WG/HHS/7

PROCESSING EDUCATION EXPENDITURE DATA FROM HOUSEHOLD SURVEYS

SDG 4.5.4:   Education expenditure per student by level of education and source of funding

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1. Introduction

Under SDG indicator 4.5.4, governments and the international community have committed to measure equal access to education through monitoring per-student educational expenditures by level and by source (public and private). As part of its mandate in monitoring SDG 4, the UNESCO Institute for Statistics (UIS) disseminates data on both sources: collecting administrative data annually on per-student public education expenditures, and less periodically, producing estimates from household surveys on private education expenditures.

While collecting accurate public education expenditure has its own challenges[1], data on private expenditure is not typically available from administrative sources and is comparatively less developed. This document serves as a guide on the estimation of private education expenditure from household surveys. It provides guidance to national bureaux of statistics, statisticians and researchers for the production of cross-nationally comparable statistics that are compatible with National Education Account methodology (NEA).

The document is structured as follows: section 2 presents an overview of the minimal and desirable survey features for the estimation of household education expenditure. Section 3 specifies what calculations can or should be made for the purposes of monitoring SDG 4.5.4. Section 4 provides examples of common obstacles that researchers face in estimating expenditure, and how they might be overcome.

2. What should surveys measure?

Assuming adequate steps have been taken in survey design and implementation to minimize sampling errors, production of accurate and internationally comparable estimates requires that survey items capture a sufficient level of detail on household education expenditure and school attendance.

2.1. Minimum requirements

For the estimation of SDG 4.5.4, survey items should fully account for household expenditures on formal education incurred over an annual period, together with the enrolment status of household members by International Standard Classification of Education (ISCED) level. More detailed information is required for estimates to inform National Education Accounts: in particular further classification by type of expenditure and the recipients of expenditure (see **Table 1**).

By definition, expenditures not linked to attendance in formal education are not eligible. In other words, if the expenditure would have still occurred whether the household member was not in school, then it should not be counted. However, expenses incurred on certain types of non-formal education - namely early childhood education and 'second chance' equivalency schooling - can be included (see **Annex 1**).

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1 Such as low country coverage and insufficient disaggregation, missing expenditures at the local government level, and double counting fiscal transfers UNESCO (2019).

Survey items should fully and exclusively capture household education expenses. In other words, surveys which only contain items on a subset of education expenses cannot be used to for the estimation of total household education expenditure, although it may be possible to estimate for relevant NEA aggregations such as expenditures to educational institutions. Determining survey eligibility requires discretion and caution on behalf of the researcher. Researchers should take care to ensure that potentially relevant survey items measure what variable names and description indicate. This will often require examining all available survey documentation, including questionnaires and enumerator instructions. It should be understood that household surveys with information on education expenditure typically aren't designed to comprehensively capture all relevant expenditures, much less enable comparability with other surveys **Annex 4** provides a more detailed overview of considerations to be taken into account when determining survey eligibility.

Table 1. Minimal item requirements for internationally comparable estimates on household education expenditure

Measure	Further classification	SDG 4.5.4	NEA
Annual expenditures incurred by household members for the purpose of formal education	None	x	
	Classification of expenditure into: 1. Household payments to educational institutions 2. Household payments for education goods and services purchased outside educational institutions, linked to participation in school		x
School attendance of household members	Can be categorised by ISCED education level	x	x
	By public and private schooling	x	x

2.2 Desirable requirements

In addition to the minimum item requirements, surveys should ideally fulfil several other criteria to facilitate analysis and increase the reliability and comparability of estimates (**Table 2).**

Table 2. Desirable survey requirements

Area	Feature
Survey items	Expenditure items are highly disaggregated and linked to specific expenditures.
	The source of funding is indicated (e.g. scholarship, government transfer).
	Education attendance is already grouped by ISCED level.
	Background information on household wealth, location, sex and other inequality dimensions.
Recall period	Recall period in reference to the school calendar year
	Recall period is appropriate relative to the interview date.
Level of reporting	Education expenditures should be collected for every qualifying individual in the household.
	Attendance and expenditure data information should be collected for all household members, regardless of age.

Survey items

Survey items should ideally capture as extensive information as possible. While there are practical limits to the amount of information survey expenditure items can elicit, these should be as specific as possible, both to facilitate analysis and to improve accuracy of recall. As such, surveys should avoid asking respondents to estimate expenditure on broad categories which encompass multiple items. Although an appropriately defined 'other expenses' item is necessary to totally account for relevant expenditures, the potential for allocation of large expenses into these items should be avoided (Oseni et al., 2018).

It is also recommended that surveys query respondents on whether they have received scholarships or cash transfers to attend schooling. Background information such as gender, location and household wealth should be available to estimate inequalities in household education expenditure.

Items should ideally be aligned with standard international classifications, both in relation to expenditure and education attendance. In the case of the latter, alignment with ISCED categories reduces or obviates the need to harmonise attendance across surveys, while alignment with NEA categories in the case of the former reduces the workload of the researcher and the potential for error.

Annex 2 provides examples of the level of detail and categorisations desired from attendance and education expenditure items in surveys.

Recall period

Surveys that simply ask respondents to account for expenditures for the 12 months preceding the interview are likely to span multiple school years. It is therefore strongly preferred that the recall period for education expenditures aligns with a single school calendar year, as defined by the educational system within each country. This allows for expenditures to be clearly attributed to a single grade or level of schooling and a single type of school, facilitating comparability between surveys and countries.

The timing of the survey is also relevant in influencing the accuracy of reported expenditures. For interviews conducted in the middle of a school year, the recall period should be the previous school year, as expenses incurred in the second half of the year will not yet be accounted. Where the survey period is conducted close to the end of the school year, referencing the current school year may be feasible if respondents are queried on expected expenses. Generally, expenses on education should be asked as soon as possible after the end of the recall period to increase the accuracy of recall.

While the recall period should generally cover 12 months, for certain recurrent expenditures (such as school meals) a shorter recall period (e.g. weekly or monthly) may increase accuracy of recall. Recurrent expenses can then be multiplied by the number of periods in the school term to arrive at an annual estimate.

Level of reporting

It is strongly preferred that education expenditures are collected for each individual in the household, rather than aggregated for the household as a whole. Although - given the latter - it is possible under

certain conditions to estimate per-student averages (**see section 4.3**), these will be less precise than if reported for each student individually, and cannot effectively be linked with individual characteristics (e.g. sex and grade attended).

Surveys that restrict questions to certain age groups (e.g. excluding individuals younger than 5 or older than 24 years) will not provide a complete picture of household education expenditure. Items on attendance and expenditure should therefore be applied to all household members. Surveys should also indicate whether respondents are de jure (usual) members of the household: exclusion of persons who are not usual residents from the analysis reduces potential for bias and double-counting.

3. What should be calculated?

SDG indicator 4.5.4 calls for the monitoring of education expenditure per student by level of education and source of funding. This requires data both on public and private total education expenditure. Estimates for private (household) expenditures should at a minimum be disaggregated by education level, and if possible, by public/private school attendance.

To provide further data on inequalities for SDG indicator 4.5.1, further disaggregation on individual and household background variables is desirable. This can include features such as:
- Location: rural or urban
- Wealth or income quintile
- Sex
- Geographic or administrative region
- Ethnicity
- Disability

In the interests of more detailed analysis, estimates for NEA categories and sub-categories can also be considered if comparability is possible.

Formally the calculation of indicator 4.5.4 can be expressed as follows:

$$\widehat{\overline{y_{gk}}} = \frac{\sum_{i \in s} w_i * y_{igk}}{\sum_{i \in s} w_i * I_{igk}}$$

- $\widehat{\overline{y_{gk}}}$ is the per-student estimate of household education expenditure at level *g*, among sub-group of interest *k*.
- *i* identifies individual *i* enrolled at a given level *g*, in the sub-group of interest *k*.
- *g* is the level of education: pre-primary, primary, lower secondary, etc.
- *k* is the sub-group of interest, such as female in rural area and in public school.
- y_{igk} is expenditure for the category of interest, such as expenditure to educational institutions, or particular sub-items such as tuition fees (if comparability is possible).
- $I_{gki} = \begin{cases} 1, i \in U_{gk} \\ 0, otherwise \end{cases}$ where U_{gk} is the sub-group of students of interest.
- w_i **is** the weight of the i*th* student in the sample.

- ***S*** is the sample size of the household members that participated in the survey.

After estimates have been calculated, they should be converted to constant prices (correcting for inflation and facilitating comparisons over time).

If estimates of household education expenditure are to be combined with administrative data on public education expenditures, transfers from governments to households should be excluded to avoid double counting. While this is possible using administrative data on education related transfers to households , researchers may want to use and/or compare and contrast with data available in surveys themselves. In this respect, respondents may be asked whether groups or individuals outside the household contributed funds to support the education of household members. Relevant items might include school vouchers, scholarships, financial aid and cash or in-kind transfers. These should specify whether the government was the source of funding to be of use.

4. Common obstacles to the estimation of household expenditure

It is often the case that surveys do not meet all the desired characteristics for the estimation of household expenditure. In reference to the issues discussed above, this section details some common barriers researchers may face when analysing surveys, and how they can be overcome or mitigated.

4.1. Education categories are not aligned with ISCED

International comparability of household education expenditure requires that attendance is disaggregated by ISCED (International Standard Classification of Education) level. However, surveys typically report attendance according to national standards and classifications, requiring researchers to recode education variables.

The UNESCO Institute for Statistics provides documentation to guide the conversion of country education systems codified in national surveys to ISCDED 2011. Country profiles are made available for a wide range of countries to map national classifications to ISCED (UIS, 2019).

However, educational programmes categorised within household surveys may not always be codified within the respective country ISCED profiles. This is particularly the case for more advanced levels of education, where the diversity of programmes is greater and the comparability between countries lower. In such cases, and in reference to official guidance, researchers must use their judgement in categorising national programmes by ISCED level (UIS, OECD and EUROSTAT, 2015).

The following table provides an example of ISCED mapping for a portion of the education curriculum of the Maldives (UIS, 2011).

4.2. The recall period does not align with the school year

Surveys sometimes use an alternative reference period to the school year, typically the 12 months prior to the interview. Nonalignment between the reference period and school year will nearly always reduce the accuracy of expenditure estimates, but the extent to which inaccuracies can be accommodated varies with the degree of non-alignment.

Table 3: ISCED mapping for Maldives – Higher education

Name of the education programme (English)	Minimum entrance requirements (English)	Main diplomas, qualifications or certificates awarded at end of programme (English)	Theoretical entrance age	Theoretical duration (in years)	ISCED 2011 level	
Higher secondary	Pass in 3 GCE/IGCSE 'O' Level (inclusive of 2 streams subjects that the student will do in the 'A' Level)	'A' Level certificate from University of London Examinations Board	16	2	Upper secondary education	3
Certificate IV	Lower secondary education	Certificate IV	16	1	Upper secondary education	3
Diploma - MNQF level 5	Lower secondary education	Diploma	16	2	Upper secondary education	3
Advanced diploma	Diploma	Advanced diploma	18	1	Post-secondary non-tertiary education	4
Advanced diploma	Higher secondary or equivalent	Advanced diploma	18	2	Post-secondary non-tertiary education	4
Associate degree	Higher secondary or equivalent	Associate degree	18	2	Post-secondary non-tertiary education	4
Professional Diploma	Advanced diploma or equivalent	Professional Diploma	20	2	Short-cycle tertiary education	5
Bachelor's degree	Higher secondary or equivalent	Bachelor's degree	18	3	Bachelor's or equivalent level	6

Surveys in which the reference period is shorter than 12 months and does not overlap with the beginning of the school year are not suitable to estimate household expenditure, as they will not capture initial substantial outlays such as tuition fees and textbooks that typically take place during this period. Surveys shorter than twelve months that overlap with the beginning of the school year and which disaggregate expenditures (capturing major expenses such as tuition fees) may be deemed acceptable if recurrent expenses such as transport and school meals can be imputed for the remainder of the school year.

A reference period spanning two school years will not allow researchers to categorically link expenses to a given grade, level or type of schooling, since multiple years imply a change in grade or level of schooling. However, given scarcity of data, researchers may allocate expenditures to a singular school year. Where the reference period spans two school years and attendance data is available for both years, expenditures should be allocated to the school year which overlaps to the greatest extent with

the reference period. Where the reference period is equally split between two school years, expenditures should be allocated to the school year in which the reference period covers the start of the year. Assignment of multi-year expenditures to a single school year is likely to result both in under and overestimations, particularly for students in the first and last grades of each education level. Types of error may vary depending on whether expenditures during the reference period are allocated forwards or backwards relative to the school year (**see Annex 3**).

Education expenditures should also be counted for individuals deemed to have attended in the school year of reference. However, surveys may not always have sufficient information to categorise student attendance by school year, while measurement of attendance may vary between surveys. For example, respondents may be queried on enrolment rather than attendance – in which case the former should serve as a substitute measure. In most cases data will not be collected on the proportion of the school year that students attended – facilitating a more consistent linkage of expenditures to attendance. Rather respondents are commonly asked if they attended school at any time in the current and/or previous school year, or if they attended school at the time of the interview.

Among surveys where the reference period for expenditure aligns with the school year and there are questions both for attendance at any point during the school year and at the time of the survey, then attendance should be based on the latter (presuming the interview took place during the school year in question.

Among surveys in which the reference period for expenditure spans two school years *and* data on attendance is available for both years, expenditures should only be counted if students attended school for both years. Doing so will avoid undercounting expenses for students that were not attending or dropped out in one of the years. Where expenditures are assigned to the second school year, exceptions should be made for first grade students for which attendance data is only available for the reference year. In circumstances where attendance data is only available for one year, it can be assumed that students attended both years, although this may lead to underestimation (see **Table 4**).

Table 4. Choice of attendance variable where the expenditure reference period spans two school years

Survey questions on attendance	Choice for education expenditure estimation	Resulting limitations
One attendance question available for each school year.	Use both: attendance is conditional on attendance for both years (except for first year primary and post-secondary students).	
One attendance question for 2nd school year.	Use as proxy for attendance during year of reference.	Expenditures for those that were out of school during previous year will be included in averages and bias the results.
One attendance question for 1st school year.	Use as proxy for attendance during year of reference.	Expenditures for drop-outs due inf the reference year will be included in averages and bias the results.

4.3. Education expenditure is not reported for individual students

Often education expenditures are only reported for the household, or adults within the household. In these circumstances it will not be possible to directly estimate average per-student expenditure by education level. It may, however, be possible to infer expenditure by level provided that information is available on the age, grade, and formal education attendance for each household member. Preferably data should also be available on whether the educational institution is public or private.

UNESCO IIEP-*Pôle de Dakar* propose a linear regression to estimate expenditures per level, based on the accounting identity that i) total household expenditure is equal to the sum of expenditures incurred by level of education and ii) for a given level of education, the total household expenditure incurred corresponds to the average per child, multiplied by the total number of children of the household enrolled at that level.

Through regressing total household education expenditure on the number of students in the household per level of education[2], coefficients will provide estimated mean education expenditure per child per level of education (Tiyab and Ndabananiye, 2013). In circumstances where expenditures for school aged students are reported by more than one caregiver, these can first be aggregated at the household level before conducting regression analysis.

4.4. Survey expenditure items are not explicitly linked to educational participation

Only expenditures linked to participation in formal education are eligible for the estimation of household education spending. Ideally, enumerator guidance, survey items and post-processing should be designed so that these expenditures linked to formal attendance can easily be aggregated. In practice, however, determination of ineligible expenditure items will typically require the judgment of researchers.

Ineligible household expenditure items should generally be considered as expenses that would have been incurred if the individual had not attended school. Alongside general living expenses, these can include expenditures such as:
- Non-mandatory textbooks
- Newspapers, journals
- Educational games
- Pocket money
- Leisure and extracurricular activities
- Gifts
- Music and art lessons

An example list of eligible expenditure items linked to educational participation is provided in the second column of **Table 5** in section 4.5. Whether or not the survey items exactly align with these examples, they should ideally be disaggregated as much as possible, avoiding grouping separate expenses together. In circumstances where an eligible expenditure item is grouped together with an ineligible one, for expediency these expenses can be included in the total.

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2 Without a constant term.

Ideally, survey items should exhaustively account for all eligible household expenditure. For practical reasons, surveys will typically require an 'other expenses' category linked to attendance to accomplish this. Moreover, where such categories are not explicitly linked to attendance-related expenses there is a possibility that they contain expenses for ineligible items. In these circumstances, data would both not be strictly accurate and comparable with other surveys. However, given data scarcity, unclearly defined 'other' categories may be considered eligible for expediency.

4.5. Education expenditures do not clearly correspond to education account methodology

Although disaggregation of education expenditures according to national education account standards is not strictly required for monitoring of SDG indicator 4.5.4, researchers may do so to facilitate more detailed and comparable analysis.

In the process of aligning to an NEA approach, expenditure items should at a minimum be classified according to whether they correspond to payments made within and outside of educational institutions. To facilitate a more detailed analysis, it is recommended that, if possible, survey items are further classified into the eight categories outlined in **Table 5** (Oseni et al., 2018; UNESCO, 2016)**.**

Table 5. Classification into National Education Account expenditure categories

NEA categories	Expenditure items
Payments to educational institutions	
1. Tuition and other fees	Tuition fees
	Exam, registration, and other official fees
2. Non-tuition related contributions to school	Contribution to parent-teacher associations and/or school-management committees
	Contribution to construction, maintenance, or other school funds
	Cash estimates of in-kind contributions
3. Ancillary fees	School canteen fees
	School boarding fees
	Fees for transport organized by the school
	Fees for health services
Payments and purchases made outside educational institutions, linked to participation in school	
4. Uniforms and other school clothing	Uniforms and other clothing
5. Textbooks and other teaching materials	Textbooks and other teaching materials (stationery, etc.)
	Other required purchases (such as computer, extra books, athletic equipment, material for arts lessons, other school-related expense specific to the country)
6. Private tutoring	Private tutoring
7. School meals and transport purchased outside educational institutions	Transport to and from school not organized by the school
	School meals purchased outside school
8. Additional books, computer, or learning software to be used at home in support of formal schooling	Additional books, computer, or learning software to be used at home in support of formal schooling

Source: Oseni et al. (2018)

Since survey items typically won't correspond on a one-to-one basis to these categories, judgement is required to determine i) whether expenditure items can clearly be allocated to payments to and outside of educational institutions[3] and ii) if so to which of the eight categories to allocate items. The second column in table 5 illustrates how various expenditure items can exclusively be allocated.[4]

It should be emphasised that estimates based on the groupings outlined above can only be considered accurate and comparable when *all* relevant educational expenditure is captured within the survey items. As noted in section 4.4, this may require that 'other' categories are associated for payments within and outside of educational institutions. A general 'other' expenses category will typically prevent a strictly accurate estimation of payments to and outside educational institutions[5], while it may lead to ineligible expenses included in total household educational expenditure estimates. Annex 4 provides further details on the difficulties of processing surveys which do not take such considerations into account (and more generally may not be designed to estimate total household education expenditure).

4.6. Educational attendance and/or expenditures are not available for all ages

For expenditure estimates to be representative of the population, surveys should collect attendance and educational expenditures for all household members. In practice, however, this condition may not be fulfilled if either item is restricted to certain ages, e.g. for children and youth aged 3-24 years. In these circumstances, researchers should consider how much these restrictions will affect estimates - for example through examining other data sources or administrative records on formal educational enrolment.

If the target population accounts for the vast majority of enrolment, researchers may consider disseminating estimates as national averages, as long as qualifiers are clearly made. If sizable groups are excluded from the analysis - for example individuals over the age of 18 years - researchers may consider only disseminating estimates for particular levels of schooling if these estimates can be considered representative.

4.7. Expenditures have not been harmonised to the same reference period

As discussed, it may be desirable for certain recurrent expenditures to be queried on a short-term basis to improve accuracy (e.g. expenditure on school transport over the past month). This data requires post-processing to make it comparable to other items that have a different reference period (e.g. over 12 months or the school year).

Researchers should use their judgment on how this should be accomplished, with reference to the academic years for school and higher education. Recurrent items that are clearly linked to expenditures to schools, such as transport and canteen fees, should accordingly be totalled over the school calendar year, typically 9 months.

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3 If not then a complete alignment to an NEA approach is not strictly possible.
4 Exclusivity means no item may be attributed to more than one category.
5 However, if it is relatively certain that survey items account for all expenditures for either one of the two groups of expenditures, it may be deduced where unknown expenditures fall.

4.8. Expenditure item(s) are compromised by non-response

Although missing data is often commonplace within surveys, questionnaires regarding household income and expenditures can be particularly affected. First, information on expenditure may be perceived by respondents as sensitive and they may therefore be hesitant to answer. Second, respondents may have difficulty recalling and/or calculating their education expenditures, preferring instead to skip these items. Typically, the percentage of missing observations in expenditure items is non-negligible and missing values cannot simply be ignored by the researcher without the risk of introducing substantial bias in estimates.

The potential bias caused by missing data, and in turn the correctional methods researchers may or may not take in response, are determined by the nature of missingness. According to the typology developed by Rubin (1976), missing data falls in to one of three categories: *missing completely at random* (MCAR), *missing at random* (MAR) and *missing not at random* (MNAR).

A variable is MCAR when missingness is uncorrelated with covariates and values of the item itself, or in other words, the probability of missingness is the same for all observations. Put more simply, if observations are missing completely at random, then they can be considered a random subset of observed data with the same distribution and mean. In these circumstances, deletion of observations or mean imputation is a viable solution for an unbiased estimation of the population average (although not for the standard error).
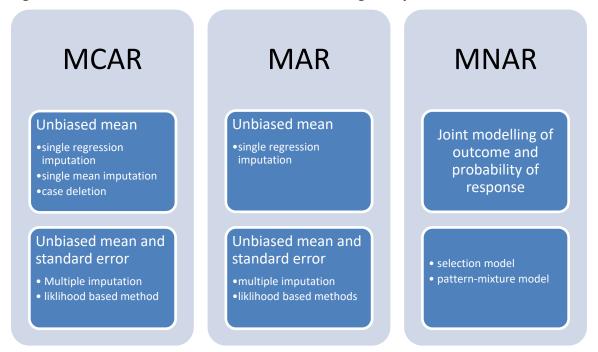
Missing cases that are not MCAR can be characterised as either 'missing at random' (MAR) or 'missing not at random' (MNAR). Despite the somewhat misleading terminology, the former is true if the missingness is systematically related *only* to the observed variables but not the unobserved data.[6] If by conditioning on such covariates missingness is random then it is MAR. For example, if the missingness of a variable is higher among males than females, but among males it is randomly missing (and all gender responses are complete) then it is considered 'missing at random'. Case deletion or mean imputation is viable if the missing observations are MAR and the missing *values* are uncorrelated with covariates. If they are correlated then some form of imputation is required.

When missingness is systematically related to unobserved data (namely unobserved variables or the missing values of the variable itself) then it is MNAR. In the context of education expenditure, it is quite plausible that households that spend higher amounts on education are more likely to refuse to report expenses, and that an estimate of average population expenditure using only available data would have downwards bias. Although methods such as case deletion theoretically do not necessarily introduce bias if the values of the missing variable are uncorrelated with unobserved variables (Mack et al., 2018), MNAR is typically understood to refer to situations where values are correlated. Correcting for bias introduced by data that is not missing at random is more complicated than when data is MAR, requiring the researcher to model the process that generates missingness.

6Under MAR it is possible that the missingness depends on unobserved data, but this dependency is eliminated when conditioning on observed data.

Unfortunately, there is no definitive way to test for which of the three categories missing data falls: this requires the missing observations themselves.[7] Deducing the pattern of missing data and the process that generated it therefore requires careful consideration and domain knowledge.

Figure 1: Estimation methods under different missing data patterns

MCAR	MAR	MNAR
Unbiased mean • single regression imputation • single mean imputation • case deletion	**Unbiased mean** • single regression imputation	**Joint modelling of outcome and probability of response**
Unbiased mean and standard error • Multiple imputation • liklihood based method	**Unbiased mean and standard error** • multiple imputation • liklihood based methods	• selection model • pattern-mixture model

Source: Adapted from Dziura et al. (2013)

As mentioned, responses to dealing with missing data should be conditional on the pattern of missingness. **Figure 1** accordingly summarises several broad methods, indicating those suitable for a) unbiased estimation of the mean, and b) unbiased estimation of the standard error of the mean. Before considering these methods, and in the context of education expenditure, datapoints where it is clear the respondent is not attending education should be replaced with zero.

In cases where data is missing completely at random, case deletion or imputation of the sample mean will provide unbiased estimates of the population. As previously noted, these are typically the first approach to dealing with missing data - regardless of the missing data pattern - and will introduce bias in the population estimate when data is not missing completely at random. Moreover, both will provide biased estimates of the standard error, case deletion leading to overestimates, mean imputation leading to underestimates[8] (van Buuren, 2018).

Single regression imputation can provide unbiased population estimates for data missing at random if the estimation method appropriately conditions on the observed data[9]. Regression encompasses a

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7 MCAR can however be rejected through determining whether missingness is associated with covariates (for example through comparing means of covariates between observations where data are missing and complete).
8 Mean imputation will also distort relationships with covariates.
9 Unless explicitly modelled, imputations for sub-categories may result in aggregates that differ from overall expenditures reported by respondents.

wide variety of methods, both simple and complex, and from parametric methods, such as generalised linear models, to non-parametric methods such as k-nearest neighbours (K-NN) or classification and regression trees. The extent to which such methods are able to accurately predict missing values clearly depends on model specification. In this regard, 'hot-deck' methods like KNN or (semi-parametric) predictive mean matching in which missing values are replaced by a similar observed unit, can be more robust to model misspecification, particularly with larger samples (Andridge and Little, 2010; van Buuren, 2018).

However, single regression imputation also tends to lead to underestimated standard errors, although bias can be reduced by incorporating a stochastic component (random error). By imputing a single value for each missing observation, no fundamental difference is assumed between the initially observed and imputed data. Variability due to the uncertainty of the missing values is therefore not considered.

Multiple imputation methods aim to take this uncertainty into account. They essentially follow three steps. First, several plausible complete versions of the incomplete data sets are generated by imputing each missing datapoint (for one or more variables), using a statistical model that accurately predicts the data, plus a random error component. Second, completed versions are analysed using standard statistical procedures and multiple outcomes of the statistical analyses. Finally, these results are combined into an overall statistical analysis in which the uncertainty about the missing data is incorporated in the standard errors and significance tests (Ginkel et al., 2019). Multiple imputation methods, such as those based on the MICE algorithm, are available in all common statistical analysis software (Azur et al., 2011; van Buuren, 2018).

Likelihood based methods are an additional class of methods that - like multiple imputation - can provide unbiased estimates of the mean and standard error when data is missing at random. In contrast to multiple imputation, these methods do not impute missing data, but rather they combine available information from the observed data with statistical assumptions to estimate population parameters directly. Full Information Maximum Likelihood (FIML) using structural equation models are perhaps the most common method in this category, so called because likelihood information is used from all cases, whether complete or not. While both FIML and multiple imputation methods should give very similar estimates, the former is more efficient and does not introduce randomness. It is however relatively less supported in statistical software (Dong and Peng, 2013; Newsom, 2015; Yung and Zhang, 2011).

Where data are not missing at random, unbiased estimation of parameters can theoretically be accomplished when the actual missing data mechanism is jointly modelled alongside the outcome. These approaches are generally formulated within two alternative ways of addressing the uncertainty about the missing data: selection and pattern-mixture models. Selection models specify the mechanism by which the data are observed as a function of the underlying data value. In contrast, pattern-mixture models formulate distinct models for respondents and non-respondents, with the overall distribution of a variable is seen as a mixture of the distribution of the observed and the distribution of the missing values (Leurent et al., 2018; Sikov, 2018).

MNAR methods should however be used with caution, as there is potential to introduce more bias than if cases were simply deleted, and ultimately the data cannot verify whether the missing data process has been accurately modelled. For any data set, there are an infinite number of possible

MNAR models, and results can differ widely accordingly. Sensitivity analysis through testing the consistency of results across different models is therefore necessary.[10]

Researchers often regard the MAR assumption as a workable approximation, even though it may not hold in reality. Both maximum likelihood and multiple imputation can yield unbiased estimates under MAR and MCAR, and will give less biased results than case deletion under MNAR. Before considering MNAR methods, researchers should exhaust attempts to make the data 'more MAR', for example through the incorporation of supplementary data that is predictive of missingness. A sensitivity analysis, a simulated departure from MAR to MNAR, may provide reasonable evidence that such an approach is warranted (Durrant, 2005; van Buuren, 2018).

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10 When asked "what can I do if my data are not missing at random" during seminars on missing data, statistician Paul Allison typically answers "not much, but you can do sensitivity analysis" (Allison, 2014).

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Annex 1: Classification of non-formal education

Like formal education, non-formal education is education that is institutionalised, intentional and planned by an education provider. However, it is an addition, alternative and/or complement to formal education. Often it does not lead to a formally recognised qualification, and nor does it necessarily follow a continuous pathway like formal education (UNESCO, 2011).

Although household educational expenditure is generally only eligible to be counted for attendance linked to formal education, in some circumstances expenses associated with non-formal education can be counted. Although it is difficult to provide comprehensive and internationally relevant guidelines for the classification of non-formal education due to heterogeneity of programs, the table below provides some examples of non-formal education, indicating whether or not associated expenditures can be counted for the purposes of estimating household education expenditure.

Type of non-formal education programs/activities	Included in estimation of household education expenditure
Early childhood education: Care and education services for young children from birth to the age of entry into primary education, as defined by the country.	Yes: For children of pre-primary school age only.
Literacy: Organized primarily to impart the ability to identify, understand, interpret, create, communicate, and compute, using printed and written materials associated with varying contexts.	No: Usually targets adult population.
Equivalency schooling: Organized primarily for children and youth who do not have access to or dropped out of formal primary/basic education; typically aims to provide an alternative to formal primary/basic education, as well as mainstream children and youth into the formal system upon successful completion of the program.	Yes: Second-chance programs, typically condensed or accelerated.
Life-skills training: Programs and activities organized to impart abilities to better function in daily life and to improve society (e.g., health and hygiene, HIV/AIDS prevention).	No
Income generation training/non-formal vocational training: Training in income-generating productive service skills and trades, also referred to as livelihood training, with the aim of increasing productivity and income.	No: Usually targets adult population.
Rural development: Education, training and extension services carried out in rural communities primarily to promote development by improving agricultural practices, animal husbandry, and natural resource management (e.g., water, soil, and forestry).	No: Usually targets adult population.

Type of non-formal education programs/activities	Included in estimation of household education expenditure
Further education/professional development: Advanced educational and training opportunities for learners who have acquired a particular level of education; can include specialized courses such as computer and language training.	No: Usually targets adult population.
Religious education: Organized learning about religion held in churches, mosques, temples, synagogues and other places of worship	No: Unless the curriculum is similar to other schools in the national education system and is officially recognized as equivalent to formal school.
Cultural/traditional education: Cultural or traditional/ indigenous educational activities.	No

Source: Oseni et al. (2018)

Annex 2: Desirable expenditure survey items

FOR ALL HOUSEHOLD MEMBERS

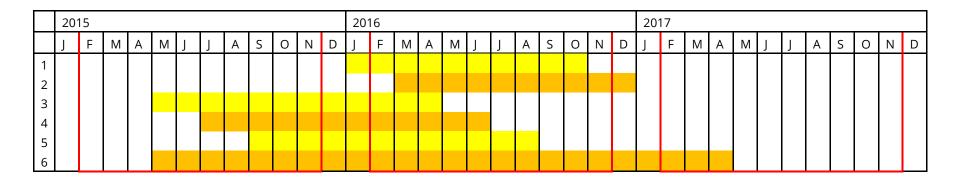| Did [NAME] attend school during the [LAST COMPLETED SCHOOL YEAR]?	What level / grade did [NAME] attend during the [LAST COMPLETED SCHOOL YEAR]?	What kind of organisation runs the school that [NAME] attended during the [LAST COM-PLETED SCHOOL YEAR]?	Did [NAME] have a scholarship during the [LAST COMPLETED SCHOOL YEAR]?	What was the amount of the scholarship [NAME] received in the [LAST COMPLETED SCHOOL YEAR]	From which organisation did [NAME] receive the scholarship during the [LAST COMPLETED SCHOOL YEAR]?
YES..1 **NO...2**	**NONE...00** **PRE-PRIMARY GRADES.........................10** **PRIMARY GRADES...............................20** **LOWER SECONDARY GRADES.............30** **UPPER SECONDARY GRADES..............40** **POST SECONDARY NON- TERTIARY, GENERAL..50** **POST SECONDARY NON- TERTIARY, VOCATIONAL......................................60** **BACHELOR'S LEVELS OR EQUIVALENT.......................................70** **MASTER'S LEVELS OR EQUIVALENT.......................................80** **DOCTORATE LEVELS OR EQUIVALENT.......................................90**	**GOVERNMENT......1** **COMMUNITY........2** **RELIGIOUS BODY....................3** **PRIVA...................4** **NGO......................5** **OTHER (SPECIFY)...6**	**YES..1** **NO...2**		**GOVERNMENT.............1** **COMMUNITY.................2** **RELIGIOUS BODY..........3** **PRIVATE.........................4** **NGO...............................5** **OTHER (SPECIFY)..........6**

How much did [NAME] spend MONTHLY on education during the [LAST COMPLETED SCHOOL YEAR] for each of the following?					
Ancillary fees (boarding, canteen, transport, health services)		Textbooks and other teaching materials	School meals and transport purchased outside educational institutions		School meals and transport purchased outside educational institutions
A. School canteen fees	B. Fees for transport organized by the school	C. Other required purchases (such as computer, extra books, athletic equipment, material for arts lessons, other school-related expense specific to the country)	D. Transportation to and from school not organized by the school	E. School meals purchased outside school	Gifts

How much did [NAME] spend IN TOTAL on education during the [LAST COMPLETED SCHOOL YEAR]?														
Tuition and other fees		Other contributions to school (PTA, SMC, school fund, in-kind contributions)			Ancillary fees (boarding, can-teen, transport, health services)		Uniforms and other school clothing	Textbooks and other teaching materials	Private tutoring	Additional books, computer, or learning software to be used at home in support of formal schooling	Other categories (music and arts lessons, gifts, extra-curricular activities, etc.)			
G. Tuition fees	H. Exam, registration and other official fees	I. Contribution to parent-teacher associations and/or school-management committees	J. Contribution to construction, mainte-nance or other school funds	K. Cash estimates of in-kind contributions	L. School boarding fees	M. Fees for health service	N. Uniforms and other school clothing	O. Textbooks and other teaching materials (statio-nery, etc.)	P. Private tutoring	Q. Additional books, computer, or learning software to be used at home in support of formal schooling	R. Music and arts lessons	S. Extra-curricular activities	T. Not Allocable	

Source : Oseni et al. (2018)

Annex 3: Identification of school year of reference

#	Recall period	Official school year: February 1st – Dec 7		
		Recall period	Assignment	Notable resulting limitations
1	Shorter than 12 months	Jan 2016 – Oct 2016	2016	• Expenses linked to end of school year may be missing.
2		Mar 2016 – Dec 2016	NA	• Not eligible for analysis: first month of school year is missing.
3	Spans two school years	May 2015 – Apr2016 (2015: 70% ; 2016: 30%)	2015	• Students in the first grade may not have initial outlays (e.g. uniforms) accounted • Students in the last grade of an education level may be assigned expenditures from the first grade in a higher level, perhaps leading to overestimation. • Students in the last grade of a given level who subsequently dropped out will not have expenditures assigned for several months of the year.
4		July 2015 – June 2016 (2015: 50%; 2016: 50%)	2016	• Students in the first grade of primary who were not in school the previous year would not have expenses allocated for a period of the year. • Students in the first grade of secondary or tertiary education will have expenses allocated from lower levels, perhaps leading to underestimation.
5		June 2015 – May 2016 (2015: 30%; 2016:70%)		
6	Spans three school years	May 2015 – Apr. 2017 (2015: 70%; 2016: 100%; 2017: 30%)		Limitations apply only to school year 2015: • Expenses for first grade of level may be underestimated for secondary and over, and overestimated for last grade of levels.

	2015												2016												2017												
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1																																				
2																																				
3																																				
4																																				
5																																				
6																																				

Annex 4: Examples of expenditure classification by category

Survey	Payments to educational institutions				Payments and purchases made outside educational institutions, linked to participation in school							Total
	Tuition and other fees (e.g. exam registration fees)	Other contributions to school	Ancillary fees (boarding, canteen, transport, health services)	Other payments to educational institutions	Uniforms and other school clothing	Textbooks and other teaching materials	Private tutoring	School meals and transport purchased outside educational institutions	Additional books, computer, or learning software to be used at home in support of formal schooling	Other payments linked to participation	Other educational expenditures	Estimated total expenditure by respondent
Ghana Socioeconomic Panel Survey 2009	School fees, registration fees and other dues	PTA contributions	Food, boarding and/or lodging at school		Uniforms and sports clothes	Books and school supplies	Extra classes	Transportation to and from school	Inkind expenses			total estimated expenditure on household members
Tajikistan Living Standards Survey 2009	School fees and tuition	School building repair, purchase of educational equipment and other similar expenses;	Meals and/or lodging		School uniforms	Textbooks and other instruction materials; Educational supplies (pens, notebooks, etc.)	Private tutoring		Cash or inkind expenses		Other expenses	
Ethiopia Socioeconomic survey (wave 3) 2015	School fees					School supplies (books, uniform, stationary)						

Source: adapted from UNESCO (2016)

Survey	Comments	Admissibility
Ghana Socioeconomic Panel Survey 2009	- Total estimated expenditure per household member allows for calculation of SDG indicator 4.5.4, but may include some ineligible items not directly linked to attendance. - Payments to educational institutions are relatively comprehensive, but there is no other payments item. As a result, aggregate expenditures are likely underestimated. - School transportation is assigned to payments made outside educational institutions, but likely includes payments to educational institutions. - No expenditures allocated to additional learning materials and software for learning at home. - Item on extra classes may not include private tutoring at home. - There is no 'other payments' item for payments made outside educational institutions.	- May estimate total household expenditure, although likely biased due to reliance on single item and inclusion of expenses not directly related to attendance. - Should not estimate total expenditure to/outside educational institutions due to several missing expenses and inappropriately grouped items and well as missing 'other' categories.
Tajikistan Living Standards Survey 2009	- Other contributions to the school do not include expenses such as PTA dues. 'Meals and/or lodging' may include expenses outside education institutions. - Cash or inkind expenses may include expenses to educational institutions and/or expenses on ineligible items. - No items relating to school transport. - No 'other' item for expenses outside educational institutions.	- May estimate total household expenditure, although may include expenses not directly related to attendance. - Should not estimate total expenditure to/outside educational institutions due to several missing expenses and inappropriately grouped items and missing 'other' categories.
Ethiopia Socioeconomic survey (wave 3) 2015	- Many important items are missing. - Expenditure on uniforms is grouped with school supplies. - There are no other expenses categories or items for total education expenditure.	Should not estimate total household education expenditure or expenditure to/outside educational institutions.