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Enriching tuberculosis research by measuring poverty better: a perspective

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Abstract

The relationship between poverty and tuberculosis (TB) is well-documented, as socio-economic deprivation constitutes a risk factor that drives TB transmission and progression while hindering treatment adherence. Despite the importance of controlling for socio-economic status (SES) in TB research, no universally accepted tool exists to measure multidimensional poverty's impact on TB-affected households. This article provides an overview of existing SES assessment tools, including income-based measures, wealth indices like the Demographic and Health Survey (DHS) and the International Wealth Index (IWI), and multidimensional indices, such as the global Multidimensional Poverty Index (MPI). Each method's strengths and limitations are considered, particularly in light of the complex deprivations relevant to TB. Recognizing the distinct SES determinants of TB, we emphasize the need for multidimensional, standardized SES measures that are contextually relevant and feasible for TB epidemiology, programmatic evaluations, and translational research. By advancing poverty metrics in TB studies, the global community can better address socio-economic drivers of TB and prioritize pro-poor interventions, fostering equitable health outcomes.

Keywords Tuberculosis, Poverty, Socio-economic factors, Global health

Background

The relationship between poverty and tuberculosis (TB) has been long recognized. Indeed, Sir William Osler described TB as "a social disease with a medical aspect." [1] Although TB can affect anyone, regardless of income or wealth status, studies have found a higher incidence of TB in the bottom economic quintile in Mongolia, Myanmar, Tanzania, Viet Nam, and India, and among the multidimensionally poor compared to the non-poor in India [1–3]. Economic inequalities often create circumstances that facilitate negative health outcomes, especially in the context of TB. Cramped living conditions and reliance on homeless shelters may increase the risk of transmission [4, 5]. Food insecurity increases the risk of undernutrition, which blunts the innate and adaptive immune response to TB and fuels disease progression [6]. Further, reduced health access and the need to prioritize wages over one's health can delay diagnosis and hinder engagement with the months-long therapy for TB [7]. Lower educational attainment among impoverished populations also increases the risk for TB stigma [8, 9]. As such, socio-economic deprivation is a critical determinant and consequence of TB incidence and treatment outcomes.

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Defining and measuring deprivations alongside TB incidence, treatment, and prevention may further our understanding of TB transmission by providing insights into the social clustering that may drive TB risk among specific groups instead of assuming homogenous mixing and transmission. Additionally, controlling for deprivation is essential to avoid unmeasured confounding and obtain meaningful results for studies of therapeutic and preventive interventions for TB. Furthermore, understanding the differential impact of TB interventions such as TB screening, novel therapeutics, new vaccines, and social protection on individuals with different degrees of deprivation can help us conduct extended cost-effectiveness and distributional analyses which inform policy [10]. For instance, such analyses can help us differentiate the impact of a social protection package on individuals across the socio-economic gradient and lead to progressive health investments that maximize the limited resources available to national TB programs.

There is no single, universally accepted assessment for capturing socio-economic deprivation. Traditional poverty measures may not capture the specific socio-economic vulnerabilities of TB-affected households. We need individual and household-level assessments of deprivation to meaningfully account for socio-economic differences. This article seeks to draw attention to the current tools and their strengths and shortcomings.

Monetary indicators

The most common approach to measure deprivation is poverty assessment based on total household income or consumption expenditure. The first poverty measure in the US, for example, was developed in the 1960s [11] and determined deprivation against a predefined "poverty threshold." This threshold was defined as "*the cost of a minimum adequate diet multiplied by three to allow for other expenses*" [12]. The US monetary poverty measure only considers pre-tax cash income, while other forms of income are not included in poverty calculations. Such country-specific poverty measures have limited applicability in global contexts, due to different currencies, prices, poverty lines, and variation in how data on income and expenditure are collected and documented across countries. On the global stage, the World Bank's international poverty line is a measure that allows for cross-country comparisons [13]. It uses purchasing power parities to harmonize world currencies into a comparable unit [14]. The extreme poverty line was updated in 2022 to $2.15 per day per capita at 2017 purchasing power parity [13]. Though this measure is helpful for large-picture, international comparisons, like country-specific poverty measures, it cannot assess individuals' unmet needs that transcend unit income per day. Monetary poverty is thus a rather crude and imprecise unidimensional proxy for the many forms and dimensions of poverty and deprivation [15, 16]. Markets are imperfect, and many goods, services, and needs are non-marketable and hence not adequately captured by money metrics. In addition, monetary measures alone may not adequately capture the economic status of people with tuberculosis (PWTB) as they tend to overlook informal income sources and non-monetary assets that are crucial to livelihoods, particularly in low-and-middle income countries (LMIC) economies [17].

Like in the US, extreme monetary poverty lines are often anchored in the notion of basic food or nutrition baskets (representing minimum caloric intake and/or dietary diversity) that may be augmented by costs of additional non-food necessities, such as clothing and shelter. Instead of relying on useful, but limited monetary proxies, another family of approaches thus seeks to measure deprivation of sufficient nutrition or other basic needs directly.

Food security and diversity indicators

Food security refers to a household's consistent access to sufficient, safe, and nutritious food to meet dietary needs for an active, healthy life [18]. While food insecurity is often driven by insufficient purchasing power, it is not exclusively linked to income and may also be influenced by factors like local food availability, social support, and cultural practices. The US Agency for International Development's household food insecurity access scale (HFIAS) and Food and Agriculture Organization of the United States' (FAO) Food Insecurity Experience Scale (FIES) are widely used tools to assess the prevalence and severity of food insecurity within households [19, 20]. The HFIAS consists of nine questions addressing food-related challenges experienced in the past 30 days, including anxiety over food availability, reduced meal quality, and instances of going without food. The FIES is an eight-question assessment on food-related behaviors and experiences associated with food access challenges.

These assessments do thereby not fully capture nutritional adequacy, as households may satisfy hunger with low-cost, energy-dense foods that lack essential nutrients, potentially leading to hidden malnutrition [21]. Supplementing the food insecurity scores with additional measures, such as household dietary diversity scores, can help provide a fuller picture of both food security and nutritional status [22]. A dietary diversity score reports the number of different food groups consumed by a household or individual over a specific period, providing insights into dietary quality and access to essential nutrients. However, assessing dietary diversity requires conducting dietary recalls, which can be time-consuming

and require trained staff. These dietary measures can offer a robust assessment of food access and quality, which is especially relevant for understanding the needs of PWTB and their household members [6]. We have included case report forms for HFIAS and a modified dietary diversity score in the supplementary materials, which have been used in an ongoing nutritional intervention study in Southern India [23]. (Additional Files 1 and 2) Food insecurity and dietary diversity scores provide valuable insights, especially in light of the link between undernutrition, immunodeficiency, morbidity, and mortality, but limit our attention to one specific aspect or consequence of socio-economic deprivation.

Wealth indices

Another approach relies on the construction of wealth indices. These are particularly prominent in applications where information on income or expenditure is not readily available, which is frequently the case in health-related studies based on household survey data. Wealth indices capture or proxy a family/household's living standard, for example by tabulating the value of assets and debts. Wealth indicators vary greatly depending on the global context and change over time. One of the most widely used wealth indices is the Demographic and Health Survey (DHS) wealth index. It was first created in 1998 by Filmer & Pritchett and has become a convenient approach to measuring deprivation through data on material living standards, including asset ownership, housing materials, sanitation, and access to drinking water [24]. Like other wealth indices, it utilizes principal component analyses (PCA) to derive weights of different assets or material living conditions, providing a differential value for each possessed asset [25]. Once calculated, households are then placed on a scale of relative wealth and categorized into wealth quintiles accordingly, indicating their ordinal degree of deprivation.

Dirksen et al. outline several limitations of wealth indices like the DHS wealth index [26]. For one, they are purely relative and examined in entirely ordinal distributional terms. Their numerical values have no direct interpretation and cannot be scrutinized against the equivalent of an absolute poverty threshold. An additional drawback of the DHS's PCA approach is that it only uses the first principal component returned in the analysis. The first component does not always capture much of the observed variance, which may jeopardize accuracy.

Furthermore, the purely endogenous nature of measurement effectively creates a different index for each survey it is applied to. Doing so does not allow for disaggregation and means that results are not comparable across time and space. Another concern is the uncertainty that the wealth index captures things of societal importance in the studied population. Because weights will be driven exclusively by the distribution of a variable and its joint distribution with other variables included in the PCA, normative importance is virtually irrelevant. For example, there may be widespread agreement that having access to safe drinking water is a basic necessity; however, its association with other indicators of deprivation may be low and it could thus end up with a meager weight as per PCA. It is possible to run PCAs on a set of deprivations that align with the stated priorities of community members, but these may not be comparable across communities and would not be immune to other limitations of wealth indices, such as incomparability across time and space; relative, ordinal measurement; no direct interpretability regarding an underlying concept of absolute socio-economic status or deprivation; and no guarantee that societal values and priorities are appropriately captured in endogenously derived weights of deprivations. Despite their shortcomings, wealth index scores are still widely used as deprivation indicators, which may lead to underestimating or miscategorising true deprivation.

Recognizing these issues, several versions of wealth indices developed in years since the creation of the DHS wealth index have attempted to address some of its limitations. The International Wealth Index (IWI) has been proclaimed to be the first asset score of deprivation allowing for cross-country comparisons [27]. Validity assessments of the IWI demonstrate stability and a solid correlation to life expectancy, human development index score, and gross national income in low & middle-income countries [27]. However, this approach diverges from PCA's original purpose by constraining endogenous identification and assuming comparability across varied socio-economic contexts, which can obscure local relevance. Yet, the IWI retains all other limitations associated with PCA-based relative wealth ranking rather than absolute poverty measurement.

Martel et al. introduced the polychoric dual-component (P2C) wealth index in 2021 as an alternative to the DHS index to address its urban bias [24]. The P2C index ensures that all assets will contribute positively to the wealth score, whereas in PCA, only certain assets contribute, and the effect of others is masked [24]. While the P2C index may correct for some biases, it also introduces new analytical complexities and does not resolve PCA's foundational limitations for informative deprivation measurement. As TB disproportionately affects urban populations, particularly in dense urban centers, indices like the P2C may offer improved precision in urban settings aligned with initiatives like Zero TB Cities [28]. However, like the other wealth indices discussed, it

retains constraints that warrant consideration of alternative or complementary methods to meaningfully measure poverty in its many dimensions across both urban and rural populations, within and across countries, and across time.

Multidimensional poverty indices

Socio-economic deprivation encompasses more than just monetary or material deprivation and inadequate nutrition. Multidimensional poverty indices (MPIs) thus seek to capture poverty in all its forms and dimensions, also including deprivations related to education, health, employment, social protection, agency, etc. MPIs consider a person as "poor" based on the degree to which they experience a critical share of simultaneous, normatively weighted deprivations across multiple dimensions of poverty. Multidimensional poverty indices are a whole family of measures at the national, subnational, and international level, based on the same method of index construction [29]. Dozens of countries have developed MPIs as official permanent statistics and policy-tools, and more are being developed. MPIs are also reported as official Sustainable Development Goals (SDG) indicator 1.2.2, which are global objectives developed by the United Nations in their path to the eradication of poverty [30, 31]. Among other things, they are also used to track trends in multidimensional poverty and socio-economic deprivation over time. India's MPI, for example, showed that 135 million people escaped multidimensional poverty between 2015–16 and 2019–22 [32]. MPIs also allow for the comparison of the socio-economic status of geographically distinct populations and other subgroups, enabling the design of targeted policies and interventions.

Analogous to the World Bank's extreme poverty line, the United Nations Development Programme and the Oxford Poverty and Human Development Initiative annually publish the global Multidimensional Poverty Index (global MPI) since 2010 [33]. Using surveys that gather a wide variety of indicators, the global MPI measures deprivations across three dimensions of poverty – health, education, and living standards – for more than 6 billion people across more than 100 countries [34].

Poverty indicators must inform the specific issue being studied and deprivations captured should be commonly accepted as necessities in the given society [35]. Routine revisions and updates to poverty measures are thus needed so that they reflect important societal changes. Monetary poverty lines are periodically updated to be re-aligned with changes in composition and prices of items in food and non-food basic needs baskets. The global MPI, too, was updated in 2018 (from its original 2010 formulation) to align with the SDG (the original formulation was aligned with the millennium development goals). Similarly, MPIs that are official statistics in countries around the world are sometimes updated after several years to better capture changing societal realities and to accommodate new available data.

Multidimensional poverty measures such as MPIs are motivated by conceptual frameworks around quality of life or deprivation thereof, such as basic needs, human rights, or the capability approach [36]. They also subsume or align with other approaches, including participatory poverty assessments or operationalizations of the Sustainable Livelihoods Framework (SLF), among many others [36]. Combined, formal measurement methods and inclusive participatory processes can help achieve more relevant, contextualized poverty measurement to inform evidence-based, localized policies and interventions. Community and civil society engagement is essential in developing meaningful and legitimate poverty assessments, also for TB-affected populations. Participatory processes can help gain insights into priorities of individuals and households in their unique contexts [37]. Involving community voices not only enhances the relevance of poverty measures but also provides a more nuanced understanding of socio-economic status and deprivation that resonates with those most affected. For instance, TB patient cost surveys frequently reveal that conventional indicators of poverty may not accurately capture the experience of financial hardship or vulnerability caused by TB [38]. Co-developing poverty metrics with communities can bridge this gap, resulting in more accurate, context-sensitive tools that better inform TB interventions. One way of doing so is to select indicators of deprivations for MPIs through participatory processes, as has been the case in numerous academic studies and also in country-level MPIs that are used as official poverty statistics [35]. Thus-informed multidimensional poverty indices usually look different than the global MPI, because they seek to capture deprivations that are relevant to the specific priorities and contexts within a country or community, rather than aiming at international comparability and standardization. They could then also be tailored specifically to the needs and priorities of populations at risk or affected by TB.

Previous studies have established the global relationship between multidimensional poverty (as measured by the global MPI) and TB incidence [39] and TB patient costs and multidimensional poverty, according to South Africa's MPI [40]. In addition, they showed the association between an adapted version of Viet Nam's MPI and different groups of TB patients in Viet Nam [41] and identified multidimensional poverty as the factor most commonly associated (as both determinant and consequence) with multidrugresistant TB infections in India [42]. Furthermore, they found TB to be more prevalent

among the multidimensionally poor than the non-poor across India [3].

The SLF, too, offers a multidimensional, community-informed approach to assessing the socio-economic impacts of TB on households [43]. Originally developed through community engagement for use in agroforestry research, the SLF assesses five core 'capital' assets within households—human, financial, physical, natural, and social capital—capturing both financial and non-monetary dimensions that communities often identify as essential to resilience. For example, TB may reduce human capital by limiting a person's ability to work, while also straining social capital due to stigma, which can erode essential support networks. Financially, households may adopt reversible strategies like reducing meal frequency, or irreversible strategies like selling property, both of which threaten long-term resilience [44]. Further, the SLF may be able to capture some social impacts of TB such as stigma [43]. However, the role of SLF in TB research remains unclear as it has not yet been widely implemented and validation is needed in this context. There are also concerns about subjectivity in the indicators selected and comparability across settings.

Data collection and availability

Any poverty measure is only as good as the data that are used to calculate it. Appropriate data and measurement algorithms are determined by the purpose of the poverty measure. This includes the concept of poverty it seeks to operationalize, which population it is meant to serve, and how it is meant to be analyzed and used for monitoring, policies, and interventions. Data collection is expensive and may not always be feasible due to time and resource constraints.

Large-scale international and country-level poverty measurement efforts – both unidimensional and multidimensional—rely primarily on household survey (and sometimes on census or administrative) data. These include international survey efforts such as the DHS, the United Nations International Children's Emergency Fund's Multiple Indicator Cluster Surveys (MICS), or World Bank sponsored Household Income and Expenditure Surveys or Living Standards Measurement Studies (LSMS) surveys, in addition to numerous surveys conducted by statistics offices around the world [45, 46]. Such surveys collect detailed information on income, consumption, education, health, housing quality, and other aspects of socio-economic status through extensive individual, household, and community level questionnaires. They thus provide rich information that can be used to calculate representative statistics of poverty and deprivation. Where they also include or can be linked to information on TB incidence, treatment, or prevention (which is not always the case), they can thus be useful resources for TB researchers interested in conducting secondary data analyses at larger-scale subnational, national, or international scale [3, 39].

However, their implementation is resource-intensive and often requires significant time and logistical coordination, with data collection sometimes extending across multiple visits to each household over a year to account for seasonal variation. Some household surveys are collected at quarterly intervals, but others updated at longer intervals of 3–5 years. Where the population of interest is a smaller community or where data from the latest household survey are feared to be somewhat outdated, relying on data from household surveys may thus not be the preferred approach.

TB also produces an economic shock to the households it afflicts, and the treatment extends for months, and even years. It is important to recognize that the economic impact of TB on households and individuals is not likely to be uniform throughout treatment. Therefore, it is wise to collect economic data at several points such as treatment initiation, end of the intensive phase, end of treatment, and even at a 6–12 month interval after completing treatment. This is only possible through longitudinal surveying that revisits the same individuals and households across time. Few household surveys are set up this way, and larger-scale efforts of this kind are not only time and resource intensive, but also prone to attrition.

Furthermore, while all of the poverty measurement methods discussed can, in principle, assess deprivation at either the individual or household level, in practice, most poverty measures (monetary poverty, wealth indices, and multidimensional poverty indices) aggregate data at the household level and generalize findings to all individuals within the household. This aggregation, while practical, can obscure critical intra-household dynamics—such as gender disparities in resource allocation and access. To some extent, this can be recovered by auxiliary analyses of gendered and other intra-household inequalities and individual-level analyses. Indeed, there have been efforts to disaggregate global MPI data by household head gender and to uncover intra-household and individual-level inequalities in select deprivations. But household survey data constraints usually do not allow comprehensive poverty measurement at the individual level [47, 48]. For instance, in TB-affected households, women may experience differential food insecurity or have fewer income-generating opportunities compared to men, yet these nuances are often lost in household-level data. These approaches underscore the need for careful consideration of poverty measurement in TB research, balancing the practicality of household-level data with the potential

for deeper, more personalized analyses of deprivations' impact on individuals within households.

For small *n,* clinical, more locally confined community-level, or more urgent measurement efforts, TB researchers looking to investigate links to socio-economic status can (time and resources permitting), also embark on their own data collection, as done for MPI measurement among TB patients in South Africa and Viet Nam, for example [40, 41]. Such efforts can also use techniques from participatory poverty assessments and the sustainable livelihoods framework, as discussed above. They can furthermore often take the relevant survey modules from existing, pre-tested household surveys to implement unidimensional or multidimensional poverty measurements in their settings. Especially for monetary poverty measures, however, simplified survey assessments often come with greater measurement error. An alternative method are scorecard approaches that have been developed to proxy monetary poverty status through short surveys in various settings. The poverty probability index (PPI) [49] is one such example of a short 5–10 min survey, which uses scorecards about asset ownership and basic living conditions to estimate the likelihood of living in monetary poverty. Such approaches, as well as participatory assessments, can also be used to inform multidimensional poverty measures – be it a new index tailored to the specificities and priorities of the population in question, or a poverty statistic in line with an official national indicator or the global MPI, for which a short questionnaire has already been developed [50].

Selecting the right poverty measure(s)

A quick PubMed search of the 100 most recent observational TB studies revealed that 69.7% did not incorporate any SES indicators in their analysis. Among the studies that included SES, 6.7% used composite SES indices such as the Kuppuswamy scale (Upper, Upper middle, Lower middle, Upper lower, and Lower) or the BG Prasad classification (Class I, II, III, IV), 13.1% assessed income as a marker of SES, 10.1% incorporated education as a proxy for SES, and 3.0% used homelessness as an indicator of SES. Additionally, some studies combined multiple metrics, such as income and education, to assess SES, indicating variability in the methodologies employed. Importantly, no study used an MPI or a wealth index to measure SES comprehensively. These findings highlight a significant gap in the use of standardized and multidimensional poverty measures in TB research, despite the recognized impact of poverty on tuberculosis outcomes. (Fig. 1, Additional File 3: Table S1).

Multidimensional indices are adept at capturing deprivations determining TB risk and therapeutic outcomes across different regions as they integrate many determinants of TB and health more broadly. Like others, we believe that the global MPI offers a comprehensive approach to assessing deprivations across health, education, and living standards, making it well-suited for TB research in large-scale international settings [39]. For country, community, or study specific purposes, official government MPIs, or pre-existing MPIs for similar purposes and populations may be more useful [40, 41].

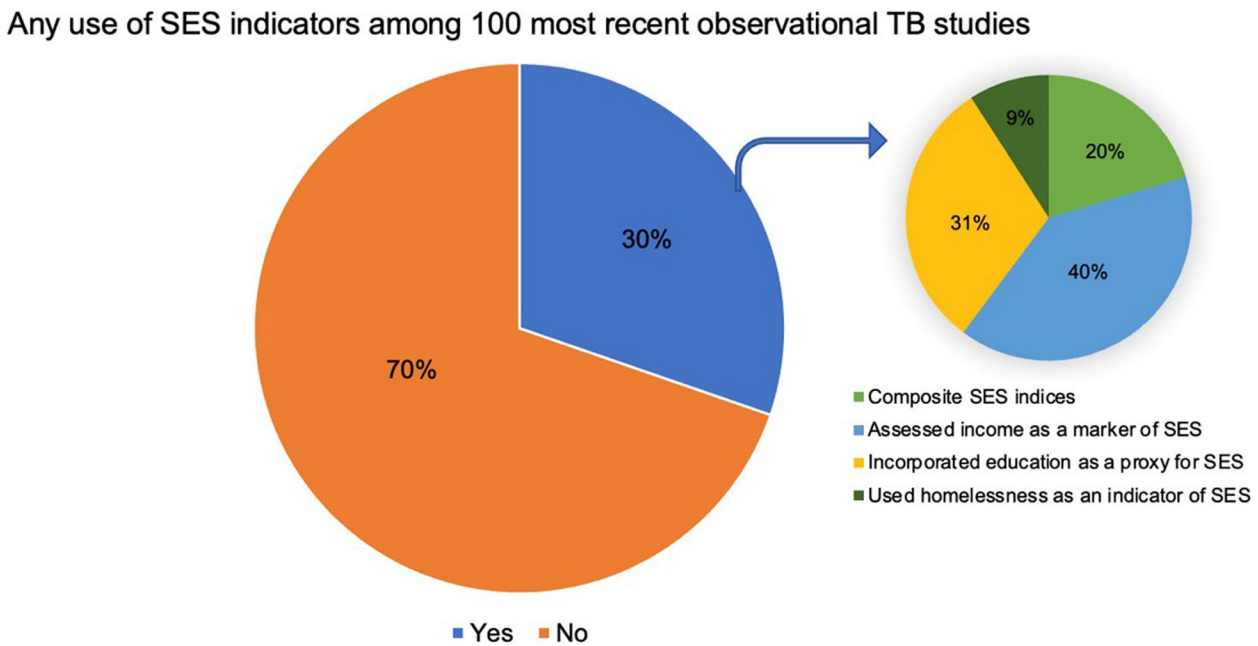

Fig. 1 Percentage of SES indicators among the 100 most recent observational TB studies and the percent of SES markers utilized

In the supplementary material, we have included a case report form (CRF) for MPIs, featuring links and additional references to Stata code to construct global MPI indicators for over 100 countries and multiple points in time, as well as a Stata toolbox that allows for the design and calculating of MPIs and auxiliary statistics generally. (Additional File 4) Estimating an MPI from scratch does require training of research personnel, which may not always be feasible, especially in programmatic research settings. We have included references to step-by-step guidance on how to design and calculate MPIs in the CRF [31, 35, 36, 50–55].

As discussed above, data collection, too, is time and resource consuming. However, for most countries, the global MPI relies on readily available household survey data (DHS and MICS), so that other researchers can apply provided statistical codes to these datasets for their own analyses. Where data are not available, outdated, or where the measurement purpose prescribes a different data source or multidimensional poverty index, researchers may want to consider the feasibility of collecting their own data and aligning the measurement structure with country or population-specific MPIs, as in Erlinger et al. and Vo et al. [40, 41].

Importantly, multidimensional poverty indices are not a substitute for other poverty metrics, such as money metrics or indicators on food security and nutritional status. On the contrary, they either complement or subsume such indicators. The global MPI and many country-level MPIs include indicators on undernutrition and food insecurity, for example, and either include or complement assessments of insufficient purchasing power [31, 35].

While wealth indices that use PCA are sometimes used as proxies for socio-economic status, they have limited scope in linking to TB-specific factors, such as housing quality and health access, in addition to their additional methodological and empirical shortcomings addressed above, particularly interpretability and comparability across time and space.

In the future, frameworks like the SLF may offer additional ways of locally adapting multidimensional measurement approaches [43]. Given the urban predominance of TB, particularly in densely populated, informal settlements, frameworks such as the Domains of Deprivation Framework could be useful in capturing the complex socio-economic and environmental factors that influence TB transmission. This framework's layered approach—spanning household, community, and area levels—offers a tailored way to address urban-specific risks and deprivation [56]. Together, these frameworks represent promising, adaptable tools for future TB research, although further validation and context-specific adaptation are essential for their effective application.

Discussion

TB is famously a disease of poverty. Factors such as an individual's built environment at work and home, their ability to acquire nutritious food, their ability to seek diagnosis promptly and remain engaged in intrusive TB care for months without jeopardizing their livelihood all determine their odds of developing TB and surviving it. To truly understand the epidemiology of TB and the effectiveness of our novel tests, drugs, and vaccines, we must account accurately for deprivation in our analyses.

To appropriately account for the impact of socio-economic factors on TB-related outcomes, we need robust metrics that transcend unidimensional measures such as income, wealth, and consumption indices. While these instruments have been and remain useful tools, we need to capture the full extent of poverty and a wide range of living conditions worldwide. TB research should thus explore indicators reflective of TB awareness, food security, living in a well-ventilated and uncrowded home, access to health services through insurance, ability to travel to health services, access to inexpensive loans to cope with catastrophic expenses, and sick leave.

Conversely, applying multidimensional indicators can also help us better understand the impact of TB on the economic health of PWTB and their households beyond what catastrophic health expenditures, an End-TB strategy metric, alone can reveal [7, 57]. By incorporating dimensions such as food security, housing stability, and asset depletion, multidimensional indicators capture how TB affects not only immediate healthcare costs but also long-term household resources and well-being. This approach can provide a fuller picture of the socio-economic consequences of TB, and can help policy makers identify the best social protection interventions for their local context.

Further, given the bidirectional relationship between TB and poverty, we must consider how working towards SDG1 (zero poverty) also contributes to TB elimination efforts that are prioritized in SDG3 (good health and well-being). Indeed, multidimensional poverty indices are the official indicator for SDG 1.2, monetary poverty measures are the indicators for 1.1. Notably, PCA wealth indices are not used as indicators for SDG 1. Enhancing deprivation measures in TB research and aligning them to those used for SDG1 can make the linkage between SDG 1 and 3 clearer and encourage cross-cutting collaborations to reduce both TB and poverty [39].

While poverty measures like the DHS wealth index and the global MPI provide valuable socio-economic insights, their direct association with TB distribution at global, national, and sub-national levels merits further empirical investigation. Currently, there are only few studies that specifically apply these measures to understand

TB incidence and outcomes, leaving an evidence gap in how effectively they capture the socio-economic drivers of TB in various settings [3, 39, 40]. Future research could explore whether more contextually tailored poverty measures – such as MPIs specifically designed to include deprivations most relevant for TB affected populations [41], offer improved accuracy in identifying at-risk populations. This presents a promising direction for TB research, where empirically testing these indices may provide a clearer understanding of their utility in capturing TB-specific vulnerabilities.

Conclusions

To move forward effectively, it is essential to ensure that socio-economic data is consistently collected in epidemiologic, translational, programmatic, operational, and policy research on TB. Further, we must foster agreement within the TB community on adopting a common standard for assessing and accounting for SES in analyses to enhance the comparability of our findings. Measuring problems is also the first step towards addressing them. We hope that as the global community better understands the severity of deprivation that affects households impacted by TB, it will prioritize social protections and pro-poor actions to alleviate their suffering.

Abbreviations

CRF	Case report form
DHS	Demographic and Health Survey
Global MPI	Global Multidimensional Poverty Index
HFIAS	Household food insecurity access scale
IWI	International Wealth Index
LMIC	Low-and- middle income countries
MICS	Multiple Indicator Cluster Survey
MPI	Multidimensional Poverty Index
P2C	Polychoric dual component
PCA	Principal component analyses
PWTB	People with tuberculosis
SDG	Sustainable Development Goals
SES	Socio-economic status
SLF	Sustainable livelihood framework
TB	Tuberculosis

Supplementary Information

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Additional file 1. HFIAS CRF.

Additional file 2. Dietary Diversity CRF.

Additional file 3. PubMed results.

Additional file 4. MPI STATA code and references.

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Authors' contributions

CC and PS conceived of the initial idea for the manuscript. CC drafted the primary draft of the manuscript. All authors contributed significantly to the editing and revising of the manuscript. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1 Fanning A. An ethical consideration of TB: still "a social disease with a medical aspect"? Int J Tuberc Lung Dis. 2008;12(3):229 Oxlade O, Murray M. Tuberculosis and Poverty: Why Are the Poor at Greater Risk in India? PLOS ONE. 2012;7(11):e47533.
2. Siroka A, Law I, Macinko J, et al. The effect of household poverty on tuberculosis. Int J Tuberc Lung Dis. 2016;20(12):1603–8.
3. Pathak D, Vasishtha G, Mohanty SK. Association of multidimensional poverty and tuberculosis in India. BMC Public Health. 2021;21(1):2065.
4. Ortblad KF, Salomon JA, Bärnighausen T, Atun R. Stopping tuberculosis: a biosocial model for sustainable development. Lancet. 2015;386(10010):2354–62.
5. Moss AR, Hahn JA, Tulsky JP, Daley CL, Small PM, Hopewell PC. Tuberculosis in the homeless. A prospective study. Am J Respir Crit Care Med. 2000;162(2 Pt 1):460–4.
6. Dauphinais MR, Koura KG, Narasimhan PB, et al. Nutritionally acquired immunodeficiency must be addressed with the same urgency as HIV to end tuberculosis. BMC Global Public Health. 2024;2(1):4.
7. Sinha P, Carwile M, Bhargava A, et al. How much do Indians pay for tuberculosis treatment? A cost analysis. Public Health Action. 2020;10(3):110–7.
8. Abebe G, Deribew A, Apers L, et al. Knowledge, health seeking behavior and perceived stigma towards tuberculosis among tuberculosis suspects in a rural community in southwest ethiopia. PLoS One. 2010;5(10):e13339.
9. Shivapujimath R, Rao AP, Nilima AR, Shilpa DM. A cross-sectional study to assess the stigma associated with tuberculosis among tuberculosis patients in Udupi district, Karnataka. Indian J Tuberc. 2017;64(4):323–6.
10. Verguet S, Kim JJ, Jamison DT. Extended cost-effectiveness analysis for health policy assessment: a tutorial. Pharmacoeconomics. 2016;34(9):913–23.
11. Bureau USC. The history of the official poverty measure. 2022. https://www.census.gov/topics/income-poverty/poverty/about/history-of-the-poverty-measure.html.
12. Bureau USC. Characteristics of the population below the poverty level: 1980. 2021. https://www.census.gov/library/publications/1982/demo/p60-133.html.

13. The World Bank. Fact sheet: an adjustment to global poverty lines. 2022. https://www.worldbank.org/en/news/factsheet/2022/05/02/fact-sheet-an-adjustment-to-global-poverty-lines#2. 2024.
14. Bank W. Fact sheet: an adjustment to global poverty lines. 2022. https://www.worldbank.org/en/news/factsheet/2022/05/02/fact-sheet-an-adjustment-to-global-poverty-lines.
15. Evans M, Nogales R, Robson M. Monetary and multidimensional poverty: correlation, mismatches, and a combined approach. J Dev Stud. 2024;60(1):147–70.
16. Our World in Data. How does extreme monetary poverty compare to multidimensional poverty? 2024. https://ourworldindata.org/grapher/share-extreme-poverty-vs-share-mpi-poor.
17. Howe LD, Galobardes B, Matijasevich A, et al. Measuring socio-economic position for epidemiological studies in low- and middle-income countries: a methods of measurement in epidemiology paper. Int J Epidemiol. 2012;41(3):871–86.
18. Mbow CC, Rosenzweig LG, Barioni TG, Benton M, Herrero M, Krishnapillai E, Liwenga P, Pradhan MG, Rivera-Ferre T, Sapkota FNT, Xu Y. Food Security. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems 2019.
19. Coates J, Anne Swindale and Paula Bilinsky,. Household Food Insecurity Access Scale (HFIAS) for Measurement of Household Food Access: Indicator Guide Washington, D.C.: Food and Nutrition Technical Assistance Project, Academy for Educational Development; 2007.
20. Food and Agriculture Organization (FAO). Voices of the hungry - the food insecurity experience scale. 2024. https://www.fao.org/in-action/voices-of-the-hungry/fies/en/.
21. Hoddinott JFY, Yisehac. Dietary diversity as a food security indicator. International Food Policy Research Institute; 2002.
22. Becquey E, Martin-Prevel Y, Traissac P, Dembélé B, Bambara A, Delpeuch F. The household food insecurity access scale and an index-member dietary diversity score contribute valid and complementary information on household food insecurity in an urban West-African setting 1,2. J Nutr. 2010;140(12):2233–40.
23. Cintron C, Narasimhan PB, Locks L, et al. Tuberculosis—Learning the Impact of Nutrition (TB LION): protocol for an interventional study to decrease TB risk in household contacts. BMC Infect Dis. 2021;21(1):1058.
24. Martel P, Mbofana F, Cousens S. The polychoric dual-component wealth index as an alternative to the DHS index: addressing the urban bias. J Glob Health. 2021;11:04003.
25. Bingenheimer JB. Wealth, wealth indices and HIV risk in East Africa. International Family Planning Perspectives 2007.
26. Dirksen J, Pinilla-Roncancio M, Wehrmeister FC, et al. Exploring the potential for a new measure of socioeconomic deprivation status to monitor health inequality. Int J Equity Health. 2022;21(1):56.
27. Smits J, Steendijk R. The International Wealth Index (IWI). Soc Indic Res. 2015;122(1):65–85.
28. Zero TB Initiative. A Comprehensive Approach in the Quest to Eliminate TB. 2024. https://www.zerotbinitiative.org.
29. Alkire S, Foster J. Counting and multidimensional poverty measurement. J Public Econ. 2011;95(7):476–87.
30. Alkire S, Dirksen J. Poverty in all its dimensions according to national definitions: a briefing on SDG Indicator 1.2.2. OPHI Briefing 58. Oxford: Oxford Poverty and Human Development Initiative (OPHI), University of Oxford; 2024. https://ophi.org.uk/publications/B-58.
31. Multidimensional Poverty Peer Network (MPPN). National Measures. MPPN 2025. https://www.mppn.org/applications/national-measures/.
32. NITI Aayog. India national multidimensional poverty index. a progress review 2023. New Delhi: NITI Aayog, Government of India; 2023. https://ophi.org.uk/publications/india-mpi-2023.
33. Oxford Poverty and Human Development Initiative (OPHI). History of the multidimensional poverty index. 2025. https://ophi.org.uk/background-to-the-mpi/.
34. Oxford Poverty and Human Development Initiative (OPHI), United Nations Development Programme (UNDP). Global multidimensional poverty index 2024: poverty amid conflict. New York: UNDP; 2024. https://ophi.org.uk/Publications/GMPI15-2024.
35. United Nations Development Programme (UNDP), Oxford Poverty and Human Development Initiative (OPHI). How to build a National Multidimensional Poverty Index. Using the MPI to Inform the SDGs. New York: UNDP; 2019.
36 Alkire S, Foster J, Seth S, Santos ME, Roche JM, Ballon P. Multidimensional Poverty Measurement and Analysis. Oxford: Oxford University Press; 2015.
37 Narayan D, Chambers R, Shah M, Petesch P. Voices of the Poor: Crying Out for Change. Vol 2. New York and Oxford: Oxford University Press; 2000.
38. World Health Organization. Tuberculosis patient cost surveys: a handbook. 2017.
39. Carter DJ, Glaziou P, Lönnroth K, et al. The impact of social protection and poverty elimination on global tuberculosis incidence: a statistical modelling analysis of Sustainable Development Goal 1. Lancet Glob Health. 2018;6(5):e514–22.
40. Erlinger S, Stracker N, Hanrahan C, et al. Tuberculosis patients with higher levels of poverty face equal or greater costs of illness. Int J Tuberc Lung Dis. 2019;23(11):1205–12.
41. Vo LNQ, Forse RJ, Codlin AJ, et al. Socio-protective effects of active case finding on catastrophic costs from tuberculosis in Ho Chi Minh City, Viet Nam: a longitudinal patient cost survey. BMC Health Serv Res. 2021;21(1):1051.
42. Najafizada M, Rahman A, Taufique Q, Sarkar A. Social determinants of multidrug-resistant tuberculosis: a scoping review and research gaps. Indian J Tuberc. 2021;68(1):99–105.
43. Timire C, Pedrazzoli D, Boccia D, et al. Use of a sustainable livelihood framework-based measure to estimate socioeconomic impact of tuberculosis on households. Clin Infect Dis. 2023;77(5):761–7.
44. Chambers R, Conway G. Sustainable rural livelihoods: practical concepts for the 21st century. IDS Discussion Paper. 1992;296.
45. Deaton A. The Analysis of Household Surveys: A Microeconometric Approach to Development Policy. Reissue Edition with a New Preface. Washington, DC: World Bank; 2018. https://doi.org/10.1596/978-1-4648-1331-3.
46. Alkire S, Robson M. On international household survey data availability for assessing pre-pandemic monetary and multidimensional poverty in developing countries. Dev Stud Res. 2022;9(1):277–95.
47. Alkire S, Ul Haq, R. Analyzing individual deprivations alongside household poverty: possibilities for gendered, intrahousehold and multidimensional analyses. OPHI Research in Progress No. 65a. Oxford: Oxford Poverty and Human Development Initiative (OPHI), University of Oxford; 2023.
48. Khan MM, Taylor S, Morry C, Sriram S, Demir I, Siddiqi M. How reliable is the asset score in measuring socioeconomic status? Comparing asset ownership reported by male and female heads of households. PLoS One. 2023;18(2):e0279599.
49. Grameen Foundation. Progress out of Poverty Index - PPI Pilot Training Participant Guide. 2008.
50. Oxford Poverty and Human Development Initiative (OPHI). Multidimensional Poverty Index Questionnaire. 2020. https://ophi.org.uk/sites/default/files/2024-07/MPI_Questionnaire_vs_2020-1.pdf.
51 Suppa N. mpitb: A toolbox for multidimensional poverty indices. Stata J. 2023;23(3):625–57.
52. Oxford Poverty and Human Development Initiative (OPHI). Stata code to construct the global MPI indicators by country. 2024. https://cloud-ophi.qeh.ox.ac.uk/index.php/s/ngk2y6x4gF9jeQP.
53. Oxford Poverty and Human Development Initiative (OPH). OPHI Online Training Portal. 2025. https://ophi.org.uk/training/online-training-portal.
54. Oxford Poverty and Human Development Initiative (OPHI), United Nations Development Programme (UNDP). Designing a Multidimensional Poverty Index (2022). 2022. https://www.learningfornature.org/en/courses/designing-a-multidimensional-poverty-index-2022-2/. 2022.
55. Oxford Poverty and Human Development Initiative (OPHI). Training and courses. 2025. https://ophi.org.uk/training.
56. Abascal A, Rothwell N, Shonowo A, et al. "Domains of deprivation framework" for mapping slums, informal settlements, and other deprived areas in LMICs to improve urban planning and policy: a scoping review. Comput Environ Urban Syst. 2022;93:101770.
57 Lu C, Chin B, Li G, Murray CJ. Limitations of methods for measuring out-of-pocket and catastrophic private health expenditures. Bull World Health Organ. 2009;87(3):238–44 244a-244d.

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