use or other factors that might affect readings. Peak flow meters are used to get a more real-world assessment of what a participant's pulmonary function is like on a day-to-day basis. Another advantage is that they can be used by participants themselves (after brief teaching of appropriate blowing techniques). The disadvantages to peak flow meters are that these meters typically provide data only about peak expiratory flow rate and not FEV₁, FVC, or FEF, as spirometry does. Additionally, in the context of a household survey, one would need to purchase one peak flow meter for each participant who is being assessed at the same time (which, depending on the size of the study and the duration of data collection for each participant, could result in substantial costs). A second disadvantage is that unsupervised peak flow assessment can lead to unreliable results because the readings are effort dependent and require supervision and coaching. Hence, it can be difficult to disentangle whether poor peak flow readings are due to airway obstruction or due to lack of effort. Furthermore, because participants are assessing peak flow in their home environment, there is a greater possibility for other external factors (e.g., physical activity, TV or other distractions) to affect peak flow readings more so than in a standardized laboratory/clinic setting. Home peak flow readings also raise questions of compliance; that is, how reliably research participants collect readings at the times they are supposed to. Unless peak flow meters are equipped with electronic time and date stamp (raising equipment costs), one is reliant on participants to report the times and results of data collection, with the possibility that some participants may report readings for data they never collected in order to appear more compliant with the research protocol.

One recent new methodological development that bridges these two approaches is the development of portable spirometers (Mortimer, Fallot, Balmes, and Tager, 2003). These are devices that can be taken to participants' homes, allowing researchers to use a gold standard approach to measuring pulmonary functioning (spirometry) but in the convenience of research participants' own homes. It could be particularly useful in household surveys in which interviewers are already going to participants' homes. We are aware of one such study in which this is currently being implemented, the Los Angeles Family and Neighborhood Survey. Study investigators decided to purchase portable spirometers in lieu of peak flow meters and trained field interviewers in spirometry techniques (N. Sastry, University of Michigan, personal communication, November 1, 2008). The advantages of this approach are that portable spirometry assessments are more reproducible than home peak flow assessments and provide additional pulmonary data beyond just peak expiratory flow readings. The disadvantages include the time and cost involved in training field interviewers to effectively coach good

performance from research participants. One would also need to employ spirometry experts both for training and to conduct regular quality checks on the spirometry data. In addition, this type of machine would cost between \$1,000 and \$2,000, and one would be needed for each field interviewer.

Other Measures of Respiratory Health

In addition to objectively measuring lung function, there are alternative methods for assessing respiratory health. Within the self-report domain, these include reports of physician diagnoses of respiratory conditions, reports of respiratory symptoms, reports of activity limitations due to respiratory problems (e.g., school/work absences), and reports of emergency room usage or hospitalizations. Reports of physician diagnosis would provide an indication of asthma prevalence, whereas reports of symptoms, limitations, and hospitalizations would provide an indication of severity or impairment among those already diagnosed with asthma. Self-reports are advantageous for providing a window into perceptions of health and for providing information that may be difficult to obtain otherwise (e.g., certain types of activity limitations). At the same time, however, self-reports may be biased by other factors (e.g., negative mood, recall ability), and different individuals may have different thresholds for reporting symptoms or limitations, creating additional noise in these measures. Self-reports of physician diagnosed conditions may also be biased by differential access to health care across groups. With respect to physical health data, self-reports are often considered a useful complement but not sufficient in themselves, both because they are subject to reporting biases and because options exist for obtaining more objective measures that would be more credible to the medical community.

One could also utilize health care system records to provide information on respiratory health. This could include medical records of hospitalizations for respiratory diseases, physician visits for respiratory problems, and prescriptions filled for respiratory diseases. The advantage to this approach is that it provides indications of objectively verified events, eliminating the reliance on participant recall. Disadvantages include the limited nature of the information (e.g., filled prescriptions do not provide an indication of medication usage), concerns about privacy, and the fact that it provides information about extreme cases (e.g., only those who are seen in emergency departments, rather than the broader population of individuals with respiratory conditions).

Finally, other biological measures relevant to respiratory disorders such as asthma include skin prick tests, which are conducted to determine allergic status. In addition, given recent breakthroughs in genetics, saliva, buccal, or blood samples could allow researchers to assess the presence of variants in certain genes that are implicated in respiratory diseases. For example, family and twin studies indicate that genetics plays an important role in asthma, with heritability estimates around 75 percent (Duffy, Martin, Battistutta, Hopper, and Mathews, 1990). Hence, one could utilize studies such as the PSID to better understand the genetic components of asthma. In addition, the assessment of genetic information would allow researchers opportunities to test gene by environment interactions and develop more comprehensive models of the etiology of various respiratory diseases. Though the scientific potential is high, disadvantages include the added costs (sample processing, storage, and genotyping), and reluctance of many respondents to provide genetic information to researchers.

What Research Synergies Would New Respiratory Health Measures Offer?

In this section, we provide some examples of the types of research questions that could potentially be answered with the addition of respiratory health measures to social science surveys such as the PSID. First, studies such as the PSID would allow researchers to pose questions about the relationships between socioeconomic dynamics and respiratory health. For example, how do changes in income or wealth over time relate to respiratory health? Do changes over time in family income or wealth predict respiratory health in children as strongly as in adults? Given prospectively collected information across the life course in income dynamics, are there critical periods (e.g., early life) during which socioeconomic factors get embedded “under the skin” and influence respiratory health later in life? Answering these questions would allow researchers to draw conclusions about whether it is the timing, duration, or variability in SES that has the greatest impact on respiratory health. The use of repeated pulmonary measures in the PSID would also allow researchers to investigate how social and environmental factors affect trajectories of pulmonary measures over time, as other large-scale studies are beginning to do (Gauderman et al. 2004).

Second, long-running panel such as the PSID would also allow researchers to investigate the converse question: That is, what are the long-ranging impacts of respiratory health problems on children and adults. For example, do respiratory problems in children limit their educational achievement or earning potential as adults? Are individuals who suffer from respiratory problems less likely to get married or to have children? If the above types of impacts are found, what are the mechanisms in childhood that might explain them? Is it due to children with respiratory problems missing more school, or having impairments in cognitive skills or physical abilities, or experiencing behavioral problems associated with respiratory disease?

Studies that collect data across several generations of family members would also allow researchers to potentially address questions related to the intergenerational transmission of effects of SES. For example, do parents’ childhood circumstances show effects on children’s respiratory health, even over and above effects of current environments on respiratory health? The large age range of participants within the PSID also could allow researchers to address whether SES has different effects on respiratory health across the lifespan. For example, one could hypothesize that SES is more strongly related to health in older adulthood, as the prevalence rate of health problems increases. Or alternatively, one could hypothesize that there will be smaller associations of SES with respiratory health later in life because of the “healthy survivor effect,” the notion that those who survive into older adulthood are healthier to begin with and hence less susceptible to effects of social factors.

Third, race and ethnic differences have long been noted in asthma. For example, African Americans have a higher prevalence rate of asthma, a higher hospitalization rate for asthma, and the difference between African American and White hospitalization rates for asthma are growing over time (Rhodes, Bailey, and Moorman 2004; Gupta, Carrion-Carire, and Weiss 2006). Hence, researchers could determine how trajectories of respiratory health vary over time across different race and ethnic groups. Researchers could also examine the extent to which genetic factors, as opposed to neighborhood environment, family SES, or health behaviors, contribute to the ethnic differences in respiratory health problems.

Fourth, studies such as the PSID contain extremely comprehensive batteries of socioeconomic questions. This would allow researchers to determine whether associations of

SES with respiratory health vary depending on the type of socioeconomic indicator used. For example, is income or education more strongly related to respiratory health? The answer could provide clues about mechanisms. If income is related to respiratory health, this might suggest that material resources provide supports to buffer or help one cope with health problems. In contrast, if education is related to respiratory health, this might suggest that knowledge about health determines respiratory health, perhaps through the behaviors it engenders.

Fifth, social surveys could potentially inform mechanistic studies of the contributors to respiratory health. For example, data on cognitive skills, social/psychological factors, daily activities, and health behavior, such as the PSID has, could be hypothesized to serve as pathways explaining how psychosocial factors play a potentially causal role in exacerbating respiratory health. There is a large literature on the effects of psychosocial factors, such as stress, on asthma (Sandberg, Paton, Ahola, McCann, McGuinness, and Hillary 2000; Wright 2005; Chen, Hanson, Paterson, Griffin, Walker, and Miller 2006), and longitudinal social surveys such as the PSID would allow researchers to more clearly determine the directionality of these effects and track effects of the accumulation of stress over time on trajectories of pulmonary function. With this information, researchers could begin to develop causal models of how the larger social environment gets under the skin of a child to influence health and well-being.

Sixth, social surveys that include geospatial data could provide new insights into respiratory health problems. For example, physical exposures such as air pollutants are known to adversely affect respiratory health (Crain et al. 2002; Trasande and Thurston 2005; Brauer et al. 2007). In addition, psychosocial characteristics of neighborhoods, such as exposure to violence, have recently emerged as a risk factor for respiratory health problems (Wright et al. 2004). The availability of data on social and physical characteristics of neighborhoods would allow researchers to investigate the relative contributions of neighborhood characteristics to respiratory health, in comparison to other types of family or individual characteristics.

Finally, adding multiple types of biomarkers to a social survey could create synergies across the various biomarkers. For example, viral infections play a role in susceptibility to respiratory diseases such as asthma (Sigurs et al. 2005), creating natural links between respiratory health and infectious disease measures. Similarly, obesity and asthma have been linked in previous research (Gennuso, Epstein, Paluch, and Cerny 1998; Camargo, Weiss, Zhang, Willett, and Speizer 1999), creating commonalities between respiratory health and metabolic assessments. Finally, as discussed earlier, the role of genetics, and gene by environment interactions, is certainly relevant to a number of respiratory diseases (S. T. Weiss 1999), also creating links between genetic and respiratory health measures.

How Would Objective Pulmonary Function Measures Add to Existing Social Surveys?

Most social surveys already collect self-reports about health problems, and adding objective measures of pulmonary function to these surveys would provide a number of benefits. First, these objective measures would provide indications of specific biological processes that self-reports cannot capture. For example, pulmonary function readings provide an indication of obstruction in the airways, whereas self-reports of health conditions and medical treatments are broader indicators of the consequences or experience of asthma for the participant. Hence to be able to draw stronger conclusions about social factors getting under the skin and altering disease processes, one needs more objective indicators of

biological systems. Second, pulmonary function measures have the potential to inform researchers about an array of respiratory health problems, whereas, often, social surveys query only about the most common respiratory problems such as asthma. Objective assessments combined with reported diagnoses also allow undiagnosed conditions to be identified. Third, pulmonary function measures provide a much more nuanced, continuous indicator of respiratory health as compared to a dichotomous variable such as physician diagnosis of asthma. This type of variable would allow researchers to move beyond predicting just the presence or absence of disease to investigating how social factors might influence characteristics related to the severity or progression of disease.

What Measurement Issues Arise in Considering Respiratory Health Measures?

One issue that arises when considering objective health measures is whether pulmonary function can be assessed once or needs to be assessed repeatedly. Assessments at a single point in time would provide some indication of current respiratory health (although readings could be affected by acute states such as current illnesses). A one-time assessment would involve either a single clinic visit for spirometry (with multiple exhalation maneuvers conducted), a single at-home visit and using a portable spirometer, or a single set of days for recording peak flows (the typical time frame being a 2-week, twice-daily assessment). However, assessing pulmonary functioning at multiple time points would certainly create a stronger research design in which one could investigate trajectories or change in pulmonary function over time. For example, spirometry assessments could be conducted annually on a longitudinal cohort of research participants. This type of research design would provide more definitive data about directionality of effects between factors such as income dynamics and pulmonary function as well as document the persistence of such factors on pulmonary function.

A second issue is which age range of participants would be appropriate for pulmonary function assessments. Fortunately, there are well-established norms that span a wide age range from 6 to 90 years (Morris et al. 1971; Wang et al. 1993). These norms allow percentiles, rather than raw scores, to be used in analyses of pulmonary function. One advantage of using percentiles is that in a longitudinal design, as participants age, one can examine change in percentile scores over time, essentially indicating how an individual's pulmonary function compares to others his or her age over time.

Third, there is the question of whether other contextual factors need to be assessed that may affect pulmonary function measures. For example, information about medication usage is important to obtain—particularly recent use of short-acting bronchodilators, which open the airways and can temporarily improve pulmonary function. Other contextual factors that are important to assess include smoking, exposure to second-hand smoke, exposure to allergens, and presence of viral respiratory infections.

Fourth, there is the issue of how pulmonary function data are processed. Typically participants complete at least three forced exhalations during one round of assessment. Using this type of protocol, the best of the three (or more) readings is selected, based on the rationale that one is interested in a participant's best possible effort. With spirometry, because trained technicians monitor the flow-volume results and only keep valid exhalations, the best reading that is selected will reflect the participant's true best, and there will be no need for a data processor to edit values. If interviewers are conducting assessments with portable spirometers, they can be trained in selecting best results, although ideally independent review of all results would be conducted by a spirometry expert. With peak

flow, generally there is also not much post-data collection processing, although it could be reasonable to determine criteria for excluding values that appear to be outliers (perhaps due to improper technique during the exhalation). Hence, the final outcome that one would have for each time point assessment of respiratory health would be a single percentile value for each different indicator of pulmonary function (e.g., FEV₁, FVC, PEF).

Procedural and Cost Issues

Different pulmonary function assessment approaches raise different procedural challenges and have different cost implications. If an in-home interview were to be planned for the collection of a battery of biomarker measures or for other interview purposes, this would make the consideration of portable spirometry measures attractive. Portable spirometry would require one unit (\$1,000–2,000 per unit currently) per field interviewer as well as costs to train field interviewers in spirometry techniques and to undertake quality control checks on the spirometry sessions that they conduct in participants' homes. If spirometry were performed by field interviews, initial training in appropriate coaching techniques would be necessary for interviewers. An expert in reading spirometry results would be necessary for reviewing results and giving ongoing feedback to interviewers. Portable spirometers could also be used in other settings, such as school- or community-based settings.

If there are no in-home interview opportunities in the survey, one could consider arranging a clinic visit for participants to do spirometry. Clinic spirometry would require one unit (>\$10,000 per unit currently) at each center that would have to be located within driving distance from participants. Additional costs would include the cost for space (either renting space or contracting with a hospital or existing clinic), the cost of personnel (trained technicians to conduct spirometry), and as well the cost to participants in time involved traveling to participate in the study. If a clinic visit were already being planned to collect a battery of biomarkers, including spirometry could be reasonable. Otherwise, the cost of this approach is quite high.

The final option would be for participants to do home peak flow monitoring. If there are no in-person contacts planned with participants, one way to do this would be to mail participants a peak flow meter, along with a video of instructions. Participants could collect peak flow measures daily for a specified period of time and then mail back the peak flow meter (the daily measures are needed in order to obtain an indication of variability in peak flow across days). Home peak flow monitoring is the least expensive per unit (\$20–\$50 currently for the least expensive models), but one unit would need to be provided for each research participant being assessed during the same study interval. Other costs would include participant time (having to collect measures every day, rather than participate in a single-session testing of spirometry), as well as the issues it would raise related to compliance and effort. Though this approach provides the least quality control over the data, it does have the advantage of being possible within the context of a telephone survey.

Ethical Concerns

Pulmonary function measures are considered relatively noninvasive and hence do not present large ethical concerns. Though the assessments would create an additional time burden for participants, and require participant effort to complete the assessments, the data collected would not raise obvious ethical concerns for either the investigators or the participants. If desired, researchers could report results of pulmonary function tests to

participants in an easily understandable format (such as the percentage predicted value that is generated in both spirometry and peak flow). If pulmonary function values were unusually low, this might prompt some participants to follow up with a physician. There is at least one well-publicized recommendation for improving pulmonary function, which is for people who smoke to stop doing so.

Ethical issues could arise if a methacholine challenge was included in a spirometry protocol. Given that methacholine is a chemical substance that induces bronchoconstriction, it could raise ethical concerns about causing temporary discomfort, with little direct health benefit. There are also some side effects associated with methacholine including headaches, throat irritation, and lightheadedness. However, the effects of methacholine are quite temporary. For research participants with respiratory conditions such as asthma, the methacholine test is stopped once participants reach a certain reduction in their pulmonary function (even if they have not completed the full protocol of methacholine doses), and albuterol can be administered to reverse the effects of methacholine.

Conclusions

In summary, the addition of objective pulmonary function assessments to a nationally-representative, longitudinal social survey such as the PSID would provide objective respiratory health data, opening the door to generating some compelling answers to a wide variety of scientific questions. The scientific value that could be gained is large in light of the few ethical or privacy concerns that it would likely raise. Options for pulmonary function assessments include spirometry conducted in a clinic setting, portable spirometry, or home peak flow monitoring. Each has a different cost associated with it. Nonetheless, the types of research questions—ranging from effects of SES and race/ethnicity on respiratory health to the social and environmental factors that contribute to respiratory health to the long-term social and economic consequences of respiratory health problems—that could be answered are grand in scope and hence the measurement of pulmonary function merits serious consideration in social science surveys.

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