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METHODS OF MEASUREMENT

Measuring socio-economic position for epidemiological studies in low- and middle-income countries: a methods of measurement in epidemiology paper

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Much has been written about the measurement of socio-economic position (SEP) in high-income countries (HIC). Less has been written for an epidemiology, health systems and public health audience about the measurement of SEP in low- and middle-income countries (LMIC). The social stratification processes in many LMIC—and therefore the appropriate measurement tools—differ considerably from those in HIC. Many measures of SEP have been utilized in epidemiological studies; the aspects of SEP captured by these measures and the pathways through which they may affect health are likely to be slightly different but overlapping. No single measure of SEP will be ideal for all studies and contexts; the strengths and limitations of a given indicator are likely to vary according to the specific research question. Understanding the general properties of different indicators, however, is essential for all those involved in the design or interpretation of epidemiological studies. In this article, we describe the measures of SEP used in LMIC. We concentrate on measures of individual or household-level SEP rather than area-based or ecological measures such as gross domestic product. We describe each indicator in terms of its theoretical basis, interpretation, measurement, strengths and limitations. We also provide brief comparisons between LMIC and HIC for each measure.

Keywords Socio-economic factors, social class, poverty, measurement, methods, developing countries

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Introduction

Much has been written about the measurement of socio-economic position (SEP) in high-income countries (HIC).[1–7] Less has been written for an epidemiology, health systems and public health audience about the measurement of SEP in low- and middle-income countries (LMIC). The social stratification processes in many LMIC—and therefore the appropriate measurement tools—differ considerably from those in HIC due to the vast differences between HIC and LMIC, e.g. the importance of the informal economy and the lack of welfare states in many LMIC.

Whereas the investigation of socio-economic inequalities in health has a long history in HIC (with physicians identifying social class and working conditions as important determinants of health as far back as the mid-nineteenth century[8]), this is a relatively young field in LMIC (with publications beginning to appear from the late twentieth century[9,10]).[11] Several factors may have influenced the relatively low priority given to examining inequalities in health in LMIC in the recent past. Firstly, research and practice have focused primarily on raising population health status towards that of high-income settings rather than reducing within-population inequalities. Second, some researchers may have assumed universally low SEP and little differentiation among the populations of these countries. Third, many LMIC often lack effective vital registration and disease surveillance systems and collect few data on the SEP of their populations.

However, in recent years, a substantial body of literature has emerged demonstrating wide socio-economic inequalities in health in several LMIC.[12–17] As in higher income settings, disadvantaged populations in LMIC generally have poorer health than their better-off counterparts; they have lower coverage of preventative health interventions, lower life expectancy, poorer nutritional status and higher incidence of infectious diseases, though as in HICs, there are exceptions.[18]

SEP, a broad term referring to the social and economic factors that affect the position(s) individuals or groups hold within a society,[4,5] is therefore a key variable in epidemiological studies in LMIC, whether as a confounder or as the main exposure when describing health inequalities.

Many measures of SEP have been utilized in epidemiological studies;[1,2] the aspects of SEP captured by these measures and the pathways through which they may affect health are likely to be slightly different but overlapping. For example, education attempts to capture knowledge-based assets, but is strongly related to other aspects of SEP such as income and occupation,[1] and may be causally related to health through numerous pathways.[19] No single measure of SEP will be ideal for all studies and contexts; the strengths and limitations of a given indicator are likely to vary according to the specific research question. Understanding the general properties of different indicators, however, is essential for all those involved in the design or interpretation of epidemiological studies.

In this article, we describe the measures of SEP used in LMIC. We concentrate on measures of individual or household-level SEP rather than area-based or ecological measures such as gross domestic product (GDP). Glossaries of SEP measures aimed at epidemiologists have previously been published, focusing primarily on high-income settings.[1,2] This article can be considered an extension to these previous glossaries, focusing on LMIC. It should be read alongside these earlier papers,[1,2] since many issues will be common to all settings. To avoid duplication, our description of indicators common to HIC and LMIC (education, income and occupation) will only focus on aspects specific to LMIC and will refer back to the earlier papers for other details. For measures used predominantly or exclusively in LMIC, in line with the previously published glossaries,[1,2] we describe the indicators in terms of theoretical basis (theories of social stratification relevant to this measure), interpretation (aspects of SEP measured by the indicator and how they may relate to health), measurement, strengths and limitations. We also provide brief comparisons between LMIC and HIC for each measure. We have included all measures identified through a literature search and through subject knowledge of the authors that either have been used in epidemiological studies in LMIC or that we considered potentially could be used in such studies.

Asset-based measures

Theoretical basis

Asset-based measures (often called a wealth index, but referred to hereafter as an asset index) arose as an attempt to facilitate the measurement of household welfare in household surveys in LMIC.[20] Much, though not all,[21] of the theoretical and methodological development of the asset index has been based around the Demographic and Health Surveys (DHS).[22] DHS do not contain economic indicators such as income or consumption expenditure (see below), but they do collect information on ownership of a range of durable assets (e.g. car, refrigerator and television), housing characteristics (e.g. material of dwelling floor and roof and main cooking fuel) and access to basic services (e.g. electricity supply, source of drinking water and sanitation facilities). These items were all originally included in the surveys because of their potential direct influences on health; for instance, television and radio ownership was of interest to identify households receiving public health messages.[20] Staff at the World Bank, DHS and Macro International began to explore the use of a composite index of these variables to measure SEP, hypothesizing that this set of variables could be used as a general indicator of material living standards.

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They have published several methodological studies advocating the approach, including the seminal paper by Filmer and Pritchett.[23] They have since presented a series of analyses of DHS data sets from 52 countries using the asset index to quantify socio-economic inequalities in a range of health and nutrition outcomes.[13] In addition to its use for measuring SEP in existing data sets where no alternative reliable economic measures are available (for instance, the DHS and UNICEF's Multiple Indicator Cluster Surveys), the asset index approach is now widely, and increasingly, used in primary data collection in LMIC.

Measurement

Since the methodology arose from the DHS, those items included in the original DHS asset index (typically—but with some country-specific variations—electricity, water supply, sanitation facilities, type of flooring, persons per sleeping room, ownership of agricultural land, domestic servant, type of vehicle, refrigerator, radio, television and telephone[20]) are also those most commonly used by other studies.

When constructing an asset index from a set of variables, a decision must be made about the weights to assign to each indicator. The simplest method would be to sum the number of indicators each household possesses. This has the disadvantage of being arbitrary; each indicator has the same weight (one) and so is implicitly given equal value in terms of SEP. Alternative weighting methods attempt to use price information to value the items, or assign weights according to the inverse of the proportion of the population owning the item (such that rare items are given a higher weight than widespread ones).[24] Another option is to use regressions of asset indicators on other SEP measures (such as consumption expenditure from a Living Standards Measurement Survey[25]—see below) in one data set, and apply the regression coefficients as weights to form an asset index in another data set from the same country.[26]

A further option, and perhaps the most common, is to use a statistical procedure such as Principal Components Analysis (PCA). PCA is a data reduction technique; correlations between the indicators are used to generate a set of uncorrelated principal components.[27] If 10 indicators are used in PCA, 10 uncorrelated components will be created. In each component, the asset indicators are each given an 'eigenvalue', which can be interpreted as the weight by which each standardized original indicator should be multiplied to get the component score. The principal components are ordered such that the first component explains the greatest proportion of variance of the indicator variables, and each subsequent component explains a lower proportion of total variance. In other uses of PCA, it is common to use multiple components; the eigenvalues/weights of indicators within a component can be used to interpret the meaning of each component. For an asset index, however, it is common to use only the first principal component to define the asset index, since the aim is to construct a single measure of SEP.[23,28] This first principal component often explains a low proportion of the total variance in the asset indicators (often <20%).[20,29,30] Despite this, there is some evidence that principal components other than the first component are not correlated with consumption expenditure,[30] and that the inclusion of additional principal components over and above the first one in multiple regression does not improve the prediction of outcomes.[23] One concern with the use of PCA for asset index data is that almost all the asset indicators are binary or ordinal variables (e.g. owning a radio—'yes' or 'no'), whereas it is an assumption of PCA that data are continuous. If this assumption is violated (e.g. by including ordinal and binary variables), then the weights produced will be incorrect.[31] One technical solution to correct the statistical error of including binary variables in a PCA analysis is to calculate the tetrachoric (or polychoric) correlation coefficients for the binary variables and then use the resulting correlation matrix in the PCA analysis.[32]

Alternative weighting procedures for creating an asset index can result in re-ranking of households, but this has been shown in some cases to have limited consequences for agreement with other SEP measures or estimation of health inequalities.[29]

Interpretation

Asset indices measure SEP at the household level and attempt to measure the material aspects of living conditions.

Since the asset index measures SEP at the household level, the interpretation of the asset index depends on the relationship of the individual to the household. For example, it may represent the parent's SEP for children and young adults still in the family home, or the SEP of the spousal household for married women living in their husband's family dwelling.

The asset index has been claimed by some proponents to provide a rational, simple and reliable alternative to consumption expenditure.[13,23] A systematic review of the literature questioned this, demonstrating at best modest agreement between the asset index and directly assessed expenditure;[33] some investigators view this disagreement between consumption data and asset data as evidence of the superior nature of the asset index in terms of measuring welfare in the face of volatile and inaccurate consumption data.[34] There is some evidence that an asset index performs as well as a measure of consumption expenditure for assessing health inequality.[35]

The interpretation of the asset index depends upon the asset indicators included. Some investigators have included additional types of assets in an index, e.g. education,[36–40] literacy,[41] occupation or income source(s),[37,42,43] other household head characteristics,

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such as age[44,45] and gender,[46,47] land ownership,[41,48,49] livestock[41,48] and measures of food consumption expenditure.[16,50–54] In these cases, the interpretation of the index changes, since it no longer focuses exclusively on material living conditions but rather it becomes a composite index encapsulating multiple aspects/domains of SEP.

Strengths

The asset index provides a rapid and simple method for collecting SEP data, requiring relatively little interview time/questionnaire space. Whereas the underlying principles of analysis with PCA are complex, their use is simple in many statistical packages.

There is some evidence that the asset index is a more stable measure of SEP than consumption expenditure, varying less in response to fluctuations in income and expenditure and being resistant to most economic shocks.[55] This may be particularly important in LMIC, which may have greater volatility and seasonality in consumption patterns than in HIC.

The wide availability of asset index data in many studies, including comparable data across multiple countries and availability in open-access data such as the DHS, is an important strength because it facilitates comparative research; however, since the asset index is a measure of relative SEP, the bottom quintile in one country cannot be directly compared with that in another country.

Limitations

When used as a composite score, the asset index is a measure of relative rather than absolute SEP, which can only be used to assess SEP ranking within a hierarchy across a population. This is in contrast to measures, such as income or consumption expenditure, which have an 'absolute' value and can therefore, with some manipulation (e.g. currency adjustments), be compared across as well as within populations. This means that asset indices cannot be used to construct poverty lines and quantify the levels of poverty within a population in the same way as income or consumption expenditure can. Prevalence of ownership of individual assets such as access to clean water sources, however, can be used as absolute measures of the proportion of a population living in poverty and can be compared across populations.

There is some evidence that an asset index has only modest inter-observer and test–retest reliability.[56] Hence, care should be exercised when using information from asset indices for decision making, e.g. the classification of households should be confirmed before using the asset index rankings to decide which households are eligible for a pro-poor intervention.

There is difficulty in ascertaining asset quality. For example, the inclusion of non-functioning assets in the index may give a false SEP ranking. A household may state that they have a car, but the car might have been parked in the compound for >5 years and be irreparably damaged. Furthermore, it may be important to adopt a more nuanced measurement of assets in middle-income countries, where most households own durables such as televisions and refrigerators. For example, many surveys may simply report the ownership of a television but not distinguish between colour and black and white. It has been argued that for middle income or transition countries, asset indices need to be more detailed in determining the quality and nature of consumer durables.[31] Some surveys have attempted to collect data on the present re-sale value of the asset, thereby capturing both quality and age.[57] However, adjusting for quality requires that appropriate categorization is available, and adjusting for depreciation re-introduces the practical difficulties of accurate data collection that the asset index is attempting to avoid.

There has been some concern that the asset index has an 'urban bias' as it is based on assets that capture social stratification better in urban than rural settings; i.e. urban households are far more likely to have access to improved water and sanitation, have electricity supply and live in a dwelling constructed from modern rather than traditional materials compared with rural households, yet assets that rural households may have such as more access to land and livestock are less often included. This urban bias can lead to a severe lack of normality in the asset index scores; typically, we observe that either (i) a large proportion of households in rural areas of very poor countries have the same score (zero or very low) because they own none or very few of the assets included in the index or (ii) a large proportion of households in urban areas of higher income countries are assigned the same score (high) because they own all of the assets included in the index.[20,28] This has the potential to misclassify 'rich' households who live in 'poor' rural areas as relatively impoverished and vice versa.

In an attempt to address these concerns about the conflation of household- and area-level influences, recent DHS questionnaires have included a wider range of asset indicators (e.g. basic furniture items and windows). Guidance has also been produced about the possible options for constructing/analysing asset indices separately for urban/rural areas, including the option of basing urban and rural indices on differing sets of indicators and scaling these so that a single index can be used that ensures comparability between urban and rural areas.[58] Similar guidance has not been produced to address concerns about the ability of an asset index to differentiate between urban households in upper middle-income countries, where the vast majority of households own key domestic goods (i.e. colour television, vacuum cleaner, washing machine, sound system and refrigerator) and have access to piped water and electricity. Linked to

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the concerns about urban bias, many of the items traditionally included in an asset index are provided at the community level, for instance, water supplies; the asset index has been shown to be more strongly associated with community-level infrastructure than other SEP measures, including consumption expenditure.[59] This has led some authors to argue that asset indices should focus on consumer durable data and eschew data on living conditions such as water and energy access,[34,60] although restricting the number of asset indicators is also problematic since sufficient variables are required to differentiate among the population.

The ability of a specific asset-based measure to differentiate levels of SEP is likely to vary across LMIC and over time within a country, due to variations or changes in the availability of some assets. Therefore, different indices may be required in different countries and within a country over time, but this is problematic for research aiming to compare inequalities across countries or examine changes in inequalities over time.

Some of the assets included in the index, in addition to capturing social stratification, may be associated with a health outcome because they measure a specific mechanism of the disease aetiology. For example, water supply or sanitation facilities can be associated with increased risk of certain infections.

Comparison with use in HIC

The specific asset-based measures already described were developed primarily for use in LMIC, although household amenities or assets have been used in HIC to measure early-life SEP when other indicators were not available.[61] Assets, such as access to a car and ownership of telephones, washing machines and colour televisions, form an integral part of the European Union's 2020 poverty measure.[62] Asset measures have also been used as a component part of the Dutch Leefsituatie (Life Situation) index since 1974.[63] This index was developed by the Social & Cultural Planning Office (SCP) to measure the progress of Dutch society and subsequently used for resource allocation. Weights were initially derived using PCA but due to concerns about the use of PCA with non-normally distributed data, non-linear canonical correlation analyses are now used to derive weights.[64]

The types of assets used in the two settings clearly differ and even where they are similar they may be differently weighted (where proportional weights are used) between LMIC and HIC. For example, car ownership is relatively rare in many LMIC but is now common in HIC households; the reverse may be true for bicycle ownership.

Consumption expenditure

Theoretical basis

Consumption expenditure attempts to capture the extent to which a household can meet its material needs, by measuring how income is used by a household—what goods and services are purchased. A summary measure of the amount of various goods and services purchased (or home produced) by a household within a set timeframe is calculated and adjusted for an estimate of the household's needs based on the number of people (see Measurement section for more details). Consumption is considered an alternative to income, since it measures how income is actually used. Data on consumption are preferred (by some) to data on income, as they are seen as being more stable over time than income. The theoretical basis for this is Friedman's 'permanent income hypothesis', which suggests that there are two dimensions of income: (i) planned and anticipated and (ii) current income.[65] Planned and anticipated income is referred to as 'permanent income'. Friedman argued that individuals and households base their consumption decisions primarily on their permanent income (i.e. their longer-term income expectations) rather than on their current income. An example of this would be that a medical student may exercise higher consumption than a nursing student, even holding family background constant, since the former anticipates a higher long-term income. According to this theory, consumption is 'smoothed' in response to fluctuations in income, for example by utilizing savings, borrowing against anticipated income or, for more long-lasting shocks, selling assets. In addition, large irregular incomes such as bonuses might be at least partially saved. Thus, consumption is viewed by some as preferable to income, since households will, for example, attempt to regulate their consumption of food throughout the year, regardless of seasonal influences on income or food availability.

Measurement

Consumption expenditure is measured by summing expenditures on a wide range of items to form an aggregate measure of total expenditure. The concept of consumer expenditure is most frequently used in the analyses of national accounts and this 'consumer spending' often accounts for a large proportion of GDP in HIC. It is defined as personal expenditure on goods (durable, semi-durable and non-durable) and services, and thus does not include expenditure on buying a dwelling (i.e. capital expenditure), business expenses, tax payments or interest payments on loans or mortgages (i.e. transfer expenditure).[66] Detailed definitions are provided in the internationally agreed *Final Consumption Expenditure of Households by Consumption Purpose* (COICOP) classification.[67]

Household surveys and expenditure diaries can be used to collect data on household expenditures. In some circumstances, expenditure diaries can be used to collect data prospectively. In this case, each member of a household may be asked to complete a diary of all expenditures each day for a certain period (usually a month or less). The period of data

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collection must be sufficient to overcome the 'prestige effect', whereby expenditures fluctuate according to time in relation to receipt of income, etc.[68]

Due to the difficulties of diary methods of consumption expenditure data collection (see Limitations section), they may be unfeasible for most research in LMIC. Consumption expenditure data collection methods have therefore been developed for large household surveys in LMIC. A long list of potential expenditure items is included on the questionnaire and respondents are asked to report frequencies and quantities of purchases, as well as expenditure amounts over a specified recall period. Since home-produced goods and goods received in kind are particularly important in many LMIC, these are also included in the questionnaire. Their values in terms of cash expenditures must then be estimated. This is often done using a price index; market price data are collected for each item across different regions, adjusted to remove the estimated costs of transport and distribution that do not apply to home produce so as to give farm-gate rather than market-gate prices, and subsequently applied to estimate the expenditure value of the home-produced goods for each household.[69]

An equivalence scale is often used to adjust the aggregate expenditure for the number of household members, for example by dividing expenditure by the total number of household members, or incorporating economies of scale such that each additional household member results in a slightly lower cost.

Due to the length of time required to collect full consumption expenditure data, it is often not deemed feasible to collect expenditure data within an epidemiological study. In an attempt to address this, Morris *et al.*[70] demonstrated when using data from Côte d'Ivoire that it was possible to identify a list of just 10 expenditure items that, when summed, correlated highly with a full expenditure measure ($r = 0.74$; items were expenditure on loans, purchase of transport, funerals, expenses related to the home, purchase of cloth, school costs, vehicle repairs and expenses, public transport, purchase of medicine and books and other school equipment). This method does, however, necessitate country-specific analysis of a large data set containing full expenditure data in order to identify the most appropriate items; the Living Standards Measurement Surveys conducted by the World Bank may be an appropriate data source for some LMIC.[25]

Interpretation

Consumption expenditure measures a household's ability to meet (or exceed) their material needs and to access services. Due to consumption smoothing in response to income fluctuations, it should theoretically be a measure of long-term SEP, i.e. combining past, present and anticipated future SEP.

Multiple types of expenditure (e.g. food, health and transport) are often combined into an overall summary measure, but if sufficiently detailed data are collected, it is possible to separate these out. The inclusion of health expenditures in a summary measure is debatable. Large expenditure on health treatment may indicate poor health, but does also reflect an ability to pay for the health care. Expenditure on preventative health interventions also demonstrates an ability to pay for the intervention, but does not indicate current ill health.

Strengths

Consumption expenditure attempts to measure a key aspect of income—i.e. how it is used. Consumption expenditure provides an assessment of long-term SEP and the value of services provided by material assets (i.e. the imputed rental value of owner occupation of dwellings) and there is a degree of consensus among development economists about the value of measuring consumption expenditure rather than income, particularly in low-income country research.[69]

There is evidence that consumption expenditure can be estimated using a fairly short list of items, thus reducing the costs of data collection.[70]

Limitations

Limitations of diary methods of consumption expenditure data collection. Diary-based data collection necessitates repeat visits to households to ensure that they are completing the diaries correctly, and often has considerable loss to follow-up potentially leading to selection bias.[68] It also requires the respondents to be literate (although pictorial diaries can be used to help where there are literacy difficulties), and responses may be influenced by the repeat visits of researchers (i.e. a Hawthorn effect).

Limitations common to all methods of consumption expenditure data collection. As for other methods of data collection on socio-economic factors, consumption expenditure data may suffer from misreport. This may be because respondents may not recall accurately, or because they do not wish to accurately disclose certain types of consumption expenditure.

An additional problem in some settings is in estimating the value of home-produced goods and those received in kind. These estimations might introduce bias for a variety of reasons. For instance, produce retained by households for own consumption could be of differing quality to that sold on at markets.[69] The imputed values of home produce have been shown to be less variable than expected, potentially leading to the underestimation of poverty and inequality.[69]

Data collection for expenditures often involves data being collected from a single household member to

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represent the entire household. Thus, the respondent may be unaware of some household expenditures. In addition, consumption is unlikely to be equally distributed across household members, and some expenditures may be shared across the broader extended family. Summary household measures will be unable to explore these issues.

Although stability of expenditure over time (particularly in comparison with income data, see below) is seen as a strength of this measure, seasonality remains an issue for both purchased and home-produced goods, but is perhaps most likely to affect rural households.[68] Despite consumption smoothing, consumption expenditure has been shown to vary considerably over time.[23] Recall periods will affect the impact of seasonality on the final consumption aggregate, e.g. recall periods used in the questionnaire should differ for items consumed soon after harvest and those stored for gradual use.[68] Living Standards Measurement Surveys (large nationally representative surveys conducted with assistance from the World Bank[25]) often ask about a 'typical month', and also ask how many months per year the food is typically consumed.[69] The choice of recall period can, however, have a huge impact on the final measure; one study in India demonstrated that switching from a standard 30-day recall period to a shorter 7-day recall period resulted in an apparent lifting of a staggering 175 million people above the poverty line due to higher reported food expenditures.[71] The appropriate recall period may vary for different expenditure items. For instance, whereas food expenditures are incurred on almost a daily basis, rent and school fees may be paid just once in a year.

The length and detail of the questionnaire can also affect the measure; there is evidence that a long and detailed list of consumption products jogs respondents' memories and encourages them to recall more expenditure.[72]

It may also be unclear what sorts of expenditures should be included, i.e. large irregular expenditures, such as funerals and weddings, health expenditures; and so on. It is difficult to capture the effect of preferences when measuring consumption expenditure for instance, someone who chooses to be a vegetarian is not the same as someone who cannot afford to buy meat, but it would be difficult to capture this. The choice of expenditure items to include in a measure may vary across settings. Finally, a number of significant assumptions are required to calculate the aggregate measures; for example, decisions about how to adjust a measure of consumption for household scale (i.e. the choice of equivalence scale) are complex and can have a large effect on the final measure.[69]

Comparison with use in HIC

Consumption expenditure in HIC has been used by economists to monitor spending on particular types of item, e.g. alcohol,[73] health-related items[74] or food,[75] and has primarily utilized diary-based measures. To our knowledge, expenditure has not been used as a measure of SEP in studies examining inequalities in health outcomes in HIC.

Education

Theoretical basis

Much of the theoretical basis of education as a measure of SEP is common to LMIC and HIC;[1,2] theoretical aspects of education are reviewed, with a specific focus on LMIC, by Buchmann and Hannum.[75,76]

Measurement

As for HIC, education is usually measured in terms of years of formal education completed, qualifications attained or literacy.[1,2]

Within LMIC, repeating school years may be more common than in HIC,[77] which may affect the choice between measures of educational milestones (e.g. completion of primary or secondary school) and measures based on the number of years spent in school. Using a continuous measure of years of education completed assumes that every year spent in education has an equal incremental contribution to SEP; therefore, when school years are repeated, this measure assumes that repeating a school year confers the same benefits as progressing through the school system. Whether this assumption is likely to hold will depend on many factors, including the health outcome under study.

Measures of literacy[78] may also be used; these reflect skills obtained through education. Literacy can be measured through direct assessment of literacy (and numeracy) skills or via self-reported skills (e.g. reported ease of reading one page in a given language, or ability to read a newspaper); direct assessments may be more accurate, with self-reports tending to result in higher estimates of literacy, but data collection will clearly be more intensive.[78]

The International Stratification and Mobility File (ISMF) is a sociology project seeking to harmonize data on social mobility across 52 countries, including both HIC and LMIC.[79] The project has developed harmonized indicators of level of achieved education that can be compared across countries. For each data set included in the project, education variables in the source data are recoded into ordered categories using documentation for the data set, expert advice and the associations of educational variables with occupation and income within that country. These categories are then mapped onto a 'virtual years of schooling' metric, which is closely related (in some files identical) to the number of years it takes competent students to reach a given level. Details of the recoding for each of their included data sets are available on their website.

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Interpretation

Education can be measured either for an individual, for a parent, or for the household head. Mostly, education can be interpreted in the same ways in both LMIC and HIC.[1,2] The interpretation of education-based measures may differ for some populations who grew up under communist regimes, e.g. in Eastern Europe or Cuba. Under communism, greater educational attainment raised social standing but did not result in higher income. Studying the populations of former communist countries may, therefore, help to untangle the causal effects of education and income.[80]

Education is strongly related to health through multiple pathways. Increases in education in LMICs are thought to be an important contributor to improving health; for instance, up to half of the dramatic reductions in child mortality observed between 1970 and 2009 may be attributable to increased educational attainment in women of reproductive age.[81]

The potential limiting effects of ill health in childhood on educational attainment may be particularly important in LMIC, where malnutrition and infectious diseases remain widespread.[82] For example, using malaria eradication campaigns in Paraguay and Sri Lanka as quasi-experiments suggests that reducing malaria infections has a causal effect on increasing educational attainment and literacy.[83]

Strengths

The strengths of education as a measure of SEP are similar for both LMIC and HIC.[1,2]

Limitations

In addition to those general to LMIC and HIC,[1,2] cohort effects and gender differences are likely to be of particular importance in LMIC. The ease, cost and social expectations of educational attendance vary across time and between places. In most LMIC, educational standards are improving over time and a higher proportion of both boys and girls are attending school. Gender differences in school attendance persist in some, though not all,[81] settings and this can make it difficult to differentiate gender from SEP inequalities or examine differences by gender in the association of SEP with any given outcome.

As already noted, when years of completed education are used, if no account is taken of repeating school years and this varies by other characteristics or between subpopulations, it will be impossible to fully differentiate between associations reflecting education or these other characteristics.

Comparison with use in HIC

In general, LMIC are less likely to have universal freely available education and rates or duration of participation in education may tend to be lower in some (but not all) LMIC compared with HIC. As such, education will reflect childhood family SEP more so in LMIC than in HIC. Unlike most other measurements of SEP that rely on report in questionnaires or at interview, in several HIC, it is now possible to obtain educational attainment from routine data sources by linking study participants to, for example, the National Pupil Database that provides attainment at key stages (ages 7, 11, 14 and 16 years) for all English children attending maintained schools. This is not possible in most LMIC.

Income

Theoretical basis

The theoretical basis of income is similar in both LMIC and HIC.[1,2]

Measurement

In middle-income settings such as many South American countries, income can be measured in ways similar to those in HIC.[1,2,84] In low-income countries, however, income is more difficult to measure due to greater reliance on the informal economy, self-employment and seasonal activity. Depending on the setting, casual and seasonal labour may be more common than formal employment, whereas multiple jobs and home enterprises may be prevalent. Households may have multiple sources of income, home production may be important, income may vary substantially between seasons or years and income may sometimes be in the form of goods. Income is generally recorded at the household level, and adjusted for household size and composition using an equivalence scale. The household head (or in some cases, their spouse) is often the only person interviewed to ascertain a measure of total household income. This may, however, lead to bias; one study in Malawi demonstrated that a husband's report of his wife's income agreed with her own report in just 6% of households.[85] Remittances from family members who have migrated to urban areas or overseas are also an important consideration, and where relevant, social support and pensions from the government or other sources should also be included. Generating income can have costs to the household in terms of lost home production.

Proxies for income are sometimes used in high-income settings, e.g. council tax band in the UK, but suitable proxies may be more difficult to identify in LMICs. Income tax payments can also be linked to individuals through national identity numbers and administrative registers in some HIC, but this is generally not possible in LMIC as such identity numbers and registers do not generally exist.

Interpretation

Income can be measured for an individual, a parent, a total household or the household head. The interpretation of income measures is generally similar for both LMIC and HIC, attempting to measure material aspects of SEP.[1,2]

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The bidirectional relationship between income and health may be particularly important in LMIC, where the lack of social security systems in many places may lead to ill health having particularly negative impacts on income.[86,87]

Strengths

The strengths of income measures are similar in both LMIC and HIC.[1,2]

Limitations

In addition to limitations common to both HIC and LMIC,[1,2] the reliability of income measures may be questionable in LMIC with a strong informal economy due to the measurement difficulties outlined above.

Comparison with use in HIC

In HIC, income is less likely to vary across seasons, although some seasonal variation in incomes is also likely in some occupations in HIC (e.g. tourism and farming). Income in HIC is also less likely to come from multiple sources for a single individual/household, be paid in kind with goods or services, or come from the informal economy (although again these issues cannot be completely excluded from HIC). Official data on income (e.g. through taxes) are less likely to be available in LMIC. Measurement issues and, therefore, reliability concerns will differ between HIC and LMIC.

The interpretation of income in capitalist societies is generally related to access to material goods and services. Under communist regimes, however, income may allow certain privileges, not substantially altering someone's SEP. In these settings, social status and access to goods of restricted availability can be conferred using contacts, favours and goods exchange. The interpretation of income is also likely to be more complex in swiftly growing economies, such as China and Vietnam, where income distributions are changing rapidly,[88] and in the mixed economies of some transition countries.

Occupation

Theoretical basis

Although some aspects of the theoretical basis of occupation-based SEP measures may be the same as those in HIC,[1,2] there will be differences in some settings. In many LMIC, formal employment is rare and casual labour and small home enterprises are more common.[89] The relationship of occupation with prestige and income is therefore likely to be different that in HIC.

Measurement

In addition to the aspects of measuring occupation common to all settings,[1,2,90] different methods for classifying occupations in LMIC are needed. Informal employment (including subsistence farming) and domestic work are common.[89] Various definitions of informal employment exist; the most common definitions include the following aspects: (i) ease of entry; (ii) reliance of indigenous resources; (iii) family ownership of enterprises; (iv) small scale of operation; (v) labour-intensive and adapted technology; (vi) skill acquired outside the formal school system; and (vii) unregulated and competitive markets.[89] The term 'informal employment' is controversial to those who claim that boundaries between formal and informal employment are increasingly blurred.[91] For example, short-term casual workers in a factory or on a large farm may not meet many of the criteria in the above definition.

DHS surveys include harmonized occupation-based social class measures for many countries, which include subdivisions of types of agricultural activity; categories are generally (with some country-specific variations) classified as professional, technical and managerial; clerical; sales or services; skilled manual; unskilled manual; household domestic; agricultural—own land; agricultural—family land; agricultural—rented land; agricultural—other; or other.[22] DHS surveys also frequently capture employer and source of income, with categories such as self-employed, earns cash; self-employed, does not earn cash; works for others, earns cash; works for others, does not earn cash; works for relative, earns cash and works for relative, does not earn cash.[22]

Some investigators in Latin America proposed and tested operational classifications of occupational social class based on employment status, type of occupation, income and number of employees[92] or participation in the labour market, ownership of the means of production, qualification of the workforce and income.[93]

The ISMF (see Education section for details) has also developed harmonized occupation variables for each of the 52 countries included in the project.[79] The variables include whether or not an individual is self-employed, how many subordinates they have in their workplace and employment type based on the 1968 categories of the International Labour Office 1968: *International Standard Classification of Occupations*.

Interpretation

In general, the interpretation of occupation-based measures will be similar in LMIC and HIC.[1,2] However, jobs involving exposure to hazardous substances or hard labour may be more common. Also, prestige aspects of occupation may differ in settings where there is little in the way of a formal economy. The occupation of a household head is commonly used as a measure of SEP of the whole household, although individual measures of occupation are also possible. Where child labour is prevalent, this may be theorized to adversely affect health through preventing school attendance,[94] or through exposure to physically strenuous or otherwise hazardous working conditions.[95]

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The interpretation of occupational measures for women will depend on the societal norms for women's employment.

Strengths

The strengths of occupation-based measures will be similar in both LMIC and HIC.[1,2]

Limitations

In addition to limitations common to all settings,[1,2] the greater complexity of occupational life in many LMIC compared with the majority of people in HIC makes occupation difficult to measure in LMIC. People may have multiple jobs, be reliant on casual/temporary jobs or employment may be seasonal. In some countries, many households rely on subsistence farming or small home enterprises. The need to differentiate small farmers to accurately identify their social status and the difficulty of determining if farmers are commercial, subsistence or managing even less than subsistence has been recognized for African countries.[96] The application of simple occupational classifications may then be quite difficult and, without a careful interpretation, broad categorization of occupation, such as 'farmer', may not be the best indicator to measure social stratification. Categorizations of occupations must be context specific.

Comparison with use in HIC

LMIC governments often collect far fewer data on their populations than HIC; this is true of occupation where death certification and labour force surveys are uncommon.

Rapid urbanization[97] means that labour force participation is likely to change with time in LMIC more rapidly than in HIC.

The lack of social support and employment rights in many settings may mean that ill health is more likely to lead to unemployment in LMIC compared with in HIC. In addition, child employment may be relevant in some LMIC.[95]

Participatory wealth ranking

Theoretical basis

Participatory techniques such as participatory wealth ranking (PWR) are widely used in health and development programmes in the field, but relatively little used in epidemiological research. The basic principle of the approach is that community members rank the wealth of households in their community. The precise implementation can vary to incorporate a number of stages such as focus group discussions and sorting techniques, where participants use cards representing households in their community to rank them in terms of SEP or sort them into piles of poor, less poor or richer.[98] The method is based on the premise that individuals within a community are best placed to understand the social hierarchy of their own community and that other survey-based measures can be highly inefficient for data collection and analyses to solve problems and make programmatic decisions.[99]

Measurement

PWR requires the participation of community members, usually recruited opportunistically, assisted by an external facilitator. As an example, steps in the data collection process might include the following: (i) recruit four to six participants; (ii) map and generate a list of households within a defined community boundary; (iii) discuss meanings of wealth and poverty in the community with participants; (iv) ask participants to rank households from poorest to wealthiest within each category; and (v) repeat the process with different groups of community members until an agreement is reached.[100] Generally, the size of the area to be considered in any given wealth ranking process should be small enough for it to be likely that a group of four to six participants can estimate the wealth of each household—100 households may be typical.[98] Although each ranking procedure in a given area can only provide a relative score for each household in relation to others in the area, there has been some work to show how over multiple processes, data can be collected and used to help generate a relative score that can be compared across areas.[98]

Interpretation

PWR is generally applied to measure SEP at the household level. In contrast to other SEP measures, community members generate the wealth distribution in PWR. Thus, it is they who weight the relative importance of different aspects of SEP in defining the hierarchy. Through the data collection process, the facilitator can both provide guidance as to the aspects of SEP most important to a given study and gather information about how the community members rank these different aspects, thereby assisting with interpretation of the final measure.

Strengths

Participatory methods incorporate the community's own perspective of SEP rather than an external standard. PWR is, therefore, capable of capturing locally relevant concepts of social stratification, since community members themselves generate the rankings and provide the information about why households were ranked in a particular way. This feature of the process may mean that participants can consider the multiple aspects of SEP and how they interact with or balance each other. It also enables insight into the socio-economic processes being captured by the final measure. Despite the potential for different participants to consider different aspects of SEP important, in one study in South Africa a very high degree of correlation was seen between the ranks given to households by three independent groups of participants.[100]

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Limitations

Researchers have reached varying conclusions about the level of agreement between PWR rankings and other SEP indicators, with some concluding strong correlation[101] and others concluding that the agreement was weak;[100] differences in methodology make comparisons between the studies difficult.

Individual PWR processes can only be conducted in relatively small, defined geographical areas within which community members are well placed to rank the SEP of their neighbours. As described above, there has been some work to support the pooling of data from across multiple rankings, and it is also possible that PWR could be combined within cluster-sample surveys.

The acceptability of the process of PWR has received little attention in the literature, although it is possible that the activities involved could be uncomfortable for some participants. This may be particularly difficult in some areas, where the concept of a homogeneous community is far from the reality. Participatory appraisal then has the problem of dealing with groups affected by fundamental conflict, and faces the challenge of ensuring that all categories within the community are heard.[102]

The ranking process in PWR is complex and arguably non-transparent. It can also be inefficient, since the process by definition yields a rank for all households in a cluster—but this may not be an efficient design for sample or case–control surveys.

Finally, because PWR is only based on external perceptions, there may be a tendency for the process to rank households higher that more visibly display their wealth level to their neighbours or for visible assets such as cars to have a particularly large influence on ranking procedures.

Comparison of use with HIC

To our knowledge, PWR has not been used in HIC.

Subjective measures

Theoretical basis

'Subjective' measures of SEP are where the research participants themselves are asked to rate their own position in the socio-economic hierarchy, in contrast to 'objective' measures where the researcher determines the individual or household's SEP based on data. For example, a subjective measure of income would ask, 'is your income sufficient to meet your household's needs?' whereas an objective measure could ask, 'how much is your income each month?' It has been argued that subjective measures may 'more accurately capture subtle aspects of social status', i.e. they may encapsulate the net effect of a variety of socio-economic factors that reinforce or counteract each other.[103] In addition, they allow the research participants to direct the process of SEP quantification, rather than imposing preconceived notions and assumptions about the important socio-economic processes for a given population.

Measurement

Various subjective SEP indicators are available. One example is an Economic Ladder Question (ELQ).[104,105] A pictorial ladder is presented to respondents, with the bottom step representing the 'most poor' and the top step representing the 'most rich'. Respondents are asked which step they feel they stand on. Other examples of subjective SEP indicators include measures of perceived consumption adequacy,[106] and questions about whether income is sufficient to meet the household's needs.[59] Respondents are asked to rate, on a sliding scale, the extent to which their household's food, clothing, housing, income, etc. meet their needs.

Interpretation

Subjective measures can be used to measure either individual or household SEP. The exact interpretation of the measures will vary depending on the type of indicator used. Arguably, the social stratification processes underlying subjective measures are unclear, although several studies have provided insight into the range of factors that affect an individual's rating of their SEP. Two separate studies have shown that consumption expenditure is highly predictive of perceived consumption adequacy, and that poverty rates are similar using the objective and subjective consumption data.[106,107] These studies also demonstrated that a wide range of other indicators tend to predict subjective consumption adequacy, including household size, educational levels of household members, employment of household members, health of household members, average community expenditure and region.

Subjective measures have been shown to be associated with a range of health outcomes in both HIC and LMIC,[108] independent of objective indicators.[109,110]

Strengths

SEP measures allow respondents to rank their own overall socio-economic conditions based on various factors that may reinforce or counteract each other.[103]

Limitations

A potentially important limitation is that we do not know how well people are able to rank their own SEP against that of others. Subjective measures require the assumption that there is inter-person comparability of question interpretation, i.e. a given question response means the same thing to all respondents in terms of SEP. The distribution of subjective measurement error may be highly differential, with rich people tending to make themselves lower and poor people tending to make themselves higher. In addition to differential measurement error, this can also result in the majority of a study sample placing themselves in the middle of the distribution and hence difficulty in assessing

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associations with any outcome. One study using data from Malawi demonstrated that over 40% of the households placed themselves on the bottom step of an ELQ, despite wider discrimination by other SEP measures.[59] Another potential limitation of subjective measures is that they can be manipulated by the respondent. If individuals feel they could gain from reporting low SEP, it would be very easy for them to do so and very difficult for the interviewer to verify.

Comparison with use in HIC

In Europe, different subjective methods of measuring SEP were developed independently by various groups.[111–113] All of these studies use a minimum income question designed to measure the smallest income required to live 'decently' or 'adequately' or to 'get along'. However, the exact wording of the minimum income question varies considerably in different studies. Empirical studies have shown that estimates of the subjective SEP position usually rise systematically with the actual income of the household/individual.[114] However, subjective measures of SEP are not very widely used in HIC or LMIC, although there are examples of subjective measures of financial difficulties being used in epidemiological studies in LMIC.[115,116]

In HIC, there is some evidence that most people tend to rank themselves in the middle of the distribution;[117] in LMIC, this lumping of SEP scores may be more likely to focus on the bottom end of the distribution.[59]

Region- and country-specific measurements of SEP

Whereas many articles describing the measurement of SEP in general, or in HIC, have focused on global measurements, there are some measurements that are unique or more commonly used in some countries or regions. The Indian caste system is perhaps the best known and most characterized region-specific SEP measure. It is a social stratification system of groups called Jatis (self-governing, closed communities), which are hereditary and cannot be changed across an individual's life course. There are a large number of Jatis, which have been grouped into four broad categories (varnas): Brahmins (priests), Kshatriyas (warriors), Vaishyas (traders and merchants) and Shudras (menial jobs).[118] Those outside the caste system are referred to as Harijans, previously called 'untouchables', and have the lowest social standing. A further way of categorizing the castes, which is now used within India to direct certain policies, is into Scheduled Castes, Scheduled Tribes, Other Backward Classes (all disadvantaged groups) and General Castes (non-disadvantaged castes).[119]

Caste remains an important line of social division in India, although modern governments have attempted to redress this through a system of Reservations (positive discrimination), whereby a certain percentage of places in higher education, public sector jobs and political positions are reserved for Scheduled Castes, Scheduled Tribes and Other Backward Classes.[120,121]

There are caste-based health inequalities in India, although there is some evidence that these are largely explained by socio-economic differences (measured by an asset index)[122] and that caste neither modifies nor fully explains adult educational differences in child mortality.[123]

Caste systems are evident across the Indian subcontinent (e.g. in Pakistan, Bangladesh, Nepal and Sri Lanka), in Asia (particularly Japan and Korea), in many African countries (such as Nigeria, Cameroon and Senegal), in Arab countries (such as Yemen) and also in South America, where the term 'caste' originated.[124,125]

In the Soviet Union, an important determinant of SEP was membership of the *nomenklatura* or bureaucratic class. The state monopoly of trade enabled scarce goods to be reserved for allocation to such favoured persons.[126] Other examples of measures of particular importance in specific regions/countries would include particular groups who suffer from marginalization, such as the Roma across Europe[127] or Black people under Apartheid in South Africa.[128]

Conclusions

We have discussed key measures of SEP that might be deployed in LMIC, identifying where these have particular methods or considerations that differ from those in HIC. In both HIC and LMIC, SEP can operate at multiple levels: individual, household, community and even wider. In this article, we have focused on individual and household measures. In all studies, it is pertinent to think about which level(s) are most appropriate. In many studies, it will be relevant to consider multiple SEP indicators, since they can have independent influences on health and since this can improve the control for socio-economic confounding if this is the goal of the analysis.

Some other issues are of particular relevance to LMIC. A key issue is data availability due to the lack of centrally collected data in many settings. SEP measures must generally therefore be included in primary data collection for epidemiological studies rather than obtained from government sources. The casual, seasonal and volatile nature of economic activity is another particularly stark difference, which will have consequences for research in many LMIC. Despite this, it is important to note that many upper middle-income countries now have economies very similar to HIC and will be able to use similar measures of SEP. Cohort effects may be particularly important for many SEP measures in LMIC given that development and urbanization are resulting in rapid changes to the socio-economic structures in many settings. Other important considerations for measuring SEP in LMIC include how to capture the SEP of those living in slums and other temporary accommodation, strong

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regional and urban–rural differences and how migration between such accommodation and regions might influence assessment of SEP in one area at one point in time. For example, if education is assessed in an urban area but there is no information in the study regarding whether most of the participant's childhood was spent in that urban area or in a rural area, lower educational attainment may reflect a wide range of characteristics related to being brought up in a rural area (including potentially lower levels of dietary energy intake in infancy and childhood) over and above any measure of SEP.

We have attempted to review the literature (although this article is not intended to be fully comprehensive) on the available methods of SEP measurement in LMIC, but we acknowledge that our article has focused primarily on English-language literature. The aim of this article is not to suggest that one method of assessing SEP in LMIC is better than another, but rather to provide epidemiologists with the necessary information to determine what might be the most suitable measurement, or the strengths and limitations of a range of measures, for their research questions in the setting where their study will be conducted and considering the available resources.

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KEY MESSAGE

- The strengths and limitations of SEP measures differ between high- and low-/middle-income countries.
- We describe the measures of SEP used in LMIC, describing each in terms of its theoretical basis, interpretation, measurement, strengths and limitations.

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