Technical Report:

Measuring Sustainable Development Goals Indicators through Population and Housing Censuses and Civil Registration and Vital Statistics Data

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United Nations Statistics Division

Contents

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Summary

The Agenda for the Sustainable Development, adopted in 2015, formulated 17 Goals (SDGs), divided into 169 targets and over 230 indicators, many of which require disaggregation at different levels. This poses a major challenge to the data generation potential, particularly to National Statistical Offices (NSOs) which may find themselves overwhelmed by the data requirements for such a large number of indicators. In many cases, new statistical procedures and new data collection instruments will have to be created in order to capture the indicators in accordance with their proposed conceptualizations which sometimes require expanding traditional data collection concepts. However, rather than create a host of new statistical instruments, it is worth reflecting on which indicators can be captured in whole or in part using existing data collection instruments and how these can be adapted in order to make them more adequate for the task at hand. In particular, this report focuses on two such instruments: the Population and Housing Census (PHC) and the Civil Registration and Vital Statistics System (CRVS).

This document was written with several audiences in mind:

- Users who may actually use it as a manual for computing SDG indicators from PHC and CRVS data;
- Users who work for methodological aspects of the PHC or CRVS and looking for guidance on how to improve these sources; and
- Those who are looking for an assessment of the relative benefits of different data sources, and particularly the value of PHC and CRVS data, or who want to advocate for the use of these sources.

It should be pointed out that it is not the first report of its kind. There have been a number of other analyses, which are mentioned in the text. For the most parts, these have come to similar conclusions, but depending on the strictness of the criteria employed and the leeway given to data producers to approximate the indicator definitions to existing data sources, there are some differences.

The analysis demonstrates that, in all, 40 SDG indicators can be credibly estimated, at least to some extent, based on PHC and CRVS data. For half of these indicators, PHC and CRVS are actually the primary data sources. For the other half, PHC and CRVS provide proxy data that require statistical manipulation to approximate the desired concept or contribute ancillary information that is relevant to the indicator, but that by itself is insufficient for its calculation. To some extent this situation can be remedied by adding or fine-tuning some of the questions asked in future censuses. In addition, population data from censuses are the main source for estimating and projecting the denominators for many population-based indicators. Finally, census, and, to some extent, CRVS data present considerable advantages over surveys in terms of their potential for disaggregation by population characteristics as they do not suffer from the restrictions of limited sample sizes that surveys have and are also capable of generating small area statistics.

Detailed discussions on the possibilities for disaggregation of the indicators by the various population groups, urban/rural areas of residence, and by age, sex, education strata, migration and disability status stress the value of these sources in monitoring the SDGs at subnational level. Linking relevant SDG indicators with the needs of national and sub-national governments can offer a greater capacity to inform policy by examining relevant disparities in population groups. The ability to analyse and compare the indicators by subgroups and subnational level can provide insights into measuring performance, driving policy reform and allocating resources effectively to socioeconomic development of a country.

The report also points out some limitations of the use of PHC and CRVS data for estimating the SDG indicators. In general, the most serious challenge is the heterogeneity in national census practices. Despite the best efforts of the international statistical community to unify concepts and homogenize the contents of census questions, there are still major variations among countries. In the case of the CRVS there is greater homogeneity, but in a number of countries the civil registration system is not fully

operational and universal and the quality of cause-of-death data is often deficient. Moreover, the information is frequently insufficient to produce all the relevant disaggregations.

Furthermore, the report identifies and discusses some SDG indicators that can be measured with the support of geospatial information in combination with geocoded PHC data. It discusses how integrating PHC data, preferably geocoded at point-based level, with geospatial data can enrich the methodological design and procedures in measuring and disaggregating SDG indicators that have geographic characteristics.

Another general issue involves the meta-data repository for the construction of the indicators. The current descriptions in the SDG meta-data are primarily directed at the scientific justification of the process by which these indicators were obtained at the international level. In theory this allows independent researchers to replicate the entire process. However, NSOs that want to compute or disaggregate specific indicators for their countries with the use of PHC and/or CRVS data may need more operational instructions to this end.

1. Introduction

The agenda for the Sustainable Development Goals (SDGs), which was adopted by the United Nations General Assembly on September 25, 2015, greatly extends the scope of its predecessor, the Millennium Development Goals (MDGs), not least in the size of its indicator framework. With 17 Goals, divided into 169 accompanying targets and over 230 indicators (see annex), many of which are subject to disaggregation, it poses a major challenge to the data generation capabilities of National Statistical Offices (NSOs), as well as international organizations.

So far most of the effort in establishing monitoring mechanisms for the SDGs has been focused on the role of international organizations in the global monitoring of the indicators. But NSOs have a major role to play in the process and often find themselves overwhelmed by the sheer number of indicators for which data need to be produced especially when called upon to provide quantitative assessment of implementation of the Agenda at national level. One of the strategies that can be articulated to deal with this challenge is to make the best of existing data sources that are already being generated for other purposes. In some cases, the SDG indicators can be directly generated from these existing sources. In other cases, they may contribute significantly to the approximation of indicators for which no other national source is available and particularly to the disaggregation of the indicators at the sub-national level, which is a particular responsibility of the national statistical authorities.

In other words, the need to create new data collection mechanisms should not devalue the importance of more traditional sources which can play a major role in providing the necessary information, particularly at the national level. The present report seeks to assist NSOs in identifying the possibilities and limitations for meeting their data needs for the monitoring of the SDGs based on data sources that are already being collected for other purposes, in this case, the population and housing censuses and civil registration and vital statistics. It is hoped that, by providing this guidance, it may contribute to optimizing the efforts undertaken by NSOs to stay abreast of the large number of demands for data that are being made on them as a result of the SDG agenda.

Two of the main traditional sources to be considered in this context are the Population and Housing Census (PHC) and the Civil Registration and Vital Statistics (CRVS) system. PHCs play a vital role in providing the necessary information, particularly at the national and sub-national levels. They provide information on a wide range of demographic, social and economic characteristics of the population allowing detailed data disaggregation by age, sex, labour force status, migration status, disability and small geographic areas. Although censuses are typically carried out once every ten years, they are often the only reliable source of information for small areas and for rare or hard to measure events, such as migration and people living in slum areas.

In addition to population and housing censuses, certain administrative sources have similar capacities for generating reliable and accurate small area statistics. This particularly applies to the civil registration system (CRVS). Registering all vital events (births, deaths, foetal deaths, marriages, divorces) in a country in a universal manner and reporting it to the statistical system allows the production of regular, reliable and accurate small area vital statistics – a critical component for monitoring the implementation of policies relevant to the SDGs agenda. In that respect, the United Nations launched the United Nations Legal Identity Agenda[1], a holistic approach to civil registration, vital statistics and identity management.

[1] https://unstats.un.org/legal-identity-agenda/

The 2030 Development Agenda requires reliable, robust, accessible and timely population and demographic data. Achievement of the SDGs will depend on the availability of fundamental data on population size, growth, distribution and characteristics of populations, at all levels – local, national, regional and international level. Civil registration data are more limited in scope and they are reliably collected in a smaller number of countries, but they are by far the best source for at least some of the SDG indicators.

Censuses and CRVS offer the following unique advantages in comparison to surveys:

- For most countries the census is the only source that produces information on population count and its distributions. For about 40% of the SDGs indicators which are related to population, the census can provide reliable data for denominators, either directly or through the population projections based on census data. For national level projections, countries may use the ones produced by the UN Population Division or produce their own, based on additional information available nationally, particularly when it comes to sub-national projections, which are not provided by the UN.
- As it is based on the entire population count, the census is not affected by the sampling errors that limit the levels to which data based on surveys can be disaggregated. To a lesser extent, this advantage also applies to CRVS data.
- The census is frequently the only potentially reliable source of information on minority populations as well as providing data on rare or hard to measure events, such as international migration and people with disabilities.
- Using the same data source for both the numerator and the denominator in deriving a rate or proportion has the advantage that any under- or over-enumerations that are not directly related to the quantity being measured will often tend to cancel out.
- The CRVS has the advantage of being continuous, so that the information can be obtained for any point in time.
- Both the PHC and the CRVS are routine data collection efforts, whereas measuring indicators through special surveys will often imply additional costs, unless the surveys are already being conducted for other purposes.

Despite their many advantages, PHC and CRVS data also have clear disadvantages:

1. The data collected in the PHC must serve a wide range of purposes and do not lend themselves to lengthy and detailed interviews, so that the amount of detail that can be provided on each individual subject is limited. The data collected in the CRVS are much more restricted in scope, but serve specific legal purposes that limit the number of questions that can be asked. In countries that collect data on vital events through the health system, the amount of information will generally be larger, but it still does not cover all the relevant dimensions that may be necessary, for example, for the disaggregation of the indicator into specific population groups.
2. The quality of information collected in censuses tends to be lower than what can be achieved in specialized surveys, while the coverage of the CRVS in a number of countries is not universal.
3. The concepts used in the census (e.g. literacy) are often less strictly or differently defined than what is needed for the computation of the respective SDG indicators.
4. The fact that censuses are typically carried out only once every ten years limits their capacity to produce data that need to be updated on a yearly basis.

Objectives and scope of the report

The UN *Principles and Recommendations for Population and Housing Censuses, Revision 3* (P&R) and other UN guidelines have emphasized the importance of integrating the 2020 round of censuses with the data gathering requirements for SDGs indicators. Countries which have sufficient time to adjust census questionaires for the 2020 census round or the next round, can include modifications to the categories or to add new questions. For many countries census is the only feasible database on which to base the computation of the SDG indicators. This document aims to assist countries in structuring census questionnaires for the production of statistics for SDG monitoring and to make the best possible use of the information that is already routinely collected in censuses and civil registration systems.

The objectives of the present report, therefore, can be summarized as follows:

a. Identifying which of the SDG indicators lend themselves to measurement or approximation using existing census or CRVS data;
b. Identifying the relative advantages and disadvantages of using census and/or CRVS data for these purposes, compared to surveys or administrative data;
c. Identifying the challenges posed by the use of census or CRVS data for the measurement of some indicators and suggesting potential analytical strategies to mitigate or overcome them;
d. Identifying the advantages of census and CRVS data for the disaggregation of the SDG indicators and, where applicable, some of the precautions that have to be taken in this regard;
e. Providing suggestions for questions that might be added to these instruments that, with a comparatively small investment, might expand their ability to capture information relevant to the monitoring of as many SDG indicators as possible.
f. Identifying those SDG indicators that could be measured with the use of geospatial information in combination with geocoded census data.

Organisation of the report

This report is structured as follows:

Chapter 2 discusses a selection of SDG indicators that can be measured wholly or partly through PHCs and CRVS. This chapter starts with a brief summary of the SDG framework and classification of the indicators on the basis of their level of methodological development and the availability of data at the global level. It also discusses criteria used for selection of SDG indicators that can be computed from PHC and CRVS taking into account topics recommended by two international guidelines, the UN *Principles and Recommendations for Population and Housing Censuses, Revision 3* and the *UN Principles and Recommendations for a Vital Statistics System, Revision 3.* Finally, this chapter provides the list of SDG indicators that can be wholly or partly calculated from PHC and CRVS.

Chapter 3 presents a comprehensive discussion for all selected indicators on definitions, possible data sources and their comparative advantages and disadvanatages, availability of data at national level and international level, methods of computation, challenges and some suggestions in measuring indicators from PHC and CRVS and suggestions for data disaggregation.

Chapter 4 discusses SDG Indicators that can be measured through geospatial and PHC data. It elaborates on how geocoded census data can support the measurement and disaggregation of some SDG indicators. It also discusses the use of geospatial information and GIS tools for measuring, disaggregating and visualizing selected SDG indicators.

Chapter 5 draws conclusions and recommendations based on the findings of detailed analysis. This section gives a list of recommendations to NSOs in maximizing the utilisation of PHC and CRVS data as well as geospatial information in measuring SDG indicators at national and subnational level.

2. SDG Indicators that can be measured through PHCs and CRVSs

SDGs are a collection of 17 goals that build on the successes of the Millennium Development Goals, while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities. The goals are interconnected – often the key to success on one will involve tackling issues more commonly associated with another.

The global indicator framework was developed by the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs) and agreed upon, including refinements on several indicators, at the 48th session of the United Nations Statistical Commission held in March 2017. The global indicator framework was later adopted by the General Assembly on 6 July 2017 and is contained in the Resolution adopted by the General Assembly on Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development.[2]

To facilitate the implementation of the global indicator framework, all indicators are classified into three tiers on the basis of their level of methodological development and the availability of data at the global level, as follows:

- *Tier 1:* Indicator is conceptually clear, has an internationally established methodology and standards are available, and data are regularly produced by countries for at least 50 percent of countries and of the population in every region where the indicator is relevant.
- *Tier 2:* Indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries.
- *Tier 3:* No internationally established methodology or standards are yet available for the indicator, but methodology/standards are being (or will be) developed or tested.

The Tier classifications are periodically updated as new methodologies are developed and data are reassessed. The classification used in this document is the updated version issued by the IAEG on July, 17 , 2020 (As of the 51st UNSC in 2020, the global indicator framework does not contain any Tier III indicators). The updated tier classification table contains 123 Tier I indicators, 106 Tier II indicators and 2 indicators that have multiple tiers (different components of the indicator are classified into different tiers)[3]. Metadata for Tier 1 and 2 indicators are available in the metadata repository.

The UN Statistics Division maintains a website to present and disseminate metadata for each SDGs indicator. The metadata include concepts and definitions, methodologies and data sources. The site is available at https://unstats.un.org/sdgs/metadata/ .

The table at the end of this section provides the list of SDG indicators which can be measured with data obtained from PHCs and CRVSs. For each indicator, this list also provides the relevant corresponding paragraph numbers in the *Principles and Recommendations for Population and Housing Censuses, Revision 3* (P&R) and the *Principles and Recommendations for a Vital Statistics System, Revision 3* (P&RVS) where applicable.

The assessment made in this report and the results summarized in the table are not the first attempt to chart the feasibility of the construction of the various SDG indicators based on PHC and/or CRVS data. Among the previous efforts in this regard, the following should be mentioned:

1. Both the US Census Bureau and the UN Statistics Division have made internal assessments of the potential of the PHC.

[2] For more information, see https://unstats.un.org/sdgs/indicators/indicators-list/.

[33] The Tier classifications of the newly updated indicators are provisional until a full data availability review is conducted.

2. The World Bank has made an assessment of the potential of the CRVS.[4] This is particularly worth mentioning because it identifies a much wider set of indicators subject to estimation based on CRVS data than the present document because the selection criteria for SDG indicators are different. In particular, indicators 1.5.1, 8.8.1 and 17.18.1, which are mentioned by the World Bank, are not included in the selection of indicators used in this document. According to Mills et al., 67 indicators can be measured effectively by using data derived from well-functioning CRVS systems. However, this includes indicators that merely use population as a denominator.
3. WHO, in its World Health Statistics Report of 2017, made an assessment of the health-related SDGs and their preferred or potential data sources, including the CRVS.[5]
4. UNFPA (2017)[6] identifies as many as 98 indicators that require population data. By and large these are the same as the ones identified by the World Bank as using CRVS data in both the numerator and the denominator.
5. The feasibility of measuring SDG indicators through PHC data, with particular emphasis on Latin America and the Caribbean region, has also been investigated by ECLAC.[7] There are some differences between this assessment and the one made in the present document. Specifically, indicators 3.8.1, 3.8.2. 4.4.1, 6.3.1, 8.5.1, 8.9.2, and 11.6.1, which were included by ECLAC, are not part of the present document. To some extent, this is due to the fact that certain types of census data are more readily available in the ECLAC region than elsewhere. However, a more important reason is that the ECLAC document in some cases proposes alternative indicators that do not follow the strict SDG definitions, in order to make them more amenable to measurement in the PHC. There are also a number of indicators included in the present document that were not considered by ECLAC. This will be noted under the specific indicator descriptions.

Even among the indicators included in this document, there is considerable heterogeneity in terms of the relevance of PHC and CRVS data for their measurement. In some cases, the PHC or CRVS is the natural data source for measuring the indicator. In other cases, the PHC or CRVS merely contributes some proxy information that is relevant to the measurement of the indicator and provides meaningful comparisons to policy makers at different levels in order to prioritize strategies and design policies for the most vulnerable groups, all with the objective of leaving no one behind. The situation also varies considerably between countries. For example, the Maternal Mortality Ratio (Indicator 3.1.1) is ideally measured through the CRVS, but there are only relatively few countries where these statistics are sufficiently reliable to serve as a basis for this purpose. In other countries, approximate estimates have to be derived from surveys or from the PHC. In some countries, the census asks the question on labour force status that allows computing child labour (Indicator 8.7.1), but this question is by no means universal.

As a result, it is desirable to divide the indicators by categories, depending on the feasibility of measuring them by means of the PHC or CRVS. This division obviously has some relationship with the division by Tiers that was mentioned above. Tier 3 indicators, for which the measurement methodology is still

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[4] Mills, Samuel et al. (2017). *Civil Registration and Vital Statistics (CRVS) for Monitoring the Sustainable Development Goals (SDGs).* Paper prepared for the eLearning course on Civil Registration & Vital Statistics Systems, see http://documents.worldbank.org/curated/en/979321495190619598/pdf/115150-WP-CRVS-for-Monitoring-the-SDGs-web-version-May-18-2017-PUBLIC.pdf.

[5] WHO (2017). *World Health Statistics 2017: Monitoring health for the SDGs, Sustainable Development Goals*. Geneva, WHO, see http://apps.who.int/iris/bitstream/handle/10665/255336/9789241565486-eng.pdf?sequence=1.

[6] UNFPA (2017). *UNFPA Strategy for the 2020 Round of Population & Housing Censuses (2015-2024).* New York, UNFPA.

[7] ECLAC (2017). 2020 *Population Census Round: Challenges for the 2030 Agenda in the areas of Sustainable Development, Sustainable Development Goals and the Montevideo Consensus on Population and Development* . Santiago, ECLAC, Serie Población y Desarrollo 120.

under development, obviously have no clear methodological standards for PHC or CRVS-based measurement either. But even for Tier 1 indicators, for which a clear methodology and data sources can be specified, the PHC or CRVS are often not the best measurement instruments. Consequently, the Tiers need to be divided into sub-groups that reflect how relevant the PHC or CRVS are for any given indicator. The sub-groups that are used for this purpose in the present study are as follows:

Tier 1 and 2

1. **Indicators for which the PHC is the most obvious source**, even though alternative data sources (including CRVS) may be available and in some cases are of better quality;
2. **Indicators for which the CRVS is the most obvious source,** but which – due to problems of data quality – in many countries are measured through the PHC or other sources;
3. **Indicators for which the PHC provides proxy estimation** that can help to enhance understanding, particularly regarding the disaggregation to specific population groups and for which a methodology to this effect has been well established;
4. **Indicators for which the PHC provides ancillary information** that could be used for analytical purposes, subject to the development of an appropriate methodology, but that by itself is insufficient to fully take account of the indicator.

The Tier 3 indicators are not included in this report because their methodology is still under discussion, thereby making it difficult to assess to what extent census and civil registration data could be part of their measurement. In any case, there do not seem to be any Tier 3 indicators that can be measured by means of census or civil registration data.

Table 1 lists the SDG indicators that can be estimated from PHC and CRVS data. It provides information about what types of data needed for calculation of the indicators based on the topics recommended by the UN Principles and Recommendations on PHC and CRVS. For some indicators, more than one topic are needed either because they combine different topics or because there are different alternatives for their computation. For example, maternal mortality should preferably be computed from CRVS data on cause-of-death, but an alternative is to compute it from the census question on deaths in the household during the past 12 months. The table does not contemplate the information that is needed to disaggregate the indicator by different social groups, such as migration status, income levels or ethnic groups, except in those cases where the disaggregation is part of the indicator definition.

Table 1. List of SDG indicators that can be fully or partly measured from PHC and CRVS data

	Indicator Number	Topics (recommended by Principles and Recommendations on PHC or CRVS)[8]	Principles & Recommendations on PHC and CRVS Paragraph numbers
Tier 1 - Group 1.I: Indicators for which the PHC is the most obvious source			
1	3.c.1 Health worker density and distribution	Occupation (CT) Place of work (AT)	4.352-4.355 4.360-4.365

[8] CT refers to Census Core Topic; AT refers to Census Additional Topic; and CRVS refers to Civil Registration and vital statistics Core Topicc.

2	4.1.2 Completion rate (primary education, lower secondary education, upper secondary education)	Educational attainment (CT)	4.272-4.280
3	4.2.2 Participation in organised learning (one year before the official primary entry age)	School attendance (CT)	4.265-4.271
4	5.3.1 Proportion of women aged 20-24 years who were married or in a union before age 15 and before age 18	Date or age at first marriage-(AT) Marital status (CT)	4.247 - 4.248 4.163-4.171
5	5.5.2 Proportion of women in managerial positions	Occupation (CT)	4.352-4.355
6	7.1.1 Proportion of population with access to electricity	Type of lighthing or availability of electricity (CT)	4.511-4.512
7	7.1.2 Proportion of population with primary reliance on clean fuels and technology	Fuel used for cooking (CT) Type and energy used for heating (AT) Type of lighting (CT)	4.510 4.513-4.514 4.511-4.512
8	8.5.2 Unemployment rate, by sex, age and persons with disabilities	Labour force status (CT) Disability (CT)	4.307-4.325 4.193-4.213
9	8.6.1 Proportion of youth (aged 15-24 years) not in education, employment or training	Scool attendance (CT) Labour force status (CT)	4.312-4.320 4.307-4.325
10	9.2.2 Manufacturing employment as a proportion of total employment	Labour force status (CT) Industry (CT)	4.307-4.325 4.356-4.359
11	11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing	Type of living quarters (CT) Type of ownership (CT) Number of rooms (CT) Water supply system (CT) Main source of drinking water (CT) Type of toilet (CT) Sewage disposal (CT) Number of occupants (CT) Year or period of construction (AT) Construction material of outer walls (CT) Construction material of floor and roof (AT) State of repair (AT) Tenure (CT) Rental and housing costs (AT)	4.421-4.562 4.476-4.481 4.482-4.484 4.490-4.493 4.494-4.495 4.496-4.499 4.500 4.524-4.525 4.526-4.534 4.545-4.547 4.548 4.552-4.553 4.556-4.559 4.560-4.562
Tier 1 - Group 1.II: Indicators for which the CRVS is the most obvious source			
12	3.1.1 Maternal mortality ratio	Cause of death (CRVS) Household deaths in the past 12 months (CT)	198-201 4.250-4.254

13	3.1.2 Proportion of births attended by skilled health personnel	Attendance at birth (CRVS)	193-194
14	3.2.1 Under-five mortality rate	Date of occurrence and date of birth (CRVS) Household deaths in the past 12 months (CT) Children ever born alive (CT) Children living (CT)	72-74 and 104-112 4.250-4.254 4.228-4.233 4.234-4.236
15	3.2.2 Neonatal mortality rate	Date of occurrence and date of birth (CRVS) Survival of the last child born alive (AT)	72-74 and 104-112 4.237-4.240
16	3.4.1 Mortality rate attributed to cardio-vascular disease, cancer, diabetes or chronic respiratory disease	Cause of death (CRVS) (CRVS)	198-201
17	3.4.2 Suicide mortality rate	Cause of death (CRVS)	198-201
18	3.6.1 Death rate due to road traffic injuries	Cause of death (CRVS)	198-201
19	3.7.2 Adolescent birth rate (aged 10-14 years; aged 15-19 years) per 1,000 women in that age group	Date of occurrence of births (CRVS) Date of birth of last child born alive (CT)	104-112 4.237-4.240
20	3.9.3 Mortality rate attributed to uninten-tional poisoning[9]	Cause of death (CRVS)	198-201
21	16.1.1 Number of victims of intentional homicide per 100,000 population, by sex	Cause of death (CRVS)	198-201
22	16.9.1 Proportion of children under 5 years of age whose births have been registered with a civil authority, by age	Date of occurrence and date of birth (CRVS) Age- Children under 5 years of age (CT)	72-74 and 75-76 4.151-4.162
Tier 1 - Group 1.III: Indicators for which the PHC provides proxy estimation			
23	1.1.1 Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/rural)	Income (AT)	4.382-4.386
24	1.2.1 Proportion of population living below the national poverty line, by sex and age	Income (AT)	4.382-4.386

[9] Two Tier 1 indicators, 3.9.1 (Mortality rate attributed to household and ambient air pollution) and 3.9.2 (Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)) can be measured through CRVS using ICD-10 classification. However, the conceptual and methodological complexity can create many challenges, especially quantifying the contribution of risks factors to the burden of disease requires good understanding of the methodology of calculation of Population Attributable Fraction (PAF). See annex for the discussion for these indicators.

25	17.8.1 Proportion of individuals using the internet	Availability of information and communication technology devices (CT)	4.564-4.571
Tier 1 - Group 1.IV: Indicators for which the PHC provides ancillary information			
26	9.5.2 Researchers (in full-time equivalent) per million inhabitants	Educational attainment (CT) Occupation (CT) Industry (CT)	4.272-4.280 4.352-4.355 4.356-4.359
27	17.6.2 Fixed Internet broadband subscriptions per 100 inhabitants, by speed	Availability of information and communication technology devices (CT)	4.571
Tier 2 - Group 2.I: Indicators for which the PHC is the most obvious source			
28	6.1.1 Proportion of population using safely managed drinking water services	Main source of drinking water (CT)	4.494-4.495
Tier 2 - Group 2.III: Indicators for which the PHC provides proxy estimation			
29	1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	Household deaths (CT) School attendance (CT) Educational attainment Characteristics of housing units and households	4.250-4.254- 4.265- 4.271 4.272-4.280 4.421-5.572
30	4.3.1 Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex	School attendance (CT)	4.265-4.271
31	4.c.1 Proportion of teachers in: (a) pre-primary; (b) primary; (c) lower secondary; and (d) upper secondary education who have received at least the minimum training	Occupation (CT) Educational attainment (CT) Field of education and training (AT)	4.352-4.355 4.272-4.280 4.281-4.288
32	5.b.1 Proportion of individuals who own a mobile telephone, by sex	Availability of mobile telephone (CT)	4.564-4.569
33	8.3.1. Proportion of informal employment in non-agricultural employment, by sex	Status in employment (CT) Industry (CT)	4.339-4.351 4.356-4.359
34	8.7.1 Proportion and number of children aged 5-17 years engaged in child labour, by sex and age	Labour force status (CT)	4.307-4.338
35	10.2.1 Proportion of people living below 50 per cent of median income, by sex, age and persons with disabilities	Income (AT)	4.382-4.386
Tier 2 - Group 2.IV: Indicators for which the PHC provides ancillary information			
36	1.3.1 Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons, persons with disabilities, pregnant women, newborns, work-injury victims and the poor and the vulnerable	Income - sources of income and social security benefits (AT)	4.385-4.386

37	1.4.1 Proportion of population living in households with access to basic services	Type of toilet and sewage system Availability of electricity Fuel used for cooking and heating Internet access	4.496-4.500 4.511-4.512 4.510 and 4.513-4.514 4.564-4.571
38	4.5.1 Parity indices (female/male, rural/ urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated	School attendance (CT) Educational attainment (CT) Income (AT) Disability (CT) Indigenous people (AT)	4.265-4.271 4.272-4.280 4.382-4.386 4.193-4.213 4.188-4.192
39	4.6.1 Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex	Literacy (CT) Literacy skills (AT)	4.258-4.264 4.261
40	6.2.1 Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water	Type of toilet and sewage disposal system (CT)	4.496-4.500

The following indicator is also in Tier 1, but has different characteristics from the ones set out in the table above, as it is measured at the global level and involves both PHCs and CRVSs: 17.19.2 Proportion of countries that (a) have conducted at least one population and housing census in the last 10 years; and (b) have achieved 100 per cent birth registration and 80 per cent death registration.

3. Detailed analysis of the selected SDG indicators that can be measured through PHC and CRVS data

This section provides detailed discussion for each of the SDG indicators listed in the table above. It discusses, specifically, how to utilise PHC and CRVS data for measuring SDG indicators and identifies potential challenges in generating measurements for the indicators with agreed international recommendations for PHC and CRVS topics. It also attempts to provide some suggestions for producing better estimates from these sources.

For each of the 40 indicators listed in the table above, the following aspects will be analysed in detail:

a. Concept and definition
b. Possible data sources, particularly PHC and CRVS, and their relative advantages/disadvantages
c. Method of computation
d. Challenges in measuring in PHC or CRVS
e. Data disaggregation

The objectives and contents of each of these items are as follows:

a) **Concept and definition:** This item provides the operational definition of the indicator according to the SDG meta-data repository. It also describes the indicator in terms of the ultimate social processes that it seeks to determine their relevance for human rights. In those cases where there are alternative operational definitions or related concepts that can be relevant in this context, these are also briefly described.

b) **Possible data sources, particularly PHC and CRVS, and their relative advantages/ disadvantages:** This item starts with the explanation on possible data sources that may be used for measuring or approximating the indicator, particularly in the context of national SDG monitoring and followed by the preferred data source as defined by the SDG meta-data. It then details how widely available the necessary information is in national PHCs and CRVSs. In the case of the PHC, there may be considerable national variation as certain questions are asked in some censuses but are not part of the core content that is widely available in censuses worldwide. The contents of the CRVSs are generally more uniform, although even here there are national variations or data quality issues that may limit the relevance of the CRVS for the computation of some indicators. Finally this section briefly describes the relative advantages and disadvantages of each data source, both in terms of its availability in the national context and in terms of its conceptual adequacy.

c) **Method of computation:** This item starts out with the standard computation of the indicator according to the SDG meta-data repository. It then turns to alternative approaches of the computation or approximation of the indicator based on PHC or CRVS data. In some cases, this computation is fairly straightforward, as in the case of demographic rates from CRVS data. In other cases, the procedures are much more complex as they involve the estimation of the indicator from one or more proxy data available in the PHC. The methodologies to this end can be relatively well established, as in the case of poverty or maternal mortality estimation. In other cases (the category IV above), there are no generally accepted methodologies available and the estimation of the relevant indicator from proxy data requires considerable ingenuity.

d) **Challenges in measuring in PHC or CRVS:** This item discusses the challenges that can emerge in estimating the relevant indicator from PHC or CRVS data. Generally speaking, these challenges come under one of three categories: i) Imperfect correspondence between the PHC concept and the concept underlying the indicator, particularly if no established methodology is available to make the conversion; ii) Limited availability of the relevant information from PHC (or possibly CRVS) sources; and iii) Deficient quality of the data as measured by the PHC or the CRVS. Where pertinent, this item provides some suggestions for capturing additional Information and improving the quality of data collected through PHC and CRVS.

e) **Data disaggregation:** This section discusses the possibilities for disaggregation of the data by the various relevant social categories, such as urban/rural area of residence, major geographical divisions, sex, age, educational strata, migration status[10], etc. It starts out with the recommended disaggregation defined by the IAEG-SDG, but adds to this with other suggestions. One of the major advantages of using PHC or CRVS data, even if they only provide proxies for the relevant concepts, is that they can usually be disaggregated to a much finer level than is the case with survey data. Nevertheless, even PHC data have their limits in terms of the possible disaggregations, which are pointed out in the process.

3.1. Indicators for which the PHC is the most obvious source (Group 1.I)

3.c.1 Health worker density and distribution

a. Concept and definition

The meta-data definition of this indicator divides it into four components, namely:

Density of medical doctors: number of **medical doctors**, including generalists and specialist medical practitioners per 10,000 population in the given national and/or subnational area. The International Standard Classification of Occupations (ISCO) unit group codes included in this category are 221, 2211 and 2212 of ISCO-08.

Density of nursing and midwifery personnel: number of nursing and midwifery personnel per 10,000 population in the given national and/or subnational area (ISCO-08 codes 2221, 2222, 3221 and 3222).

Density of dentists: number of dentists per 10,000 population in the given national and/or subnational area (ISCO-08 code 2261).

Density of pharmacists: number of pharmacists per 10,000 population in the given national and/or subnational area (ISCO-08 code 2262).

The rationale for this indicator is that it provides an overview on the capacity of the health system to attend to demands in different areas. The fact that it addresses four components of the system of health professionals means that it allows for the assessment of imbalances, for example in the number of medical doctors and nurses and midwives, given that in many countries these numbers are unbalanced.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

[10] UN Expert Group meeting on Improving Migration Data in the Context of the 2030 Agenda, held in 2017, agreed on taking a step - wise approach in defining migratory status. As a first step, migratory status can be classified regardless of legal status, as (i) Native-born and foreign-born persons, (b) Citizens, non-citizens (including stateless persons). The report of the expert Group is available at https://unstats.un.org/unsd/statcom/49th-session/documents/BG-Item4a-MigrationEGMRecommendations-E.pdf.

At the country level, the numbers can be determined by the PHC, estimated by national labour force surveys and by key administrative national and regional sources, such as registers of accredited medical doctors and nursing personnel maintained by the Ministry of Health or by the professional associations.

Most of the data from administrative sources that feed this system are derived from published national health sector reviews and/or official country reports to WHO offices. The main limitations of this source are that data on health workers tend to be more complete for the public health sector and may underestimate the active workforce in the private, military, non-governmental organization and faith-based health sectors. In many cases, information maintained at the national regulatory bodies and professional councils are not updated. As data is not always published annually for each country, the latest available data has been used. Due to the differences in data sources, considerable variability remains across countries in the coverage, periodicity, quality and completeness of the original data. Densities are calculated using population estimates from the United Nations Population Division's *World Population Prospects* database or by national data such as projections based on a PHC.

In general, a sample-based Labour Force Surveys may be as good a source as the PHC. An advantage of both data sources compared to administrative data base is that both sources are population-based and hence less sensitive to the bias of administrative data mentioned above.

Because occupation is a core question in the census (ISCO-2008, Sub-major group 22 and 32), it is available from almost every census. Both the PHC and the Labour Force Survey data are based on the question about occupation and its ISCO-08 coding. In order to correctly compute the four components of this indicator, these data have to be available up to the fourth digit. This may pose a problem in some countries where the census data are coded only up to three digits.

c. Method of computation

If the data have been collected at the necessary level of detail and accuracy, the computation of the indicator presents no special challenges. The latter can be a problem, however, if the occupational data of the PHC or other relevant source have not been coded with the required ISCO codes. For doctors and nurses, 3 digits are sufficient (221 and 222 / 322, respectively), but in order to identify dentists and pharmacists, 4 digits are required (2261 and 2262, respectively). The following lists the relevant ISCO codes:

22 Health Professionals
- *221 Medical Doctors*
  - 2211 Generalist Medical Practitioners
  - 2212 Specialist Medical Practitioners
- *222 Nursing and Midwifery Professionals*
  - 2221 Nursing Professionals
  - 2222 Midwifery Professionals
- *226 Other Health Professionals*
  - 2261 Dentists
  - 2262 Pharmacists

32 Health Associate Professionals
- *322 Nursing and Midwifery Associate Professionals*
  - 3221 Nursing Associate Professionals
  - 3222 Midwifery Associate Professionals

Four components of this indicator are computed as following;

Density of medical doctors: total of medical doctors (221) divided by total population and multiplied by 10,000.

Density of nursing and midwifery personnel: total of nursing and midwifery professionals (222) and nursing and midwifery associate professionals (322) divided by total population and multiplied by 10,000.

Density of dentists: number of dentists (2261) divided by total population and multiplied by 10,000.

Density of pharmacists: number of pharmacists (2262) divided by total population and muiltiplied by 10,000.
Many countries have their own national versions of the ISCO. In general, these have been updated to reflect the latest version of ISCO and their coding of the categories listed above is the same as in the ISCO-08, possibly with sub-divisions beyond those provided in the international version. In some countries, however, the process of updating the national classification is still underway. In Brazil, for example, the national CBO system is still based on the ISCO-88, which codes the occupations listed above differently, but for the purposes of the 2010 census a new coding system (COD) was developed that is more in line with the ISCO-08 and that uses the categories listed above.

d. Challenges in measuring in PHC

The main challenge for measuring this indicator with census data is the accuracy of coding of occupations during the data processing of the census. All four components of the indicator require coding at the level of at least three digits and the identification of dentists and pharmacists requires four digits. Even if all the occupations have been coded at the required level of detail, the quality of census data on occupations may be less than in a specialized labour force survey.

e. Data disaggregation

Collecting the data from the PHC creates the possibility of disaggregation by sex and geographic units, as well as by major socioeconomic areas such as counties or municipalities stratified by poverty level. It is not recommended to disaggregate the indicator by very small geographic levels because the census counts health professionals where they live, not in terms of the areas they serve. Even the disaggregation by urban/rural areas may be biased in this respect as many health professionals serving rural areas may reside in towns. Most appropriate breakdown by geographic areas can be achieved with the information on 'place of work'. In order to disaggregate the indicator by such geographical areas orby urban and rural areas, the PHC should ask about place of work.[11]

4.1.2 Completion rate (primary education, lower secondary education, upper secondary education)

a. Concept and definition

The indicator measures the percentage of a cohort of children or young people aged 3-5 years above the intended age for the last grade of each level of education who have completed that grade. The intended age for the last grade of each level of education is the age at which pupils would enter the grade if they had started school at the official primary entrance age, had

[11] The UN Principles and Recommendations for Population and Housing Censuses Revision 3 recommend "Place of work " as an additional topic, see paragraphes 4.360-4.365.

studied full-time and had progressed without repeating or skipping a grade. For example, if the official age of entry into primary education is 6 years, and if primary education has 6 grades, the intended age for the last grade of primary education is 11 years. In this case, 14-16 years (11 + 3 = 14 and 11 + 5 = 16) would be the reference age group for calculation of the primary completion rate. The age group 3-5 years above the official age of entry into the last grade for a given level of education was selected for the calculation of the completion rate to allow for some delayed entry or repetition. In countries where entry can occur very late or where repetition is common, some children or adolescents in the age group examined may still attend school and the eventual rate of completion may therefore be underestimated.

A completion rate at or near 100% indicates that all or most children and adolescents have completed a level of education by the time they are 3 to 5 years older than the official age of entry into the last grade of that level of education. A low completion rate indicates low or delayed entry into a given level of education, high drop-out, high repetition, late completion, or a combination of these factors.

The completion rate can be used either as a self-standing indicator or in combination with indicator 4.1.1 (proportion of children and young people (a) in Grade 2 or 3; (b) at the end of primary education; and (c) at the end of lower secondary education achieving at least a minimum proficiency level in (i) reading and (ii) mathematics). Combining the completion rate with indicator 4.1.1 provides information on the percentage of children or young people in a cohort who achieve a minimum level of proficiency, and not only on the percentage of children in school who achieve minimum proficiency. Indicator 4.1.1, however, is not part of this report because it cannot be measured through PHC.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The data can be obtained from population censuses and household surveys such as the Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS), and European Union Statistics on Income and Living Condition (EU-SILC), that collect information on the highest level of education completed by children and young people in a household. Typical questions in a survey to collect data on educational attainment are:

1. What is the highest level of education [name of household member] has attended?
2. What is the highest grade of education [name of household member] has completed at that level?

Educational attainment is a core topic for PHCs covered under paragraphs 4.272-4.280 of the P&R. These are aligned with the categories of the 2011 revision of ISCED, issued by UNESCO. In accordance with national conditions and requirements, many countries can continue to apply national classifications of levels and grades of education and of fields of education in collecting and tabulating statistics from PHCs. Educational attainment in the PHC is defined as the highest ISCED level successfully completed. It is usually measured with respect to the highest education programme successfully completed, which is typically certified by a recognized qualification. Some countries may also find it useful to present data on educational attainment in terms of the highest grade completed. For international purposes a “grade” is a specific stage of instruction usually covered in the course of an academic year.

For international comparison, data from the PHC are needed for all levels of education defined in ISCED. To the extent possible, countries should classify statistics on educational attainment by the individual ISCED-A (or ISCED-Attainment) levels listed below, which are used for the classification of educational attainment in ISCED 2011 (or by their equivalent as set forth according to the national classification of levels of education):

ISCED level 1: Primary education
ISCED level 2: Lower secondary education
ISCED level 3: Upper secondary education

Par. 4.278 of the P&R also recommends that countries could consider asking a question that captures levels of education not successfully completed, should this be of interest to policymakers or other users. This could be in the form of a direct question asking if a person has some education at the relevant level or via a question asking the last grade or year completed from any given level of education.

Basing the computation of indicator 4.1.2 on PHC data has the major advantage of eliminating sampling biases and allowing a much more detailed level of data disaggregation than can be attained with survey data. The obvious disadvantage of using PHC data is that in most countries this information is only available once every ten years.

c. Method of computation

The number of persons in the relevant age group who have completed the last grade of a given level of education is divided by the total population of the same age group.

Formula:

$$CR_n = \frac{P_{C_n, AG_{a+3t5}}}{P_{AG_{a+3t5}}}$$

where:

CR_n = completion rate for level *n* of education
$P_{C_n, Age_{a+3t5}}$ = population aged 3 to 5 years above the official entrance age *a* into the last grade of level *n* of education who completed level *n*
$P_{Age_{a+3t5}}$ = population aged 3 to 5 years above the official entrance age *a* into the last grade of level *n* of education
n = ISCED level 1 (primary education), 2 (lower secondary education), or 3 (upper secondary education)

d. Challenges in measuring in PHC

National data are often collected and reported in reference to national systems of education. The mapping from a national classification to the International Standard Classification of Education (ISCED) is not always straightforward and can cause discrepancies between national and international indicator estimates. Special attention needs to be paid to establishing appropriate level or grade equivalence for persons who have received education under a different or foreign educational system. These national classifications, however, should be able to be converted or mapped to the ISCED 2011 classification system, this typically being achieved during post-census processing.

A potential obstacle in some cases is that the relevant PHC data may only be available in published format, aggregated into age intervals that are not compatible with the format required for the computation of this indicator. In situations where it is difficult to obtain the data by single years of age, it may be necessary to estimate them by means of interpolation, which obviously diminishes their accuracy. In most PHCs, however, either the original data are already disaggregated by single years of age or else they can be reprocessed for this purpose with relative ease.

In theory, errors in age declaration may also pose a problem in some cases, but this should be relatively minor as it affects both the numerator and the denominator and both span a 3-year age range.

e. Data disaggregation

The indicator is disaggregated by sex, location, and wealth or socio-economic status (ECSC). With the exception of the latter, these can all be easily implemented using census data. Other proposed disaggregation criteria include grade, language spoken at home, migration status, disability status, wealth stratum, and ethnicity. All of these can be captured with relative ease in most censuses. In countries where not the entire population speaks the official national language, a question about language proficiency is often included.

4.2.2 Participation in organised learning (one year before the official primary entry age)

a) Concept and definition

The participation rate in organised learning (one year before the official primary entry age), by sex as defined as the percentage of children in the given age range who participate in one or more organised learning programme, including programmes which offer a combination of education and care. It refers to current participation in early childhood and in primary education if there are children who are attending the primary education at ages below the official primary entry age. Early childhood and primary education are defined in the 2011 revision of the International Standard Classification of Education (ISCED 2011), under category 0 and 1. The age range will vary by country depending on the official age for entry to primary education.

An organised learning programme is one which consists of a coherent set or sequence of educational activities designed with the intention of achieving pre-determined learning outcomes or the accomplishment of a specific set of educational tasks. Early childhood and primary education programmes are examples of organised learning programmes.

The indicator measures children's exposure to organised learning activities in the year prior to the start of primary school. A high value of the indicator shows a high degree of participation in organised learning immediately before the official entrance age to primary education.

b) Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The main sources of data include administrative data from schools and other centres of organised learning, as reported to UNESCO, and censuses or household surveys on school attandence by single year of age in early learning programmes.

One of the advantages of collecting this information from census (or survey) data, as opposed to administrative sources, is that the numerator and denominator come from the same source, thereby reducing biases. Another advantage is that censuses are less sensitive to the typical bias found in administrative data with respect to the under-registration of children enrolled in private institutions.

School attendance is part of the core content of virtually in many censuses. Ideally, it should be coded by ISCED-P (or ISCED-Programmes) levels, which are used for the classification of education programmes in ISCED 2011. ISCED level 0 corresponds to early childhood education and ISCED level 1 corresponds to primary education. Correspondence between a national education system and ISCED can be established through mapping of national education programmes to the ISCED classification.

c) Method of computation

The number of children in the relevant age group who participate in an organised learning programme is expressed as a percentage of the total population in the same age range.
The indicator can be calculated through PHC using two types information: the number of children who are attending in organised learning programmes (early childhood education or primary education) in the age group one year below the official primary entry age; and, the total population in the same age group. For example, if the official age for starting primary education is 6 (completed age), this indicator will be calculated for children at age 5.

Nationally-published figures may differ from the international ones because of differences between national education systems and the International Standard Classification of Education (ISCED); or differences in coverage (i.e. the extent to which different types of education – e.g. private or special education – are included in one rather than the other) and/or between national and the United Nations Population Division (UNPD) population estimates.

d) Challenges in measuring in PHC

The main challenge is the correctness of the ISCED coding applied during the data processing of the census and comparability with administrative registers.

PHC usually collects information particularly for the population of official school age, which ranges in general from 5 to 20 years of age but vary from country to country depending on the national education structure. In the case of collecting data for pre-primary education, the age range should be adjusted as appropriate.

It should be noted that PHC collects information on school attendance while administrative data usually refers to enrolment in school. Thus, results from censuses and administrative data may differ. A child could be enrolled in school but not necessarily attending.

e) Data disaggregation

The minimum required disaggregation is the one by: a) sex, b) rural-urban area, c) geographical areas (such as by regions and provinces) and d) disability status.

Disaggregations may include by household income. Censuses are limited with respect to the possibility to implement the latter, as many of them do not collect income data.

5.3.1 Proportion of women aged 20-24 years who were married or in a union before age 15 and before age 18

a) Concept and definition

This indicator refers to the proportion of women aged 20-24 years who were married or in a union before age 15 and before age 18. Both formal (i.e., marriages) and informal unions are covered under this indicator. Informal unions are generally defined as those in which a couple lives together for some time, intends to have a lasting relationship, but for which there has been no formal civil or religious ceremony (i.e., cohabitation). Cohabitation – when a couple lives 'in union', as if married – raises the same human rights concerns as marriage. When a couple cohabitates, this relation is also considered early/child marriage if one or both has not yet reached the age of 18. Additional concerns due to the informality of the relationship – in terms of inheritance, citizenship and social recognition, for example – may make children in informal unions vulnerable in different ways than those who are formally married.

The practice of early/child marriage is a direct manifestation of gender inequality and as such a fundamental violation of human rights. Child marriage often compromises a girl's development by resulting in early pregnancy and social isolation, interrupting her schooling, limiting her opportunities for career and vocational advancement and placing her at increased risk of intimate partner violence. In many cultures, girls reaching puberty are expected to assume gender roles associated with womanhood. These include entering a union and becoming a mother. Although marriage is not mentioned directly in the Convention on the Rights of the Child, child marriage is linked to other rights – such as the right to freedom of expression, the right to protection from all forms of abuse, and the right to be protected from harmful traditional practices.

b) Possible data sources, particularly PHC and CRVS, and their relative advantages/ disadvantages

The data source for this indicator can be either those national censuses or household surveys which collect data on age or date at first marriage or entering a union.

Household surveys such as DHS and MICS supported by UNICEF have been collecting data on this indicator in low- and middle-income countries since around the late 1980s. The modules used to collect information on marital status among women and men of reproductive age (15-49 years) in the DHS and MICS have been fully harmonized.

While the question on age at first marriage/union or date of first marriage/union is routinely asked in surveys such as the DHS and MICS, it is relatively rare in censuses. A review of census questionnaires of 124 countries for the 2010 census round carried out by UNSD identified only 10 countries that asked for the date of first marriage and 14 countries that asked for the age at first marriage. The question on duration of marriage was also asked by a few countries but this information has the limitation that it does not allow the estimation of the age at first marriage in those cases where the current marriage or union is not the first.

In the absence of information on the age or date of first marriage, the marital status of women by single age from aged 15 to 18 can be used to approximate this indicator. Information on marital status is available almost universally from PHCs.

The P & R (4.169) recommends that information on marital status should be collected and tabulated for persons of all ages, irrespective of the national minimum legal age, or the customary age for marriage, because the population may include persons who were married in another country with a different minimum marriage age. In most countries, there are also likely to be persons who were permitted to marry below the legal minimum age because of special circumstances. In order to permit international comparisons of data on marital status, however, any tabulations of marital status not cross-classified by detailed age should at least distinguish between persons under 15 years of age and those 15 years of age and over.

The P & R (4.247) make reference to the date of first marriage as the day, month and year when the first marriage took place. In countries where date of first marriage is difficult to obtain, it is advisable to collect information on age at first marriage or on how many years ago the first marriage took place (duration of marriage). The information should relate to all types of marriages such as contractual first marriages and de facto unions, customary marriages and religious marriages. The P & R also recommends (4.248) that for women who are widowed, separated or divorced at the time of the census, information on the "date of/age at/number of years since dissolution of first marriage" should be collected.

In view of the former, it is suggested that countries consider the possibility of including the question on age at first marriage or age at first consensual union in their PHCs, particularly in the case of women.

In theory it is also possible to approximate this indicator through CRVS data. The main limitation is that the CRVS only has information on official marriages (which are legal and binding under customary law) and generally excludes extralegal unions known such as de facto or consensual unions. In countries with a tradition of religious marriages these unions are also not necessarily reported by the official statistics.

c) Method of computation

If a census asks questions on marital status and age at first marriage or date of first marriage, the standard method is to divide the number of women aged 20-24 who were first married or in union before age 15 or before age 18 by the total number of women aged 20-24 in the population and multiply by 100.

In censuses that do not have a question on date of or age at first marriage, an alternative approach is to compute the proportion of women who have ever-married (married, divorced or widowed) or in union by single year of age and to establish specifically how many girls are ever-married by age 15 or age 18. This approach would provide valuable information for analysing regional/subnational variation in early/child marriage as the census includes all young women living in a country. This approach would provide useful information especially for national monitoring of early/child marriage and disaggregating data with other relevant topics discussed below.

On the other hand, it should be noted that this alternative approach does not produce exactly the right indicator, for two reasons:

a. Some very young women may hide the fact that they are currently married or in a union, but once they reach the age of 20-24 they may be less reticent about admitting that they were married at a very young age.
b. As the standard definition of the indicator refers to women who are aged 20-24, child marriages will have taken place about 5-10 years in the past (in the case of the 15 year age limit) or a little more recently (in the case of the 18 year age limit). The indicator of women aged exactly 15 or 18 who are ever married refers to marriages that have occurred during the past 0-4 years.

d) Challenges in measuring in PHC

As was mentioned above, only a minority of countries (about 20 percent) asked the question on first marriage, either by age of the woman or by date, in their 2010 round of censuses. Therefore, the indicator can be computed with the agreed SDG metadata definition in about a fifth of the countries. However, there are numerous variations about the nature of marriage in many countries which may create a comparability problem across countries.

e) Data disaggregation

The PHC allows disaggregation of this indicator by a variety of topics. It is recommended that this indicator should be disaggregated by:
b) Place of Residence (urban and rural);
c) Administrative units, for example metropolitan areas, cities and districts;
d) Education level;
e) Ethnicity (where relevant);
f) Labour force status;
g) Migration status

The census would be efficient in establishing the indicator for small ethnic groups, even if only in an approximate fashion. The census can also be disggregated to smaller geographical areas for which the sample sizes of the surveys are too small. Disaggregation by monetary income may be difficult but non-monetary approaches such as UBN, MPI or wealth quintiles may be an acceptable alternative.

5.5.2 Proportion of women in managerial positions

a) Concept and definition

This indicator refers to the proportion of women in the total number of persons employed in managerial positions. It is recommended to use two different measures jointly for this indicator: the share of women in (total) management and the share of females in senior and middle management (thus excluding junior management). The joint calculation of these two measures provides information on whether women are more represented in junior management than in senior and middle management, thus pointing to a possible ceiling for women to access higher-level management positions. In these cases, calculating only the share of women in (total) management would be misleading, in that it would suggest that women hold positions with more decision-making power and responsibilities than they actually do.

b) Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The recommended source for this indicator is a labour force survey or, if not available, other similar types of household surveys that include a module on employment. The PHC has this kind of information as well, which can be accessed in the same way as in a labour force survey, although the quality of occupational data in the census may be less than in specialized labour force surveys.

In the absence of any labour-related household survey, establishment surveys or administrative records may be used to gather information on the female share of employment by the required International Standard Classification of Occupation (ISCO) groups. In cases where establishment surveys or administrative records are used, the coverage is likely to be limited to formal enterprises or enterprises of a certain size.

Occupation is a core issue in every census and one question asked is the position that a person occupies within his/her occupation. Together with the type of activity, this information is coded into the ISCO code, with the following categories for managerial functions

1 Managers
- 11 Chief Executives, Senior Officials and Legislators
- 12 Administrative and Commercial Managers
- 13 Production and Specialized Services Managers
- 14 Hospitality, Retail and Other Services Managers

For purposes of international comparison, it is recommended that countries make it possible to prepare tabulations involving occupations in accordance with the latest revision available of the International Standard Classification of Occupations (ISCO). This is especially relevant in countries where the official classification of occupations is still not completely aligned with the ISCO-08 norm.

c) Method of computation

For the purpose of computing the total proportion of women in management, the number of women with ISCO codes in main category 1 is computed as a proportion of the total number of persons with ISCO codes in category 1.

The proportion of women in senior and middle management can be calculated by dividing the total number of women in ISCO-08 categories 11, 12 and 13 by the total number of people employed in the same categories.

d) Challenges in measuring in PHC

The main limitation in measuring this indicator in PHC is that the question often does not reflect differences in women's level of responsibility. Nor does it reflect the importance of the organization in which the woman is employed. Even if all the occupations have been coded at the required level of detail, the quality of census data on occupations may be less than in a specialized labour force survey.

Stated differently, the census may be good at capturing the total proportion of women in management, but when it comes to proportion of women in senior/middle management, an additional question/information on the level of management is needed. One possible strategy for remedying this situation is by introducing another question to address the issue of level of management. Another possibility is to combine census and administrative records, where possible, to obtain relevant information for the second component (proportion of women in senior/middle mangement).

Some PHCs distinguish between a person's primary and secondary occupation. For example, a person may have a day job that generates most of his/her income, but also be the Director of a Foundation for which he/she receives a formal compensation. In such cases it has to be decided whether the assessment is made only for the main occupation or for the totality of a person's professional activities.

e) Data disaggregation

This indicator should be produced by major geographical divisions, including urban/rural areas, and by level of education. The latter may provide a better idea about the degree to which differences in management responsibilities between men and women can be explained (or not) by differences in educational qualifications. Some of the educational categories may be fairly small (e.g. post-graduate studies) which favours disaggregations of such data based on census data, provided that the census identifies these categories. The UN Expert Group Meeting on Migration Data (March 2018) also considered this indicator migration-relevant and recommended its disaggregation by migratory status.

If statistics are available and the sample size permits, it may be of interest to cross-tabulate this indicator by economic activity (International Standard Industrial Classification of All Economic Activities) or disaggregate further to observe the share of women across more detailed occupational groups, to analyse sectoral biases.

When using census data, it has to be borne in mind that censuses enumerate persons at their place of residence, which does not always coincide with their place of work. This is particularly true of persons in managerial positions. Therefore, this indicator should be cross classified by "place of work" for disaggregation of geographical divisions.[12]

7.1.1 Proportion of population with access to electricity

a. Concept and definition

The proportion of population with access to electricity is the percentage of population whose dwelling is served by electrical energy. The target has a wide range of social and economic impacts, including facilitating development of household-based income generating activities and lightening the burden of household tasks.

In many parts of the world, the presence of an electricity connection in the household does not necessarily guarantee that the energy supplied is adequate in quality and reliability or affordable in cost and it would be desirable to have fuller information about these critical attributes of the service, which have been highlighted in SDG7. Substantial progress has already been made toward developing and piloting a new methodology known as the Multi-Tier Framework for Measuring Energy Access (World Bank) which is able to capture these broader dimensions of service quality and would make it possible to go beyond a simple yes/no measure of energy access to a more refined approach that recognizes different levels of energy access, and also takes into account the affordability and reliability of energy access explicitly referenced in the language of SDG7. The adoption of this methodology will allow – over time – the more refined measurement of energy access, making it possible to report more disaggregated information regarding the type of electricity supply (grid or off-grid), the capacity of electricity supply provided (in Watts), the duration of service (daily hours and evening hours), the reliability of service (in terms of number and length of unplanned service interruptions), the quality of service (in terms of voltage fluctuations), as well as affordability and legality of service.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

[12] See also the discussion in section e under indicator 3.c.1.

Data for access to electricity are collected from household surveys and censuses, tapping into a wide number of different household survey types including: Demographic and Health Surveys (DHS) and Living Standards Measurement Surveys (LSMS), Multi-Indicator Cluster Surveys (MICS), the World Health Survey (WHS), other nationally developed and implemented surveys, including those by various government agencies (for example, ministries of energy and utilities).

An alternative source are the household consumption statistics compiled from energy companies which, apart from the number of users, provide information on the amount of electricity consumed. The limitation of these statistics is that they only register paying consumers and thus ignore the number of households served by clandestine energy taps, which are common in many developing countries.

Presence of electrical energy in the housing unit is a core topic recommended by the P&R (4.511-4.512). As such it is available in the vast majority of PHCs in the world. In some cases, the census may provide additional information, such as the way electricity is used (for lighting, cooking, heating) and whether the connection is legal.

c. Method of computation

The population served can be computed easily by counting the number of occupants of housing units served by electricity connections and then dividing by the total population.

As was pointed out above, census data on electricity connections in housing units may not correspond to the number of suscribers registered by the energy companies, due to the problem of illegal energy taps.

d. Challenges in measuring in PHC

Census data normally do not provide information on the amount of energy consumed or the time periods when it is available. A substantial portion of households may have only intermittent access.

e. Data disaggregation

Access to electricity can be disaggregated by rural or urban area and geographic location such as state, region and province. Census data allow much finer disaggregations by geographical area (e.g. at the level of enumeration areas) that cannot be achieved with the use of surveys. Censuses also allow disaggregations by particular characteristics such as small ethnic communities or people living in slum areas (see Indicator 11.1.1).

Other useful disaggregations include those by: 1. End-Use: Cooking / Heating / Lighting and 2. Household income. The disaggregation by household income is made difficult by the fact that most censuses do not have household income data, although different proxies are available.

7.1.2 Proportion of population with primary reliance on clean fuels and technology

(i) Concept and definition

The proportion of population with primary reliance on clean fuels and technology is calculated as the number of people using clean fuels and technologies for cooking, heating and lighting divided by total population reporting that any cooking, heating or lighting, expressed as percentage. “Clean” is defined by the emission rate targets and specific fuel recommendations (i.e. against unprocessed coal and kerosene) included in the normative guidance WHO guidelines for indoor air quality: household fuel combustion.

Current global data collection focuses on the primary fuel used for cooking, categorized as solid or non-solid fuels, where solid fuels are considered polluting and non-modern, while non-solid fuels are considered clean. This single measure captures a good part of the lack of access to clean cooking fuels, but fails to collect data on type of device or technology is used for cooking, and also fails to capture other polluting forms of energy use in the home such as those used for lighting and heating. The latest WHO guidelines recommend against the use of unprocessed coal, but also discourage the use of kerosene (a non-solid but highly polluting fuel) in the home. They also recommend that all major household energy end uses (e.g. cooking, space heating, lighting) use efficient fuels and technology combinations to ensure health benefits. For this reason, the technical recommendations in the WHO guidelines, access to modern cooking solution in the home will be defined as “access to clean fuels and technologies” rather than “access to non-solid fuels.”

Substantial progress has already been made toward developing and piloting a new methodology known as the Multi-Tier Framework for Measuring Energy Access (World Bank) which is able to capture the affordability and reliability of energy access explicitly referenced in the language of SDG7 and harnesses the normative guidance in the WHO guidelines to benchmark tiers of energy access. The methodology for the Multi-Tier Framework for Measuring Energy Access has already been published based on a broad consultative exercise and represents a consensus view across numerous international agencies working in the field.

(ii) Possible data sources, particularly PHC, and their relative advantages/ disadvantages

Primary household fuels and technologies, particularly for cooking, are routinely collected in most countries, using censuses and surveys. Survey sources include Demographic and Health Surveys (DHS) and Living Standards Measurement Surveys (LSMS), Multi-Indicator Cluster Surveys (MICS), the World Health Survey (WHS), and other nationally developed and implemented surveys. The advantage of surveys is that they can be held at relatively short intervals compared to the PHC.

The same information is also routinely collected in PHCs. Although the census has the disadvantage of the long periods between once census and the next, it has the major advantage of allowing disaggregations at small geographical levels which allow, for example, establishing relationships between the use of fuel wood and the local availability of such materials.

The type of fuel used for cooking, lighting and heating is a core subject in the P&R (4.510-4.514). The recommended classification of fuel used for cooking is as follows:
1. Gas
2. Electricity
3. Liquefied petroleum gas (LPG)
4. Kerosene/paraffin (petroleum-based)
5. Oil (including vegetable oils used as fuel)
6. Coal
7. Firewood
8. Charcoal
9. Animal dung
10. Crop residues (for example, cereal straw from maize, wheat, paddy rice, rice hulls, coconut husks, groundnut shells)

11. Other

National census practices vary, however. The 2010 census of Argentina, for example, used only 1, 2, 3 (broken down in 3 sub-categories), and 6-8 lumped together, whereas Nigeria in 2006 used only 1, 2, 4, 7, 9 and 11 (solar). To some extent, these diferences reflect differences in actual practices, as some methods (coal, animal dung) may be extremely rare in some countries. But some of the diferences are more arbitrary. For example, the PHC of Mozambique in 2017 asked for the energy source used in lighting, but not in cooking.

No classification is specifically recommended in the P&R for the type of energy used for lighting and heating.

(iii) Method of computation

The indicator is computed as the number of population that use gas, electricity, LPG and oil (in other words do not use solid fuels or kerosene) either for cooking, lighting and heating divided by total population.

The indicator can be calculated separately for the population relying on clean fuels for cooking, lighting or heating from PHC.

(iv) Challenges in measuring in PHC

The main challenge is that countries do not use the same categories for fuels and that some countries may not ask one of the three questions (cooking, lighting, heating). While the absence of the heating question in countries with warm climates may not be serious, the other two are essential and absence of one of the two may lead to biased results.

(v) Data disaggregation

It would be desirable to disaggregate by geographic location (urban/rural, regions and provinces); and end-use (cooking / lighting / heating). It may also be relevant to disaggregate by whether the household has access to electricity. The fact that a “non-clean” type of energy is used despite the availability of “clean” electrical energy may reveal something about the costs of different options.

8.5.2 Unemployment rate, by sex, age and persons with disabilities

a. Concept and definition

The unemployment rate conveys the percentage of persons in the labour force who are unemployed. Persons in unemployment are defined as all those of working age (usually persons aged 15 and above) who were not in employment, carried out activities to seek employment during a specified recent period and were currently available to take up employment given a job opportunity, where:

(a) “not in employment” is assessed with respect to a short, specified reference period for the measurement of employment;
(b) to “seek employment” refers to any activity when carried out, during a specified recent period comprising the last four weeks or one month, for the purpose of finding a job or setting up a business or agricultural undertaking;

(c) “currently available” serves as a test of readiness to start a job in the present, assessed usually with respect to the same reference period used to measure employment (depending on national circumstances, the reference period may be extended to include a short subsequent period not exceeding two weeks in total, so as to ensure adequate coverage of unemployment situations among different population groups).

The unemployment rate is a useful measure of the underutilization of the labour supply. It reflects the inability of an economy to generate employment for those persons who want to work but are not doing so, even though they are available for employment and actively seeking work. It is thus seen as an indicator of the efficiency and effectiveness of an economy to absorb its labour force and of the performance of the labour market.

A broad concept of disability and functioning has been elaborated in the International Classification of Functioning, Disability and Health (ICF). However, in data collection, countries apply various concepts of disabilities pertaining to impairments, activity limitations, and/or participation restrictions. An impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations (WHO).

The P&R defines persons with disabilities as those persons who are at greater risk than the general population for experiencing restrictions in performing specific tasks or participating in role activities. This group would include persons who experience limitations in basic activity functioning, such as walking or hearing, even if such limitations were ameliorated by the use of assistive devices, a supportive environment or plentiful resources. Such persons may not experience limitations in specifically measured tasks, such as bathing or dressing, or participation activities, such as working or shopping, because the necessary adaptations have been made at the personal or environmental levels. These persons would still, however, be considered to be at greater risk of restrictions in activities or participation than the general population because of the presence of limitations in basic activity functioning, and because the absence of necessary accommodations would jeopardize their current levels of participation.

Based on the recommendations developed and tested by the Washington Group on Disability Statistics, the P&R recommends that a comprehensive measure to determine disability should include the following six domains of functioning: (a) Walking; (b) Seeing; (c) Hearing; (d) Cognition; (e) Self-care; (f) Communication. The first four domains are to be considered essential in determining disability status. The additional domains (e) and (f) comprise a more comprehensive measure for determining disability.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The preferred official national data source for this indicator is a household-based labour force survey. In the absence of a labour force survey, a DHS and/or other type of household surveys with an appropriate employment module may also be used to obtain the required data. It should be noted that while the indicator is widely available from national labour force surveys or other types of household surveys, disaggregation by disability, is not widely available in these surveys. It is increasingly reported but coverage is still very low.

While the measurement of unemployment from PHC data may be less accurate than in specialized labour surveys, one of the important advantages of the census is that it allows much greater disaggregation in general and particularly by disability status as most censuses now include a question on disability. A limitation of the latter is that there is still a lot of variation between countries in terms of the exact format of this question.

Many PHCs now include a question on disability, most often using the Washington Group criterion for limitations of sight, hearing, walking/climbing stairs, autonomy in clothing and personal hygiene, communication, and use of the upper limbs. However, there are still variations in the application of this concept and in the 2010 census round only about a third of those that collected information on disability strictly applied the Washington short set of questions. Also, some censuses use a different disability concept based on specific clinical states such as paralysis or amputation of one or more limbs. Other censuses use screening questions at the household level, a practice not recommended by the Washington Group. Finally, the number of categories for the severity of the limitations to functioning or impairment (depending on the concept of disability used) varies. This means that there is still considerable national variation in the definition of disability. However, the fact that census data on employment can usually be disaggregated by this category should be seen as a major advantage, as disaggregation by disability status is not widely available in labour force surveys.

A third way of obtaining unemployment data is from administrative data like employment office records or unemployment registers. The way these records are maintained depends on national practices that may not be fully in accordance with the statistical definition of the indicator, i.e. being without a job, seeking employment and available for employment. For example, some people registered as unemployed may not have a formal job but make a living with informal activities. Unpaid family workers may not be considered employed for administrative purposes. In some countries, unemployment benefits may also be limited to a maximum period, after which the person is automatically assumed to be non-active.

c. Method of computation

Unemployment rate for total population is calculated as a percentage of the number of unemployed population divided by total population in the labour force.

$$Unemploment\ rate = \frac{Total\ unemployed\ population}{Total\ population\ in\ labour\ force} * 100$$

The computation of the relevant indices is a simple matter of computing this rate by age/sex/disability status (i.e. population with disabilities and without disabilities).

$$Unemploment\ rate\ for\ people\ with\ disabilities = \frac{Unemployed\ population\ with\ disabilities}{Total\ population\ with\ disabilities\ in\ labour\ force} * 100$$

d. Challenges in measuring in PHC

Although census data have the advantage of lending themselves more easily to disaggregation by the relevant categories, including disability status, than data from labour force surveys, the measurement of unemployment based on census data is more subject to problems, as they do not typically allow for detailed probing on the labour market and job search activities of the respondents. In particular, the census has more difficulty in distinguishing between persons who are unemployed and those who are not economically active (discouraged workers). Consequently, censuses tend to produce higher estimates of unemployment than specialized labour force surveys. Finally, the periodicity of census data on unemployment is a major limitation as economic conditions can change relatively quickly and their impact on the labour market needs to be assessed frequently.

e. Data disaggregation

This indicator should, ideally, be disaggregated by sex, age group and disability status. The age group of 15-24 years requires special attention due to the fact that young people are particularly vulnerable to unemployment. It is recommended to disaggregate this indicator by duration of unemployment, geographical location (including urban/rural area, regions and provinces), and education. The latter two are relatively easy to implement with PHC data, but the census generally does not have information that allows the specification of duration of unemployment. The UN Expert Group Meeting on Migration Data (March 2018) also considered this indicator migration-relevant and recommended its disaggregation by migratory status.

8.6.1 Proportion of youth (aged 15-24 years) not in education, employment or training

a. Concept and definition

This indicator measures the proportion of youth (aged 15-24 years) not in education, employment or training. This indicator also is known as "the youth NEET rate"[13].

The share of youth not in employment, education or training (youth NEET rate) provides a measure of youth who are outside the educational system, not in training and not in employment, and thus serves as a broader measure of potential youth labour market entrants than youth unemployment.

It includes discouraged worker youth as well as those who are outside the labour force due to disability or engagement in household chores, among other reasons. NEET is also a better measure of the current universe of potential youth labour market entrants as compared with the youth inactivity rate, as the latter includes those youth who are outside the labour force and are in education, and thus are furthering their skills and qualifications.

It is important to clarify some concepts:

a) For the purposes of this indicator, youth is defined as all persons between the ages of 15 and 24 (inclusive).
b) According to the International Standard Classification of Education (ISCED), education is defined as organised and sustained communication designed to bring about learning. Formal education is defined in ISCED as education that is institutionalized, intentional, and planned through public organizations and recognized private bodies and, in their totality, make up the formal education system of a country.
c) Non-formal education, like formal education is defined in ISCED as education that is institutionalized, intentional and planned by an education provider but is considered an addition, alternative and/or a complement to formal education. It may be short in duration and/or low in intensity and it is typically provided in the form of short courses, workshops or seminars. Informal learning is defined in ISCED as forms of learning that are intentional or deliberate, but not

[13] For more information about the concept, please access: What does NEETs mean and why is the concept so easily misinterpreted? https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_343153.pdf

institutionalized. It is thus less organised and less structured than either formal or non-formal education. Informal learning may include learning activities that occur in the family, in the work place, in the local community, and in daily life, on a self-directed, family-directed or socially-directed basis.

d) For the purposes of this indicator, persons will be considered to be in education if they are in formal or non-formal education, as described above, but excluding informal learning.
e) Persons in employment are defined as all those who, during a short reference period, such as one week or one day, performed work for others in exchange for pay or profit.
f) For the purposes of this indicator, persons are considered to be in training if they are in a non-academic learning activity through which they acquire specific skills intended for vocational or technical jobs.

Vocational training prepares trainees for jobs that are based on manual or practical activities, and for skilled operative jobs, both blue and white collar related to a specific trade, occupation or vocation. Technical training on the other hand imparts learning that can be applied in intermediate-level jobs, in particular those of technicians and middle managers. The coverage of vocational and technical training includes only programmes that are solely school-based vocational and technical training. Employer-based training is, by definition, excluded from the scope of this indicator.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages[14]

Labour force surveys are typically the preferred source of statistics to determine the share of youth not in employment, education or training. This kind of data allows information to be gathered on both the labour market situation of individuals and their participation in education or training programmes.

Population censuses and other types of surveys could also be used as sources of data on the youth NEET. The information obtained from such sources may however be less reliable since they do not typically allow for detailed probing on the labour market activities of the respondents and they typically do not ask about non-formal training activities.

Population censuses are designed to cover virtually the entire population of a given country while household surveys usually cover only the non-institutional population. Both surveys and censuses can collect data from people working in all branches of economic activity, all sectors of the economy and all categories of workers, including the self-employed, contributing family workers, casual workers and multiple jobholders. In addition, such surveys and censuses generally provide an opportunity for the simultaneous measurement of the employed, the unemployed and persons outside the labour force (and thus, the working-age population) in a coherent framework.

In PHCs, collecting data for population who are in attending school is almost universal, but few countries collect information for population who are attending vocational or technical training. ECLAC (2017)[15] suggests that "…..censuses could be adapted to capture this reality in the most objective way. Knowing how to access education outside the formal regime, in which the offer is increasingly broad and heterogeneous, is a necessity for the current situation in the region. This is not just the case for the groups that are targeted by this indicator, but also for other situations in which training extends their employment opportunities and knowledge (for example professors or teachers who study extracurricular courses)." For example, Barbados asked a question in 2010 census for collecting data on

[14] For more information about the concept, please access: What does NEETs mean and why is the concept so easily misinterpreted? https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_343153.pdf

[15] Op. cit. footnote 5.

people who are currently attending technical and vocational training. In the case of PHC it is important to bear in mind that this data may be less reliable compared to LFS since they do not typically allow for detailed probing on the labour market activities of the respondents.

c. Method of computation

The computation method to calculate the NEET rate is simply 100 minus the percentage of youth that are employed or not employed but in education or training.

Youth NEET rate:

$$= \frac{Youth - (Youth\ in\ employment +\ Youth\ not\ in\ employment\ but\ in\ education\ or\ training)}{Youth} \times 100$$

NEET rate = 100 – % of youth employed – % of youth not employed, but in education or training

Care should be taken not to double-count those who are both employed and in education or training.

d. Challenges in measuring in PHC

The main challenge in measuring NEET is that the calculation of this indicator requires reliable information on both the labour market status and the participation in education or training of young persons. The quality of such information is heavily dependent on the questionnaire design and the accuracy of respondents' answers. This is particularly the case for the “training” component which may not be captured by the traditional education categories of the census questionnaire.

e. Data disaggregation

This indicator should be disaggregated by sex and by detailed age groups within the youth age range. Disaggregation by urban/rural arera of residence and by major geographical areas seems desirable. The UN Expert Group Meeting on Migration Data (March 2018) also considered this indicator migration-relevant and recommended its disaggregation by migratory status. Disaggregation by highest level of completed education may also be relevant. Highly educated young people who can afford it often do not accept employment below their aspirations and may prefer to wait for the “right job”. Another important disaggregation is whether or not the person is actively looking for work, as this may occupy a significant portion of his/her time.

9.2.2 Manufacturing employment as a proportion of total employment

a) Concept and definition

The indicator represents the share of manufacturing employment in total employment. It measures the ability of the manufacturing sector to absorb surplus labour forces from agricultural and other traditional sectors towards production labour with higher wages. However, in developed countries an opposite trend is expected where emphasis has shifted to the reduction in labour in manufacturing as part of cost-cutting measures, to promote more capital-intensive industries.

Employment (as previously defined) comprises all persons of working age who during a short reference period (one week), were engaged in any activity to produce goods or provide services for pay or profit. The working-age population is usually defined as all persons aged 15 and above, although some countries use a lower cut-off age. No distinction is made between persons employed full time and those working less than full time.

Manufacturing is defined according to the International Standard Industrial Classification of all Economic Activities (ISIC) revision 4 (2008, the latest) or revision 3 (1990). It refers to industries belonging to sector C in revision 4 or sector D in revision 3.

b) Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The preferred official national data source for this indicator is a household-based labour force survey or other type of household survey with an appropriate employment module. This is largely because of the greater accuracy of economic data in such surveys, compared to the PHC. However, the information required is also collected in virtually all censuses and at the level of detail that is required. Its quality may actually not be significantly worse than in a typical labour survey. Countries with business registers that are complete and up to date can link census data to the register in order to obtain the industry code given to the establishment.

Where no household survey exists, establishment surveys or some types of administrative records may be used to derive the required data, keeping into account the limitations of these sources in their coverage. Specifically, they may exclude some types of establishments, establishments of certain sizes, some economic activities or some geographical areas. Establishment surveys usually have a minimum establishement size cut-off point and small units which are not officially registered (whether in manufacturing or not) would thus not be included in the survey.

Industry or branch of economic activity is a core topic in the P&R and is asked in virtually all PHCs. It recommends that countries compile this information according to the most recent revision of the (ISIC) available at the time of the census, currently version 4, and at the lowest possible level of ISIC or a related national classification supported by the information given in each response. Many countries also collect the name and address of the establishment.

In preparation for the coding of the industry responses that cannot be matched to a precoded register, the P&R (4.359) recommend that the organization responsible for the census should create a coding index that reflects the type of responses that will be given on the census questionnaire. This coding index should be constructed by industry classification experts on the basis of available lists of enterprises, establishments, businesses and so forth, as well as from responses to similar questions in other data collections, including previous censuses, census tests and labour force surveys. The coding index should clearly distinguish between responses belonging to “not elsewhere classified” categories and responses that do not provide enough information to allow for the coding of a detailed industry group.

c) Method of computation

The method of computation is a simple division of employment in manufacturing activities by the total employment in all sectors, multiplied by 100.

$$Proportion\ of\ manufacturing\ emploment\ in\ total\ employment$$

$$= \frac{Total\ employment\ in\ manufacturing\ activities}{Total\ employment\ in\ all\ economic\ activities} * 100$$

d) Challenges in measuring in PHC

Apart from the general problem that censuses tend to be less accurate on employment data than special labour force surveys, there may be problems with respect to the coding of occupations and industry in the data processing. For example, certain occupations in agro-industry may be ambiguous in terms of whether they should be coded as industrial or agricultural. The same may be true of certain service jobs which can be classified under services or under manufacturing, depending on the exact organizational structure of the business.

e) Data disaggregation

This indicator can be disaggregated by sex, occupation, and/or subnational geography and place of work if available in census data. Detailed geographical disaggregations of place of work can be produced to show areas with particularly high concentrations of industrial workers. Break-downs by detailed manufactural sector can be very useful to obtain a better idea of the industrial profile of a country.

11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing

a. Concept and definition

Indicator 11.1.1 includes three topics 'inadequate housing and housing affordability', 'informal settlements' and 'slums'. The SDG metadata provides detailed information for each topic.

Definition of slums

The agreed definition classified a *'slum household'* as one in which the inhabitants suffer one or more of the following *'household deprivations'*:

1. Lack of access to improved water source,
2. Lack of access to improved sanitation facilities;
3. Lack of sufficient living area;
4. Lack of housing durability; and
5. Lack of security of tenure

However, since information on security of tenure is not available for most countries, only first four indicators are often used to define a slum household.

By extension, the term *'slum dweller'* refers to a person living in a household that lacks any of the above attributes.[16]

Definition of informal settlements

Informal settlements are usually seen as synonymous of slums, with a particular focus on the formal status of land, structure and services. They are defined by three main criteria, according to Habitat III Issue Paper #22[17], which are already covered in the definition of slums. These are:

1. Inhabitants have no security of tenure vis-à-vis the land or dwellings they inhabit, with modalities ranging from squatting to informal rental housing;

[16] UN-Habitat (2003), Slums of the World: The face of urban poverty in the new millennium; <mirror.unhabitat.org/pmss/getElectronicVersion.aspx?nr=1124&alt=1>

[17] United Nations (2015), Conference on Housing and Sustainable Urban Development – Habitat III, Issue Paper No. 22 on Informal Settlements; UN-Habitat (2015), Slum Almanac 2015-2016.

2. The neighbourhoods usually lack, or are cut off from, formal basic services and city infrastructure; and
3. The housing may not comply with current planning and building regulations, is often situated in geographically and environmentally hazardous areas, and may lack a municipal permit.

Definition of inadequate housing
For housing to be adequate, it must provide more than four walls and a roof, and at a minimum, meet the following criteria:
1. Legal security of tenure, which guarantees legal protection against forced evictions, harassment and other threats;
2. Availability of services, materials, facilities and infrastructure, including safe drinking water, adequate sanitation, energy for cooking, heating, lighting, food storage or refuse disposal;
3. Affordability, as housing is not adequate if its cost threatens or compromises the occupants' enjoyment of other human rights;
4. Habitability, as housing is not adequate if it does not guarantee physical safety or provide adequate space, as well as protection against the cold, damp, heat, rain, wind, other threats to health and structural hazards;
5. Accessibility, as housing is not adequate if the specific needs of disadvantaged and marginalized groups (such as the poor, people facing discrimination; persons with disabilities, victims of natural disasters) are not taken into account;
6. Location, as housing is not adequate if it is cut off from employment opportunities, health-care services, schools, childcare centres and other social facilities, or if located in dangerous or polluted sites or in immediate proximity to pollution sources; and
7. Cultural adequacy, as housing is not adequate if it does not respect and take into account the expression of cultural identity and ways of life.

Summary of criteria defining slums, informal settlements and inadequate housing			
	Slums	Informal Settlements	Inadequate Housing
Access to water	X	X	X
Access to sanitation	X	X	X
Sufficient living area, Overcrowding	X		X
Structural quality, durability and location	X	X	X
Security of tenure	X	X	X
Affordability			X
Accessibility			X
Cultural adequacy			X

As seen in the table above, most of the criteria for defining slums, informal settlements and inadequate housing overlap. The three criteria of informal settlements ('*Inhabitants have no security of tenure', 'the neighbourhoods usually lack, or cut off from, formal basic services*' and *'the housing may not comply with current planning and building regulation*') are essentially captured in the definition of slums, which sustains the combination of both (slums/informal settlements). From the seven criteria of inadequate housing ('*legal security of tenure', 'availability of services, materials, facilities and infrastructure', 'affordability', 'habitability', 'accessibility', 'location' and 'cultural adequacy'*) the three that are not covered by slums / informal settlements are affordability, accessibility and cultural adequacy. For the purpose of composing an indicator, affordability is the most relevant and easier to measure.

Indicator 11.1.1 does not capture homelessness.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

Data for the slum/informal settlements components of the indicator can be computed from PHC and national household surveys, including DHS and MICS. Data for the inadequate housing component can be computed through income and household surveys that capture housing expenditures.

For primary reporting, national data providers (especially NSOs) will play an important role generating the primary data through census and surveys.

The P&R (4.419) recommends a long list of topics regarding housing conditions which is reproduced below, in as far as it is relevant to the measurement of this indicator:

	Housing topics	Type of topic [18]	Dimension of quality of housing
1	Living quarters—type of (paras. 4.421- 4.462)	C	Structural Quality /Durability
2	Ownership—type of (paras. 4.476- 4.481)	C	Security of Tenure
3	Rooms—number of (paras. 4.482- 4.484)	C	Sufficient Living Area
4	Useful floor space—(paras. 4.487- 4.489)	A	Sufficient Living Area
5	Water supply system (paras. 4.490- 4.493)	C	Access to Imp. Water Supply
6	Drinking water—main source of (paras. 4.494- 4.495)	C	Access to Imp. Water Supply
7	Toilet—type of (paras. 4.496- 4.499)	C	Access to Imp. Sanitation
8	Sewage disposal (para. 4.500)	C	Access to Imp. Sanitation
9	Occupants—number of (paras. 4.524- 4.525)	C	Sufficient Living Area
10	Year or period of construction (paras. 4.535- 4.539)	A	Structural Quality/Durability
11	Construction material of outer walls (paras. 4.545- 4.547)	C	Structural Quality/Durability
12	Construction material of floor and roof (para. 4.548)	A	Structural Quality/Durability
13	State of repair (paras. 4.552- 4.553)	A	Structural Quality/Durability
14	Tenure (paras. 4.556- 4.559)	C	Security of Tenure
15	Rental and housing costs (paras. 4.560- 4.562)	A	Affordability

With respect to the first item, the P&R (paragraph 4.446) clarifies that **informal housing units** comprise three subgroups: “improvised housing units”, “housing units in permanent buildings not intended for human habitation” and “other informal housing units”. These units are characterized by the fact that they are either makeshift shelters constructed of waste materials and generally considered unfit for habitation (squatters’ huts, for example) or places that are not intended for human habitation although in use for that purpose at the time of the census (barns, warehouses, natural shelters and so on). Under almost all circumstances, such places of abode represent unacceptable housing and they may be usefully grouped together in order to analyse the housing conditions of the population and to estimate housing needs. They alert, however, (the P&R, paragraph 4.444) that “although mobile housing units are significantly different from other housing units in that they can be readily moved or transported, mobility in itself is not necessarily an indicator of low quality. For the assessment of housing conditions in countries with a substantial number of mobile units, it may be useful to classify them further as tents,

[18] The codes in the third column refer to whether the question is considered a Core (C), Additional (A), or Derived (D) topic (see P&R, 2017). The last column refers to the different dimension of quality of housing.

wagons, boats, trailers or other unit types.” Examples of sub-standard housing according to this criterion include census descriptors such as the following:

Argentina, 2010:	Local no construído para habitación
Jamaica, 2011:	Improvised housing unit
Nigeria, 2006:	Informal/improved dwelling
Panamá, 2009:	Improvisada; Local no destinado a habitación, pero utilizado como vivenda
South Africa, 2011:	Informal dwelling (shack in backyard / informal squatter settlement)

Security of tenure can be characterized by the question on home ownership or tenant status, accompanied by the appropriate assurances of legal status of either. In the case of home ownership, most censuses ask if the inhabitants have completely paid for the dwelling or are still in the process of paying. In the case of tenant status, it is rare to have a question on the existence of a formal rental contract. Categories such as (occupied rent free, condemned structure, squatted) tend to indicate insecurity of tenure. Some PHCs ask whether the terrain is owned by the occupants, but this question is relatively rare. It is recommended that this question (16 in the list above) should be included in more censuses, so as to allow the assessment of the security of tenure. However, it might be sensitive topic for some countries, particularly if any document is requested as a proof of a tenure arrangement or owner of the dwelling.

The vast majority of PHCs asks about the household water supply (core topic), toilet facilities (core topic), and about the kind of waste disposal (core topic) , although the number of categories that is distinguished can vary considerably (depending on national circumstances), particularly with respect to the origin of the water consumed. Paragraph 4.494 of the P&R specifies that an improved water source (piped water, public tap or standpost, tubewell or borehole, protected dug well, protected spring, rainwater) can be safely managed. The details of establishing whether the household has access to an improved water supply are discussed under indicator 6.1.1.

Access to improved sanitation can be established by asking the question on toilet facilities and the type of sewage disposal (9 and 10 in the list above), which form part of the core content recommended by the P&R. The details of establishing whether the household has access to an improved sanitation system are discussed under indicator 6.2.1.

Most PHCs ask about the **building materials** used in the construction of the dwelling. The precise number of items and the types of building materials vary from country to country, but generally the following components are asked:

- Materials used for the roof;
- Materials used for the external walls;
- Materials used for the internal walls;
- Materials used for paving the floor.

Some of these items, such as earth floors, can be used as indicators of poor quality of construction. Some censuses also ask for the age of the building. Some PHCs ask a direct question about the quality of the construction, but this is fairly rare.

It is generally not possible to characterize the **security of the location** of the dwelling through direct census questions. However, any hazards that may be present due to locational hazards (such as earthquakes or flooding) can usually be assessed by studying the cartography, provided that the maps identify any such hazards or can be overlaid with specific hazard maps. This, however, goes beyond the data processing that is normally carried out in the processing of a PHC.

Most PHCs ask about the total **number of rooms (core topic**) and the number of rooms being used as **bedrooms**. This allows calculating the number of occupants per (bed)room. A few PHCs also ask for the total floor surface of the dwelling. This allows the characterization of the sufficiency of living area.

In the cases of rented property, some PHCs ask for the value of the rent paid, which allows the characterization of affordability.

c. Method of computation

The indicator considers two components: one for slum/informal settlements (SISH) and one for inadequate housing households (IHH). In both cases, the component indicator is computed simply as the number of people living in SISH or IHH households in each category divided by the city (or urban) population.

This indicator is expected to be a composite one, with the main components of slum/informal settlements and the added component of affordability defining inadequate housing. Table below details the proposed definition of Slum/Informal Settlements and Inadequate Housing as well as the respective measurements (see metadata).

Definition and measurement criteria for slums, informal settlements and inadequate housing in the census

Slums / Informal Settlements	**DEFINITION:** As adopted in the MDG, household where the inhabitants suffer one or more of the following 'household deprivations': 1) Lack of access to improved water source, 2) Lack of access to improved sanitation facilities, 3) Lack of sufficient living area, 4) Lack of housing durability and, 5) Lack of security of tenure.	
	Measurement in the census[19]	
	1. Lack of access to improved water source	A household whose members have acess to improved water source, if they have an acess to a piped water in the housing unit, plot or yard; public tap/stand pipe service; protected spring and rain water collection (for the classification of water source, see P&R paragraph 4.494). Otherwise, the household has no acess to improved water source and will be included in slum dweller. For the classification of improved and unimproved water sources in the census, see the discussion under indicator 6.1.1.
	2) Lack of access to improved sanitation facilities	A household whose members have acess to improved sanitation facilities if they have access to a piped system connected to a public sewage disposal plant or an individual sewage disposal system (septoc tank, cesspool).

[19] Measurements based on those in the (2003) UN-Habitat Challenge of Slums, p.12.

		Otherwise a household has no access to improved sanitation system (there is no disposal system or toilet empties into an open ditch, a pit, a river or the sea) and will be included in slum dweller. For the classification of sewage disposal system, see P&R paragraph 4.500.
	3) Lack of sufficient living area	A house is considered to provide a sufficient area for the household members if not more than two people share the same habitable room that is a minimum of four-square meters in area. Every census provides data for calculating the number of persons per room at housing unit level (see the table above). If a household does not have a sufficient space for living, people living in this household will be included in slum dweller.
	4) Lack of housing durability (Structural quality and permanency of the structure)	A house is considered as 'durable' if it has a permanent and adequate structure able to protect its inhabitants from the extremes of climatic conditions such as rain, heat, cold, and humidity. The following criteria should be considered when placing a housing unit in the category of dilapidated structure: Type of housing units which are not expected to maintain its durability for as long a period of time as a conventional dwelling (P&R para. 4.437), such as semi-permanent housing unit and informal housing unit; Materials used for the walls, roof and floor. Depending on a country specific definition, some construction materials are considered not permanent structure such as mud, unburnt clay, earth, palm and straw; Housing unit is in a dilapidated state if there is a need for serious repair or it is irreparable (see P&R paragraph 4.552) Housing unit is located in hazardous areas such as near toxic waste, in a flood plain, steep slope If at least one of these conditions exits, then housing units will be included in slum dweller.
	5) Lack of security of tenure	For measuring security of tenure, the census should provide data for the following topic: If the household is owner, whether they have formal title deeds for land and/or housing unit If the household is tenant, whether they have aggrements or any document as a proof of a tenure arrangement Households which do not meet with the above-mentioned criteria will be included in slum dweller.

		As explained above, this item can be ignored if it is not available in the census.
Inadequate housing	**DEFINITION:** Proposed to complement the slums/informal settlements measuring affordability of housing at the global level.	
	Measurement in the census	
	Inadequate housing	A household with net monthly expenditure on housing exceeding 30% of the total monthly income of the household will be considered as inadequate housing. Some countries collect this information through a question on (proportion of) net monthly expenditure or rent and total income of the household (see P&R 4.560-4.562)

Steps for identifying a slum/informal settlement/inadequate households:

The slum households estimation process proceeds as follows:
First stage- the response categories for each household to questions on water, sanitation, structural quality of housing, overcrowding and security of tenure in the census data are reviewed;
Second stage- each response category can be classified as slum/informal households or not slum/informal households according to the given criteria;
Third stage- each household lacking one or more of the indicators presented in the table above is identified. This stage can start with tallying the number of households in a city area (or urban area if interested) that lack access to improved water as water appeared to be the most influential of the five indicators. Thereafter, the number of households lacking improved sanitation, without durable housing, living in overcrowded conditions and lacking secure tenure can be tallied in this sequence.
Fourth stage - total of households lacking one or more of the five attributes is calculated. The slum indicator is then computed as the total number of people living in households in urban area (or cities) that lack one or more of the conditions listed in the table above divided by the urban (or city) population , expressed as a percentage.

> The sequential order of the estimation procedure prevents the double counting of households, as each household is eliminated after being evaluated against a given indicator. If a household lacks both improved water and sanitation, it should be counted once. Likewise, households lacking all five acceptable conditions were counted once. The order of the estimation procedure approximates the availability of data, with lack of access to improved water and sanitation being the major classifiers of slum households, while information on secure tenure was the least available.

The indicator considers two components to be computed as follows:

Proportion of population living in slum/informal households (SISH) is calculated using the following formula:

$$= \frac{Number\ of\ people\ living\ in\ SISH\ households}{City\ population} * 100$$

Proportion of population living in inadequate housing households (IHH) is calculated using the following formula:

$$= \frac{Number\ of\ people\ living\ in\ IHH\ households}{City\ population} * 100$$

d. Challenges in measuring in PHC

The main challenge in defining population living in slums and assessing the quality and affordability of housing is the heterogeneity of the questions that PHCs in individual countries ask about types of housing units and its characteristics. Although PHCs generally attempt to collect a significant amount of information on the characteristics of the housing unit, the specific questions vary considerably. In the more developed countries, the basic information on the characteristics of the building may not be asked because it is available in separate data bases that can be linked to the census. But this is by no means the case everywhere. Questions such as the security of land and dwelling tenure are asked in some censuses, but not nearly in all. Although there is a good number of countries that ask questions on number of rooms/bedrooms and construction materials, questions about the total floor surface or the quality of construction are rare.

Although the question on the availability and origin of the water consumed in the household is asked almost universally, the amount of detail available to assess the safety of this supply varies from country to country, in ways that do not always allow distinguishing between safe and unsafe water supply (see indicator 6.1.1).

Some of its components are difficult to define in a uniform manner. For example, it is difficult to agree universally on some definitions and characteristics when referring to deteriorated housing conditions, often due to political or economic considerations.

Although the type of building materials used can provide useful clues as to the quality of construction, there is usually no way to verify whether the construction complies with local building codes, standards and bylaws.

There is generally no direct information in the PHC on whether the dwelling is located on or near a hazardous site. Making this assessment may be possible by a careful analysis of the census cartography, provided that it identifies or can be merged with geographical data bases that identify such sites.

Although a fair number of PHCs ask for the value of the rent paid for the home or apartment, few censuses have income data that make it possible to assess the percentage that this constitutes of the total household income.

As was mentioned earlier, indicator 11.1.1 does not consider the criterion of homelessness, even though there are a good number of PHCs that collect information on the homeless.

e. Data disaggregation

The following disaggregations are suggested:

- Disaggregation by location (city, urban)
- Disaggregation by income group (or wealth group)
- Disaggregation by sex, age, ethnocultural characteristics, migration status (household members)
- Disaggregation by disability (household members)

In addition, the following derived indicators can be calculated:

Proportion of households with durable housing
Proportion of households with improved water
Proportion of households with improved sanitation
Proportion of households with sufficient living space
Proportion of households with security of tenure
Proportion of households with one (1) housing deprivation
Proportion of households with multiple (3 or more) housing deprivations
Proportion of households with (in) adequate housing (affordability)

3.2. Indicators for which the CRVS is the most obvious source (Group 1.II)

3.1.1 Maternal mortality ratio

a. Concept and definition

The maternal mortality ratio (MMR) is defined as the number of maternal deaths during a given time period per 100,000 live births during the same time period. It depicts the risk of maternal death relative to the number of live births and essentially captures the risk of death in a single pregnancy or a single live birth. Maternal deaths are defined as female deaths from any cause related to or aggravated by pregnancy or its management (excluding accidental or incidental causes) during pregnancy and childbirth or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, expressed per 100,000 live births, for a specified time period.

Due to the fact that maternal deaths are a relatively rare phenomenon and their measurement is affected by several sources of uncertainty, point estimates of the MMR have relatively wide uncertainty intervals. For example, while the global MMR estimate from the 2017 estimation round is 211 deaths per 100,000 live births, the 80% uncertainty interval extends from 199 to 243, meaning that there is still a 20% chance that the true ratio was smaller than 199 or larger than 243.

Although the MMR is the most common maternal mortality indicator, there are other measures. The maternal mortality rate (MMRate) is calculated as the number of maternal deaths divided by person-years lived by women of reproductive age. The MMRate captures the combined risk of maternal death per pregnancy or per total birth (live birth or stillbirth) and the level of fertility (mean number of births per year) of women in the population. It provides a better approximation of the total weight of maternal mortality in the population but is less adequate as a measure of the risk of individual pregnancies. In addition to the MMR and the MMRate, it is possible to calculate the adult lifetime risk of maternal mortality for women in the population. An alternative measure of maternal mortality, the proportion of deaths among women of reproductive age that are due to maternal causes (PM), is calculated as the number of maternal deaths divided by the total deaths among women aged 15–49 years.

b. Possible data sources, particularly PHC and CRVS, and their relative advantages/ disadvantages

The data sources for maternal mortality are quite varied. While the natural source for data on maternal deaths is the CRVS, this source is often affected by data quality problems, both in terms of the coverage of deaths in general and of the classification of maternal deaths. Even in countries with generally good CRVS data, the erroneous classification of deaths often leads to under-estimation of the number of maternal deaths. The Maternal Mortality Estimation Inter-Agency Group (MMEIG) developed a specific model to correct the CRVS data. Despite its problems, the CRVS system, when of acceptable quality, is still the preferred data source for measuring maternal mortality.

A national census, with the addition of a limited number of questions, can produce estimates of maternal mortality. This approach eliminates sampling errors (because all women aged under 50 are covered) and hence allows a more detailed breakdown of the results, including trend analysis, geographic subdivisions and social strata. The census has some comparative advantages and limitations:

a. This approach allows identification of deaths in the household in a relatively short reference period (1–2 years), thereby providing recent maternal mortality estimates, but is conducted at 10-year intervals and therefore limits monitoring of maternal mortality.
b. Like the sisterhood method, it identifies pregnancy-related deaths (not maternal deaths); however, if combined with verbal autopsy, maternal deaths could be identified.
c. Training of enumerators is crucial, since census activities collect information on a range of other topics unrelated to maternal deaths.
d. Results must be adjusted for characteristics such as completeness of death and birth statistics and population structures, in order to arrive at reliable estimates.

Maternal mortality can be also measured through other data sources. This section provides brief information about these sources below.

Demographic and Health Surveys (DHS) and **Multiple Indicator Cluster Surveys** (MICS) use the direct "sisterhood" method using household survey data. This method obtains information by interviewing a representative sample of respondents about the survival of all their siblings (to determine the age of all siblings, how many are alive, how many are dead, age at death and year of death of those dead, and among sisters who reached reproductive age, how many died during pregnancy, delivery or within two months of pregnancy). This approach has the following limitations.

f) It identifies pregnancy-related deaths (i.e. deaths occurring during pregnancy, childbirth or the period of 42 days after childbirth), rather than maternal deaths per se.
g) It produces estimates with wide confidence intervals, thereby diminishing opportunities for trend analysis.
h) It provides a retrospective rather than a current maternal mortality estimate (referring to a period approximately 5 years prior to the survey); the analysis is more complicated.

Reproductive Age Mortality Studies (RAMOS) identify and investigate the causes of all deaths of women of reproductive age in a defined area or population, by using multiple sources of data (e.g. interviews of family members, CRVS, health-care facility records, burial records, traditional birth attendants). This method has the following characteristics:

1. Multiple and diverse sources of information must be used to identify deaths of women of reproductive age; no single source identifies all the deaths.
2. Interviews with household members and health-care providers and reviews of facility records are used to classify the deaths as maternal or otherwise.
3. If properly conducted, this approach provides a fairly complete estimation of maternal mortality (in the absence of reliable routine registration systems) and could provide subnational MMRs. However, inadequate identification of all deaths of reproductive-aged women results in underestimation of maternal mortality levels.
   This approach can be complicated, time-consuming and expensive to undertake – particularly on a large scale.
   The number of live births used in the computation may not be accurate, especially in settings where most women deliver at home.

Finally, the **verbal autopsy method** is used to assign cause of death through interviews with family or community members, where medical certification of cause of death is not available. Verbal autopsies may be conducted as part of a demographic surveillance system maintained by research institutions that collect records of births and deaths periodically among small populations (typically in a district). This approach may also be combined with household surveys or censuses. In special versions, and in combination with software that helps to identify the diagnosis, verbal autopsy is suitable for routine use as an inexpensive method in populations where no other method of assessing the cause of death is in place. The following limitations characterize this approach.

- Misclassification of causes of deaths in women of reproductive age is not uncommon with this technique.
- It may fail to identify correctly a group of maternal deaths, particularly those occurring early in pregnancy (e.g. ectopic, abortion-related) and indirect causes of maternal death (e.g. malaria).
- The accuracy of the estimates depends on the extent of family members' knowledge of the events leading to the death, the skill of the interviewers, and the competence of physicians who carry out the diagnosis and coding. The latter two factors are largely overcome by the use of software.
- Detailed verbal autopsy for research purposes that aims to identify the cause of death of an individual requires physician assessment and long interviews. Such systems are expensive to maintain, and the findings cannot be extrapolated to obtain national MMRs. This limitation does not exist where simplified verbal autopsy is aiming to identify causes at a population level and where software helps to formulate the diagnoses.

The latest global study of maternal mortality levels carried out by the Maternal Mortality Estimation Inter-agency Group (MMEIG),[20] made extensive use of CRVS data (2204 data points over a 17-year period), but also used RAMOS and other specialized studies (534 data points), other studies that provide maternal mortality data (216 data points) and 1169 data points based on sources that provide information on pregnancy-related mortality, i.e. mortality occurring while the woman is pregnant, delivering or within 42 days after a birth, but that cannot be classified as maternal with certainty. These are primarily census and survey data. In the 2010 census round, this method for measuring maternal mortality has been followed in more than 30 countries that do not have reliable registration data, particularly in Africa.

The census method for computing maternal mortality is generally based on the question about household deaths in the past 12 months, classified by sex of deceased and age at death. In order to estimate maternal mortality, the previous question can be followed up by two additional ones, namely:
(*a*) Was the death due to an accident, violence, homicide or suicide?
(*b*) If the deceased was a woman aged 15 to 49 (or 12 to 49, in countries with very early fertility), did the death occur while she was pregnant or during childbirth or during the six weeks after the end of pregnancy?

c. Method of computation

Calculation from CRVS data

In CRVS systems of good quality, the MMR can be computed directly dividing the number of maternal deaths by the number of births and multiplying by 100,000. Adjustments for the under-statement of the number of maternal deaths are often necessary. Some, mostly developed countries correct their CRVS data, usually as the result of a Confidential Enquiry into Maternal Deaths (CEMD). In others it is necessary to impute model-based correction factors.

Calculation from PHC data

[20] WHO; UNICEF; UNFPA; World Bank and the UN Population Division (2019). *Trends in Maternal Mortality: 2000 to 2017: Estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division*. Geneva, WHO.

In most countries the census data on maternal mortality are based on the question about household deaths during the past 12 months, classified by sex of the deceased and age at death, and – in case of the death of a woman of reproductive age – whether the woman was pregnant, giving birth or had given birth during the past 42 days.

In order for the information derived from these items to be reliable, it is important that all deaths to household members during the past 12 months be recorded as completely and accurately as possible. Typically, however, reports of deaths in censuses under-estimate the overall number of deaths, if only because some deaths result in the disintegration of households, so that household survivors, if any, may not report their occurrence (in particular, deaths of persons living alone at the time of death are unlikely to be reported). Nevertheless, provided that there are no serious errors in the reporting of age at death, estimates of completeness of death reporting can be derived via indirect estimation and adequate mortality estimates can be obtained. The typical methods used to correct the census data are the Generalized Growth Balance (GGB) method and the Synthetic Extinct Generation (SEG) method.[21] Although the estimate obtained from the census includes deaths to women during pregnancy, childbirth or post-partum period that were not due to maternal causes, question 'Was the death due to an accident, violence, homicide or suicide?' (see the previous section) allows the elimination of at least the most obvious non-maternal deaths. The proportion of deaths that are maternal (PM) is then applied to the number of deaths of women of reproductive age to produce national estimates (using data from household deaths or estimates based on other indirect methods).

[21] See chapter 4 on methods for data evaluation and adjustment in WHO, *WHO Guidance for Measuring Maternal Mortality from a Census* (Geneva, World Health Organization, 2013), available from http://apps.who.int/iris/bitstream/10665/87982/1/97892415 06113_eng.pdf; and T. A. Moultrie, R. E. Dorrington, A. G. Hill, K. Hill, I. M. Timæus and B. Zaba, eds., *Tools for Demographic Estimation* (International Union for the Scientific Study of Population, 2013), available from http://demographicestimation.iussp.org.

BOX. Brief summary of Indirect Method

The country-level statistical model used by MMEIG to estimate maternal mortality has changed a number of times, most recently between the 2015 and 2017 updates. While the statistical properties of the model have improved over time, it has also become more difficult to apply at the country level, for example to disaggregate national level data into regional estimates. This is because the structure of the model requires it does not provide any simple explicit formulas that can be used to link the raw data to the estimates, without going through the entire estimation process. Providing such a simple procedure that countries can use to disaggregate the model into sub-national estimates has become an important issue to be dealt with.

As it is, the model consists of the following parts:
1. A Bayesian CRVS adjustment model, for countries that have a CRVS system of sufficient quality;
2. The BMat model, for all countries, including those that have CRVS data of sufficient quality, to estimate the final MMR.
The BMat model models MMR for each country-year as the sum of the HIV MMR (i.e. the portion of MMR that is due to HIV-related maternal deaths) and the non-HIV MMR (i.e. the portion of MMR that is due to non-HIV-related maternal deaths):

MMR = Non-HIV MMR + HIV MMR,

where non-HIV-related maternal deaths refer to maternal deaths due to direct obstetric causes or to indirect causes other than HIV, while HIV-related maternal deaths are those HIV-related deaths for which pregnancy was a substantial aggravating factor (also known as HIV-related indirect maternal deaths).

The non-HIV MMR is estimated as follows:

Non-HIV MMR(t) = Expected non-HIV MMR(t) * Data-driven multiplier(t)

where the expected non-HIV MMR(t) is estimated from a hierarchical regression model using covariates (predictor variables) and country-specific intercepts. The data-driven multiplier(t) allows for deviations away from the rate of change in MMR implied by the expected non-HIV MMR, as indicated by country-year-specific data points.

The regression model for the later has the following form:

$$\text{Log}\,(EPM^{NA}) = b_0 + b_1 \log(GDP) + b_2 \log(GFR) + b_3\, SBA + \gamma_j + \varphi_k$$

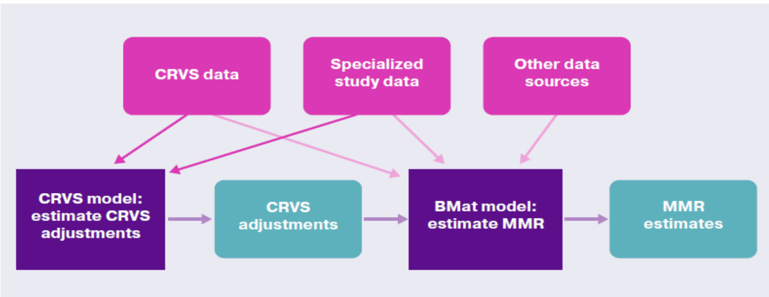
Where:
EPM^{NA} = expected proportion of non-HIV-related deaths to women aged 15–49 years that are due to maternal causes
GDP = gross domestic product per capita (in 2011 PPP US dollars)
GFR = general fertility rate (live births per woman aged 15–49 years)
SBA = proportion of births attended by skilled health personnel
γ_j = random intercept term for country j
φ_k = random intercept term for region k.

For countries with data available on maternal mortality, the expected proportion of non-HIV-related maternal deaths was based on country and regional random effects, whereas for countries with no data available, predictions were derived using regional random effects only.

The final maternal mortality indicators are now estimated as follows:

MMR = PM * D / B

where D is the number of deaths in women aged 15–49 years and B is the number of live births for the country-year corresponding to the estimate.



The MMEIG methodology cannot be easily reproduced at the national level in a way that is consistent with the country-level model. Until the MMEIG proposes an explicit methodology to this end, probably the best that can be done is to follow the methods explained earlier in this section, based on the GGB or SEG corrections, and then make a correction to the final results, in order to ensure overall consistency with the MMEIG country estimate.

d. Challenges in measuring in CRVS and PHC

As was indicated above, CRVS data may be affected by both under-registration of deaths and by misclassification of maternal deaths. On average the MMEIG estimates that CRVS data have to be adjusted by 50% in order to correct the misclassification bias, but CEMD investigations carried out in different developed countries show a significant variation around this value.

Census estimates based on household deaths during the past 12 months are typically affected by the general tendency for under-declaration of such deaths. While indirect demographic estimation methods exist that may correct this bias (the GGB and SEG methods referred to in section c), it is not known if pregnancy-related deaths are under-stated by the same factor as deaths due to other causes. The other problem is that the census, strictly speaking, does not measure maternal deaths but identifies pregnancy-related deaths (i.e. deaths occurring during pregnancy, childbirth or the period of 42 days after childbirth).

e. Data disaggregation

Due to the fact that maternal mortality is a relatively rare event, the opportunities for data disaggregation are limited. In small countries, with less than a million inhabitants, and moderately low maternal mortality, the annual number of maternal deaths may be less than 25, thereby making disaggregation impractical. In larger countries, it is generally recommended to disaggregate the indicator by major age categories and by major geographical divisions, including urban and rural areas. It may also be possible to disaggregate the information by educational levels and by wealth strata.

At present, disaggregations are foreseen by 1. Place of residence; 2. Educational attainment; 3. Ethnicity; 4. Migration status and refugees, 5. Income (or wealth) group;. The disaggregation by education and residence (main geographical divisions) should generally not be a problem, but income groups can probably only be established in an approximate way (using the MPI or wealth quintile criterion) and ethnic groups may, in some cases, be too small to allow reliable estimates.

Current MMR estimates prepared by the MMEIG are reported at Country, Regional, and Global levels. Regional level estimates have income strata per World Bank classification.

3.1.2 Proportion of births attended by skilled health personnel

a. Concept and definition

The percentage of births attended by skilled health personnel (generally doctors, nurses or professionally trained midwives) refers to the percentage of births attended by health personnel trained in providing lifesaving obstetric care, including giving the necessary supervision, care and advice to women during pregnancy, labour and the post-partum period, conducting deliveries on their own, and caring for newborns. Traditional birth attendants, even if they receive a short training course, are not included.

Having a skilled attendant at the time of delivery is an important lifesaving intervention for both mothers and babies. Not having access to this key assistance is detrimental to women's health and gender empowerment because it could cause the death of the mother or long-lasting disability, especially in marginalized settings.

b. Possible data sources, particularly CRVS, and their relative advantages/ disadvantages

National-level household surveys are the main data sources used to collect data for the antenatal care indicators, including DHS, MICS, and Reproductive Health Surveys (RHS) and national surveys based on similar methodologies. The surveys are undertaken every 3-5 years. UNICEF and WHO maintain joint databases on skilled attendance at delivery (doctor, nurse or midwife) and both collaborate to ensure the consistency of data sources.

In countries where the completeness of birth registration is high and where the attendance at birth is systematically recorded, the information can be reliably estimated from CRVS data. Even in countries where birth statistics are under-stated to some extent, the proportion of births attended by skilled health personnel could theoretically be assessed based on these statistics, provided that there is no statistical correlation between attendance by skilled health personnel and registration of the birth. However, in practice this condition is not likely to be satisfied, as attendance by skilled health personnel is likely to be tied to hospital deliveries and hospitals are also likely to provide birth registration.

There are problems regarding the definition of what constitutes skilled health personnel. In this regard, CRVS figures compiled at the health facility level actually tend to be more accurate than those based on survey data collected at the household level as some survey reports may present a total percentage of births attended by a skilled health professional that does not conform to the SDG definition (e.g., total includes provider that is not considered skilled, such as a community health worker). In some countries where skilled attendant at birth is not available, birth in a health facility (institutional births) is used instead. This is frequent among Latin American countries, where the proportion of institutional births is very high. However, institutional births may underestimate the percentage of births with skilled attendant.

The P&RVS (UN Principles and Recommendations for a Vital Statistics System Revision 3) lists attendance at birth as one of its recommended topics that can be collected directly from CRVS data. In section 38, the publication refers to the attendant at birth or delivery as the person who assisted the mother in delivering a live-born infant or a dead foetus. The attendant should be classified as: (a) physician, (b) nurse, (c) nurse-midwife, (d) midwife, (e) other paramedical personnel, (f) layperson or (g) "not stated".

The P&RVS further explains that attendance at birth or delivery provides useful information on the utilization of medical-care facilities and resources. Statistics on live birth by site of delivery and attendant at birth are of great use in evaluating the need for medical services and for providing insight into patterns of infant mortality.

c. Method of computation

The number of women aged 15-49 with a live birth attended by a skilled health personnel (doctors, nurses or midwives) during delivery is expressed as a percentage of women aged 15-49 with a live birth in the same period.

d. Challenges in measuring in CRVS

The primary problem concerns the under-registration of births. This would not be a problem per se in the absence of any correlation between registration and delivery by skilled health personnel, but in practice it is likely that this correlation exists, i.e. the higher the under-registration, the higher the tendency to over-estimate attendance by skilled health personnel.

Another potential problem is that some countries may not systematically collect CRVS data on attendance at birth, even although this practice is recommended by the P&RVS. In some countries, the data may not be organised by residence of the mother, but rather by place of delivery. This can potentially affect the interpretation of any detailed geographical disaggregations made.

e. Data disaggregation

For this indicator, when data are reported from household surveys, disaggregation is available for area of residence of the mother (urban/rural), household wealth quintiles, maternal age, and major geographic regions. The wealth quintiles may actually not be a viable option as CRVS data may be insufficient to construct viable wealth quintiles based on the standard DHS methodology. Simpler stratification variables such as maternal education may be a more viable alternative. The disaggregation by detailed geographical regions needs to be handled cautiously if the data has not been reclassified by the residence of the mother. Another relevant disaggregation may be by place of delivery (hospital / home), which provides an idea about the viability of home delivery with adequate attendance.

3.2.1 Under-five mortality rate

a. Concept and definition

Under-five mortality is the probability of a child born in a specific year or period dying before reaching the age of 5 years, if subject to the age-specific mortality rates of that period, expressed per 1,000 live births. The under-five mortality rate as defined here is, strictly speaking, not a rate (i.e. the number of deaths divided by the number of population at risk during a certain period of time) but a probability of death derived from a life table and expressed as a rate per 1,000 live births.

Mortality rates among young children are a key output indicator for child health and well-being, and, more broadly, for social and economic development. The under-five mortality rate is a closely watched public health indicator because it reflects the access of children and communities to basic health interventions such as vaccination, medical treatment of infectious diseases and adequate nutrition.

b. Possible data sources, particularly PHC and CRVS, and their relative advantages/ disadvantages

The preferred source of data is a CRVS system that records births and deaths on a continuous basis. CRVS data are the preferred data source for under-five, infant and neonatal mortality estimation. The calculation of the under-five and infant mortality rates from CRVS data is derived from a standard period abridged life table, in which the observed numbers of deaths are divided by by the number of population (child or infant) at risk during a certain period of time. A probability of death derived from a life table is expressed as a rate per 1,000 live births. If registration is complete and the system functions efficiently, the resulting estimates will be accurate and timely. Where CRVS data are not sufficiently accurate, the PHC and surveys such as DHS and MICS may be a better alternative.

In the case of the PHC, the most common approach for estimating under-5 mortality is through the questions on Children Ever Born and Children Surviving which most censuses in developing countries ask. The information needs to be processed by means of indirect estimation techniques of the kind developed by Brass, Preston, Feeney and others. Although these methods provide an estimate of the mean time before the census to which the estimate refers, they do not allow establishing precisely what the mortality rate was during any specific period, e.g. the 5-year period before the census.

Ideally, the PHC should also collect information on mortality for each household, in terms of the total number of deaths in the 12-month period prior to the census date. For each deceased person reported, name, age, sex and date (day, month and year) of death should also be collected. Care should be taken to clearly specify the reference period to the respondent so as to avoid errors due to its misinterpretation. For example, a precise reference period could be defined in terms of a festive or historic date for each country. However, the experience teaches that these data are usually under-stated, particularly so in the case of children under age 5.

A more reliable approach than what PHCs can provide is through summarized birth histories, as in DHS and similar types of surveys. In the PHC, women are typically asked only about the number of their children ever born and the number that have died (or equivalently the number still alive). It is recommended that the census also ask for the date of birth of the last child and, in case the child died, the date of death. However, this last information is collected in relatively few censuses.

For under-five mortality at the global level, UNICEF and the UN Inter-agency Group for Child Mortality Estimation (UN IGME) compile data from all available data sources, including household surveys, censuses, CRVS data etc. UNICEF and the UN IGME compile these data whenever they are available publicly and then conduct data quality assessments. UNICEF also collects data through UNICEF country offices by reaching national counterpart(s). The UN IGME collects CRVS and other registration data reported by Ministries of Health or other relevant agencies to the WHO. Adjustments of empirical data are made in high-HIV prevalence settings to adjust for under reporting of under-five deaths due to missing mothers in survey data. The same correction would also apply to census data.

c. Method of computation

The method used for calculating the rate depends on the data source being used. The ways to calculate the rate using each data source are:

> CRVS: The under-five mortality rate can be derived from a standard period abridged life table using the age-specific deaths and mid-year population counts from CRVS data to calculate death rates, which are then converted into age-specific probabilities of dying.
>
> PHC: An indirect method is used based on a summary birth history, a series of questions asked of each woman of reproductive age as to how many children she has ever given birth to and how many are still alive. The Brass method and its variants, together with model life tables, are then used to obtain an estimate of underfive and infant mortality rates.[22] An alternative method is to use the information on date of birth and date of death of the last born child, where this information is available.

d. Challenges in measuring in CRVS and PHC

The availability of information in CRVS data is wide but may not be of good quality as many developing countries do not have complete coverage of deaths, particularly in this age range. The standard

[22] See K. Hill, "Indirect Estimation of Child Mortality" in *Tools for Demographic Estimation*, T.A. Moultrie, R.E. Dorrington, A.G. Hill, K. Hill, I.M. Timæus and B. Zaba, eds. (Paris: International Union for the Scientific Study of Population, 2013), available from http://demographicestimation.iussp.org/content/indirect-estimation-child-mortality; and J.K. Rajaratnam, L.N. Tran, A.D. Lopez, and C.J.L. Murray, "Measuring under-Five Mortality: Validation of New Low-Cost Methods, PLoS Med 7(4) (2013), available from http://demographicestimation.iussp.org/content/indirect-estimation-child-mortality.

alternative in situations where CRVS data are not reliable is to use indirect census questions on the number of children ever born and the number of children surviving, by age of the mother. The limitation of these data is that, with the possible exception of the last live-birth, they do not provide a direct measure of the exposure time of each child. As a result, indirect estimation methods have to produce approximate exposure times based on the shape of the fertility curve. This produces good results if fertility has remained relatively stable over time, but in the case where there have been major changes in fertility, data from different censuses are necessary to separate the effects of the age pattern of fertility from those of fertility change.

Many countries lack a single source of high-quality data covering the last several decades. Data from different sources (PHC or CRVS) require different calculation methods and may suffer from different errors, for example PHCmay have missing values or systematic errors due to misreporting, while CRVS usually suffers from a full coverage of deaths and births. Data collected through household surveys will have sampling errors and may also have data collection errors. As a result, different surveys often yield widely different estimates of under-five mortality for a given time period and available data collected by countries are often inconsistent across sources. It is important to analyse, reconcile and evaluate all data sources simultaneously to produce best estimate at national and subnational level. Each new survey or data point must be examined in the context of all other sources, including previous data.

e. Data disaggregation

It is recommended that NSO should produce under-five mortality rates by sex and age (infant mortality rate and child mortality rate), wealth quintile, mother’s place of residence and mother’s education. Wealth quintiles can be constructed from PHC data, but usually not from CRVS data.

Disaggregation by geographic location of mother`s residence can be generated for different level of geographical areas usually at regional level, or the minimum provincial level and even sometimes district/town level for census data. Data from high quality CRVS systems can provide further geographical breakdowns.

3.2.2 Neonatal mortality rate

(i) Concept and definition

The neonatal mortality rate is the probability that a child born in a specific year or period will die before reaching 28 completed days of life, if subject to the age-specific mortality rates of that period, expressed per 1,000 live births.

Neonatal deaths (deaths during the first 28 completed days of life) may be subdivided into early neonatal deaths, occurring during the first 7 days of life, and late neonatal deaths, occurring after the 7th day but before the 28th completed day of life.

Mortality rates among young children are a key output indicator for child health and well-being, and, more broadly, for social and economic development. The neonatal mortality rate is a closely watched public health indicator because it reflects the access of children and communities to basic health interventions such as vaccination, medical treatment of infectious diseases and adequate nutrition.

(ii) Possible data sources, particularly PHC and CRVS, and their relative advantages/ disadvantages

Representative estimates of neonatal mortality can be derived from a number of different sources, including CRVS and sample surveys. The preferred source of data is a CRVS that records births and deaths on a continuous basis. If registration is complete and the system functions efficiently, the resulting estimates will be accurate and timely. However, mortality data in the CRVS systems of many developing countries are deficient. According to WHO, reliable CRVS is available for only about one third of the world's population. This is particularly true of infant mortality and even more so of neo-natal mortality. Even in developed countries neo-natal mortality tends to be under-registered.[23] Very early mortality can be confused with stillbirths and in many cultures a child that dies before having been named is not even considered live-born and his or her death is unlikely to be registered. Also, there are no obvious benefits to registering the birth of a child that has already died, so in many cases both the birth and the death of a child that died soon after birth go unregistered.

In cases where no reliable CRVS exists, countries usually estimate this indicator from the birth histories in periodic household surveys, such as the DHS and MICS which have become the primary sources of data on under-five and neonatal mortality. These surveys ask women about the survival of their children occurred in their life time, and if died, date of death of a child. This information provides the basis of neonatal mortality estimates for a majority of low- and middle- income countries. These data, however, are often subject to sampling and/or non-sampling errors, which might be substantial.

To some extent, the PHC can also collect data for neonatal mortality. In the PHC, women are typically asked about the date of birth of the last child for estimating fertility and whether this child is alive or not. A potential advantage of PHC data is that early neo-natal mortality that might go undetected by CRVS systems, because neither the birth nor the subsequent death was registered, may be detected in a retrospective census question. The same is true of surveys. Although this is currently not a common practice, countries might also consider the possibility of asking for the date of death of the child, if applicable. This approach is explained below.

The crucial question that the census needs to ask is the date of birth of the last live-born child. This is now the recommended format for asking the fertility question of the census, rather than asking for the number of live births during the past 12 months. In addition, many censuses ask for deaths that occurred during the past 12 months, although this question is usually not very appropriate for measuring neonatal mortality, both because of understatement and because of inadequate declaration of age (in years, rather than months) for this purpose. Some censuses also inquire about the survival of the last-born child and even the date of death. A review of census questionnaires of 124 countries for the 2010 census round carried out by UNSD identified only 16 that asked for the survival of the last-born child. An additional 23 asked for the date of birth of the last live-born child, but without the question on his or her survival.

It is recommended that more PHCs should ask the question on survival of the last-born child, as well as the date of birth of this child, as this would be very helpful in the computation of the indicator from census data. Asking for the date at which the last-born child died, if applicable, may not be as feasible as the previous recommendations, but would help in the computation of this indicator.

(iii) Method of computation

Calculation with CRVS data:

[23] Sabine Anthony et al. (2001). The reliability of perinatal and neonatal mortality rates: differential under-reporting in linked professional registers vs. Dutch civil registers. *Paediatric and Perinatal Epidemiology*, 15, 306–314 found under-registration of 13,5% for neo-natal mortality in the Netherlands.

The calculation involves simply dividing the number of children born during a particular period that died within 28 days of their birth by the total number of children born. If the data come from a CRVS, this calculation is straightforward.

Calculation with PHC data:
In the case of census data, the computation is more complicated and depends on which data exactly are available and their quality. As a minimum requirement, it is necessary to have the date of birth of the last child and his/her survival status, either from the question on household deaths during the past 12 months or (preferably) based on a direct census question asking if the child is still alive. By looking only at the survival status of children born during the past 28 days and applying statistical estimation techniques for censored data (e.g. the Kaplan-Meier estimator or a day-by-day life table)[24] this allows computing the probability of death up to the age of 28 days. If, in addition, the date of death is known, the method can be extended to children that were born more than 28 days ago by looking at those that died during the first 28 days as a proportion of the total number born. However, this question is rarely asked in PHCs.

The estimates of the UN Inter-agency Group for Child Mortality Estimation (UN IGME) are derived from national data from censuses, surveys or CRVSs. The UN IGME does not use any covariates to derive its estimates. It only applies a curve fitting method to good-quality empirical data to derive trend estimates after data quality assessment. In most cases, the UN IGME estimates are close to the underlying data.

(iv) Challenges in measuring in CRVS and PHC

Unlike under-five mortality, for which there is a well-established methodology of estimation based on census data, neo-natal mortality has not been extensively measured except in countries with reliable CRVS data. Although the estimation of this indicator based on census data is theoretically possible, it relies heavily on two or three data that are collected less frequently and have been tested less widely than the traditional Brass questions, namely the date of birth of the last-born child, his or her survival and, if possible, the date of death of the last-born child. The survival of very young children is often not reliably recorded as their deaths may be confused with stillbirths. In some cultures a child that dies before having been named is not considered a live birth. Therefore, the methodology for determining neo-natal mortality from census data may require more testing before it can be reliably applied, particularly bearing in mind the known difficulties of detecting neo-natal deaths even in countries with good CRVS systems.

(v) Data disaggregation

As in the case of under-five mortality, it is recommended that NSO should produce neo-natal mortality rates by sex, wealth quintile, mother's place of residence and mother's education. Wealth quintiles can be constructed from PHC data, but usually not from CRVS data.

Disaggregation by geographic location of mother's residence can be generated for different level of geographical areas usually at regional level, or the minimum provincial level and even sometimes district/town level for census data. Data from well-functioning CRVS systems can provide further geographical breakdowns.

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[24] E. L. Kaplan and P. Meier (1958). Non-parametric Estimation from Incomplete Observations. *Journal of the American Statistical Association* 53: 457-481. In practice, this approach is almost the same as constructing a day-by-day life table in which the denominator is made up of the children that survived up to that day. For example, the probability of death from day x to day x+1 is the number of children who died on day x, divided by the number that were born at least x days ago and that were still alive at the beginning of day x.

3.4.1 Mortality rate attributed to cardio-vascular disease, cancer, diabetes or chronic respiratory disease

a. Concept and definition

This indicator refers to the probability of dying between the ages of 30 and 70 years from cardiovascular diseases, cancer, diabetes or chronic respiratory diseases, defined as the per cent of 30-year-old-people who would die before their 70th birthday from such diseases, assuming that they would experience current mortality rates at every age and would not die from any other cause of death (e.g. injuries or HIV/AIDS).

Cardiovascular diseases, cancer, diabetes and chronic respiratory diseases are the four main causes of non-communicable disease (NCD) burden. Measuring the risk of dying from these four major causes is important to assess the extent of burden from premature mortality due NCDs in a population.

b. Possible data sources, particularly CRVS, and their relative advantages/ disadvantages

The preferred data source is CRVS systems with complete coverage and medical certification of cause of death. Other possible data sources include household surveys with verbal autopsy, and sample or sentinel registration systems, special studies and surveillance systems. In most cases, these data sources are combined in a modelling framework. According to the official meta-data provided with indicator 3.4.1, around 70 countries currently provide WHO with regular high-quality data on mortality by age, sex and causes of death, and another 40 countries submit data of lower quality.

The CRVS is the primary data source for the relevant data. The International Classification of Diseases (ICD-10) specifies the following codes for the relevant causes: Cardiovascular disease: I00-I99, Cancer: C00-C97, Diabetes: E10-E14, and Chronic respiratory disease: J30-J98. The method requires the computation of mortality rates by age, sex and cause. The denominators for these rates have to be provided by the most recent PHC or by projections based on the PHC.

c. Method of computation

This indicator can be calculated using the following steps as explained in the WHO methodology[25]. There are 4 steps involved in this process:

1. Estimation of life table (WHO estimates life tables based on the UN World Population Prospects 2012 revision).
2. Estimation of cause-of-death distributions.
3. Calculation of age-specific mortality rates from the four main NCDs for each five-year age range between 30 and 70.
4. Calculation of the probability of dying between the ages of 30 and 70 years from cardiovascular diseases, cancer, diabetes or chronic respiratory diseases.

However, countries may choose to use a different methodology for steps 1 and 2, based on their own life tables. The primary objective of these steps is to correct the overall under-registration of deaths and correct misstatement of causes of death. In countries that have a very complete death registration,

[25] For details see *NCD Global Monitoring Framework: Indicator Definitions and Specifications*. Geneva: World Health Organization, 2014 (http://www.who.int/nmh/ncd-tools/indicators/GMF_Indicator_ Definitions_ FinalNOV2014.pdf?ua=1).

there may be no need to compute a general life table first and then apply the cause-of-death distribution to it and the cause-specific death rates may be obtained directly from the CRVS.

d. Challenges in measuring in CRVS

The primary challenge is the lack of accuracy of cause-specific mortality data in the CRVS systems of many developing countries. Less than one half (about 70 countries) of WHO Member States have CRVSs with high quality registration of deaths, including causes of death. This may require the use of other methods to determine the distribution of causes, as mentioned above. The use of verbal autopsy methods in sample registration systems, demographic surveillance systems and household surveys provides some information on causes of death in populations without high quality death registration systems, but there remain considerable challenges in the validation and interpretation of such data, and in the assessment of uncertainty associated with diagnoses of underlying cause of death. Another problem is that cause-of-death estimates tend to have large uncertainty ranges for some causes and some regions.

In countries with high quality CRVSs, point estimates sometimes differ primarily for two reasons: 1) WHO redistributes deaths with ill-defined cause of death; and 2) WHO corrects for incomplete registration of deaths.

e. Data disaggregation

The indicator should be disaggregated by sex and by each of the individual causes. In general, it should also be possible to disaggregate by major geographical areas and by rural/urban area of residence. Other types of disaggregations, by socioeconomic criteria, may be more difficult due to the relatively limited socioeconomic information provided by CRVS systems.

3.4.2 Suicide mortality rate

a. Concept and definition

The Suicide mortality rate as defined as the number of suicide deaths in a year, divided by the population, and multiplied by 100,000. The complete recording of suicide deaths in the CRVS requires good linkages with coronial and police systems, but can be seriously impeded by stigma, social and legal considerations, and delays in determining cause of death.

b. Possible data sources, particularly CRVS, and their relative advantages/ disadvantages

The preferred data source is CRVS systems with complete coverage and medical certification of cause of death. Other possible data sources include household surveys with verbal autopsy, and sample registration systems. According to the official meta-data provided with indicator 3.4.2, around 70 countries currently provide WHO with regular high-quality data on mortality by age, sex and causes of death, and another 40 countries submit data of lower quality. The International Classification of Diseases (ICD-10) specifies the following codes for the relevant causes: X60-X84, Y87.0. Apart from the few countries that have a well-functioning population registry, the mid-year population has to be estimated from a PHC or projected from a PHC.

c. Method of computation

The following formula is used:

$$Suicide\ mortality\ rate = \frac{Number\ of\ suicide\ deaths\ in\ a\ year}{Mid - year\ population\ for\ the\ same\ calender\ year} * 100{,}000$$

For countries without high-quality death registration data, cause of death estimates are calculated using other data, including household surveys with verbal autopsy, sample or sentinel registration systems, special studies and surveillance systems. In most cases, these data sources are combined in a modelling framework.

d. Challenges in measuring in CRVS

The primary challenge is the lack of accuracy of cause-specific mortality data in the CRVS systems of many developing countries. Less than one half of WHO Member States have CRVS systems with high quality death registration, including causes of death. This may require the use of other methods to determine the distribution of causes, as mentioned above. Suicide rates may be more under-recorded than other causes because of the social stigma associated with them, although the evidence on this issue is mixed.[26]

Another problem is that cause-of-death estimates tend to have large uncertainty ranges for some causes and some regions. This is particularly the case for suicide rates because the number of cases is so small.

e. Data disaggregation

The primary disaggregations are by sex and age group. It may also be possible to disaggregate by major geographical areas and urban/rural area of residence. Other types of disaggregations may be difficult due both to the lack of specific socioeconomic data in the CRVS and to the small number of cases.

3.6.1 Death rate due to road traffic injuries

a. Concept and definition

Death rate due to road traffic injuries as defined as the number of road traffic fatal injury deaths per 100,000 population.

b. Possible data sources, particularly CRVS, and their relative advantages/ disadvantages

The preferred data source is CRVS systems with complete coverage and medical certification of cause of death. The International Classification of Diseases (ICD-10) specifies the following codes for the relevant causes: V01-V99, depending on the exact nature of the victim and the vehicle that caused the injury. Apart from the few countries that have a well-functioning population registry, the mid-year population has to be estimated from a PHC or projected from a PHC.

[26] In a meta-analysis by Ingvild Maria Tøllefsen, Erlend Hem and Øivind Ekeberg in the *BMC Psychiatry* vol. 12 (9), 2012, entitled "The reliability of suicide statistics: a systematic review", the authors reviewed 31 studies (20 of them from Europe and 7 from North America) and found that 13 reported fairly reliable suicide statistics or under-reporting of 0-10%, whereas 16 found more than 10% under-reporting and 12 found more than 30% under-reporting or poor suicide statistics.

In the absence of a well-functioning CRVS, there are other potential data sources. WHO bases much of its estimates of data from the Global Status Report on Road Safety survey based on the expert opinions of health, police, transport, nongovernmental organizations and/or academia and other relevant sectors. Data of this kind are available for 194 countries.

c. Method of computation

The numerator for the computation of this indicator is the number of deaths due to road traffic crashes (an absolute figure indicating the number of people who die as a result of a road traffic crash) in a year, while the denominator is the mid-year population (total number of people).

d. Challenges in measuring in CRVS

The primary challenge is the lack of accuracy of cause-specific mortality data in the CRVS systems of many developing countries. Less than one half of WHO Member States have CRVS with high quality registration of deaths, including causes of death. This may require the use of other methods to determine the distribution of causes, as mentioned above.

e. Data disaggregation

The ICD-10 classification makes it possible to disaggregate the data (but not their denominators) by types of road users. The data can also be disaggregated by age and sex and in this case the denominators are available. Disaggregation by major geographical areas and rural/urban areas in which the road accident occured should also be possible in most cases. WHO also recommends disaggregation by income group, but this is difficult in the case of CRVS data.

3.7.2 Adolescent birth rate (aged 10–14 years; aged 15–19 years) per 1,000 women in that age group

a. Concept and definition

The adolescent birth rate (ABR) represents the risk of childbearing among females in a particular age group, generally defined as covering 15-19 years. It is generally measured as the age-specific fertility rate (ASFR) for ages 15-19 years, a designation commonly used in the context of calculation of total fertility estimates. This requires knowledge not only of the number of births in the relevant age category, but also of the number of female in this age category in the general population. A related measure, which does not require the latter, is the proportion of births occurring to adolescent mothers, measured as the percentage of the total number of births. This indicator, however, has the disadvantage that it depends on the number of births in other age groups, so that it can change even without any change in the fertility of adolescent women. Nevertheless, it can be useful in the context of service planning, where service providers need to know the age profile of their clients.

In addition to the 15-19 age category, there is growing interest in births occurring to females in the 10-14 year age group. However, despite some progress in recent years, the measurement of fertility in this age group still encounters significant obstacles compared to the measurement of fertility in the 15-19 year age group.

b. Possible data sources, particularly PHC and CRVS, and their relative advantages/ disadvantages

Generally, CRVS, if sufficiently complete (at least 90% coverage) and otherwise reliable, is the preferred data source. However, in some countries, especially countries lacking a civil registration system or where the coverage of that system is lower than 90 per cent of all live births, the adolescent birth rate is obtained from census data and household survey data. Data on births by age of mother are obtained from civil registration systems covering 90 per cent or more of all live births, supplemented eventually by census or survey estimates for periods when registration data are not available.

Sample surveys have also become a major source of information for estimating national fertility levels. Their main advantage is the greater quality of fertility data compared to the PHC, but surveys usually do not permit the derivation of reliable estimates at subnational levels. Obviously, another difference between CRVS, PHC and surveys is their different time frame: while PHC data are only available every ten or – at best – five years, CRVS data are continuous and survey data are usually somewhere in between.

The advantages of the PHC relative to the CRVS and to sample surveys are:

a) For PHC data, both the numerator and denominator come from the same population and cover the entire population, and are therefore not subject to sampling biases.
b) The data are reported for place of residence of the mother, not by place of occurrence of the births. While most CRVSs also allow identification by place of residence of the mother, this usually requires additional coding and analysis of the data.

For census data, the adolescent birth rate is computed from data on births in the preceding 12 months by age of mother. Most countries, especially countries lacking reliable CRVS data, collect data on number of live births in the last 12 months before the census reference time. When census data are used, the estimation of fertility, including adolescent fertility, requires the use of indirect estimation methods to adjust the estimates obtained from the question about births during the preceding 12 months.

Most countires put an age limit to this question, thereby limiting the universe of women asked. In particular, with respect to estimates of the birth rate among women aged 10-14 years, there is still a certain lack of information. Sample surveys such as DHS and MICS do not interview women under the age of 15, but the information on births that occurred before the age of 15 can be reconstructed from birth histories.[27] Although some censuses, in the 2010 census round, asked the fertility questions to women over the age of 12 (e.g. most African countries, Bulgaria, Colombia, Costa Rica, Ecuador, El Salvador, Mexico, Palestine, Panama, Peru, Venezuela) or even 10 (Bangladesh, Brazil, Burkina Faso, Ethiopia, Indonesia, Iran, Seychelles), the P & R recommend that the question should be asked to women over the age of 15. The possibilities for reconstructing births that occurred before this age are more limited in this case than in sample surveys. In theory, CRVS data do not have these limitations, but births to very young women may suffer from very high under-registration and/or age misstatement.

According to the official meta-data for indicator 3.7.2, comparative evidence suggests that a very small proportion of births in this age group occur to females below age 12. Other evidence based on retrospective birth history data from surveys indicates that women aged 15-19 years are less likely to report first births before age 15 than women from the same birth cohort when asked five years later at ages 20–24 years.

c. Method of computation

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[27] For a recent analysis based on DHS data, see UN Population Division (2019). *Fertility among very Young Adolescents. Population Facts 2019/1.* Available at: https://www.un.org/en/development/desa/ /PopFacts_2019-1.pdf.

The adolescent birth rate is computed as a ratio. The numerator is the number of live births to women aged 15-19 years, and the denominator is the estimate of the exposure to childbearing by women aged 15-19 years. The computation is the same for the age group 10-14 years. The numerator and the denominator are calculated differently for civil registration and census data.

In the case of CRVS data, the numerator is the registered number of live births born to women aged 15-19 years during a given year, and the denominator is the estimated, projected or enumerated population of females aged 10-14 and 15-19 years.

In the case of the PHC, the adolescent birth rate is computed on the basis of the date of last birth or the number of births in the 12 months preceding the enumeration. The census provides both the numerator and the denominator for the rates. In some cases, the rates based on censuses are adjusted for under-enumeration based on indirect methods of estimation. It might be necessary to correct the ASFR using one of the standard methods for correcting fertility data, of the type known as P/F or Relational Gompertz methods.

The proportion of births occurring to adolescent mothers, measured as the percentage of the total number of births, does not require any corrections as long as the basic assumption underlying the P/F method is satisfied, namely that under- or over-declaration of births during the past 12 months is uniform by age. However, if the 15-19 or 10-14 year age groups are affected by specific biases that are not contemplated by the P/F correction, this indicator too may require adjustments.

d. Challenges in measuring in CRVS and PHC

The main challenges in measuring the adolescent birth rate are related to the availability and quality of the basic data. Discrepancies between the sources of data at the country level are common and the level of the adolescent birth rate depends in part on the source of the data selected. The major problems in the case of the CRVS are:

- Under-registration of births and particularly of births in the relevant age group;
- The treatment of infants born alive but that die before registration or within the first 24 hours of life;
- The quality of the reported information relating to age of the mother;
- The inclusion of births from previous periods;
- Differential under-registration by urban/rural area of residence, income level and level of education of the mother, which may make disaggregation of the data more difficult;
- Registration by place of occurrence, rather than by place of usual residence of the mother, which may inflate the adolescent birth rates of areas that have maternity clinics.

In addition, CRVS data provide the numerator, but not the denominator of the rate. The denominator has to be derived from population estimates or projections by age and sex. These estimates or projections may also be subject to limitations connected to age misreporting and coverage.

The main challenge of PHC data is to overcome problems like the following:

1. Omission of births, particularly of children that died very young;
2. Differential omission of births of unmarried women, which can be of particular significance in the 15-19 year age group;
3. Errors in the age declaration of females, which may be worse than in the case of the CRVS if information about a mother is provided by a proxy respondent and not be confirmed by her;
4. Misreporting the date of birth of the child or erroneous inclusion/exclusion of children in the 12-month period before the census.

As was mentioned above, census data often need to be adjusted using P/F or Relational Gompertz methods. However, it must be borne in mind that these methods were developed primarily to improve the quality of total fertility measures like the Total Fertility Rate. Their ability to correct fertility estimates for particular age groups and especially for the 15-19 and 10-14 year age groups is less well established.

As noted in the P & R (4.238), the data provided by the question on the date of birth of the last child are more accurate for estimating current age-specific fertility rates and other fertility measures than information that may have been collected in earlier censuses from a question on the number of births to a woman during the 12 months immediately preceding the census, but about half of the countries still used the later in their censuses of the 2010 round.

Regarding births to females in the 10-14 year age group, all three sources tend to under-estimate the numbers, but the problem is greatest in census data based on a lower limit of 15 years for the fertility questions. If the census asked the question on the date of birth of the last child, it will capture births to women currently older than 15, but who were less than 15 years old when their last child was born. However, if these children were born more than a year ago, they are not directly relevant to the construction of the indicator. Children born to women currently under age 15 are not detected, nor are the children of women over age 15 who had a birth before age 15 but who had additional children after age 15. In some cases, it may be possible to infer from the total number of children ever born and the date of birth of the last child, that the woman must have had another birth before the age of 15, but again such births generally occurred too long ago to be directly relevant for the construction of the indicator.

Combining the information on the number of children ever born and the dates of birth of the last child for single ages in the 15-19 age range, it may be possible to estimate fertility rates for females under age 15 indirectly.

CRVS data do not have the limitation of censoring births to females under age 15, but births to very young women may suffer from very high under-registration and/or age misstatement. The campaigns to outlaw child marriage that are currently underway in many countries may have the unintended side effect of making it more difficult for under-age girls (below the legal minimum age for marriage) to register their children.

e. Data disaggregation

At present, the required disaggregation is for the 15-19 year age group, with an additional possibility of providing information for the 10-14 year age group. The difficulties presented by the latter were already discussed above. This indicator can be disaggregated by education, number of living children, marital status, economic cahacteristics of the mother, and geographic location, depending on the data source.

Disaggregations by geographic location can, in principle, be based on either the PHC or the CRVS although the PHC avoids the problem of classification by place of occurrence, rather than the usual residence of the mother, that may be present in CRVS data. Disaggregation in terms of the marital status of the mother can also, in principle, be based on either the PHC or the CRVS. In this case the CRVS probably is a better source because it usually documents the marital status of both parents with greater care and because the marital status of the mother may have changed between the date of birth of the child and the date of the census. This is particularly relevant in the 15-19 year age group where marital status may change rather quickly. Disaggregation by the number of living children is possible using PHC data and may be possible with CRVS data, if the relevant question is asked. This is not the case in all CRVSs. In Brazil, for example, it is not part of the standard information collected by the birth registry, although it is part of the parallel system maintained by the Ministry of Health. Some other countries have similar parallel systems. Others do not collect the information at all.

Disaggregation by education and socioeconomic status is usually more feasible using census data, although some CRVSs (e.g. all of the Latin-American CRVSs) do ask for data on education and occupation of the parents.

3.9.3 Mortality rate attributed to unintentional poisoning

a. Concept and definition

Measuring how the mortality rate from unintentional poisonings provides an indication of the extent of inadequate management of hazardous chemicals and pollution, and of the effectiveness of a country's health system. The ICD-10 codes corresponding to the mortality rate in the country from unintentional poisonings per year include X40, X43-X44, X46-X49.

b. Possible data sources, particularly CRVS, and their relative advantages/ disadvantages

The natural data source for the data mentioned above is a high-quality CRVS with medical certification of cause-of-death. Other possible data sources include household surveys with verbal autopsy, sample or sentinel registration systems, special studies and surveillance systems. Data on deaths are widely available from countries from death registration data or sample registration systems, which are feasible systems, but good quality data are not yet available in all countries. In particular, deficiencies in certification and the use of the wrong definitions are major problems in cause-of-death statistics. The denominators for the death rates can be obtained from a population census or projected based on such a census.

c. Method of computation

The methods used for the analysis of causes of death depend on the type of data available from countries. For countries with a high-quality CRVS including information on cause of death, these data can be used directly to compute cause-specific death rates, with adjustments where necessary, e.g. for under-reporting of deaths or classification errors.

$$Mortality\ rate\ attributed\ to\ unintentional\ poisoning$$

$$= \frac{Number\ of\ deaths\ of\ unintentional\ poisonings\ in\ a\ year}{Mid-year\ population} * 100{,}000$$

For countries without high-quality death registration data, cause of death estimates are calculated using other data, including household surveys with verbal autopsy, sample or sentinel registration systems, special studies and surveillance systems. In most cases, these data sources are combined in a modelling framework.

d. Challenges in measuring in CRVS

The primary challenge is the fact that many developing countries do not have cause-of-death registration systems of sufficient quality to accurately measure the relevant death rates.

e. Data disaggregation

Data can be disaggregated by: 1. Age group; 2. Sex; and 3. Detailed cause of death. To the extent that unintentional poisoning is related to localized sources of pollution such as chemical plants, it may be desirable to disggregate the data by detailed geographical area. However, due to the small number of cases, data may have to be accumulated over relatively long time periods in order to identify discernable geographical patterns.

16.1.1 Number of victims of intentional homicide per 100,000 population, by sex

a. Concept and definition

The indicator is defined as the total count of victims of intentional homicide divided by the total population, expressed per 100,000 population.

In the International Classification of Crime for Statistical Purposes (ICCS, 2015) intentional homicide is defined as the ''Unlawful death inflicted upon a person with the intent to cause death or serious injury". This definition contains three elements characterizing the killing of a person as intentional homicide:
1. The killing of a person by another person (objective element);
2. The intent of the perpetrator to kill or seriously injure the victim (subjective element);
3. The unlawfulness of the killing, which means that the law considers the perpetrator liable for the unlawful death (legal element).

This definition states that, for statistical purposes, all killings corresponding to the three criteria above should be considered as intentional homicides, irrespective of definitions provided by national legislations or practices.

The ICCS provides important clarifications on the definition of intentional homicide. In particular, it states that the following killings are included in the count of homicide:
Murder

Honour killing

Serious assault leading to death

Death as a result of terrorist activities

Dowry-related killings

Femicide

Infanticide

Voluntary manslaughter

Extrajudicial killings

Killings caused by excessive force by law enforcement/state officials

Furthermore, the ICCS provides indications on how to distinguish between intentional homicides, killings directly related to war/conflict and other killings that amount to war crimes.

This indicator is widely used at national and international level to measure the most extreme form of violent crime and it also provides a direct indication of lack of security. Security from violence is a pre-requisite for individuals to enjoy a safe and active life and for societies and economies to develop freely. Intentional homicides occur in all countries of the world and this indicator has a global applicability. Monitoring intentional homicides is necessary to better assess their causes, drivers and consequences and, in the longer term, to develop effective preventive measures. If data are properly disaggregated (as suggested in the ICCS), the indicator can identify the different type of violence associated with homicide: inter-personal (including partner and family-related violence), crime (including organised crime and other forms of criminal activities) and socio-political (including terrorism, hate crime).

b. Possible data sources, particularly CRVS, and their relative advantages/ disadvantages

Homicide data are typically produced by two separate and independent sources: criminal justice and public health, through the CRVS. This represents a specific asset of this indicator, as the comparison of the two sources is a tool to assess accuracy of national data. Usually, for countries where data from both sources exist, a good level of matching between the sources is recorded. Data on homicides produced by the CRVS are classified according to the ICD-10, which provides a definition of 'Death by assault' (codes X85-Y09) that is very close to the definition of intentional homicide of the ICCS. UNODC collects and publishes data from criminal justice systems through its long-lasting annual data collection mandated by the UN General Assembly in the UN Crime Trends Survey (UN-CTS).

Due to the social importance of homicide as a cause of death, homicide statistics tend to be of better quality than other kinds of causes of death. Nevertheless, the gathering of comprehensive data on intentional homicide – including breakdowns by sex, method/arms used, and situational context – is still beyond the capacity of many countries across the world, and particularly so in Africa (see above).

Currently, when national data on homicide are not available from neither of the two types of source above, estimates are produced by WHO.[28]

c. Method of computation

The indicator is calculated as:

$$= \frac{\text{Total number of victims of intentional homicide recorded in a given year}}{Mid - year\ population} * 100{,}000$$

d. Challenges in measuring in CRVS

Discrepancies might exist between country produced and internationally reported counts of intentional homicides as national data might refer to national definition of intentional homicide while data reported by UNODC aim to comply with the definition provided by the ICCS (approved in 2015 by Member States in the UN Statistical Commission and the UN Commission on Crime Prevention and Criminal Justice). UNODC makes special efforts to count all killings falling under the ICCS definition of intentional homicide, while national data may still be compiled according to national legal systems rather than the

[28] For information on the methodology, see WHO-UNDP-UNODC, *Global Status Report on Violence Prevention 2014*.

statistical classification. In countries in conflict situations, there may be difficulties distinguishing between deaths as a result of combat and non-combat related homicides.

e. Data disaggregation

Recommended disaggregations for this indicator are:
Sex and age of the victim and the perpetrator (suspected offender)

Relationship between victim and perpetrator (intimate partner, other family member, acquaintance, etc.)

Means of perpetration (firearm, blunt object, etc.)

Situational context/motivation (organised crime, intimate partner violence, etc.)

While the CRVS normally provides detailed information on the first and the third items, establishing the relationship between the victim and the perpetrator and the situational context based on CRVS data may be more challenging. Obtaining this level of detail is often only possible by special surveys directed towards the authorities or surviving family members.

16.9.1 Proportion of children under 5 years of age whose births have been registered with a civil authority, by age

a. Concept and definition

This indicator refers to proportion of children under 5 years of age whose births have been registered with a civil authority.

Registering children at birth is the first step in securing their recognition before the law, safeguarding their rights, and ensuring that any violation of these rights does not go unnoticed. Children without official identification documents may be denied health care or education. Later in life, the lack of such documentation can mean that a child may enter into marriage or the labour market, or be conscripted into the armed forces, before the legal age. In adulthood, birth certificates may be required to obtain social assistance or a job in the formal sector, to buy or prove the right to inherit property, to vote and to obtain a passport.

It is important to explain some concepts:

a) **Birth registration:** Birth registration is defined as ‘the continuous, permanent and universal recording, within the civil registry, of the occurrence and characteristics of births in accordance with the legal requirements of a country’.
b) **Birth certificate:** A birth certificate is a vital record that documents the birth of a child. The term ‘birth certificate’ can refer either to the original document certifying the circumstances of the birth, or to a certified copy or representation of the registration of that birth, depending on the practices of the country issuing the certificate.
c) **Civil authority:** In this context, a civil authority is the official body that is authorized to register the occurrence of a vital event and to record the required details.

b. Possible data sources, particularly PHC and CRVS, and their relative advantages/ disadvantages

Censuses and household surveys such as MICS and DHS and CRVS systems can all be used towards this purpose.

CRVS systems that are functioning effectively compile vital statistics that are used to compare the estimated total number of births in a country with the absolute number of registered births during a given period. These data normally refer to live births that were registered within a year or the legal time frame for registration applicable in the country. The main limitation of CRVS data is that they provide a numerator, but not a denominator. Consequently, the "real" number of births has to be estimated using data from some other source, such as a PHC or a survey.

In the absence of reliable administrative data, household surveys have become a key source of data to monitor levels and trends in birth registration. The standard indicator used in DHS and MICS to report on birth registration refers to the percentage of children under age 5 (0-59 months) with a birth certificate, regardless of whether or not it was seen by the interviewer, or whose birth was reported as registered with civil authorities at the time of survey. Depending on the country, surveys collecting these data may be conducted every 3-5 years, or possibly at more frequent intervals.

PHCs could also provide data on children who have acquired their right to a legal identity through asking a question to children below age 5 whether they are registered in national registration system. However, censuses are conducted only every ten years (in most countries) and are therefore not well-suited for routine monitoring. In addition, there are relatively few countries that ask this question in their PHC. Belize, Bolivia, Brazil, Burundi, Ecuador, Honduras, Malawi, Mexico, Mozambique, Namibia, Nicaragua, Paraguay, Peru, the Philippines, Swaziland, Timor-Leste and Zambia are among the countries that asked specific questions in their 2010 census round to make it possible to assess which individuals have been registered. Developing countries with deficient birth registration that have not included such questions in their PHCs until now are encouraged to do so in future censuses.

If the question is not asked in the PHC and no specific surveys are available to this end, the PHC may nevertheless be used to provide an estimate of the number of births during a recent period such as the 12-month period preceding the census. Some censuses ask directly for the number of births during that period; in others, the number can be reconstructed from the date of birth of the last-born child. In either case, indirect methods such as Brass's P/F method are needed to correct these figures.

Estimating the number of children born during the past 5 years from fertility questions in the census, in order to determine the denominator for the indicator, is usually more difficult, but not impossible. Another possibility is to back-project the number of children found in the census to their approximate dates of birth.[29] By comparing the data thus obtained, with the necessary corrections, to the number of births for the same period registered in the CRVS, it becomes possible to estimate the amount of under-registration of the CRVS and thus the proportion of children under 5 years of age whose births have been registered.

c. Method of computation

The computation method for this indicator is: Number of children under age of five whose births are reported as being registered with the relevant national civil authorities divided by the total number of children under the age of five in the population multiplied by 100. If the special census question on birth

[29] See T.A. Moultrie, R.E. Dorrington, A.G. Hill, K. Hill, I.M. Timæus and B. Zaba, eds., *Tools for Demographic Estimation* (International Union for the Scientific Study of Population, 2013), available at http://demographicestimation.iussp.org.

registration is used, this is a direct proportion. If the numerator is taken from the CRVS and the denominator from the PHC, it is a ratio and some distortions may occur (see under d).

d. Challenges in measuring in CRVS and PHC

The main challenge in measuring this indicator in the PHC is that many censuses do not include the relevant question. In the 2010 census round it was only asked in about a dozen countries. Also, censuses are conducted only every ten years (in most countries) and are therefore not well-suited for routine monitoring of time series.

If the coverage is measured by comparing registered births in the CRVS with births measured through the fertility questions in the PHC, the problem is that the PHC itself also does not measure these numbers perfectly. There are correction methods such as Brass's P/F method to bring the census figures for births during the past 12 months more in line with historical trends, but these methods also have a certain margin of error, especially in situations where fertility has been falling. The alternative comparison, with children currently under age 5 counted in the PHC, also has some limitations, notably the fact that very young children (ages 0 and 1) are often under-counted and that the current number of survivors has to be corrected for infant and child mortality, thereby adding another factor of uncertainty to the denominator. In the case of sub-national estimates, the results may also be significantly affected by migration, i.e. children no longer residing in their place of birth.

Finally, when using CRVS data in the numerator, there is the problem of delayed registration. The births registered during the past 5 years do not only refer to children born during that period, but include the late registration of births that occurred during a previous period. In this case, date of birth of children registered during the past 5 years can be used to determine children born during the five-year period. In some cases it can be assumed that this excess registration is compensated for by delayed registration (at a future time) of children that were born during the period. However, this compensation mechanism can be disrupted by certain events, such as campaigns to promote birth registration or stricter reinforcement of administrative rules for pre-school enrolment.

e. Data disaggregation

This indicator is disaggregated by: 1. Sex; 2. Age; 3. Area of residence; 4. Rural and urban; and 5. Disability status. The UN Expert Group Meeting on Migration Data (March 2018) also considered this indicator migration-relevant and recommended its disaggregation by migratory status. The feasibility of these disaggregations depends on exactly what measurement method is used. Disaggregation by disability status is normally not possible with CRVS data as a numerator, but the PHC has the significant advantage that most censuses do contain this information, so if the estimation is entirely based on a special census question, this disaggregation actually becomes possible. When PHC is used, some care should be taken in the interpretation of the results because the place of residence of the children may not coincide with their place of registration, so the percentage of children in a particular small geographic area whose birth was registered may not be a good indication of the quality of the registration system in that area. In particular, when comparing children under age 5 counted in the PHC with births registered in that area, it should be borne in mind that children may have migrated from the place where their births were registered.

3.3. Indicators for which the PHC provides proxy estimation (Group 1.III)

1.1.1 Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/rural)

a) Concept and definition

The 'international poverty line' is currently set at \$1.90 a day at 2011 international prices. The proportion of population below the international poverty line is defined as the percentage of the population living on less than this amount. As differences in the cost of living across the world evolve, the international poverty line has to be periodically updated using new PPP price data to reflect these changes. The last change was in October 2015, when the World Bank adopted \$1.90 as the international poverty line using the 2011 PPP. Prior to that, the 2008 update set the international poverty line at \$1.25 using the 2005 PPP. Poverty measures based on international poverty lines attempt to hold the real value of the poverty line constant across countries, as is done when making comparisons over time.

In the standard methodology for poverty measurement, consumption is the preferred welfare indicator for a number of reasons[30]. Income (as defined below) is generally more difficult to measure accurately. For example, the poor who work in the informal sector may not receive or report monetary wages; self-employed workers often experience irregular income flows; and many people in rural areas depend on idiosyncratic, agricultural incomes. Moreover, consumption accords better with the idea of the standard of living than income, which can vary over time even if the actual standard of living does not.

b) Possible data sources, particularly PHC, and their relative advantages/ disadvantages

There are several potential sources for poverty data. The standard methodology developed by the World Bank, is based primarily on household surveys such as the LSMS, preferably using consumption, rather than income as the poverty criterion.

Poverty can also be determined from censuses, especially if PHC is a fully register based census, this data can be derived from tax registers. However, most censuses are conducted with field enumeration and do not ask questions on individual or household income. To calculate this indicator, censuses should collect information on the amounts of income received by individual persons or households. The UN Principles and Recommendations for Population and Housing Censuses Revision 3 describes income as all receipts whether monetary or in kind (goods and services) that are received by the household or by individual members of the household at annual or more frequent interval. However, collection of reliable data on income presents special problems in terms of burden of work, response errors and privacy concerns (UN P&R, 2017, para. 4.382-4.384).

A poverty line as defined for this indicator is a monetary cut-off point below which a person is considered as poor. The monetary based measures are highly quantitative, and they are ideal to measure poverty at a national level using expenditure and income data however due to the data quality problems, non-monetary approach for poverty analysis might be more relevant especially for sub-national analysis. Most non-monetary measures are highly qualitative, can accommodate perceptions of individuals and hence can be ideal to measure poverty in a small region/community. Non-monetary approaches are discussed below in the section of Indicator 1.2.2.

Personal or household income data are collected only in a minority of PHCs. A review of census questionnaires of 124 countries for the 2010 census round carried out by UNSD identified only 16 that asked for individual income and 5 that asked for household income (among which Brazil, 2010; Hong Kong, 2011; Israel, 2008; Kazakhstan, 2009; South Africa, 2011; several countries in the Caribbean and Pacific regions, but none in Europe and almost none in Africa). In some of these countries, the income question did not require an exact answer, but only a classification in terms of broad income ranges.

[30] For a discussion on reasons consumption is preferred, check: Deaton, Angus (2003). “Household Surveys, Consumption, and the Measurement of Poverty”. Economic Systems Research, Vol. 15, No. 2, June 2003.

Income is usually measured at the individual level, but some PHCs ask only for the aggregate household income. Since poverty is measured at the household level, this is sufficient, although the quality of the information thus obtained may be significantly lower than in situations where each individual has to declare his/her income.

According to the P&R (4.383 and 4.385), household income covers (*a*) income from employment (both paid and self-employment); (*b*) income from the production of goods for own final use; (*c*) income from the provision of household services for own final use; (*d*) property income; and (*e*) current transfers received. **T**he income from employment of employed persons should include wages and salaries of employees, income of members from producers' cooperatives and the mixed income of employers and own-account workers operating business and unincorporated enterprises. In addition to the income from employment of employed household members, the total income of the household should include, for example, the interest, dividends, rent, social security benefits, pensions and life insurance annuity benefits of all its members. The Handbook on household income statistics provides further guidance on concepts and methods related to this topic. *Canberra Group Handbook on Household Income Statistics*, 2nd ed. (2011), available from www.unece.org/fileadmin/DAM/stats/groups/cgh/Canbera_Handbook_2011_WEB.pdf .

c) Method of computation

In the minority of cases in which income data are available from the census, poverty estimates can be made by comparing per capita household income to the international poverty line or an acceptable proxy. As mentioned above, interpolation may be necessary for the purpose of aggregating individual data stated in terms of income ranges to a household total and in order to compute the percentage of households whose total income falls below a particular limit.

In the absence of monetary income or consumption data, an approximate monetary poverty measure can be constructed by integrating the micro-data of the census with the data of a standard consumption or income survey in order to derive proxy estimates that allow data disaggregation to levels that go beyond the possibilities of these surveys. To this end, there are two main strategies: construction of proxy variables and statistical matching. This consists in developing a regression model or other multivariate model based on the survey data and using explanatory variables that are common to the survey and the census, to predict the value of the variable that one would like to include in the census data base. The census value of the variable is then constructed by using the same equation on the explanatory variables, as found in the census. Typically, this approach has been used for the construction of household income data for censuses that do not have this information, by regressing household characteristics such as ownership of consumer durables or the quality of construction of the home on income data from a Living Standards Measurement Survey or other kind of household survey that provides income data.[31] The primary objective, in this case, is to construct poverty estimates for smaller geographic areas than is feasible with the income survey itself.

d) Challenges in measuring in PHC

In the standard methodology for poverty measurement, consumption is the preferred welfare indicator. However, even in the few countries where the PHC provides monetary information, this information refers to income, not to consumption. In addition, in PHCs that only collect income data in terms of broad income categories, data may have to be interpolated for the purpose of aggregating individual

[31] See, for instance, Elbers, C., J. O. Lanjouw and P. Lanjouw (2002). *Micro-Level Estimation of Welfare*. Washington DC, Development Research Group, World Bank.

data to a household total and in order to compute the percentage of households whose total income falls below a particular limit.

According to the P&R (4.384), the collection of reliable data on income, especially income from self-employment and property income, is extremely difficult in general field enquiries, particularly population censuses. The inclusion of non-cash income further compounds the difficulties. Collection of household income data in a census, even when confined to cash income, presents special problems in terms of burden of work, response errors, and so forth. Therefore, this topic is generally considered more suitable in a sample survey of households or from administrative data sources such as tax or social security records. Depending on the national requirements, countries may nonetheless wish to obtain limited information on personal or household income, by covering only some of the income components (such as income from employment), for shorter reference period (such as one month), and cover only cash income.

While model based income or consumption estimates do provide a solution for the lack of income data in most censuses, they do so only imperfectly. In particular, the variables on which these estimates are based tend to change only slowly and may not reflect the current income or consumption level of the household.

e) Data disaggregation

The minimum required disaggregation is by age and sex. The UN Expert Group Meeting on Migration Data (March 2018) also considered this indicator migration-relevant and recommended its disaggregation by migrant and non-migrant households. Regardless of whether the data are obtained from surveys or from censuses, these disaggregations have to be treated with great caution. Poverty is computed at the household level, based on pooled consumption or income data. It does not contemplate intra-household differences in individual consumption or income. Therefore, disaggregation by individual characteristics should be interpreted in terms of the probability of belonging to a poor household, not as individual welfare indicators.

In this regard, disaggregation by urban/rural residence and by detailed geographical areas may be more valid. The possibility of obtaining such detailed geographical disaggregation is the primary rationale for the methodologies described in section c.

1.2.1 Proportion of population living below the national poverty line, by sex and age

a) Concept and definition

The national poverty rate is the percentage of the total population living below the national poverty line. Within a country, the cost of living is typically higher in urban areas than in rural areas. Therefore, some countries may have separate urban and rural poverty lines to represent different purchasing power. The rural poverty rate is the percentage of the rural population living below the national poverty line (or in cases where a separate, rural poverty line is used, the rural poverty line). Urban poverty rate is the percentage of the urban population living below the national poverty line (or in cases where a separate, urban poverty line is used, the urban poverty line). National poverty lines are used to make more accurate estimates of poverty consistent with the country's specific economic and social circumstances, and are not intended for international comparisons of poverty rates.

The national poverty rate, a “headcount” measure, is one of the most commonly calculated measures of poverty. Yet it has the drawback that it does not capture income inequality among the poor or the depth of poverty. For instance, it fails to account for the fact that some people may be living just below the poverty line, while others experience far greater shortfalls. Policymakers seeking to make the largest possible impact on the headcount measure might be tempted to direct their poverty alleviation resources to those closest to the poverty line (and therefore least poor).

National poverty estimate is a different concept from international poverty estimates. National poverty rate is defined at country-specific poverty lines in local currencies, which are different in real terms across countries and different from the USD 1.90-a-day international poverty line. Thus, national poverty rates cannot be compared across countries or with the USD 1.90-a-day poverty rate. National poverty estimates are typically produced and owned by country governments (e.g., National Statistic Office), and sometimes with technical assistance from the World Bank and UNDP. Upon release of the national poverty estimates by the government, the Global Poverty Working Group of the World Bank assesses the methodology used by the government, validates the estimates with raw data whenever possible, and consults the country economists for publishing.

b) Possible data sources, particularly PHC, and their relative advantages/ disadvantages

National poverty estimates are derived from nationally representative household surveys, which contain detailed responses to questions regarding spending habits and sources of income. The issues of data availability and limitations in the case of the national poverty criterion are the same as in the case of the international criterion discussed under indicator 1.1.1.

The issues of data availability from the PHC and the inherent limitations of this approach in the case of the national poverty criterion are the same as in the case of the international criterion discussed under indicator 1.1.1.

c) Method of computation

The techniques for computing national poverty estimates based on census data are the same as in the case of the international poverty estimates discussed under indicator 1.1.1. The only difference is the criterion used for classifying a household as poor under the monetary poverty approach: the international poverty line in the case of 1.1.1, the national poverty line in the case of indicator 1.2.1. If non-monetary approaches are used, there is essentially no way to differentiate between these two indicators.

The formula for calculating the proportion of the total, urban and rural population living below the national poverty line, or headcount index, is as follows:

$$P_0 = \frac{1}{N}\sum_{i=1}^{N} I(y_i < z) = \frac{N_p}{N}$$

Where $I(.)$ is an indicator function that takes on a value of 1 if the bracketed expression is true, and 0 otherwise. If individual consumption or income y_i is less than the national poverty line z (for example, in absolute terms the line could be the price of a consumption bundle or in relative terms a percentage of the income distribution), then $I(.)$ is equal to 1 and the individual is counted as poor. N_p is the total, urban or rural number of poor. N is the total, urban or rural population.

d) Challenges in measuring in PHC

Some countries do not have an official poverty line, so that the poverty estimates depend on a more or less ad hoc decision on which criterion to adopt. Of course, this problem does not only affect poverty estimates derived from the census, but even those based on the standard methodology using consumption survey data. Otherwise the issues involved in the process are the same as in the case of the international poverty line discussed under indicator 1.1.1.

e) Data disaggregation

The data disaggregation issues that arise in the context of national poverty assessment are the same as those discussed with respect to the international poverty criterion, under indicator 1.1.1.

17.8.1 Proportion of individuals using the internet

a) Concept and definition

This indicator is defined as the proportion of individuals who used the Internet from any location in the last three months.

Despite growth in networks, services and applications, information and communication technology (ICT) access and use is still far from equally distributed, and many people cannot yet benefit from the potential of the Internet. This indicator highlights the importance of Internet use as a development enabler and helps to measure the digital divide, which, if not properly addressed, will aggravate inequalities in all development domains. Classificatory variables for individuals using the Internet –such as age, sex, education level or labour force status – can help identify digital divides in individuals using the internet.

b) Possible data sources, particularly PHC, and their relative advantages/ disadvantages

While the data on the percentage of individuals using the Internet are very reliable for countries that have collected the data through household surveys, they are less reliable in cases where the number of Internet users is estimated by the International Telecommuication Union (ITU). The American Community Survey (ACS) in the United States, for example, provides annual estimates of household internet use, based on ten questions. Some countries conduct a household survey where the question on Internet use is included every year. For others, the frequency is every two or three years. Overall, the indicator is available for 100 countries at least from one survey in the years 2011-2014.

Increasingly PHCs do include questions about internet use, but the format of these questions often does not facilitate their use for the computation of this indicator. However, in most cases, the time since the last use is not specified.

The P & R (4.564) recommend the following questions on access to telecommunication devices in the census allowing to collect data on households which have access to the Internet:

1. Household having a radio
2. Household having a television set
3. Household having a fixed-line telephone
4. Household having one or more mobile cellular telephones
5. Household having a personal computer
6. Household accessing the Internet from home
    6.1. Landline connection

    6.2. Mobile connection
7. Household accessing the Internet from elsewhere other than home
8. Household without any access to the Internet

In the 2010 census round, only about two dozen countries (including Bahamas, Belize, Costa Rica, Djibouti, Kenya, Macao, Micronesia, Nauru, Namibia, Qatar, Romania, St. Lucia, Trinidad & Tobago, Vanuatu, among others) included one or more questions on internet access in their PHCs, although it is likely that more will do so in the 2020 round. Some PHCs ask individual questions for collecting data on the number of individuals using the Internet. This type of information can provide the data needed for calculation of this indicator.

c) Method of computation

For countries that collect data on this indicator through a household survey, this indicator is calculated by dividing the total number of in-scope individuals using the internet (from any location) in the last 3 months by the total number of in-scope individuals.

Most censuses provide data on the internet connection at the household level. Only a few PHCs ask this question at the individual level. If the data is available at the individual level, the computation method explained above can be used for census data, although in general the time frame is not established. But this indicator can provide information for individuals who currently have access to the Internet.

PHCs which collect data on internet connection at the household level, a proxy estimate can be produced as proportion of households with internet access and can be aggregated by small geographic areas.

d) Challenges in measuring in PHC

The biggest challenge is the fact that only a minority of censuses so far provide data on internet use. Another, smaller problem is that generally no data are available on the time since last use. Some censuses only collect data on whether an internet connection is available in the household, without specifying which household members make use of it. A recommendation to be derived from this is that PHC should preferably ask this question at the individual level, i.e. if household members have used the internet, rather than only asking if an internet connection is available in the household. Also, an explicit time limit of three months should be included in the question on use.

e) Data disaggregation

For countries that collect this data on the proportion of individuals using the Internet, the indicator can be broken down by location (geographic and/or urban/rural), by sex, by age group, by educational level, by labour force status, and by occupation. All of these breakdowns can be readily generated with census data.

If PHCs provide this data at the household level, proportion of households with internet access can disaggregated by regions, urban/rural as well as by slum areas. It is also possible to disaggregate by migration status of the reference person or head of households.

3.4. Indicators for which the PHC provides ancillary information (Group 1.IV)

9.5.2 Researchers (in full-time equivalent) per million inhabitants

a) Concept and definition

The number of researchers (in full-time equivalent) per million inhabitants is a direct measure of the number of research and development workers per 1 million people. This in turn is a measure of the intensity of national investment in technological development and technological autonomy.

The OECD Frascati Manual (OECD, 7th edition released in 2015) provides the relevant definitions for research and experimental development, gross domestic expenditure on R&D and researchers.[32] The following definitions are taken from this document.

Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge. Note that this definition excludes research undertaken for routine purposes and that does not generate knowledge that can be generalized to other contexts, such as legal research for mounting a litigation strategy, consumer research for the purpose of understanding consumer preferences or priorities, political opinion research, market research for the purpose of understanding different purchasing or investment options, etc.

Researchers are professionals engaged in the conception or creation of new knowledge. They conduct research and improve or develop concepts, theories, models, techniques instrumentation, software or operational methods.

The Full-time equivalent (FTE) of R&D personnel is defined as the ratio of working hours actually spent on R&D during a specific reference period (usually a calendar year) divided by the total number of hours conventionally worked in the same period by an individual or by a group.

b) Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The three main data sources for computing this indicator at the country level are administrative data bases, surveys and censuses.

Many countries have their own administrative data bases on R&D institutions in the country, often maintained by the Ministry of Science and Technology or similar Ministries. These may include both financial data from revenue agencies as well as other types of administrative sources, such as company records. The limitation of such sources is that the concepts and definitions used in them may not coincide with those used in the Frascati manual. For example, administrative data may cover mostly governmental or semi-governmental institutions and universities and under-state the significance of R&D being done in the private business sector.

Business registers are major tools for compiling R&D statistics, but may not be sufficient to identify the relevant population to be surveyed about R&D. Although they provide essential information on key characteristics of enterprises potentially included in an R&D survey sample (e.g. size, industry, ownership, age, etc.), business registers often do not include information on their actual R&D or likelihood for R&D performance.

Ideally, the R&D data need to be collected through surveys or business censuses, which are expensive, and are not done on a regular basis in many developing countries. Furthermore, (developing) countries do not always cover all sectors of performance. Surveys may face problems of sample design as R&D is

[32] All countries follow the guidelines of this manual which is available at: https://www.oecd.org/sti/inno/Frascati-Manual.htm.

relatively rare and tends to be concentrated in a small number of institutions. A few large insitutions may account for a majority of researchers. Therefore if the structure of R&D is not correctly mapped in the sample design, e.g. because particular sectors are overlooked (start-up businesses, NGOs, philanthropic institutions), this can significantly affect the assessment of the number of professionals involved in R&D activities.

The UNESCO Institute of Statistics (UIS) sends out a questionnaire every year to collect R&D data from all countries (around 125 countries), which are not covered by the data collections of the other partner organizations such as the Organisation for Economic Co-operation and Development (OECD), Eurostat (Statistical Office of the European Union) and the Network on Science and Technology Indicators – Ibero-American and Inter-American (RICYT).

The Frascati manual does not contemplate the PHC as a potential source of data. The primary instrument afforded by PHC data to characterize R&D is the ISIC coding of the industry question, where code 72 (Section M - Professional, scientific and technical activities) corresponds to R&D. The other ISIC code that covers activities mostly related to R&D is 853 (Higher Education). Additional information may be obtained from the question on occupation (ISCO-08 codes) and the question on highest level of education, specifically the post-graduate level, where this is part of the census contents. If the PHC specifies educational attainment up to the level of post-graduate studies (Master’s or PhD degree), this information may be used to establish the person’s credentials as a researcher. Most censuses do distinguish post-graduate studies from a bachelor’s degree, although censuses like those of Argentina, Egypt, Ghana, Indonesia, Nigeria, the Philippines, and South Africa do not distinguish between a Master’s and a PhD degree. Apart from this, the census usually is the appropriate point of departure for the estimation of the relevant denominators.

Although ISIC codes 72 and 853 will cover most of the R&D sector, it is doubtful that PHCs can accurately map all of their relevant census data to this category. However, while the combination of industry (ISIC code), occupation (ISCO-08) and level of education may help in classifying/distributing reasearchers by occupation (or field of research using UNESCO/ISCED field of education classification), they are generally insufficient to identify reserachers in and of themselves. They are, nonetheless, useful for classifying/distributing reasearchers by occupation (or field of research).

c) Method of computation

Operationally, the proxy indicator being proposed here measures the number of people who are professionals and working at establishments that conduct scientific R&D activities and/or higher education, as a proportion of the total population. In terms of industry, these persons can be characterized as having ISIC codes 72 or 853. In terms of education, they should at least have a Master’s degree. In terms of occupation, they should belong to one of the following ISCO-08 categories:
1223 Research and Development Managers;
2111 Physicists and Astronomers;
2112 Meteorologists;
2113 Chemists;
2114 Geologists and Geophysicists;
2120 Mathematicians, Actuaries and Statisticians;
213 Life Science Professionals;
2141 Industrial and Production Engineers;
2142 Civil Engineers;
2144 Mechanical Engineers;
2145 Chemical Engineers.;
2146 Mining Engineers, Metallurgists and Related Professionals;

2151 Electrical Engineers;
2152 Electronics Engineers;
2153 Telecommunications Engineers;
2161 Building Architects;
2162 Landscape Architects;
2164 Town and Traffic Planners;
2165. Cartographers and Surveyors;
2212 Specialist Medical Practitioners;
2221 Nursing Professionals;
2222 Midwifery Professionals;
2230 Traditional and Complementary Health Professionals;
2262 Pharmacists;
2264 Physiotherapists;
2265 Dieticians and Nutritionists;
2310 University and Higher Education Teachers;
2351 Education Methods Specialist;
2352 Special Needs Teachers;
2353 Other Language Teachers;
2421 Management and Organization Analysts;
2422 Policy Administration Professionals;
2512 Software Developers;
2631 Economists;
2632 Sociologists, Anthropologists and Related Professionals;
2633 Philosophers, Historians and Political Scientists;
2634 Psychologists;
2635 Social Work and Counseling Professionals;
2643 Translators, Interpreters and Other Linguists.

It is important to emphasize that the overwhelming majority of the professionals belonginging to some of these categories (e.g. 2112, 2113, 2114, 2141, 2221, 2262, etc.) are not researchers in the sense defined above. They can only tentatively be characterized as such if they work in research institutions or institutions of higher learning. However, the listing above excludes some professional categories such as journalists, librarians, religious professionals and authors, who, even if they work at universities or research institutions, are not likely to be involved in actual R&D activities, in the sense referred to here.

d) Challenges in measuring in PHC

It is important to note that the indicator described in the previous section is only a proxy for the actual indicator, as defined in the SDG metadata and the Frascati manual. The precise characterization of R&D personnel is only possible based on the analysis of their specific activities. For example, while most librarians, even if they are employed at institutions of higher learning, do not qualify, a librarian assigned to documentary research in support of a specific R&D project would. This amount of detail is impossible to discern purely on the basis on census data. Specifically, the Frascati manual, on pages 161 and 162, alerts to the following:

“It is stressed that in this manual this classification of R&D personnel refers to the actual function (in terms of tasks) of the individuals contributing to the intramural R&D activities of the statistical unit. From a practical perspective, it is acknowledged that reporting units (and even statistical offices compiling R&D data) may sometimes rely on existing and easily accessible criteria for categorising R&D personnel. Hence, it may be useful to summarise criteria that should not be the sole basis for classifying

R&D personnel as “researchers”, “technicians” or “other supporting staff”, although these criteria may help in identifying the appropriate classification category.
It is not based on job positions. Although some employees have job contracts as “researchers”, it does not necessarily mean that they undertake the tasks of “researchers” in all of their employer’s R&D activities. In some cases, a “researcher” could perform the tasks of a “technician” in a specific R&D project. The latter should be reported in R&D statistics. Conversely, individuals with a formal position of “technician” could be asked to perform tasks similar to that of “researchers” for a specific project: again, it is the latter (i.e. the tasks actually performed by the individual) that should define what is reported on R&D surveys.
It is not based on formal qualifications or level of education. While persons who hold a doctorate degree will most likely be involved in R&D projects as “researchers”, it should not be assumed that the R&D tasks undertaken by all individuals will always be consistent with their qualifications. For example, a technician with several years of work-related experience, but only a secondary education degree, might undertake tasks similar to that performed by a “researcher” in a given context.
It is not based on seniority at work. It is not uncommon for young “researchers” to manage complex R&D projects and for colleagues (or consultants) with more experience to have functionally different roles (technical or administrative support, for instance).
It is not based on employment relationships with the R&D-performing unit. Although most intramural R&D activities are managed by employees (or by working proprietors in small enterprises), it is also possible for external R&D personnel to perform the same R&D tasks as “persons employed”. As a consequence, a statistical unit can perform intramural R&D relying only on the R&D activity undertaken by external R&D personnel.”

The full-time equivalent (FTE) concept (rather than head count) used by the Frascati manual is also difficult to apply in a census, so that it becomes difficult to distinguish between those for whom R&D is the primary function rather than a secondary function/part-time activity.

Other challenges may include: classifying by field of research; and, institutional sector/sector of employment. Finally, par. 3.47 of the Frascati manual points out that the location of R&D-performing units is of great user interest but is challenging from the perspective of statistics collection, as statistical units defined on the basis of the R&D decision making can span several locations, in different countries and in different regions within each country. This is particularly relevant for data disaggregation.

e) Data disaggregation

Researchers can be broken down by: 1. Sector of employment (Government; Higher education; Private non-profit); 2. Field of R&D (Natural sciences / Engineering and technology / Medical and health sciences / Agricultural and veterinary sciences / Social sciences / Humanities and the arts); 3. Sex; and 4. Age (<25 / 25-34 / 35-44 / 45-54 / 55-64 / >65). In case the indicator is measured with census data, most of these disaggregations should be relatively easy to achieve, with the possible exception of 2). Linking/cross-tabulating with field of education (UNESCO/ISCED field of education classification or occupation) could be useful for classifying/distributing reasearchers. Geographical disaggregation presents the challenge mentioned at the end of the previous section, with the additional problem that, in the case of PHC data, the researchers are recorded by their place of residence and can be disaggregated by place of work if this information is collected in the PHC.

17.6.2 Fixed Internet broadband subscriptions per 100 inhabitants, by speed

a) Concept and definition

The indicator fixed Internet broadband subscriptions, by speed, refers to the number of fixed-broadband subscriptions to the public Internet, split by advertised download speed, irrespective of the type of access, device used to access the Internet, or the method of payment. Broadband may be defined loosely as transmission capacity with sufficient bandwidth to permit combined provision of voice, data and video. Fixed (wired) broadband consists of technologies providing Internet access over wireline networks such as fixed telephone lines, coaxial cable television networks, fibre-optic cable, in-building ethernet cable and electrical power lines and other fixed (wired) broadband (wireless broadband is not included in this category).[33]

Access to the Internet is measured irrespective of the type of access, device used to access the Internet, or the method of payment. Fixed internet broadband subscriptions refer to subscriptions to high-speed access to the public Internet (a TCP/IP connection), at downstream speeds equal to, or greater than, 256 kbit/s. It excludes subscriptions that have access to data communications (including the Internet) via mobile-cellular networks. It should include fixed WiMAX and any other fixed wireless technologies. It includes both residential subscriptions and subscriptions for organizations.

Many countries, especially in the developing world, have not only a very limited amount of fixed-broadband subscriptions, but also at very low speeds. The indicator highlights the potential of the Internet (especially through high-speed access) to enhance cooperation, improve access to science, technology and innovation, and share knowledge. The indicator also highlights the importance of Internet use as a development enabler and helps to measure the digital divide.

b) Possible data sources, particularly PHC , and their relative advantages/ disadvantages

The main data sources are administrative data collected from internet service providers by the Information and Communication Technology Ministries and reported to the International Telecommunications Union (ITU). The main limitation of these data is that they usually do not allow any meaningful disaggregations as the internet service providers only collect minimum commercially relevant data on suscribers. Some countries hold periodic household surveys on Internet use. The American Community Survey (ACS) in the United States, for example, provides annual estimates of household internet use, based on ten questions.

Increasingly censuses do include questions about internet use, but the format of these questions often does not facilitate their use for the computation of this indicator. In some cases they are formulated in terms of the use of Internet by household members, regardless of where this use takes place. The type of internet connection is usually not specified, particularly with regard to the speed of the connection.

The P & R (4.564) recommend the following questions on access to telecommunication devices in the census:

1. Household having a radio
2. Household having a television set
3. Household having a fixed-line telephone
4. Household having one or more mobile cellular telephones
5. Household having a personal computer
6. Household accessing the Internet from home
    6.1. Landline connection
    6.2. Mobile connection
7. Household accessing the Internet from elsewhere other than home

[33] ITU Handbook for the collection of administrative data on Telecommunications/ICT 2011, pages 40-54).

8. Household without any access to the Internet

In the 2010 census round, only about two dozen countries included one or more questions on internet access in their PHCs, although it is likely that more will do so in 2020. This information differs from that obtained from internet servise providers in at least the following aspects:

As happens with other services, such as electricity, the data provided by internet service providers refer to the number of suscribers. The number of households using the service may exceed the number of subscribers as one connection may serve more than one household.

The data from internet service providers do not indicate the number of users within each household, thereby limiting the possibility to know what percentage of the population (rather than households) has access to internet service. Some censuses ask about Internet use by individual household members. If not, the number of household members provides an indication of the potential number of users. Some censuses, however, only ask household members if they have used the internet during a recent period, regardless of whether it was at home, at work, or through a public internet service such as an internet café.

The information collected in the census refers to internet access of any kind, usually without indication of the type of connection (broadband, dial-up, through mobile phone). Only very few countries (Australia, for example) break the information down by categories of internet access.

Given the considerations above, it is recommended that future PHCs consider modifying the question on access to ICTs (internet, more specifically) by including access to broadband at the household level or at individual level by explicitly referring to this category, rather than just using the term "internet" indiscriminately.

c) Method of computation

The prospects for using census data in order to obtain more detailed profiles on broadband internet use by speed seem rather daunting given that:

No PHC provides information on internet speeds;

Very few PHCs have information on method / technology of access;

The majority of PHCs identify only if household members have used the internet, without specifying where.

For all of these reasons, an alternative indicator that only measures the proportion of households with internet access, without specifying the speed of the connection is proposed.

Proportion of households with Internet access can be computed by number of households which have Internet access at home including both narrowband and broadband connection divided by total number of households and multiplied by 100.

it may be possible to develop estimates of internet use by different social groups if at least a minimum stratification of internet services provided can be obtained by sufficiently disaggregated geographical areas. By comparing the information of internet service providers for such small areas with the number of users found in the PHC, the PHC estimates can be calibrated and recombined for other types of social groupings, in order to obtain estimates in terms of other criteria, such as level of education or age.

The methodology that would allow these kinds of estimates is not well established and further work will be necessary to assess its feasibility.

d) Challenges in measuring in PHC

Apart from the fact that most censuses do not specify the kind of internet access, no census so far provides any information on the speed of the connection. The P & R (4.571) foresees the possibility of including a question on bandwidth / speed of access, but it is doubtful that high quality data can be obtained this way as household members may not be familiar with the technical specifications of their internet servisse. Even the American Community Survey, which provides anual updates on internet household internet use in the United States, does not include this question.

Given national context, countries may collect data/disaggregate in different speed categories than those shown here (especially in countries that use data plans/packages that do not align with the speeds used for this indicator). Another potential problem is that the actual speed of the internet service provided in many countries does not always correspond to the speed as advertised.

e) Data disaggregation

Proportion of households with Internet acess can be disaggregated by rural and urban areas and by small geographical areas. It is also possible to construct estimated disaggregations by characteristics of household population, such as the age (minimum age can be 10 and over) and sex, education, labour force status, etc. of household members residing in households that have access to broadband internet services.

3.5. Indicators for which the PHC is the most obvious source (Group 2.I)

6.1.1 Proportion of population using safely managed drinking water services

a) Concept and definition

The proportion of population using safely managed drinking water services is currently being measured by the proportion of population using an improved basic drinking water source which is located on premises, available when needed and free of faecal (and priority chemical) contamination. Improved drinking water sources include: piped water into dwelling, yard or plot; public taps or standpipes; boreholes or tubewells; protected dug wells; protected springs; packaged water; delivered water and rainwater.

A water source is considered to be located on premises if the point of collection is within the dwelling, yard, or plot. 'Available when needed' means that households are able to access sufficient quantities of water when they need them. 'Free from faecal and priority chemical contamination' means that the water complies with relevant national or local standards. In the absence of such standards, reference is made to the WHO Guidelines for Drinking Water Quality (http://www.who.int/water_sanitation_health/dwq/guidelines/en/).

At the start of the MDG period, there was a lack of nationally representative data about drinking water safety in developing countries, as such data were not collected through household surveys or censuses. The Joint UNICEF/WHO Monitoring Programme (JMP) developed the concept of 'improved' water sources, which was used as a proxy for 'safe water', as such sources are likely to be protected against faecal contamination, and this metric has been used since 2000 to track progress towards the MDG target. International consultations since 2011 have established consensus on the need to build on and address the shortcomings of this indicator; specifically, to address normative criteria of the human right to water including accessibility, availability and quality. This led to the conclusion that JMP should go beyond the basic level of access and address safe management of drinking water services, including dimensions of accessibility, availability and quality. The proposed indicator of ‘safely managed drinking water services’ is designed to address this.

Access to water and sanitation are considered core socio-economic and health indicators, and key determinants of child survival, maternal, and children’s health, family wellbeing, and economic productivity. Drinking water and sanitation facilities are also used in constructing wealth quintiles used by many integrated household surveys to analyse inequalities between rich and poor.

b) Possible data sources, particularly PHC, and their relative advantages/ disadvantages

Data on availability and safety of drinking water is increasingly available through a combination of household surveys and administrative sources including regulators, but definitions have yet to be standardized. Data on faecal and chemical contamination, drawn from household surveys and regulatory databases, will not cover all countries immediately. However, sufficient data were available to make global and regional estimates of safely managed drinking water services for four out of eight SDG regions in 2017. Access to drinking water and sanitation is therefore a core indicator for most household surveys. Data on availability and quality of water supplies are currently available from household surveys or administrative sources including regulators for over 70 high-income countries, and at least 30-40 low- and middle-income countries. Currently the JMP database holds over 1,700 censuses and surveys. In high-income countries where household surveys or censuses do not always collect information on basic access, data are drawn from administrative records. Time series data are available for the basic drinking water level of service over the period 2000-2015. These serve as the foundation for the safely managed drinking water service indicator. Some elements of safe management (e.g. water quality) were not collected during the MDG period and trend analysis will only be possible several years into the SDGs.

By and large, the merits of measuring this indicator through census data or through households are the same. Unless special provisions are taken in surveys to measure faecal and chemical contamination, surveys measure the concepts largely in the same way that PHCs do, with the advantage that PHCs cover all of the population and not just a sample. The potential disadvantages of the census derive from the fact that not all countries ask the questions in the same way.

The main source of drinking water is a core topic of the P&R that is implemented in virtually every PHC. The P&R paragraph 4.494 emphasizes the need for operational criteria regarding the safety of the drinking water service. It specifies that an improved water source (piped water, public tap or standpost, tubewell or borehole, protected dug well, protected spring, rainwater) can be safely managed. Unimproved sources, which by definition are not safely managed, include unprotected dug well, unprotected spring and surface water from a river, stream, dam, lake, pond, canal or irrigation channel. Delivered water (for example, through trucks, carts, sachets or bottles) can potentially be safely managed, but if these are the primary drinking water sources, other improved sources of water must be accessible at the household for other domestic uses (for example, washing, bathing).

As a result, it recommends the following classification (P&R 4.491):

- 1. Piped water inside the unit
    - 1.1. From the community scheme subject to inspection and control by public authorities
    - 1.2. From an individual source
- 2. Piped water outside the unit but within 200 metres
    - 2.1. From the community scheme
        - 2.1.1. For exclusive use
        - 2.1.2. Shared
    - 2.2. From an individual source

        2.2.1. For exclusive use
        2.2.2. Shared
3. Other
    3.1. Borehole/tubewell
    3.2. Protected dug well
    3.3. Protected spring
    3.4. Rainwater collection tank
    3.5. Delivered water—bottled, sachet
    3.6. Delivered water—tanker trucks, carts
    3.7. Unprotected dug well/spring/river/stream/lake/pond/dam/canal/irrigation channel

Actual national census questionnaires show a great variety and their categories cannot always be easily mapped to the categories listed above. It is recommended that countries should follow the categories listed above as much as possible and make sure that, where categories are lumped together, this is done in a way that does not mix safe with unsafe water sources.

c) Method of computation

The P&R specifies an improved water source and unimproved sources, as explained above.

The following sources should be considered improved water sources:

1. Piped water inside the unit
    1.1. From the community scheme subject to inspection and control by public authorities
    1.2. From an individual source
2. Piped water outside the unit but within 200 metres
    2.1. From the community scheme
        2.1.1. For exclusive use
        2.1.2. Shared
    2.2. From an individual source
        2.2.1. For exclusive use
        2.2.2. Shared
3. Other
    3.1. Borehole/tubewell
    3.2. Protected dug well
    3.3. Protected spring
    3.4. Rainwater collection tank
    3.5. Delivered water—bottled, sachet
    3.6. Delivered water—tanker trucks, carts

while the following sources are not included:

    3.7.a. Unprotected dug well
    3.7.b. Unprotected spring
    3.7.c. River, stream, lake or pond
    3.7.d. Dam, canal or irrigation channel.

After establishing which households have access to an improved source of drinking water, their total number of household members should be added to the numerator. The denominator consists of the total population:

$$Proportion = 100 \times \frac{Total\ Population\ in\ Households\ with\ Improved\ Source\ of\ Drinking\ Water}{Total\ Population}$$

d) Challenges in measuring in PHC

The major challenge is that national census practices vary and the questions are not always asked in the same way. In particular, the recommendation on the qualification of “other” sources of drinking water, as explained above is not followed in all PHCs, which limits the possibility to classify certain sources as “safe” or “unsafe”. For example, the 2015 census of Equatorial Guinea lumps together several types of surface water (river, lake, stream, pond) with rainwater reservoirs in the same category, even though the former are considered unsafe and the latter safe. Similarly, in the 2015 census of Sierra Leone, rainwater reservoirs, lakes, ponds and irrigation channels all come under the residual category (“others”), even though some are safe and some are not. The distance from the nearest water source, particularly if it is a community water source, is often not specified.

In addition, it must be noted that most censuses only make reference to water in general terms, without specifying its specific use. A recommendation in this regard could be that PHCs should formulate their questions on the provision of water more specifically in terms of “water for drinking ”, since for other types of uses its origin is less critical.

e) Data disaggregation

Disaggregation by area of residence (urban/rural), regions and by other administrative units. Disaggregation by service level (including no services, basic, and safely managed services) should normally also be possible.

Due to its universality of enumeration, the census offers certain advantages in disaggregating the information by special groups such as small ethnic communities or other particular disadvantaged groups and small geographical areas down to the enumeration area level.

Disaggregation by socioeconomic status such as education is straightforward. This indicator can be further disaggregated by wealth quintile if data on income is available or if any poverty index is calculated, such as the Multidimensional Poverty Index (MPI).

3.6. Indicators for which the PHC provides proxy estimate (Group 2.III)

1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions

a. Concept and definition

Metadata for this indicator is not available. This report introduces an option for monitoring this indicator on multidimensional poverty according to national experiences developed by United Nations Development Programme.[34]

[34] UNDP, (2019), *How to build a National Multidimensional Poverty Index,* https://www.undp.org/content/undp/en/home/librarypage/poverty-reduction/how-to-build-a-national-multidimensional-poverty-index.html

National multidimensional poverty as an approach of non-monetary poverty measurement can complement existing measures of monetary poverty and reveal populations living in poverty who would otherwise be overlooked. National multidimensional poverty helps identify not only who is living in poverty, but how they experience poverty. They reveal the overlapping deprivations within and across groups in different parts of a country and enable policymakers to see how these deprivations change over time.

Living under the extreme poverty line often encompasses deprivations of safe drinking water, proper sanitation, access to modern energy, sustainable mobility to economic resources, information technology, healthcare, education, etc. Poverty is also a manifestation of hunger and malnutrition, limited access to education and other basic services, social discrimination and exclusion as well as the lack of participation in decision-making. In other words, poverty is multidimensional and covers many aspects of life ranging from access to opportunities, livelihoods and means of survival. The strategy for constructing non-monetary poverty indicators consists in combining different social indicators that have been proven good indicators of welfare and combining them into some sort of numerical index. Several methods exist to this end, such as Multiple Poverty Index (MPI), Unmet Basic Needs (UBN) and Wealth Index (WI). This report will provide a detailed discussion of the MPI which is suggested by UNDP as an option for monitoring Indicator 1.2.2.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

Data for the construction of non-monetary poverty measures can be obtained both from PHCs and from different kinds of surveys, such as general purpose household surveys, LSMS, DHS and MICS. Although surveys may have some advantages in terms of the range of dimensions of poverty that can be measured through them, these advantages are generally outweighed by the more detailed geographical coverage of the PHC, which allows the construction of non-monetary poverty measures at a much more granular geographical level.

The main advantage of using a census as a source of information for multidimensional poverty calculations is that it provides information with an almost negligible sampling error, as the whole population is considered. This allows a high level of disaggregation and the creation of poverty maps. PHC collects information for whole population groups allowing separate data analysis which is not usually possible from other sources of data, such as people living in remote areas, slums, refugees and homeless people.

As was indicated in the previous paragraph, while PHCs may not have data on all dimensions relevant to the measurement of non-monetary poverty (e.g. nutrition), they usually allow measuring most of the relevant dimensions, including the following:

Health

Recent deaths in the household and proportion of children that have died;

Education

Level of education of the household members;
School attendance for school age children;

Employment

Number of persons per working household member-employed, unemployed and people who are outside the labour force;

Standard of living

- Number of persons per bedroom and room;
- Earthen floor or use of sub-standard materials for the walls or roof;
- Access to safe drinking water (for definition of safe drinking water, see Indicator 6.1.1);
- Absence of an indoor toilet or running water inside the home;
- Sewage disposal;
- Access to electricity;
- Cooking fuel used;
- Household assets such as radio, TV, telephone, bike, motorbike, phone, cell phone, computer, animal cart or refrigerator, car or truck.

c. Method of computation

As yet, no unified methodology has been proposed for the assessment of non-monetary poverty in the SDGs. However, there are a number of existing methodologies that may be employed to this end. This report suggests the use of the Multidimensional Poverty Index launched by UNDP in 2010 and revised in 2014 and 2018. This report also briefly explains two other methods: Unmet Basic Needs and Wealth Index.

A. Multidimensional Poverty Index (MPI)[35]

The MPI is an index designed to measure acute poverty and it has two main characteristics. First, it includes people living under conditions where they do not reach the minimum internationally agreed standards in indicators of basic functioning, such as accessing health services, being educated or drinking clean water. Second, it refers to people living under conditions where they do not reach the minimum standards in several aspects at the same time. In other words, the MPI measures those experiencing multiple deprivations, people who, for example, are simultaneously not educated and do not have clean drinking water, adequate sanitation or clean fuel.

The global MPI identifies multiple deprivations at the household level in health, education and standard of living. It uses micro data from censuses and household surveys. It is crucial that all the indicators needed to construct the index must come from the same data source.[36,37] According the latest revision of the method, it uses 10 indicators in three dimensions as follows[38]:

List of indicators for MPI

Dimension	Indicator	Deprived if ….[38]	Availability in PHC
Health	1.Maternal mortality (replacing Nutrition) [38]	If nutrition data is available (usually from household surveys) -Any adult or child, for whom there is nutritional information, is underweight (for definition of underweight by age	No census collects data on nutrition. This report suggests replacing this variable with maternal deaths (see P&R, 2017, paragraphs 4.250-4.254).

[35] S. Alkire, J. Foster (2011). *Understandings and misunderstandings of multidimensional poverty measurement, Journal of Economic Inequality,* 9, pp. 289-314.
[36] UNDP (2018). *Human Development Indices and Indicators: 2018 Statistical Update.*
[37] UNDP, OPHI and University of Oxford (2019). How to Build a National Multidimensional Poverty Index (MPI): Using the MPI to Inform the SDGs.
[38] *PHC does not collect data on nutrition but asks a question for measuring recent deaths including maternal deaths in households. National application of MPI is tailored to choose country specific dimensions or variables (see UNDP, 2019) according to national priorities. Based on the flexibility of the national MPI, this report suggests to include a variable for maternal mortality instead of nutrition for measuring MPI from censuses.*

		groups, see the publication UNDP, 2018) For population and housing censuses, if maternal mortality is available - Any female aged 15-49 in the household has died while she was pregnant or during childbirth or during the six weeks after the end of pregnancy.	Maternal death is defined as female deaths aged 15 to 49 occurred while she was pregnant or during childbirth or during the six weeks after the end of pregnancy.
	2.Child mortality	Any child under the age of 18 years in the household has died in five years preceding the survey	-Core topic- PHC collects data on household member deaths in the past 12 months preceding the census reference date.
Education	3.Years of schooling	No household member age 12 or older has completed 6 years of schooling (assuming that official age for starting school is 6)	- Core topic - PHCs ask a question on “school attendance” to the population of official school age, in general from 5 to 29 years of age by current level of education. The PHC also asks collects data on educational attainment for all people five years of age and older. Years of schooling can be derived from these two topics for people age 12 or older.
	4.School attendance	Any school-age child is not attending school up to the age at which he or she would complete class 8	- Core topic - As explained above, PHC can provide data on school attendance by the ISCED classification.
Standard of living	5.Electricity	The household has no electricity	- Core topic – PHC ask a question to every household whether electricity is available or not. Households with no electricity can be easily identified from this information (see indicator 7.1.1.)
	6.Sanitation	The household does not have access to improved sanitation (according to Sustainable Development Goal guidelines), or it is improved but shared with other households. A household is considered to have access to improved sanitation if it has some type of flush toilet or latrine or ventilated improved pit or composting toilet that is not shared.	- Core topic - PHC collects data on type of toilet and sewage disposal. The households do not have access to improved sanitation can be identified using classification of type of toilet and sewage disposal (see Indicator 6.2.1)

	7.Drinking water	The household does not have access to an improved source of drinking water (according to Sustainable Development Goal guidelines), or safe drinking water is at least a 30-minute walk from home, roundtrip. A household is considered to have access to an improved source of drinking water if the source is piped water, a public tap, a borehole or pump, a protected well, a protected spring or rainwater. When a survey uses a different definition of safe drinking water, the survey report is followed.	- Core topic - PHCs collect data on main source of drinking water for whole households. Households which have access to improved source of drinking water can be identified using the categories of main source of drinking waters (see indicator 6.1.1)
	8.Housing	At least one of the household's three dwelling elements—floor, walls or roof—is made of inadequate materials—that is, the floor is made of natural materials and/or the walls and/or the roof are made of natural or rudimentary materials. ;	- Core topic - PHC asks specific questions for collecting data on construction materials of floor, walls and roof (see indicator 11.1.1.). There is no international standard for inadequate materials, however the following materials can be considered inadequate materials: The floor is made of natural materials such as mud, clay, earth, sand or dung; the dwelling has no roof or walls the roof or walls are constructed using natural materials such as cane, palm, trunks, sod, mud, dirt, grass, reeds, thatch, bamboo or sticks or rudimentary materials such as carton, plastic or polythene sheeting, bamboo or stone with mud, loosely packed stones, uncovered adobe, raw or reused wood, plywood, cardboard, unburnt brick, or canvas or tent.
	9.Cooking fuel	The household cooks with dung, wood, charcoal or coal.	- Core topic The fuel used for cooking is collected by each housing unit (see P&R, 2019, paragraph 4.510). The classification of fuels used for cooking depends

			on national circumstance but usually it is possible to distinguish the household using coal, firewood, charcoal, animal dung, crop residues for cooking from census data.
	10. Assets	The household does not own a car or truck and does not own more than one of the following assets: radio, television, telephone, computer, animal cart, bicycle, motorbike or refrigerator	- Additional topic - This topic is not core but many countries collect data on number of/availability of cars or trucks in PHC. Also ask a question about the availability of durable household appliances which are decided depending on national circumstances (see P&R, 2017, paragraphs 4.572 and 4.573)

Main steps of measurement[39]

National MPIs are tailored to their national priorities, so countries can choose their own set of dimensions, indicators, weights and cut-offs, according to their national priorities, plans and contexts. Following this general principles, this report provides all steps of computation procedures of national MPI which starts with the selection of dimension and indicators. This report also provides guidance for selection of dimensions and indicators which can be generated from many PHCs based on the availability of data as discussed above.

National MPI can be built using the following five steps:

1. **Selecting the dimensions and indicators**

A key step in the development of a national MPI is to decide the structure of the measure—that is, the dimensions and indicators that together measure poverty in the country. The indicators are the fundamental components of the MPI; they should capture deprivations in functionings that define poverty, according to the purpose of the measure. Dimensions are conceptual groupings of indicators that are used to communicate the final measure.

To determine the suitability of the selected indicators, it is necessary to make an assessment for their availability in the selected data source and statistical validation and as well as comparability across diverse contexts within a country).

For monitoring SDG 1.2.2 from PHCs, three dimensions (health, education and standards of living) and ten indicators (as listed above) are recommended.

2. **Setting the deprivation cut-offs for each indicator**

Deprivation cut-offs refer to the minimum level of achievement that a household or individual must have to be considered non-deprived in each indicator. For instance, the deprivation cut-off for years of

[39] UNDP, 2018, *Human Development Indices and Indicators: 2018 Statistical Update*

schooling could be six years, so that a person is considered deprived if she/he has not completed at least six years of schooling. Alternatively, "no school attendance" indicator could be used for school-aged children (usually 5 to 17 or 18). Or the deprivation cut-off could require that both a woman and a man have completed primary education, or that half of the adults in the household have received a primary education.

3. Identifying the indicators' weights

Once the indicators and their corresponding cut-offs have been selected, the next step is to define the weight for each indicator. Weights refer to the value that is given to indicators (and, by association, to dimensions) within the MPI. Weights, like dimensions, indicators, and cut-offs, are fixed over time. Setting weights plays a fundamental role in defining the relative importance of each deprivation in the final measure.

This report suggests equal weights for three dimensions, so that each of them receives a 1/3 weight. The indicators within each dimension are also equally weighted. Thus, each indicator within the health and education dimension receives a 1/6 weight and each indicator within the living standards dimension receives a 1/18 weight (1/3 ÷ 6).

As a result, the total of the indicators` weights must be equal to 1:

$$\sum_{i=1}^{d} w_i = 1$$

The following table presents the weights for the indicators discussed above:

Dimension	Indicator	Weight	Component weight
Health	1.Maternal mortality	1/6	1/3
	2.Child mortality	1/6	
Education	3.Years of schooling	1/6	1/3
	4.School attendance	1/6	
Standard of living	5.Electricity	1/18	1/3
	6.Sanitation	1/18	
	7.Drinking water	1/18	
	8.Housing	1/18	
	9.Cooking fuel	1/18	
	10. Assets	1/18	

4. Setting the poverty cut-off (identifying the poor):

The poverty cut-off k identifies those who are multidimensionally poor in at least k weighted indicators. The value of k reflects the minimum level of deprivations or deprivation score an individual or household must be suffering simultaneously to be considered poor. The setting of this poverty line needs to reflect the priorities and policy goals of the country. For example, if the purpose is to target resources to the poorest population, the value of k must capture those who are facing the highest number of simultaneous deprivations. In turn, if the goal is to monitor poverty, k should reflect the minimum level of deprivations acceptable in a country to be considered non-poor.

For national MPI, there is no universal rule for defining the poverty cut-off. Ordinarily, the poverty cut-off reflects the weighting structure of the index. For example, if there are three dimensions, it would be natural to explore cut-offs of 33 percent —which translate to being deprived in at least one dimension or deprived in more than one dimension or the equivalent of weighted indicators.

If calculation of the national MPI from PHC data includes three dimensions, a cut-off of 1/3 can be used to distinguish between poor and nonpoor people. Poor people can be further classified based on the deprivation scores as follows:

If the deprivation score is 1/3 or higher, that household (and everyone in it) is considered **multidimensionally poor**.
People with a deprivation score of 1/5 or higher but less than 1/3 are considered to be **vulnerable to multidimensional poverty**.
People with a deprivation score of ½ or higher are considered to be in **severe multidimensional poverty**.

5. Computing the MPI

The MPI combines two key pieces of information:
the headcount ratio (H) is the proportion of multidimensionally poor people in the given population

$$H = \frac{q}{n}$$

Where: q is the number of people who are multidimensionally poor and
n is the total population.

the intensity of poverty (A) is the average proportion of the weighted component indicators in which multidimensionally poor people are deprived. For multidimensionally poor people only (those with a deprivation score c greater than or equal to 33.3 percent), the deprivation scores are summed and divided by the total number of multidimensionally poor people:

$$A = \frac{\sum_1^q ci}{q}$$

Where: c_i is the deprivation score that the ith multidimensionally poor person experiences. The deprivation score c_i of the ith multidimensionally poor person can be expressed as the sum of the weights associated with each indicator j (j = 1, 2, ..., 10) in which person i is deprived,

$$C_i = w_1 * p_{i1} + w_2 * p_{i2} + ... + w_{10} * p_{i10}$$

Pij indicates if person is deprived in terms of indicator j and w_j is the weight for the indicator j.

The MPI value is the product of two measures: the multidimensional poverty headcount ratio and the intensity of poverty:

$$MPI = H \times A$$

The contribution of dimension d to multidimensional poverty can be expressed as:

$$Contribd = \frac{\frac{\sum_j \sum_1^q cij}{n}}{MPI}$$

Where: d is health, education or standard of living.

Example using hypothetical data

A hypothetical example of people living in 4 households can help explaining how the MPI is constructed[40].

Indicator	Indicator weight	Household 1	Household 2	Household 3	Household 4
Household size		4	7	5	4
Health					
At least one member is undernourished	(⅓) ÷ 2 = 16.7%	0	0	1	0
One or more children have died	(⅓) ÷ 2 = 16.7%	1	1	0	1
Education					
No one has completed six years of schooling	(⅓) ÷ 2 = 16.7%	0	1	0	1
At least one school-age child not attending school	(⅓) ÷ 2 = 16.7%	0	1	0	0
Living conditions					
No electricity	(⅓) ÷ 6 = 5.6%	0	1	1	1
No access to improved sanitation	(⅓) ÷ 6 = 5.6%	0	0	1	0
No access to an improved source of drinking water	(⅓) ÷ 6 = 5.6%	0	1	1	0
House built with inadequate materials	(⅓) ÷ 6 = 5.6%	0	0	0	0
Household cooks with dung, wood, charcoal or coal	(⅓) ÷ 6 = 5.6%	1	1	1	1
Household does not own a car or truck and does not own more than one of the following assets: radio, television, telephone, computer, animal cart, bicycle, motorbike or refrigerator.	(⅓) ÷ 6 = 5.6%	0	1	0	1
Results					
Individual deprivation score, *c* (sum of each deprivation multiplied by its weight) for each household member		22.2%	72.2%	38.9%	50.0%
Is the household multidimensionally poor ($c \geq 1/3$)?		No	Yes	Yes	Yes

Note: 1 indicates deprivation in the indicator; 0 indicates nondeprivation.

Weighted deprivations:

Household 1: (1*16.67) + (1*5.56) = 22 percent
Household 2: 72.2 percent
Household 3: 38.9 percent
Household 4: 50.0 percent

[40] UNDP, 2018, *Human Development Indices and Indicators: 2018 Statistical Update*

Based on this hypothetical population of four households:

Headcount ratio (H) = (0 + 7 + 5 + 4) / (4 + 7 +5 +4) = 0.80

i.e. 80 percent of people are multidimensionally poor.

Intensity of poverty (A) = (72.2*7 + 38.9*5 + 50.0*4) / (7 + 5 + 4) = 56.3 percent

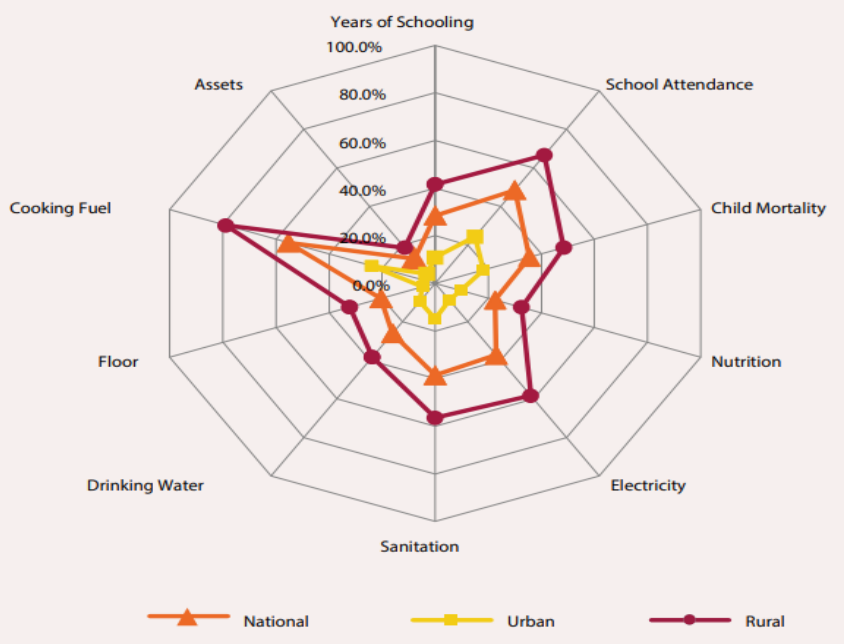
i.e. the average multidimensionally poor person is deprived in 56.3 percent of the weighted indicators.

MPI = H * A = 0.8 * 0.563 = 0.450

Contribution of deprivations in:

Health: Contrib1 = (16.67*5 + 16.67 * (7+4)) / ((4 + 7 + 5 + 4)*0.450) = 29.6 percent
Education: Contrib2 = (16.67*(7+4) + 16.67*7) / ((4 + 7 + 5 + 4)*0.450) = 33.3 percent
Living conditions: Contrib3 = (55.6*(7*4 + 5*4 + 4*3)) / ((4 + 7 + 5 + 4)*0.450) = 37.1 percent
Calculating the contribution of each dimension to multidimensional poverty provides information that can be useful for revealing a country's deprivation structure and can help with policy targeting.

Figure B. Percentage of the population who are MPI poor and deprived by rural/urban areas, Senegal 2015



Results for Senegal also show that the indicator that contributes the most to the MPI is school attendance with a percentage contribution of 24.5 percent. The second highest contribution is child mortality with a contribution of 17.9 percent. The indicator with the lowest contribution is the asset index with a 2 percent contribution (figure C).

Source: UNDP and OPHI (2019). How to Build a National Multidimensional Poverty Index (MPI): Using the MPI to Inform the SDGs.

B. The Unmet Basic Needs (UBN)

This approach uses standard indicators of the household's socioeconomic level that do not yield precise income estimates, but only broad classifications of the household's situation. Typically this approach uses six variables which are calculated at household level. Components of the UBN Index are the following:

1. Crowding: number of persons per bedroom;
   This variable can be easily calculated by number of persons divided to the number of bedrooms.
2. Quality of the dwelling: earthen floor or use of sub-standard materials for the walls or roof;
3. Sanitation: Absence of an indoor toilet or piped water inside the home;
4. Educational attendance: number of school-age children not attending school;
5. High dependency: number of persons per working household member;
6. Education: level of education of the household head.

For each of these components, critical limits are defined (e.g. more than three persons per bedroom for 'Crowding', or less than two years of formal education for 'Education of the household head'). This defines the number of Unmet Basic Needs. Finally, all households that have more than one, two, or three (i.e. depending on the country) Unmet Basic Needs are considered to be poor.

C. Wealth Index A similar methodology that has been developed in the context of the DHS,[41] but that is potentially applicable to PHC data as well, is the computation of wealth quintiles based on the characteristics of households. The variables normally included in this analysis are the source of drinking water, type of toilet, sharing of toilet facilities, material of principal floor, walls, roof, cooking fuel, household services and possessions, such as electricity, TV, radio, watch, types of vehicles, agricultural land size owned, type and number of animals owned, bank account, types of windows. The items vary somewhat between surveys as well as the categories of the core questionnaire items. Since the wealth index is an indicator of the household's economic status, type of area, level of education, occupation (other than domestic servants), are not included since they are determinants of health status in their own right and are used along with the wealth index. The available data are subjected to a factor analysis which is normally conducted separately for urban and rural areas. The main factor score of this analysis is then divided into quintiles.

d. Challenges in measuring in PHC

Other than the fact that some dimensions of non-monetary poverty (e.g. nutrition) may not be readily measurable through the PHC, the PHC seems to be ideally suited for the purpose, particularly if the objective is to measure poverty at the level of small geographical levels.

e. Data disaggregation

The minimum required disaggregation is by age and sex. The UN Expert Group Meeting on Migration Data (March 2018) also considered this indicator migration-relevant and recommended its disaggregation by migrant and non-migrant households. A possible bias in the case of migrant households is that recently arrived migrants may have fewer material assets than those that have lived longer in their current place of residence and hence have had more time to accumulate assets. Such differences may not correspond to current differences in welfare.

Regardless of whether the data are obtained from surveys or from censuses, individual disaggregations have to be treated with great caution. Like monetary poverty, non-monetary poverty is computed at the household level. It does not contemplate intra-household differences in individual welfare.

[41] See, for instance, Shea O. Rutstein (2008). *The DHS Wealth Index: Approaches for Rural and Urban Areas*. Calverton, Maryland, USA: Macro International.

Therefore, disaggregations by individual characteristics should be interpreted in terms of the probability of belonging to a poor household, not as individual welfare indicators. In this regard, disaggregations by urban/rural residence and by detailed geographical areas may be more valid than disaggregations by individual characteristics.

4.3.1 Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex

a. Concept and definition

The percentage of youth and adults in a given age range (e.g. 15-24 years, 25-64 years, etc.) participating in formal or non-formal education or training in a given time period (e.g. last 12 months). Formal education and training is defined as education provided by the system of schools, colleges, universities and other formal educational institutions that normally constitutes a continuous ‘ladder’ of full-time education for children and young people, generally beginning at the age of 5 to 7 and continuing to up to 20 or 25 years old. In some countries, the upper parts of this ‘ladder’ are organised programmes of joint part-time employment and part-time participation in the regular school and university system. Non-formal education and training is defined as any organised and sustained learning activities that do not correspond exactly to the above definition of formal education. Non-formal education may therefore take place both within and outside educational institutions and cater to people of all ages. Depending on national contexts, it may cover educational programmes to impart adult literacy, life-skills, work-skills, and general culture.

Formal and non-formal education and training can be offered in a variety of settings including schools and universities, workplace environments and others and can have a variety of durations. Administrative data often capture only provision in formal settings such as schools and universities. Participation rates do not capture the intensity or quality of the provision nor the outcomes of the education and training on offer.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The main data source for this indicator are administrative records from schools and other places of education and training. Household survey data on participants in formal and non-formal education and training by single year of age is also another source of data. Census data and projections can be used to obtain population data by age and sex and thereby convert the enrolment data in rates. The PHC can also provide data on people who are attending education and training, but the PHC may not adequately cover non-formal and adult education.

Although school attendance is a core census topic, the coverage of formal and informal education in the PHC tends to be incomplete. The P&R (4.265) define school attendance as as regular attendance at any *regular accredited educational institution or programme*, public or private, for organised learning at any level of education at the time of the census or, if the census is taken during the vacation period, at the end of the school year or during the previous school year. According to the International Standard Classification of Education (ISCED), education is taken to comprise all institutionalized, intentional and planned activities designed to meet learning needs. However, instruction in particular skills that is not part of the recognized educational structure of the country (for example, in-service training courses in factories) is not normally considered “school attendance” for census purposes.

According to paragraph 4.266 of the P&R, information on school attendance should, in principle, be collected for persons of all ages. It relates in particular to the population of official school age, which ranges in general from 5 to 29 years of age but can vary from country to country depending on the national education structure. In the case where data collection is extended to cover attendance in preprimary education or other systematic educational and training programmes organised for adults in productive and service enterprises (such as the in-service training courses mentioned in paragraph 4.265), community-based organizations and other non-educational institutions, the age range may be adjusted as appropriate.

Paragraph 4.269 of the P&R alerts that there is a difference between "attending school" and "enrolled in school", thus results from censuses and administrative data may differ. A child can be enrolled in school but not necessarily be attending. It is recommended that these concepts be clearly defined so that countries can determine which variable they wish to collect via the census.

c. Method of computation

The PHC provides data for calculation of participation rate of youth in formal education and training. It is the number of people in age group15-24 participating in formal education or training expressed as a percentage of the population of the same age.

d. Challenges in measuring in PHC

PHCs cover education in regular accredited educational institutions or programmes, but may under-state non-formal education in particular skills that are not taught as part of the recognized educational structure of the country. PHCs may also not cover adult education programmes. Finally, the PHC measures school attendance, rather than school enrollment, which may result in differences with administrative data which are usually based on school enrollment.

e. Data disaggregation

Minimum Required Disaggregation Dimension: 1. Sex; 2. Age; 3. Regions and Urban/Rural area of residence and 4.Small population groups and geographic areas. Future disaggregations may contemplate income. This cannot be measured by administrative data and is generally not available in the PHC, although non-monetary equivalents can be defined in terms of criteria such as UBN, MPI or wealth quintiles.

4.c.1 Proportion of teachers in: (a) pre-primary; (b) primary; (c) lower secondary; and (d) upper secondary education who have received at least the minimum training

a. Concept and definition

The percentage of teachers by level of education taught (pre-primary, primary, lower secondary and upper secondary education) who have received at least the minimum organised pedagogical teacher training pre-service and in-service required for teaching at the relevant level in a given country.

Teachers play a key role in ensuring the quality of education provided. Ideally all teachers should receive adequate, appropriate and relevant pedagogical training to teach at the chosen level of education and be academically well-qualified in the subject(s) they are expected to teach. This indicator measures the share of the teaching work force which is pedagogically well-trained. A high value indicates that students are being taught by teachers who are pedagogically well-trained to teach.

National minimum training requirements can vary widely from one country to the next. This variability between countries lessens the usefulness of global tracking because the indicator would only show the percent reaching national standards, not whether teachers in different countries have similar levels of training. Further work would be required if a common standard for teacher training is to be applied across countries.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The primary data sources for this indicator are administrative data from schools and other organised learning centres. In principle, Ministries of Education should maintain data bases on their teaching personnel although such bases may be incomplete in the case of private sector educational institutions. At the global level, the UIS (UNESCO Institute of Statistics) produces time series based on teachers' data reported by Ministries of Education or National Statistical Offices.

To some extent, the information can also be collected through PHCs and household surveys. The question in this case is whether teachers are classified by level of education at which they teach and whether the highest educational level distinguished is sufficiently detailed to identify the minimum required qualifications of teachers. One of the advantages of using information of surveys or censuses is that these data are less affected by certain biases that tend to occur in administrative data, such as the tendency to under-count private teaching institutions.

The ISCO-08 distinguishes teachers at the following levels:

- 23 Teaching Professionals
  - 231 University and Higher Education Teachers
  - 232 Vocational Education Teachers
  - 233 Secondary Education Teachers
  - 234 Primary School and Early Childhood Teachers
    - 2341 Primary School Teachers
    - 2342 Early Childhood Educators
  - 235 Other Teaching Professionals
    - 2351 Education Methods Specialists
    - 2352 Special Needs Teachers
    - 2353 Other Language Teachers
    - 2354 Other Music Teachers
    - 2355 Other Arts Teachers
    - 2356 Information Technology Trainers
    - 2359 Teaching Professionals not Elsewhere Classified

This covers the first half of the information needed, i.e. to establish whether a person is a teacher and if so, at what level. The other thing that needs to be verified is if this teacher has received the appropriate training. This may be partially possible through census data, provided that the census categories on highest level of education attained and field of education and training are sufficiently detailed, it is possible to ascertain if the teacher has the academic credentials to be teaching at his/her level.

According to paragraphs 4.281-4.288 of the P&R, PHC can collect data on field of education and training and educational qualifications. The ISCED Fields of Education and Training 2013 (ISCED-F 2013) classifies the field of education and training by detailed fields with a separate category of "Education". Education category includes education science, training of pre-school teachers, teacher training without subjectspecialisation, teacher training with subject specialisation and inter-disciplinary programmes and qualifications involving education.

c. Method of computation

Number of teachers in pre-primary, primary and secondary educations are widely available from census data using the following ISCO-08 codes:

2342 Early Childhood Educators;
2341 Primary School Teachers
232 Vocational Education Teachers
233 Secondary Education Teachers

For information on teachers who received adequate, appropriate and relevant pedagogical training in the census, teachers who have the highest completed level of education, for example, at least university degree (ISCED-2011 level 6 and over) in the field of education can be used to produce a proxy estimate for this indicator.

The indicator is calculated as the total number of teachers in a given level of education who are trained is expressed as a percentage of all teachers in that level of education.

This indicator is calculated by each level of education (pre-primary, primary, lower secondary and upper secondary education).

d. Challenges in measuring in PHC

Although the ISCO-08 and the ISCED-2011 and ISCED-F 2013 contemplate all the relevant categories, they may not be reflected accurately in the actual coding of the census data. In the case of the field of education, the question might be pre-coded and may not contain the relevant categories for teacher training. Moreover, the required teacher training may have other components, besides simply having the required level of education. For example, in order to be a secondary school teacher, national legislation may require not only having a university degree in the relevant field, but also having spent some time as a trainee under the supervision of an experienced teacher. These components of the teaching requirements may not be captured by the PHC unless specific questions are included to this end.

e. Data disaggregation

The disaggregations foreseen thus far are the ones by sex, level of education and type of institution (public/private). Census data allow finer disaggregations, such as those by major geographic area and urban and rural area. It is not recommended to disaggregate the indicator by very small geographic levels because the census counts teachers where they live, not in terms of the areas they serve. Even the disaggregation by urban/rural areas may be biased in this respect as many teachers serving rural areas may reside in towns. However, if the PHC collects data on place of work, this indicator can be disaggregated more meaningful by small geographic areas and urban and rural.

5.b.1 Proportion of individuals who own a mobile telephone, by sex

a) Concept and definition

The definition of the proportion of individuals who own a mobile telephone, by sex, is self-explanatory. An individual owns a mobile cellular phone if he/she has a mobile cellular phone device with at least one active SIM card for personal use.

Mobile cellular phones supplied by employers that can be used for personal reasons (to make personal calls, access the Internet, etc.) are included. Individuals who have a mobile phone for personal use that is not registered under his/her name are also included. Individuals who have only active SIM card(s) and not a mobile phone device are excluded.

An active SIM card is a SIM card that has been used in the last three months. A mobile (cellular) telephone refers to a portable telephone subscribing to a public mobile telephone service using cellular technology, which provides access to the Public Switched Telephone Network (PSTN). This includes analogue and digital cellular systems and technologies. Users of both postpaid subscriptions and prepaid accounts are included.

Mobile phone networks have spread rapidly over the last decade and the number of mobile-cellular subscriptions is quasi equal to the number of the people living on earth. However, not every person uses, or owns a mobile-cellular telephone. Mobile phone ownership, in particular, is important to track gender equality since the mobile phone is a personal device that, if owned and not just shared, provides women with a degree of independence and autonomy, including for professional purposes. A number of studies have highlighted the link between mobile phone ownership and empowerment, and productivity growth. Existing data on the proportion of women owning a mobile phone suggest that less women than men own a mobile phone.

b) Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The primary source of data on the number of cell phone users is from cell phone vendors and internet providers which are reported to the International Telecommunications Union (ITU). However, these data have many limitations, particularly the fact that they cannot be easily disaggregated as the providers collect only a very limited set of data on users that are mainly commercial in nature.

Ownership of a cellular phone is also increasingly asked in many household surveys and in censuses. However, the information is often collected only at the household level and not at the individual level. Also, the criterion of ownership used in the census is less strict than the definition used in a).

As was mentioned before, the P&R (4.564) recommend the following questions on access to telecommunication devices in the census:

1. Household having a radio
2. Household having a television set
3. Household having a fixed-line telephone
4. **Household having one or more mobile cellular telephones**
5. Household having a personal computer
6. Household accessing the Internet from home
    6.1. Landline connection
    6.2. Mobile connection
7. Household accessing the Internet from elsewhere other than home
8. Household without any access to the Internet

In the 2010 census round, questions on the ownership of cellular telephones were not very common: as with internet access, only about two dozen countries asked about it, although this number will likely increase in the 2020 census round.

This includes cellular phones as a core subject to be inquired about at the household level. Some PHCs (e.g. the census of Mozambique in 2017) also ask for individual ownership of cellular phones, but this is less common. In the Latin American region, in the 2010 census round only four countries asked for the information at the individual level, but this number is expected to be expanded in the 2020 round.

c) Method of computation

If the PHC collects data on the ownership of cellular phones, the indicator is calculated simply by dividing the total number of persons who own a mobile phone by the total population.

In the case of asking only for cellular phone ownership at the household level, it may be possible, through statistical analysis, to establish the probability that an individual of a given age, sex, and relationship to the head of household in a household that owns one or more cellular phones, is the individual owner of such a device.

As a proxy estimate, proportion of people living in households having a mobile phone can be calculated from census data, particularly for enhancing understanding regarding the disaggregation to specific population groups and geographic areas.

d) Challenges in measuring in PHC

As was mentioned above, the main limitation of the PHC is that relatively few censuses thus far ask the question on individual ownership of a cellular phone. The more common question is asked at the household level.

The other potential problem is that ownership of a cellular phone in the census is usually not very well defined. The conditions and distinctions made in section a) are usually not part of the wording of the census question or even the instructions of the enumerator.

e) Data disaggregation

For countries that collect this indicator through a census, and if data allow breakdown and disaggregation, the indicator can be broken down not only by sex but also by region (geographic and/or urban/rural), by age group, by educational level, by labour force status, and by occupation. As is usually the case, these categories can be broken down to more precise levels in the census than is possible in surveys. Thus it may be possible to map cellular phone ownership by census enumeration area or for small ethnic groups that could not be mapped by any other means.

8.3.1. Proportion of informal employment in non-agricultural employment, by sex

a. Concept and definition

This indicator presents the share of non-agricultural employment which is classified as informal. Informal employment comprises persons who in their main or secondary jobs were in one of the following categories:

- Own-account workers, employers and members of producers' cooperatives employed in their own informal sector enterprises (the characteristics of the enterprise determine the informal nature of their jobs);
- Own-account workers engaged in the production of goods exclusively for own final use by their household (e.g. subsistence farming);

Contributing family workers, regardless of whether they work in formal or informal sector enterprises (they usually do not have explicit, written contracts of employment, and are not subject to labour legislation, social security regulations, collective agreements, etc., which determines the informal nature of their jobs);

Employees holding informal jobs, whether employed by formal sector enterprises, informal sector enterprises, or as paid domestic workers by households (employees are considered to have informal jobs if their employment relationship is, in law or in practice, not subject to national labour legislation, income taxation, social protection or entitlement to certain employment benefits).

An enterprise belongs to the informal sector if it fulfils the three following conditions:

It is an unincorporated enterprise (it is not constituted as a legal entity separate from its owners, and it is owned and controlled by one or more members of one or more households, and it is not a quasi-corporation: it does not have a complete set of accounts, including balance sheets);

It is a market enterprise (it sells at least some of the goods or services it produces);

The enterprise is not registered or the employees of the enterprise are not registered or the number of persons engaged on a continuous basis is below a threshold determined by the country.

The considerable heterogeneity of definitions and operational criteria used by countries to measure informal employment greatly hinders the international comparability of statistics on informality. Also, the scope of this indicator is limited to non-agriculture. However, to have a comprehensive picture of the importance of informality in the economy and to better understand its patterns, statistics on informal employment should be produced and analysed for both agricultural and non-agricultural activities.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The preferred source of data for this indicator is a labour force survey, with sufficient questions to determine the informal nature of jobs and whether the establishment where the person works in belongs to the formal or the informal sector. The PHC contains some of the information needed in order to characterize informality, particularly the percentages of economically active persons in informal status in their employment, such as contributing family workers.

With respect to the issue of status in employment, a core census topic, the P&R introduce the relevant concepts in paragraphs 4.339-4.351. Specifically, paragraph 4.340 recommends that the main job of employed persons be classified by status in employment in accordance with the latest standards for statistics on this topic, which at the time was International Classification of Status in Employment (ICSE-93) adopted by the Fifteenth International Conference of Labour Statisticians in 1993. Based on ICSE-93, jobs may be classified by status in employment as follows:

(*a*) Employees;
(*b*) Self-employed:
  i. Employers;
  ii. Own-account workers;
  iii. Members of producers' cooperatives;
  iv. Contributing family workers;
(*c*) Persons not classifiable by status.

This allows part of the characterization of workers as formal or informal. What the PHC does not allow is the characterization of the enterprises where these workers exercise their activities as either formal or informal.

c. Method of computation

As such, the method of computation is a simple division of the number of workers with informal employment in non-agricultural activities by the total employment in non-agricultural employment.

Method of computation:
Informal employment in non agricultural activities/ Total employment in non agricultural activities × 100

The difficulty resides in the characterization of informal employment. This is a relatively new census topic and national census practices have not yet been adapted to capture it adequately. In a PHC, the main table required is one that cross-classifies 'kind of economic activity' (agriculture, mining, manufacturing, trade, services, etc., by ISIC) by 'status in employment' (employers, own-account workers, contributing family workers, employees, etc.) and possibly by sex and/or by urban and rural area. But not all workers in categories such as employees or own-account workers are part of the formal sector. This depends on the characteristics of the enterprises where they work.

UNSD Handbook on Measuring the Economically Active in Population Censuses recommends a set of questions (see paragraphs 411-432) in order to capture informality. However there is little experience with collecting data on the informal sector in censuses and no experience in collecting data on informal employment.

In the absence of such questions, certain assumptions have to be made. The following criteria provide some guidance in this respect:

All unpaid family workers are to be considered in informal employment.

All workers employed in the government or parastatal sector are to be considered in formal employment.

Certain highly regulated occupational groups such as doctors, lawyers, architects (including own-account workers), bank employees and employees classified as teachers (including university teachers) are to be considered as part of the formal sector.

If the census asks a question about contributions to the social security system, all those who contribute are to be considered formally employed.

If the census asks a question about the size of the enterprise where the respondent works, all employees of enterprises beyond a certain size (generally 5 or 10 employees) are to be considered as part of the formal sector.

All household employees (maids, gardeners, nannies, etc.) who do not satisfy criterion 4) are to be considered in informal employment.

Unfortunately, these criteria do not cover all the possible situations. Own-account workers in commerce or services are likely to be part of the informal sector, but without additional questions it is not possible to be sure. Even category 6) is not certain as some governments are making efforts to formalize household employment.

An alternative technique suggested by ILO to separate these categories is the residual balance technique.[42] This technique compares labour force statistics produced through a PHC, a labour force survey or another household survey covering employment with statistics on 'formal' employment from establishment censuses or surveys, social insurance registrations or fiscal records. The first type of source, also referred to as the 'exhaustive' source, is assumed to capture all forms of employment (formal and informal) from which statistics based on the second type of source, providing statistics on

[42] ILO (2013). *Measuring informality: A statistical manual on the informal sector and informal employment.* Geneva, ILO.

'registered' or 'formal' employment, can be subtracted. The estimates from the population census or labour force survey are always larger than those from the economic census, establishment survey or administrative records. The difference between both sources is an estimate of the size of the informal sector.

The disadvantages of this approach are the following:

- It requires an establishment census or similar data source, in addition to the PHC;
- Establishment censuses tend to produce statistics on jobs, not on persons employed as workers may have multiple jobs;
- Establishment censuses may omit small establishments and own-account workers that do satisfy the requirements of formal sector activity.

d. Challenges in measuring in PHC

As was explained above, the main limitation of the PHC for assessing informality is that it does not provide information on the characteristics of the enterprises where workers are employed. In some countries, such as Brazil, the census does ask whether the employee has a formal labour registration card with the Ministry of Labour, which guarantees the payment of employee benefits, but such additional census questions are not common.

e. Data disaggregation

Data on this indicator is requested disaggregated by sex. In order to produce this indicator, employment statistics disaggregated by formal / informal employment and by economic activity (agriculture / industry / services) are needed. All of these disaggregations are relatively easy to provide based on census data.

8.7.1 Proportion and number of children aged 5-17 years engaged in child labour, by sex and age

a) Concept and definition

The proportion of children engaged in child labour is determined by the percentage of children aged 5 to 17 reported to be in child labour during the reference period (usually the week prior to the survey). In accordance with the ICLS resolutions, child labour can be measured on the basis of the production boundary set by the United Nations System of National Accounts (SNA) or on the basis of the general production boundary. The former limits the frame of reference to economic activity, while the latter extends it to include both economic activity and unpaid household services, that is, the production of domestic and personal services by a household member for consumption within their own household, commonly called "household chores".

According to the latest ILO global estimates, about 152 million children worldwide – 64 million girls and 88 million boys - are child labourers, accounting for almost 10 percent of the child population. These stark figures underscore the need for accelerated progress against child labour in the lead up to the 2025 target date for ending child labour in all its forms, and the accompanying need for child labour statistics to monitor and guide efforts in this regard. Reliable, comprehensive and timely data on the nature and extent of child labour provide a basis for determining priorities for national global action against child labour. Statistical information on child labour, and more broadly on all working children, also provide a basis for increasing public awareness of the situation of working children and for the development of appropriate regulatory frameworks and policies.

More specifically, two indicators are used for measuring child labour for the purpose of SDG reporting, the first based on the production boundary set by the UN System of National Accounts (SNA) and the second based on the general production boundary.

- *Indicator 1:* Proportion and number of children aged 5-17 years engaged in economic activities at or above age-specific hourly thresholds (SNA production boundary basis)
  - Child labour for the 5-11 age range: children working at least 1 hour per week in economic activity;
  - Child labour for the 12-14 age range: children working for at least 14 hours per week in economic activity;
  - Child labour for the 15-17 age range: children working for more than 43 hours per week in economic activity.
- *Indicator 2:* Proportion and number of children aged 5-17 years engaged in economic activities and household chores at or above age-specific hourly thresholds (general production boundary basis):
  - Child labour for the 5-11 age range: children working at least 1 hour per week in economic activity and/or involved in unpaid household services for more than 21 hours per week;
  - Child labour for the 12-14 age range: children working for at least 14 hours per week in economic activity and/or involved in unpaid household services for more than 21 hours per week;
  - Child labour for the 15-17 age range: children working for more than 43 hours per week in economic activity.

The concept of child labour also includes the worst forms of child labour other than hazardous (18th ICLS paragraphs 33 to 34) as well as hazardous work (18th ICLS paragraphs 21 to 32). The worst forms of child labour include all forms of slavery or similar practices such as trafficking and the recruitment and use of child soldiers, the use or procurement of children for prostitution or other illicit activities, and other work that is likely to harm children's health, safety or well-being.

b) Possible data sources, particularly PHC , and their relative advantages/ disadvantages

Household surveys such as national labour force surveys, national multipurpose household surveys, MICS, DHS, the ILO-supported Statistical Information and Monitoring Programme on Child Labour (SIMPOC), and World Bank Living Standard Measurement surveys (LSMS) are among the most important instruments for generating information on child labour in developing countries.

Estimates of child labour generated by these survey instruments are increasingly relied on by countries to monitor progress towards national and global child labour elimination targets. Many countries also produce national labour estimates and reports that often include data on child labour and/or employment among children.

Basic information on employment is available in almost all censuses and can be cross-tabulated to some extent by age, but there are several limitations in this regard. The main limitations are that:

The definition as given above requires the quantification of the time worked. This information is collected in some censuses (P&R 4.369-4.375), but it is not a core topic.

Unpaid household services are generally not quantified in censuses.

The lower limit on the recording of economic activities in the census is generally in the range of 10 to 15 years. A review of census questionnaires of 124 countries for the 2010 census round carried out by UNSD established that this was the case for 88 of them. Only 15 PHCs had a lower limit of 5 or 6 years.

c) Method of computation

The proportion of children aged 5-17 years engaged in labour force is calculated as the number of children aged 5-17 reported in child labour during the week prior to the census divided by the total number of children aged 5-17 in the population, multiplied by 100.

This indicator can be calculated for age categories of 5-11, 12-14 and 15-17 separately.

d) Challenges in measuring in PHC

The main challenge in measuring this indicator is that is not totally available in PHC data, as these lack information on household work, may cut off information on economic activity below age 10 or 15, and may not ask about the number of hours worked per week. A review of census questionnaires of 124 countries for the 2010 census round carried out by UNSD identified only 42 that asked for the number of hours worked, more than half of them in North America or Oceania.

e) Data disaggregation

This indicator can be disaggregated by: 1. Sex; 2. Age (especially 5-14 and 15-17). Further disaggregations can be made by area of residence (urban/rural) and detailed geographical area, by sector of activity of the head of household and other household characteristics which may shed light on the type of households that depend on child labour.

10.2.1 Proportion of people living below 50 per cent of median income, by sex, age and persons with disabilities

a. Concept and definition

The proportion of people living below 50% of median income (or consumption) is the share (%) of a country's population living on less than half of the consumption/income level of the median of the national income/consumption distribution. Per capita income or consumption is estimated using total household income or consumption divided by the total household size. Estimating the share of people living below 50% of the national median is less sensitive to comparability limitations than estimates of international poverty. The relative nature of the threshold (a function of the distribution median) means that it is not sensitive price differences across time and countries.

This measure is an indicator of relative poverty and inequality of the income distribution within a country. This indicator and similar relative measures are commonly used for poverty measurement in rich countries (including Organization for Economic Cooperation and Development's (OECD) poverty indicators and Eurostat's indicators of risk of poverty or social exclusion) and are increasingly also used as a complementary measure of inequality and poverty in low- and middle- income countries. In order to guarantee consistency, the estimation relies on the same harmonized welfare vectors (distributions) that are used for indicator 1.1.1 (see Tier 1 indicators).

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

Like for poverty rates (SDG 1.1.1), estimates are usually based on income or consumption data collected in household surveys, led by NSOs.

Data is collected with great heterogeneity and ex-post harmonization will always face limitations. Similar surveys may not be strictly comparable because of differences in timing, sampling frames, or the quality and training of enumerators. Comparisons of countries at different levels of development also pose problems because of differences in the relative importance of the consumption of nonmarket goods. The local market value of all consumption in kind (including own production, particularly important in underdeveloped rural economies) should be included in total consumption expenditure, but in practice are often not. Most survey data now include valuations for consumption or income from own production, but valuation methods vary. Appropriately adjusting for price differences is a major challenger in absolute poverty measurement.

Income data can also be collected through PHCs, but relatively few countries do because it is generally not possible to include all the probing questions that need to be included in order to capture all types of income, particular non-wage income. On the other hand, the PHC does have the advantage of covering the entire population, thereby eliminating the sample variations and biases that may affect income surveys.

As was indicated under indicator 1.1.1, PHCs do not collect data on household consumption and relatively few collect data on personal or household income. A review of census questionnaires of 124 countries for the 2010 census round carried out by UNSD identified only 16 that asked for individual income and 5 that asked for household income (among which Brazil, 2010; Hong Kong, 2011; Israel, 2008; Kazakhstan, 2009; South Africa, 2011; several countries in the Caribbean and Pacific regions, but none in Europe and almost none in Africa).

According to the P&R (4.383 and 4.385), income may be defined as all receipts whether monetary or in kind (goods and services) that are received by the household or by individual members of the household at anual or more frequent intervals, but excluding windfall gains and other such irregular and typically one-time receipts. Household income covers (*a*) income from employment (both paid and self-employment); (*b*) income from the production of goods for own final use; (*c*) income from the provision of household services for own final use; (*d*) property income; and (*e*) current transfers received. **T**he income from employment of employed persons should include wages and salaries of employees, income of members from producers' cooperatives and the mixed income of employers and own-account workers operating business and unincorporated enterprises. In addition to the income from employment of employed household members, the total income of the household should include, for example, the interest, dividends, rent, social security benefits, pensions and life insurance annuity benefits of all its members. The Handbook on household income statistics provides further guidance on concepts and methods related to this topic. *Canberra Group Handbook on Household Income Statistics*, 2nd ed. (2011), available at www.unece.org/fileadmin/DAM/stats/groups/cgh/Canbera_Handbook_2011_WEB.pdf.

c. Method of computation

If a PHC asks questions for income, the indicator can be measured using the national distribution per capita measure of income, as derived from the census. The indicator is calculated by estimating the share (in percent) of the population living on less than 50% of median of the national distribution of income. The median is estimate from the same distribution as the indicator is estimated from, thus the 50% of median threshold will vary over time. Per capita income is estimated using total household income divided by the total household size.

In the absence of direct monetary income data, approximate measures can be constructed by integrating the micro-data of the census with the data of a standard consumption or income survey in order to derive proxy estimates that allow data disaggregation to levels that go beyond the possibilities of these surveys. The methodology was already described under indicator 1.1.1. There are two main strategies: construction of proxy variables and statistical matching. This consists in developing a regression model or other multivariate model based on the survey data and using explanatory variables that are common to the survey and the census, to predict the value of the variable that one would like to include in the census data base. The census value of the variable is then constructed by using the same equation on the explanatory variables, as found in the census. Typically, this approach has been used for the construction of household income data for censuses that do not have this information, by regressing household characteristics such as ownership of consumer durables or the quality of construction of the home on income data from a Living Standards Measurement Survey or other kind of household survey that provides income data.[43] The primary objective, in this case, is to construct poverty estimates for smaller geographic areas than is feasible with the income survey itself.

d. Challenges in measuring in PHC

As stated in paragraph 4.384 of the P&R, the collection of reliable data on income, especially income from self-employment and property income, is extremely difficult in general field enquiries, particularly population censuses. The inclusion of non-cash income further compounds the difficulties. Collection of household income data in a census, even when confined to cash income, presents special problems in terms of burden of work, response errors, and so forth. Therefore, this topic is generally considered more suitable in a sample survey of households or from administrative data sources such as tax or social security records.

Paragraph 4.386 of the P&R adds that the concepts involved in determining income are not simple to grasp and respondents may be unable or unwilling to provide exact information. For example, income should include social security benefits, pension fund contributions and direct taxes withheld from employees' salaries, but some persons will undoubtedly not include these amounts in reporting their salaries. Significant items of total household income may also be excluded or misstated. Despite instructions given to enumerators, the data collected can therefore only be expected to be approximate. Accordingly, in the presentation of results it is usually appropriate to use broad income or earnings size classes.

While model based income estimates do provide a solution for the lack of income data in most censuses, they do so only imperfectly. In particular, the variables on which these estimates are based tend to change only slowly and may not reflect the current income level of the household.

e. Data disaggregation

At present, the minimum required disaggregation dimensions include: 1. Sex; 2. Age; 3. Disability Status; 4. Ethnocultural characteristics; and 5.Migration status;

3.7 Indicators for which the PHC provides ancillary information (Group 2.IV)

1.3.1 Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons, persons with

[43] See, for instance, Elbers, C., J. O. Lanjouw and P. Lanjouw (2002). *Micro-Level Estimation of Welfare*. Washington DC, Development Research Group, World Bank.

disabilities, pregnant women, newborns, work-injury victims and the poor and the vulnerable

a. Concept and definition

This indicator reflects the proportion of persons effectively covered by a social protection system, including social protection floors. It also reflects the main components of social protection: child and maternity benefits, support for persons without a job, persons with disabilities, victims of work injuries and older persons. Effective coverage of social protection is measured by the number of people who are either actively contributing to a social insurance scheme or receiving benefits (contributory or non-contributory). Social protection systems include contributory and non-contributory schemes for children, pregnant women with newborns, people in active age, older persons, for victims of work injuries and persons with disabilities. Social protection floors provide at least a basic level in all main contingencies along the life cycle, as defined in the Social Protection Floors Recommendation 2012 (no. 202) referred to in SDG 1.3.

When assessing coverage and gaps in coverage, distinctions need to be made between coverage by (1) contributory social insurance, (2) universal schemes covering all residents (or all residents in a given category), and (3) means-tested schemes potentially covering all those who pass the required test of income and/or assets. Measurements of *effective coverage* should reflect how in reality legal provisions are implemented. It refers to the percentage of people actually receiving benefits of contributory and non-contributory social protection programmes, plus the number of persons actively contributing to social insurance schemes.

b. Possible data sources, particularly PHC , and their relative advantages/ disadvantages

The main data source are administrative data from national ministries of labour, social security, welfare, finance, and others which are periodically reported to ILO and published in the the *Social Security Inquiry*. Secondary data sources include existing global databases of social protection statistics, including those of the World Bank, UNICEF, UNWOMEN, HELPAGE, OECD and the International Social Security Association.

At present, PHCs are an important data source for estimating the population of potential beneficiaries, but much less so for estimating actual recipients of benefits. Some countries, such as Brazil, ask a question on whether a person contributes to the national social security system. Some countries in the Caribbean and Pacific and a few others ask whether the person receives any social security benefits and in some cases how much. The Israeli census of 2008 asked about income from pension or benevolent funds and also about income received from German reparations pensions.

Some countries also assess the coverage of social security benefits for certain groups such as the aged through surveys, such as the Current Population Survey in the United States. The World Bank regularly reviews this information from surveys and enters it into the data base for its Atlas of Social Protection - Indicators of Resilience and Equity (ASPIRE).

The components of the indicator are formulated as proportions. The availability of relevant data in the PHC is different for the numerator and the denominator of these proportions. Although not all the relevant denominators can be estimated based on census data (see section c), most of them can. This makes the PHC an important data source for the estimation of this indicator.

With respect to the numerators, the current availability of information in PHCs is much more limited. As was mentioned above, some countries do include data on social security in their PHCs, but not in a comprehensive way. The P&R (4.385) only alerts to the need to include interest, dividends, rent, social security benefits, pensions and life insurance annuity benefits of all its members in the income data, but do not make any recommendations regarding the disaggregation of these separate categories.

However, the PHC holds great potential for assessing not only the denominators, but also at least some of the numerators for indicator 1.3.1. Some PHCs, such as the 2011 census of Bulgaria, already contain a question on the different kinds of sources of income that respondents have. These are not mutually exclusive and coded as a sequence of binary choices (yes/no). By making sure that all or at least some the relevant types of social security benefits (see below) are included as options, it becomes possible to determine the proportions of potential beneficiaries for each specific benefit and also the proportion of the population that receives at least one of them. No additional question is required to assess the number of contributors to the social security system, as in the 2010 Brazilian census.

ECLAC (2017)[44] observes the following about the measurement of this indicator by means of censuses or surveys: "In the case of the WB proposal, it is recognized that household surveys face limitations in capturing information on transfers and specific programs. Often, household surveys do not capture the universe of social protection and work programs (SPL) and therefore only offer an approximate measure that generally captures data from larger programs. In the case of censuses, it is possible to inquire about people's access to the different protection programs that are being implemented, as defined by the SDG. The complexity of inquiring about the current programs is recognized, since it would be necessary to present them specifically with their names, and not in a general way. However, the universality with which these programs have been implemented in most countries deserves to be captured in this source. Not only does this facilitate being aware of the scope of each program beyond the direct beneficiary, but it also characterizes groups based on specific situations (geographical, residential, migratory, occupational, educational, ethnic, etc.), as requested by the SDG in the name of the indicator. The minimum level of coverage (at least one or two dimensions, etc.) should be agreed on by the countries."

c. Method of computation

The standard methodology calls for the identification of seven types of benefits:
Benefits to children;
Maternity benefits;
Benefits or pensions to persons with disabilities;
Unemployment allowances;
Employment injury benefits or pensions;
Retirement pensions; and
Social assistance benefits to vulnerable population groups.

If all of these categories are identified in the census as potential sources of income, with the possibility of selecting more than one, it is actually very easy to enumerate the number of people and hence the proportion of the population receiving at least one of these benefits. In practice, however, it may not be realistic to ask about all of these benefits in the census. Items c), d), and f) are the most feasible. Maternity benefits may present some challenges because they are not necessarily paid in cash, but can consist of access to certain services. Benefits to children present some difficulties because children do not answer the question on sources of income and parents may forget to declare this benefit under their income.

The denominators or potential beneficiaries of these benefits are the following:
Total number of children/households with children.

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[44] Op. cit. footnote 5.

Women giving birth in any given year.
Persons with severe disabilities, derived from the data on disability through taking the total of two categories of disability 'a lot of difficulty' and 'cannot do at all' (see theP&R para. 4.207).
Number of unemployed persons.
Total employment or labour force.
Persons above statutory retirement age (including contributory and non-contributory).
Total number of vulnerable persons. The latter are calculated by subtracting from total population all people of working age who are contributing to a social insurance scheme or receiving contributory benefits, and all persons above retirement age receiving contributory benefits.

As mentioned above, the PHC is an important data source for assessing the number of potential beneficiaries of several of these components. The denominator for a) can be determined by direct enumeration of the number of children and households with children. In countries where the PHC asks for information on children ever born and on recent births, the denominator for component b) can be estimated based on this information. Otherwise, published age-specific fertility rates from CRVS can be used, corrected for the share of twin and triplet births. In countries like the Russian Federation, where special maternity benefits exist for births beyond a certain birth order, birth order information has to be considered. The number of unemployed persons that is the denominator for d) can be estimated from the census, even though it is not ideally suited for this purpose. Finally, f) can be determined from census data by enumerating the number of persons above the statutory retirement age. Other categories, such as g) may be more difficult to enumerate with census data and c) has the limitation that census data on disability may not line up with the administrative eligibility criteria for disability benefits.

The aggregate indicator is calculated as the proportion of the total population receiving cash benefits under at least one of the contingencies (contributory or non-contributory benefit) or actively contributing to at least one social security scheme. In the PHC, determining the number of persons receiving at least one benefit is straightforward, based on the question on different categories of income, provided that it offers a)-g) as potential choices. Determining the total of persons contributing to social security requires a specific question, of the kind asked in the Brazilian census.

If administrative data are used, the procedure may be more complex. In countries where the data systems pertaining to the different potential benefits are integrated or where beneficiaries are registered with a unique person identity number, it is possible to determine all persons receiving at least one benefit, without double counting of those receiving more than one. By the same mechanism, it may be possible to identify persons contributing to the system, without double counting those that are both contributors and recipients. However, if the benefits are administered separately, without the possibility of cross-linking data, converting all of the different ratios a)-g) into one overall population estimate is challenging. If it can be assumed that the receipt of one kind of benefit is statistically independent from the receipt of any other one, the problem can be solved statistically. But this is clearly not the case with benefits such as a) and e), or d) and f), which are mutually exclusive.

d. Challenges in measuring in PHC

The overwhelming challenge is that information on this topic in the PHCs is very partial in nature. Most of the denominators can be estimated using census (and, to some extent, CRVS) data, but some are problematic. The criteria used for characterizing the beneficiary population in the census may not coincide with the administrative criteria. This is particularly the case with disability pensions, given that administrative criteria of disability may be substantially different from those suggested by the standard Washington Group questions of the census. Few censuses have information on numerators. This situation may be remedied by including the appropriate census question, but some problems remain, particularly in the case of non-cash benefits. The example of quantifying maternity benefits was already mentioned above.

e. Data disaggregation

The PHC can allow the disaggregation of this indicator by: 1. Sex; 2. Age; 3. Employment Status; 4. Disability; and 5. Wealth quintiles. Census data also allow detailed geographical disaggregations and disaggregations by occupation and migrant status.

1.4.1 Proportion of population living in households with access to basic services

a. Concept and definition

Providing access to basic services such as safe drinking water, sanitation facilities, sustainable energy and mobility, housing, education, healthcare etc, helps to improve the quality of life of the poor. Adequate basic service delivery systems promote socio-economic improvements and help to achieve economic growth, social inclusion, poverty reduction and equality. They can help to raise well-being and productivity of communities, create jobs, save time and human effort in transporting water, support food security, better use of energy, production of essential commodities, improve health or enhance the level of education.

Access to basic services implies that sufficient and affordable service is reliably available with adequate quality. Basic Services refer to public service provision systems that meet human basic needs including drinking water, sanitation and hygiene, energy, mobility, waste collection, health care, education and information technologies. More specifically, this involves the following components:
Access to Basic Drinking Water Services (based on SDG indicator 6.1.1) refers to drinking water from an improved source is available with collection time not more than 30 minutes for a round trip, including queuing. Improved sources include; piped water, boreholes or tube wells, protected dug wells, protected springs, and packaged or delivered water.

Access to Basic Sanitation Services (based on SDG indicator 6.2.1) refers to the use of improved facilities that are not shared with other households. Improved facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, composting toilets or pit latrines with slabs.

Access to Basic Hygiene Facilities (based on SDG 6.2) refers to availability of a handwashing facility on premises with soap and water. Handwashing facilities may be fixed or mobile and include a sink with tap water, buckets with taps, tippy-taps, and jugs or basins designated for handwashing. Soap includes bar soap, liquid soap, powder detergent, and soapy water but does not include ash, soil, sand or other handwashing agents.

Access to electricity (based on SDG indicator 7.1.1).

Access to clean fuels and technology (based on SDG indicator 7.1.2).

Access to Basic Mobility refers to having access to all-weather-roads in a rural context (SDG 9.1.1, also not part of this document) or having access to public transport in an urban context (based on SDG indicator 11.2.1, which is not part of this document). To synergize with SDG indicator 9.1.1 “Proportion of the rural population who live within 2 km of an all-season road”, it was suggested to use the Rural Access Index (RAI)[45] that measures the percentage of the population within 2km from an all-season road (equivalent to a walk of 20-25 mins).[46] Access to mobility has shown some of the largest impacts on poverty reduction and has a strong correlation to educational, economic and health outcomes ("transport as an enabler"). The urban context of access to transport is measured utilizing the methodology of SDG indicator 11.2.1 – the proportion of the population that has convenient access to public transport by sex, age and persons with disabilities". The metadata methodology is available and uses a combination of spatial and qualitative analysis. A 500 m buffer around each public transport stop is used and overlaid with socio-demographic data – in order to identify the population served. Complementary to the above, other parameters of tracking the transport target related to street density / number of intersections, affordability, or quality in terms of safety, travel time, universal access, are all tracked.

Access to Basic Waste Collection Services refers to both formal municipal and informal sector services. A 'collection service' may be 'door to door' or by deposit into a community container. 'Collection' includes collection for recycling as well as for treatment and disposal (so includes e.g. collection of recyclables by itinerant waste buyers). The service has to be regular, with a frequency that will depend on local conditions and on any pre-separation of the waste. For example, both mixed waste and organic waste are often collected daily in tropical climates for public health reasons, and generally at least weekly; source-separated dry recyclables may be collected less frequently.

Access to Basic Health Care Services refers to access to services that cover in and out-of-area emergency services, inpatient hospital and physician care, outpatient medical services, laboratory and radiology services, and preventive health services. Basic health care services also extend to access to limited treatment of mental illness and substance abuse in accordance with minimum standards prescribed by local and national ministries of health.

Access to Basic Education (based on SDG indicator 4.1.1) refers to access to education services that provide all learners with capabilities they require to become economically productive, develop sustainable livelihoods, contribute to peaceful and democratic societies and enhance individual well-being. This component is operationalized as access to education services in the school going age of 5 – 21 years.

Access to Basic Information Services refers to having a broadband internet access (based on SDG indicator 17.6.2, 17.8.1 and/or 9.c.1). Broadband is defined as technologies that deliver advertised download speeds of at least 256 kbit/s.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

The main source of data for this indicator remains household surveys including DHS, MICS, LSMS, World Bank, UNICEF and UNDP, the censuses and administrative data. These data sources are also described in the various metadata for the constituent SDG indicators. A lot of the pre-processed data is also derived from the SDG indicators that form this indicator. Data sources can be other SDG indicators monitoring results as well as additional data from household surveys or censuses.

[45] http://www.worldbank.org/en/topic/transport/brief/connections-note-23

[46] https://www.ssatp.org/sites/ssatp/files/publications/HTML/Gender-RG/Source documents/Tool Kits & Guides/Monitoring and Evaluation/TLM&E7 Access Index TRB 06.pdf

Indicator 1.4.1 is a composite of various partial indicators, most of which are the object of separate calculation elsewhere in this document. Consequently, in most cases the availability of information from the PHC is assessed under the heading of those indicators. Specifically:

See under indicator 6.1.1;
See under indicator 6.2.1;
See under indicator 6.2.1;
See under indicator 7.1.1;
See under indicator 7.1.2;
The existing RAI methodology relies on household level survey data – however, is currently being revised into a GIS-based index that exploits advances in digital technology with the aim to create a more accurate and cost-effective tool. Generally, this information is not directly available from PHC data. However, the cartography underlying the census operation may provide valuable inputs for the assessment of the road and public transportation infrastructure available to individual households. Also, a good number of PHCs now ask questions about the method of transportation to work or school and the time it takes to get there.
Based on indicator 11.6.1, which is not part of this document. Although a few PHCs, particularly in Latin America (where 17 countries asked about it in the 2010 census round), do contain questions on garbage disposal, they do not allow the identification of the final disposal of waste that is not disposed of on the household premises.
Generally not measurable with census data, although, like in the case of component 6), it may be possible to develop data bases based on census cartography and data on the location of health service points;
Based on indicator 4.1.1, which is not part of this document;
Based on indicator 17.6.2, 17.8.1 and/or 9.c.1 (the latter not part of this document).

In order to make the indicator more operational, particularly for measurement in the PHC, countries should negotiate a consensus on the specific dimensions included in the concept and their relative weights, including basic services at home (access to water and sanitation; access to electricity; type of fuel used for cooking) up to access to the health system, education, social security, etc.).

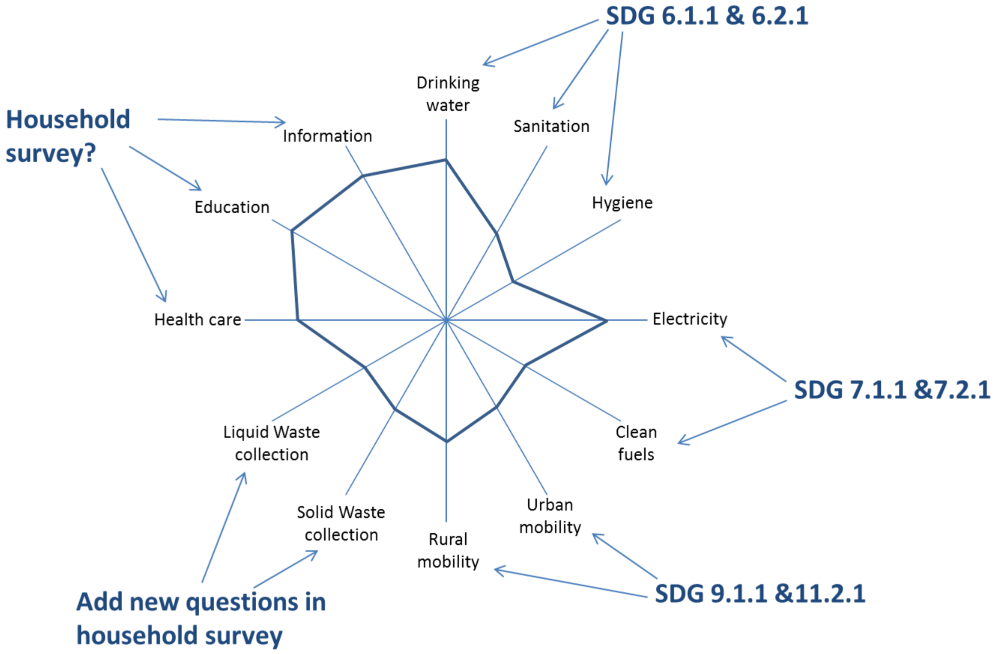
c. Method of computation

There are two computation stages. Step 1 involves obtaining the proportion of the population living in households that have access to all the basic services mentioned above that can be measured from primary data sources such as household surveys and census (components 1-5 and 10).

$$\textbf{Proportion of Population with access to basic services} = \mathbf{100}\left[\frac{\textbf{No. of people with access to ALL the basic services}}{\textbf{population}}\right]$$

This is then followed by computations of metrics for other components that are not measured at the household level such as access to health, education, transport, etc. For example, access to mobility for households is measured through GIS data (possibly helped by census cartography), rather than household survey. Individual components of access to basic services are computed first, followed by an aggregation of the components with no weights.

Currently, no overall index is being computed to express the coverage of basic services. Rather, the data for this component-based indicator is now presented as a spider web of the achievement of access to different basic services in a country through plotting the various components of the indicator which also doubles as other SDG indicators. Most of the components that provide the inputs to this diagram are already computed under the respective indicators. In this way policy makers can be informed of most needed intervention areas. If all the relevant service areas are adequately covered, the diagram will be a large circle. Deficient areas will show up as “dents” in this circular diagram. At present, countries are still investigating the data availability for this indicator and the best way to report on it, so concrete country examples are not readily available.



d. Challenges in measuring in PHC

The challenges are presented under the different component indicators. Compoents 6) and 8) are not directly measurable in the PHC, although it may be possible to generate geospatial data on them by special studies linking the census maps with the corresponding census data (see chapter 5 on the Use of Geospatial information and Geographic Informatio System.

e. Data disaggregation

The minimum required disaggregation involves the following dimensions: 1. Sex ; 2. Age; 3. Employment status; 4. Geographic location (urban/rural); 5. Household Income. An additional disaggregation has been proposed by type of settlement (formal/informal). By and large, all of these disaggregations can be provided based on PHC data, although the practicality does vary according to the different components.

4.5.1 Parity indices (female/male, rural/urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated

a. Concept and definition

Parity indices require data for the specific groups of interest. They represent the ratio of the indicator value for one group to that of the other. Typically, the likely more disadvantaged group is placed in the numerator. A value of exactly 1 indicates parity between the two groups.

Global Indicator 4.5.1 sets the parity index as the main measure of inequity in education within the SDG 4 agenda. This indicator casts a wide scope for measuring inequity, as it is meant to be applied to all other SDG 4 indicators with available data and can be used to measure inequity along several dimensions. Specifically, these indicators are the following:

Indicator 4.1.1: Proportion of children and young people: (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex (not part of this document);
Indicator 4.2.1: Proportion of children under 5 years of age who are developmentally on track in health, learning and psychosocial well-being, by sex (not part of this document)
Indicator 4.2.2: Participation rate in organised learning (one year before the official primary entry age), by sex;
Indicator 4.3.1: Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex;
Indicator 4.4.1: Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill; (not part of this document)
Indicator 4.6.1: Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex
Indicator 4.b.1: Volume of official development assistance flows for scholarships by sector and type of study; (not part of this document)
Indicator 4.c.1: Proportion of teachers in: (a) pre-primary; (b) primary; (c) lower secondary; and (d) upper secondary education who have received at least the minimum organised teacher training (e.g. pedagogical training) pre-service or in-service required for teaching at the relevant level in a given country.

Due to limitations in data availability, the primary dimensions of equity usually analysed are sex (male/female), location (rural/urban) and socio-economic status, either measured using the index of economic, social and cultural status (ESCS) or proxied by parental education. The ESCS is a composite score, based on the Programme for International Student Assessment (PISA) student questionnaire. As no direct income measure has been available from the PISA data, the existence of household items has been used as a proxy for family wealth. For more details on the computation of the ESCS, see the *PISA Technical Report 2015*, pages 339-344.Similarly, due to issues of data availability, the indicators most often disaggregated by these criteria are 4.1.1 and 4.2.2, due to the fact that the basic indicator information is also available from PISA.

b. Possible data sources, particularly PHC , and their relative advantages/ disadvantages

The sources are the same as for the underlying indicators.

The availability of the indicator information, to the extent that each indicator can be assessed based on PHC data, is discussed under each of the respective indicators:
Indicator 4.1.1: Not measurable with PHC data
Indicator 4.2.1: Not measurable with PHC data
Indicator 4.2.2: See under indicator 4.2.2
Indicator 4.3.1: See under indicator 4.3.1
Indicator 4.4.1: Not measurable with PHC data
Indicator 4.6.1: See under indicator 4.6.1
Indicator 4.b.1: Not measurable with PHC data
Indicator 4.c.1: See under indicator 4.c.1

It should be noted that only indicators 4.2.2 belongs to category I, i.e. indicators for which the PHC is the natural data source. Indicator 4.3.1 and 4.c.1 are in category III, i.e. PHCs only provide a proxy mechanism for its computation, while indicator 4.6.1 is in category IV, for which PHCs only provide ancillary information.

c. Method of computation

The indicator value of the likely more disadvantaged group is divided by the indicator value of the other sub-population of interest. This means that the expected outcome of each parity index is smaller than 1.

$$DPI = \frac{Indicator\ d}{Indicator\ a}$$

where:

DPI = the Dimension (Gender, Wealth, Location, etc.) Parity Index
Indicator = the Education 2030 Indicator i for which an equity measure is needed. From PHC, as explained below, DPI can be calculated for 4.2.2, 4.3.1, 4.6.1, and 4.c.1.
d = the likely disadvantaged group (e.g. female, poorest, etc.)
a = the likely advantaged group (e.g. male, richest, etc.)

The more challenging part of the computation is the determination of the stratification variable underlying the parity index. Because the ESCS is based on PISA data, its application is mostly limited to indicators 4.1.1 and 4.2.2. When working with PHC data, the stratification variables can be applied to indicator 4.2.2. The best stratification variables for census data would be those that approximate the components of the ESCS; parental education and parental occupation. However, these components may not be available for every person. Even parental education, the proposed proxy for the ESCS, may be difficult to establish, especially in the case of students that do not live with their parents. Other stratification variables, such as sex, urban/rural residence, wealth quintile, disability status, migration status, and belonging to particular ethnicities or vulnerable population groups, may be less challenging using PHC data.

The most feasible parity ratios therefore would be the following:

- Parity by sex (male/female);
- Parity by urban/rural residence;
- Parity in terms of the education of parents or the head of household or reference person, classified according to the main groupings applicable to the country, e.g. less than complete primary versus at least primary;
- Parity in terms of the occupation of persons or the head of household or reference person , classified according to a grouping that makes sense in the country context, e.g. agriculturel versus non-agriculturel activities ;
- In countries that have clear ethnic divides, parity in terms of belonging to the more advantaged or less advantaged group.

In some countries, rather than looking at ethnicity, it may be more relevant to divide children by whether parents or the head of household speaks the official language of the country.

d. Challenges in measuring in PHC

The main challenge is that some of the indicators mentioned above belong to categories III and IV, which can only be imperfectly or partially measured by means of PHC data. In addition, the ESCS is a concept based on the PISA methodology which can only be captured in the census through proxies. A final, more conceptual, problem has to do with the parity ratio itself. While this concept works well with binary variables such as sex or urban-rural residence, it may be harder to apply to variables that have multiple categories, such as ethnicity.

e. Data disaggregation

The primary disaggregation variables are sex (male/female), location (urban/rural), and socio-economic status (ECSC). With the exception of the latter, these can all be easily implemented using census data. Other proposed disaggregation criteria include grade, language spoken at home, migrantion status, disability status, wealth stratum, and ethnicity. All of these can be captured with relative ease in most censuses. In countries where not the entire population speaks the official national language, a question about language proficiency is often included.

4.6.1 Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex

a. Concept and definition

The proportion of youth (aged 15-24 years) and of adults (aged 15 years and above) that have achieved or exceeded a given level of proficiency in (a) literacy and (b) numeracy. The minimum proficiency level is to be measured relative to new common literacy and numeracy scales currently in development. Due to heterogeneity of performance levels set by national and cross-national assessments, these performance levels must be mapped to the globally defined basic and proficiency levels. Once the performance levels are mapped, the global education community will be able to identify for each country the proportion of youth and adults above and below minimum level. The fixed level of proficiency is the benchmark of basic knowledge in a domain (literacy or numeracy) measured through learning assessments. Until August 2018, there was no globally agreed definition on minimum proficiency level, but now there are common standards validated by the international community and countries.

b. Possible data sources, particularly PHC , and their relative advantages/ disadvantages

The measurement of youth and adult skills requires some form of direct assessment, such as skills assessment surveys of the adult population (e.g. PIAAC, STEP, LAMP, RAMAA) and national adult literacy surveys. Using household surveys to measure learning can be costly and difficult to administer and may underestimate learning in areas that are critical to daily life but are harder to assess in standardized approaches. The result may be inaccurate representations of what youth and adults know and can do, especially in relation to applying skills that may vary across contexts. The same applies to PHC data which depend on self-assessment of literacy, with no similar question regarding numeracy.

Literacy is a core census topic which may be taken as a proxy for basic reading skills, though not for reading proficiency. This is particularly the case for adults who, unlike children, are not routinely submitted to educational performance tests. While declared literacy in the PHC may not be a perfect match for performance on a basic reading skills test, there are few realistic alternatives for adults not attending schools.

According to paragraph 4.259 of the P&R, the notion of literacy applies to any language insofar as it exists in written form. In multilingual countries, the census questionnaire may also enquire into the languages in which a person can read and write. Such information can be essential for the determination of educational policy. This item would, therefore, be a useful additional subject of enquiry. Paragraph 4.261 recommends that simple questions with response categories that reflect different levels of literacy skills should be used. In addition, since literacy is an applied skill, it needs to be measured in relation to a particular task, such as reading, with understanding, personal letters and newspapers or magazines, or writing a personal letter or message. Respondents may be able to do so easily, with difficulty or not at all, reflecting the different levels of literacy skills. Reading and writing may be measured separately to simplify the questions.

The census is not an adequate instrument for collecting data on actual reading and writing performance/proficiency. According to P&R paragraph 4.262, administering a literacy test to all household members in the course of enumeration may prove impractical and affect participation, therefore limiting the utility of the results. Instead, administering such a test to a sample of respondents may be considered either in the census itself or in a targeted post-enumeration follow-up survey. Some countries have regularly used simple self-assessment questions within a census to provide an indication of literacy rates at the small-area level. An evaluation of the quality of statistics should be provided with census statistics on literacy.

The PHC generally does not permit the assessment of numeracy, even if based on self-declaration. The topic is not considered in the P&R.

c. Method of computation

Once the number of individuals in the relevant age group that have achieved above the minimum threshold of proficiency as defined for large-scale (sample representative) adult literacy assessment has been established, the computation of the proportion is straightforward.

Given the difficulty of measuring the indicator, as it is currently defined, through PHCs, proportion of illiterate young people (15-24 years) and adults (15+) can be measured through the PHC as an alternative indicator particularly for countries which have a high illiterate population.

d. Challenges in measuring in PHC

As indicated by paragraph 4.264 of the P&R, the literacy question currently varies across countries and, as a result, the data based on it are not always internationally comparable. In addition, it generally depends on self-assessment and no comparable question is asked about numeracy. More importantly, literacy or even functional literacy are not equivalent to the criteria of the basic and proficiency levels as defined in the relevant tests. Therefore, census data on literacy may deviate considerably from the results obtained by means of standardized tests.

e. Data disaggregation

This indicator can be disaggraegated by five-year age-group and for youth (aged 15-24 years) and adult (aged 15 and over), by sex, rural and urban areas of residence and by regions and administrative units. Disability status is not currently available in most national and cross-national learning assessments, but it is generally available in the PHC. This is one of the advantages of the PHC in this context. The PHC also allows disaggregation by socio-economic status (non-monetary poverty criterion) and migrant status.

6.2.1 Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water

a. Concept and definition

The proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water is currently being measured by the proportion of the population using a basic sanitation facility which is not shared with other households and where excreta is safely disposed in situ or treated off-site. Improved sanitation facilities include: flush or pour flush toilets to sewer systems, septic tanks or pit latrines, ventilated improved pit latrines, pit latrines with a slab, and composting toilets. The population with a basic handwashing facility refers to a device to contain, transport or regulate the flow of water to facilitate handwashing with soap and water in the household.

The Joint UNICEF/WHO Monitoring Programme (JMP) developed the metric of use of improved sanitation facilities, which are likely to hygienically separate human excreta from human contact, and has used this indicator to track progress towards the MDG target since 2000. International consultations since 2011 have established consensus on the need to build on and address the shortcomings of this indicator; specifically, to address normative criteria of the human right to water including accessibility, acceptability, and safety. Furthermore, the safe management of faecal wastes should be considered, as discharges of untreated wastewater into the environment create public health hazards. The above consultation concluded that post-2015 targets, which apply to all countries, should go beyond the basic level of access and address indicators of safe management of sanitation services, including dimensions of accessibility, acceptability and safety. The Expert Working Group called for analysis of faecal waste management along the sanitation chain, including containment, emptying of latrines and septic tanks, and safe on-site disposal or the transport and treatment of wastes at a designated treatment site. Classification of treatment will be based on categories defined by SEEA (the System of Environmental-Economic Accounting) and the International Recommendations for Water Statistics and following a laddered approach (primary, secondary and tertiary treatment).

A framework for measuring faecal waste flows and safety factors has been developed and piloted in 12 countries (World Bank Water and Sanitation Program, 2014), and is being adopted and scaled up within the sanitation sector.

b. Possible data sources, particularly PHC, and their relative advantages/ disadvantages

Data on sanitation can be obtained from PHCs or surveys, or in developed countries where such data are not included in the census, from administrative data sources. PHCs do not include questions on handwashing facilities, but surveys such as DHS and MICS do. Since the handwashing with soap survey questions were standardized in 2009, over 70 DHS and MICS surveys have included the module. As usually, PHC data is the basis for estimates of the urban and rural population estimates used in the denominators.

Data on sanitation infra-structure are a core topic of the PHC. Paragraph 4.498 of the P&R recommends the following classification of housing unit by toilet facilities:

1. With toilet within housing unit
    1.1. Flush/pour flush toilet
    1.2. Other
2. With toilet outside housing unit
    2.1. For exclusive use
        2.1.1. Flush/pour flush toilet
        2.1.2. Ventilated improved pit latrine

2.1.3. Pit latrine without ventilation with covering
2.1.4. Holes or dug pits with temporary coverings or without shelter
2.1.5. Other
2.2. Shared
2.2.1. Flush/pour flush toilet
2.2.2. Ventilated improved pit latrine
2.2.3. Pit latrine without ventilation with covering
2.2.4. Holes or dug pits with temporary coverings or without shelter
2.2.5. Other
3. No toilet available
3.1. Service or bucket facility (excreta manually removed)
3.2. Use of natural environment, for example, bush, river, stream.

The unit of enumeration for this topic is the housing unit. However, some countries may find it useful to collect information on the availability of toilet facilities for the use of occupants in collective living quarters. Living quarters of this type are usually equipped with multi-facilities for the use of large groups, and information on the number and type of toilets in relation to the number of occupants would be significant in terms of analysing housing conditions. The availability of toilets for collective living quarters represents an additional topic.

In addition, paragraph 4.500 recommends that information on toilets should be combined with the sewage disposal system to which they are connected in order to determine the adequacy of sanitation facilities of the housing unit. To be considered adequate sanitation, toilets or latrines have to be connected to non-clogged sewage disposal systems. The information on housing units by type of sewage disposal system may be classified as follows:

1. Empties into a piped system connected to a public sewage disposal plant;
2. Empties into a piped system connected to an individual sewage disposal system (septic tank, cesspool);
3. Other—toilet empties into an open ditch, a pit, a river, the sea, etc.;
4. No disposal system.

c. Method of computation

As explained above “Safely managed sanitation” is defined as the use of an improved sanitation facility which is not shared with other households and where:

- excreta is safely disposed in situ or
- excreta is transported and treated off-site

It should be noted that improved sanitation facilities include flush/pour flush to piped sewer, septic tank or pit latrine; composing toilet or pit latrine with slab. Unimproved sanitation facilities include pit latrines without a slab or platform, hanging latrines and bucket latrines.

Data for this indicator can be calculated using two census topics on type of toilet and type of sewage disposal system. For generating information for population using safely managed sanitation system, the following two steps can be applied:

The first step is to identify households having one of the following toilet facilities:

1. With toilet within housing unit
1.1. Flush/pour flush toilet

1.2. Other
2. With toilet outside housing unit
   2.1. For exclusive use
      2.1.1. Flush/pour flush toilet
      2.1.2. Ventilated improved pit latrine

The second step is to identify households which use safely managed sanitation among households which were selected in the first step. In this step, households which use one of the following two types of sewerage system will be selected:

1. Empties into a piped system connected to a public sewage disposal plant;
2. Empties into a piped system connected to an individual sewage disposal system (septic tank, cesspool);

The percentage of the population using safely managed sanitation services is calculated by the population living in the households which use safely managed sanitation divided by total population of that area.

d. Challenges in measuring in PHC

PHCs measure the availability of sanitation services at the level of the housing unit, but they do not provide any information on the treatment of the material after it leaves the household. Whether the sewerage is treated or simply dumped into local waterways or otherwise disposed of in unsanitary ways cannot be ascertained based on PHC data. In addition, PHCs do not normally ask any questions on handwashing facilities or behavior.

e. Data disaggregation

The disaggregations called for include those by urban/rural place of residence, wealth stratum, detailed geographical area, sex and age of the members of the housing unit, and particular disadvantaged groups, such as population living in slum areas can generally be obtained based on census data, at least as far as the basic sanitation infrastructure of the housing units is concerned.

4. Use of geospatial information, GIS and geocoded census data for measuring and disaggregating SDG indicators with spatial characteristics

4.1 Introduction

Population and housing censuses (PHCs) have always been conducted with the support of cartographic materials, paper maps or digital spatial data. Following recent technological developments in the field of geospatial information, the use of geospatial data including Earth Observation (EO) data such as satellite images and aerial photographs, Global Navigation Satellite Systems (GNSS) such as the Global Positioning System (GPS) or Galileo or GLONASS, and Geographical Information Systems (GIS) have become common in most census operations around the world, irrespective of the census method used, either based on field activities, registers or a combination of them. Geospatial information has become crucial to maximise census coverage, to increase data quality, to implement spatial analysis and to improve the dissemination and analysis of census results.

Through geocoding approaches and techniques, geospatial technology allows the linkage of census data to places at different geographic levels, from the sub-national level down to the level of Enumeration Areas (EAs), buildings and addresses. The integration of geospatial and statistical data offers the opportunity to achieve a more ambitious and complete dissemination and analysis of census results. It also provides valuable support for the computation of several SDG indicators, along with their disaggregation and visualization.

The objective and scope of this chapter is to discuss the role of geospatial information in computing SDG indicators from census data, and to provide methodological and technical inputs on techniques that could be used for measuring and disaggregating a selected number of SDG indicators.

4.2 SDG indicators that can be measured through geospatial and PHC data

Although it is generally accepted that geospatial data, and especially Earth Observation (EO) data, can be effectively used for monitoring progress in achieving some SDGs (for example, SDG 1 by applying poverty mapping techniques, SDG 2 by working in crop yield estimation and forecasting in agriculture, and SDG 13 by detecting the impact of climate on population groups), little experience has been developed so far in measuring SDG indicators with the help of geoinformation. Indeed, geospatial data is one of the most promising data sources for measuring some of the SDG indicators, especially if such data is combined with other data sources such as PHCs.

The initial work conducted by the *UN-GGIM IAEG-SDGs Working Group on Geospatial Information (IAEG-SDG WG GI)* concluded in November 2017 that 24 SDG indicators can directly or indirectly benefit from geospatial information. A total of 15 of them were classified as indicators where geospatial information has a direct contribution, and the remaining 9 as indicators where geospatial information has a significant or supporting contribution. In the first group are included the SDG indicators 2.4.1, 6.3.2, 6.5.2, 6.6.1, 9.1.1, 9.c.1, 11.2.1, 11.3.1, 11.7.1, 14.2.1, 14.5.1, 15.1.1, 15.1.2, 15.3.1, and 15.4.1. In the second group are the SDG indicators 1.1.1, 1.4.2, 4.5.1, 5.2.2, 5.4.1, 5.a.1, 5.a.2, 11.7.2, and 15.4.2.[47]

In February 2020, the Working Group on Data Integration of UN-GGIM: Europe compared the 2017 short list with a list of indicators developed by the Group on Earth Observations (GEO), providing that a

[47] IAEG-SDGs 2017. Shortlist. Results of the analysis of the Global Indicator Framework with a "geographic location" lens.

total of 29 SDG indicators can be directly or indirectly supported by earth observations, adding to the list the SDG indicators 3.9.1, 6.4.2, 6.5.1, 7.1.1, 9.4.1, 11.1.1, 11.6.2, 12.a.1, 13.1.1, 14.3.1, 14.4.1, 15.2.1, 17.6.1 and 17.18.1, and removing the indicators 1.1.1, 4.5.1, 5.2.2, 5.4.1, 5.a.2, 6.5.2, 9.c.1, 11.7.2, 14.2.1.[48] The comparison showed that 14 out of the 29 indicators identified by the GEO correspond to the same indicators identified by the IAEG-SDG WG GI.

The discussion on the identification of SDG indicators that could be measured with the support of geoinformation is currently open and involves many actors, such as the custodian organisations of the SDG goals, global and regional institutions, national institutes of statistics, the academia, and the private sector. Additional work is being carried out in the context of the UN-GGIM initiative, such as:

- Further analysis of SDG indicators with focus on the use of EO data for official statistics
- Analysis of emerging trends in data capture, creation, maintenance, and management of geospatial data to enhance data integration
- Exploration of ways of managing data integration post 2020 census round.

The SDG indicators presented and analysed in this chapter have been identified from the list of the 15 indicators classified by the *IAEG-SDG WG GI* in the first group (where geospatial information has a direct contribution), and therefore based on their geographical relevance (i.e., the computation of the SDG indicator is highly dependent on geospatial data), in connection with one or more statistical variables that can be derived from a PHC questionnaire.

This chapter provides detailed discussion of four SDG indicators that can be generated from geocoded census data. These SDG indicators consist of:

- 9.1.1 Proportion of the rural population who live within 2 km of an all-season road
- 11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
- 11.3.1 Ratio of land consumption rate to population growth rate
- 11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.

These four SDG indicators have been selected from the list established by the *IAEG-SDG WG GI,* among the 15 indicators for which geospatial information has a direct contribution to their computation and disaggregation. The selection criteria were:

- Geographical relevance, i.e., the computation of the SDG indicator is highly dependent on geospatial data
- At least one statistical variable for generating the indicators can be derived from a PHC
- Geospatial and census data need to be integrated through GIS functions for measuring and/or disaggregating SDG indicators
- Sufficient methodological documentation is available in the SDG metadata repository.

4.3 The use of geospatial information and GIS tools for measuring, disaggregating and visualizing selected SDG indicators

Geospatial information and Geographic Information Systems (GIS) tools are nowadays widely used in official statistics. They are often used in censuses and household surveys (for example, for assigning a location to economic structures of business registers) and are increasingly a part of the overall processes of statistical production and data dissemination of national statistical systems (NSSs). Through geocoding methods, geography and statistics are integrated using GIS tools, irrespective of source of

[48] UN-GGIM: Europe | Work Group on Data Integration | subgroup I. 2020. The integration of geospatial data and statistics to compute SDG indicators – requirements and practices: Scoping Paper Version 1.0.

statistical data, whether derived from administrative sources or from survey data collected in the field. Geospatial information is data related to a geographic location, while GIS tools are computerised functions and procedures that capture, store, manage, analyse, and disseminate geospatial information.

Geospatial data (or spatial data) may have different forms, such as maps, images, points, lines, polygons, grids, and can be originated from many sources, i.e., GIS, Global Navigation Satellite Systems (GNSS) devices, photos and data from Earth Observation (EO) that involves remote-sensing technologies for the production of satellite images at different resolutions and for several uses in natural and built environments. GNSS and EO are becoming widely used in statistics, to establish geospatial frameworks within National Statistical Offices (NSOs), and for the analysis of statistical data integrated with geospatial data.

Together with GIS, GNSS and EO are geospatial technologies that contribute to the geographic mapping and analysis of the earth and human societies and that are increasingly used in official statistics by integrating geospatial and statistical information. Recent technological developments in Big Data, Internet of Things (IoT)[49], Artificial Intelligence (AI) systems[50], will probably strengthen in the near future the integration between geospatial and statistical data to further support decision-making processes for the implementation of national and regional strategies and for a more effective fulfilment of the 2030 Agenda for Sustainable Development at national and sub-national levels.

Although geospatial information has commonly been used in the field of statistics, mainly for population and housing census operations, it can be used for many other statistical activities, such as in the development of a new sample frame for household surveys, the setup of a national register of buildings and dwellings and its linkage with population register, and the comparison of data over space and time. Also, it contributes to the enrichment of the National Spatial Data Infrastructures (NSDIs), supports national policies and sustainable development providing evidence-based solutions, and helps to produce small area data that can support policy actions of local governments. Geospatial data in official statistics can also support the computation, disaggregation, and dissemination of SDG indicators and the development of platforms for monitoring their progress.

Indeed, it is largely recognised that many SDGs have a spatial relevance and can benefit, directly or indirectly, from geospatial information. Although considerable progress has been made so far in the use of geospatial information for monitoring and disseminating SDG indicators, little was investigated regarding the potential of geospatial data for generating and disaggregating SDG indicators by geographic location, especially in connection with statistical data derived from population and housing censuses. This relates to the work in designing methodologies to measuring and disaggregating SDG indicators that have a spatial relevance and making use of the currently available and emerging geospatial technologies. For instance, one of the most critical factors in achieving and monitoring the progress of the targets identified in the 2030 Agenda for Sustainable Development is the availability of good quality statistical data disaggregated by geographic locations for decision-making. Goal 17

[49] The International Telecommunication Union (ITU) defined the IoT in 2012 as "a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies" (Recommendation ITU-TY.2060, note, s.8.4). In official statistics, it refers to the future possibility to use algorithms for handling large amounts of data for exploiting statistical data derived from smart technologies. Smart technologies involve real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices.

[50] The 2019 OECD Recommendation of the Council on Artificial Intelligence defines an AI system as "a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. AI systems are designed to operate with varying levels of autonomy".

“Strengthen the means of implementation and revitalize the global partnership for sustainable development” indicates that countries should “increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts”.

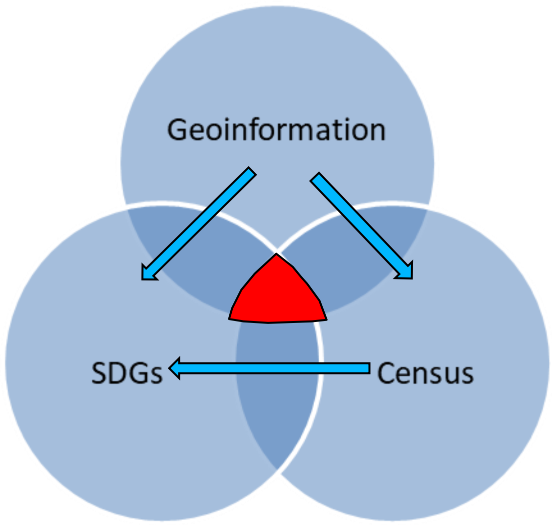
The first report of the UN-GGIM: Europe WG on Data Integration, *the territorial dimension in SDG indicators: geospatial data analysis and its integration with statistical data*[51], provided a set of recommendations with the purpose of enhancing the contribution of geospatial data and its integration with statistics in SDG Indicators. The main recommendations are:

- use geospatial layers generated from Earth Observation data with a stable and validated methodology at global (e.g., Global Human Settlement Layer) and European level (e.g., Copernicus High Resolution Layers, CORINE) to enable data comparability across countries
- create capacity building initiatives for National Statistical Institutes to take full advantage of Earth Observation based data to produce new statistical indicators and to increase territorial disaggregation of traditional indicators already reported by NSOs
- ensure availability and accessibility of processing workflows, including open formats of programming codes, allowing the automatic or semi-automatic extraction of information from satellite images, the development of algorithms for indicator calculation and territorial classifications and of its associated metadata, to improve reporting harmonization and comparability of data
- increase the collaboration with researchers and data providers to take full advantage of the available data and processing infrastructures and for tuning operational workflows and regular computation of SDG indicators.

This chapter intends to make a contribution to the ongoing methodological work in measuring some of the SDG indicators (Tier II indicators), for which methodology was established but data is not widely available. The objective is to investigate and describe how geospatial data combined with population census data can help countries to measure some SDG indicators and discuss potentialities and limitations of geospatial information in supporting both computation and disaggregation of these indicators. Figure 4.1 summarises the relationship among geoinformation, SDGs and census data: geospatial data and tools can serve independently SDG indicators and PCHs. Census data is crucial for many SDG indicators; integrating geoinformation and census data may support the measurement and disaggregation of some SDG indicators.

Figure 4.1 Conceptual relation between Geoinformation, PHCs and SDGs

[51] UN-GGIM: Europe (2019). The territorial dimension in SDG indicators: Geospatial data analysis and its integration with statistical data. INE, Lisboa.



The next sub-chapter discusses the main role of geospatial information in population and housing census operations with a focus on geocoding methods, while the subsequent sub-chapter elaborates on how geocoded census data can support the measurement and disaggregation of some SDG indicators.

4.4 Main uses of geospatial data in population censuses and geocoding methods

4.4.1 Uses of geospatial data in population and housing census operations

Geospatial data is nowadays widely used in censuses and other statistical surveys, in countries where data is collected in the field by enumerators, and in countries where census data are compiled fully or partially from registers where reliable data on addresses or cadastral units are available. Moreover, geospatial information is instrumental for other statistical activities as well, for example, in the development of sample frames and for conducting listing operations for household surveys, in the setup of national registers of buildings and dwellings linked with population registers, in the integration of census data with national systems of addresses, and, in the monitoring and quality control of statistical data collected in the field.

Countries collecting data on population and housing from the field could use geospatial tools i) in the pre-enumeration phase, ii) during the census enumeration, and iii) in the post-enumeration phase.

In the pre-enumeration phase, the appropriate delineation of Enumeration Area (EA) boundaries allows the development of an accurate organisation of fieldwork activities that is reflected in the quality of the census data, and helps planning the needed materials for the field and for proper allocation of human and financial resources. The results of a population and housing census are always affected by a degree of uncertainty on the coverage of housing units, households, and individuals. Coverage errors refer to the non-inclusion or double inclusion of units that may result in under-counting or over-counting, respectively. In the planning process, the occurrence of these errors can be reduced by defining accurately the hierarchy among administrative, geographic, and statistical units composing the census spatial framework, and by representing their boundaries on maps, with unique ID codes. This phase allows the definition of the census geography, that is the division of the whole territory of a country for census purposes. In field-based census operations, EAs are the operational geographic units for the collection of census data.

More recently, some countries are adopting an integrated electronic system approach to implement census mapping activities. It is usually composed of GIS tools, GNSS, high-resolution satellite imageries and mobile computing (e.g., tablets) for conducting map updating activities, EA boundaries updating, numbering of buildings, and listing of households. The system is also intended to be linked with Computer Assisted Personal Interviewing (CAPI) applications used in the enumeration phase, and to support the field management and monitoring activities. One of the main characteristics of these systems is the integration between geospatial and census data at point-based level, geocoded through unique identifiers and geographic coordinates. Such characteristics allow the aggregation of census data in any spatial dimension, not only by administrative units.

During the census enumeration phase, the use of geospatial information can help to easily identify EAs and enumerate all housing units and households living in these areas. For ensuring full coverage of population, not only an accurate definition of the census geography and the delineation of EA units is important but also representing physical features on maps within EAs, especially buildings, streets, addresses if available, and points of interest, which help enumerators for field orientation. Indeed, an EA map showing in detail all buildings where households may live is usually provided to each enumerator. The coding system reported on the map should be consistent with ID codes reported on the census forms. EA maps are a tool for the enumerators to ensure that during the enumeration period all buildings, structurally permanent and not permanent, built for residential and non-residential purposes, are investigated to identify and interview private and collective households, and to monitor that the areas assigned to enumerators are completely covered by such investigation. Moreover, a monitoring system is usually implemented for the census enumeration, to verify that the number of households, persons and housing units enumerated in the field match their corresponding figures estimated during map updating and household listing operations conducted during the pre-enumeration phase.

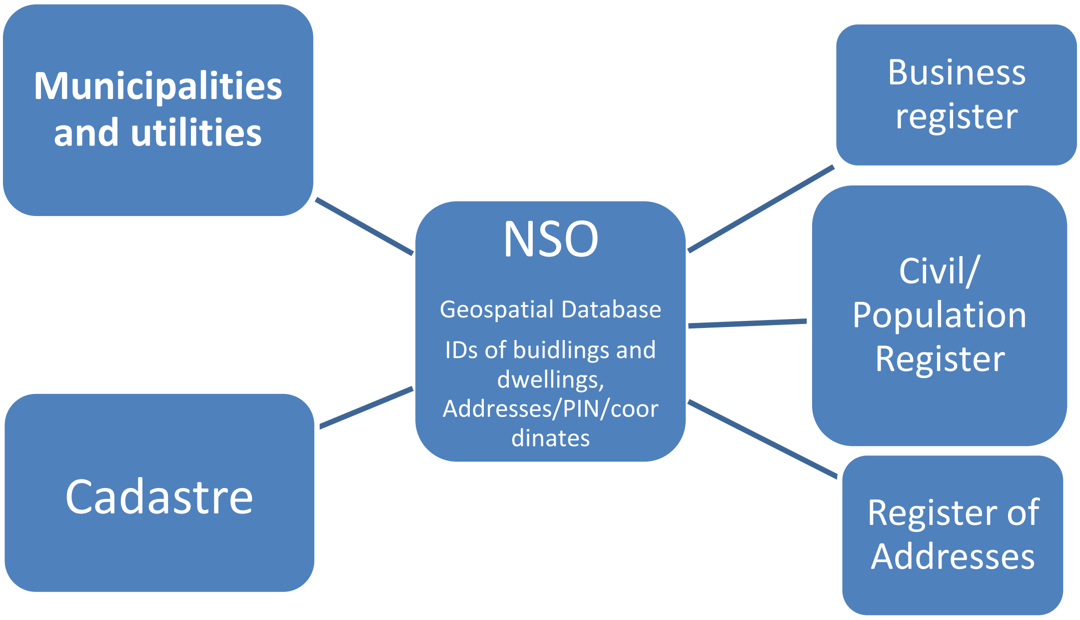
In the post-enumeration phase, geoinformation can be a precious tool to support data editing, by comparing geospatial data collected during the pre-enumeration phase with the data collected during the census enumeration. Moreover, geospatial data and tools may support the preparation and implementation of the Post Enumeration Survey (PES), in addition to the dissemination and analysis of census results. The dissemination of the census data includes the preparation of thematic maps and outputs of spatial-related socio-economic analysis. If maps are prepared following a GIS-based approach, they are an important tool to disseminate census results. They can be used to produce digital and hard-copy thematic maps, census atlases and used for internet mapping applications. They are also useful to perform geo-spatial analyses by combining variables to investigate relationships and to represent them where they occur. The use of a GIS-based approach in census dissemination is also encouraged by international recommendations in order to produce small area data which, once data confidentiality is ensured, are of a crucial importance not only for understanding demographic and socio-economic characteristics of small population groups, but also for applications that would be strategic in non-statistical public sectors such as planning disaster management, planning and delivering social services and transportation.

As stated in the UN Principles and Recommendations for Population and Housing Censuses: the 2020 Round[52], geospatial technology plays an increasingly crucial role in national census operations. Nowadays, the available and emerging technologies combined with new census methods that involve the use of administrative data, offer the opportunity to develop a more ambitious and sustainable census mapping strategy, that goes beyond a national census exercise (figure 4.2). Indeed, the geocoding of census data do not refer only to census operations conducted with field activities. It also addresses the need of enriching official registers and administrative data used for statistics with

[52] Principles and Recommendations for Population and Housing Censuses: the 2020 Round – Revision 3, United Nations, New York 2015.

locations associated to their records. Examples of official registers used for statistical purposes are address registers, registers of buildings and dwellings, population registers, farm registers, tax registers and business registers.

Figure 4.2 – Conceptual scheme of a census mapping programme

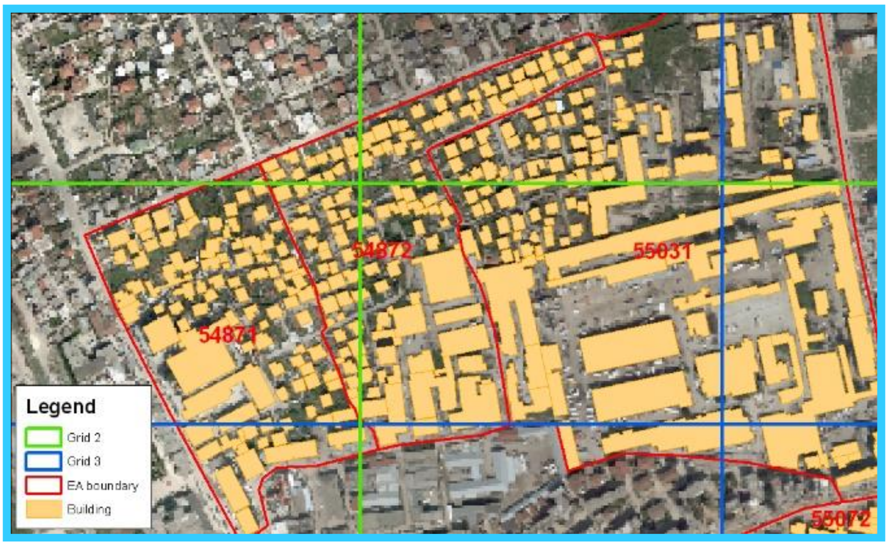


4.4.1 Geocoding in population and housing census operations

Web-based tools and mobile hand-held devices allow a direct linkage of geospatial and census data in the field where data collection is conducted entirely or partially. Register-based censuses ensure data integration through addresses or building and dwelling identification numbers (IDs), or through geographic coordinates. In countries where geospatial technologies are used, census data is geocoded by Enumeration Areas (EAs), or by points representing the centroids of building footprints or building entrances or addresses. Census data is geocoded by grids as well, mainly in European countries, for dissemination purposes (figures 4.3 and 4.4).

Figure 4.3 – Example of census data geocoded by centroids of buildings

Figure 4.4 – Example of census data geocoded by grid cells



The UN Handbook on Geographic Information Systems and Digital Mapping (Studies in Methods, Series F, No. 79, United Nations Department of Economic and Social Affairs, Statistics Division, New York, 2000, Annex VI – Glossary) defines "Geocoding" as "(a) a GIS function that determines a point location based on an address; (b) the process of assigning geographic codes to features in a digital database.

In a more complex and evolved term, geocoding is the process that assign a geocode to statistical units (e.g., individuals, households, dwellings, or businesses) using location information, such as physical addresses, localities, or geographic coordinates, that is reflected in a digital database of the statistical units. If authoritative lists of physical addresses or unique IDs for buildings and dwellings are not available, EAs or localities are often used to obtain a more general geocode. Geocoding usually include location geographic coordinates (i.e., Latitude and Longitude) of physical addresses or IDs (e.g., centroids of polygons representing buildings, building entrances, centroids of polygons representing EAs or localities).

Geocode is a single physical address, location coordinate or a unique code that can be used to determine the position of a location on the Earth's surface. The unique code provides a direct link to a set of coordinates that defines a geographic object that represents that location – commonly a point or a polygon centroid. The coordinates used must be related to a defined geospatial referencing system, such as the WGS84 (the 1984 World Geodetic System is a standard geographic coordinate system used in cartography, geodesy, and satellite navigation including GPS) or ETRS89 (the European Terrestrial Reference System 89 is the reference geographic coordinate system used in Europe) (could you give a reference and brief information for the definition of these systems?), or national coordinate systems.

The UN Principles and Recommendations also invite countries to consider geographic characteristics in collecting census data, for core and non-core census topics[53]:

- Census data should be collected with reference to the place of usual residence and/or place of enumeration of individuals (paras. 4.52-63)
- The collection of geographic location of living quarters by address, locality, urban and rural classification is recommended as a core topic (paras. 4.463- 4.470)
- A classification of areas as urban or rural should be done at the smallest administrative unit of the country, or the smallest census collection unit (para 4.95)
- The identification of slums and urban agglomerations are recommended as core topics (para. 4.91).
- The location of places of work of individuals is recommended as a non-core topic (para. 4.363)
- The location of schools, colleges or universities is recommended as a non-core topic (para. 3.86)

As a result, countries are encouraged by the international recommendations to geocode census data by points and not only by EAs/Census Districts or localities, providing that point-based geocoding method has several benefits (figure 4.5):

- Census results are consistent with the international recommendations on the geographic characteristics of census variables, thus facilitating comparisons among countries
- Even though GIS tools allow data disaggregation of census data geocoded by EA to smaller geographic units, it is a complex and error-prone process. Instead, point-based geocoding allows easily, and with minimal statistical bias, the aggregation of census data to any territorial level
- Point-based geocoding allows to integrate census records with addresses, cadastral and other administrative data through GIS overlay functions, thus laying the foundations for the establishment of registers of addresses and buildings/dwellings
- Point-based geocoding allows distance calculations between places
- Point-based geocoding supports generating SDG indicators and spatial data disaggregation greater than the geocoding of census data by area.

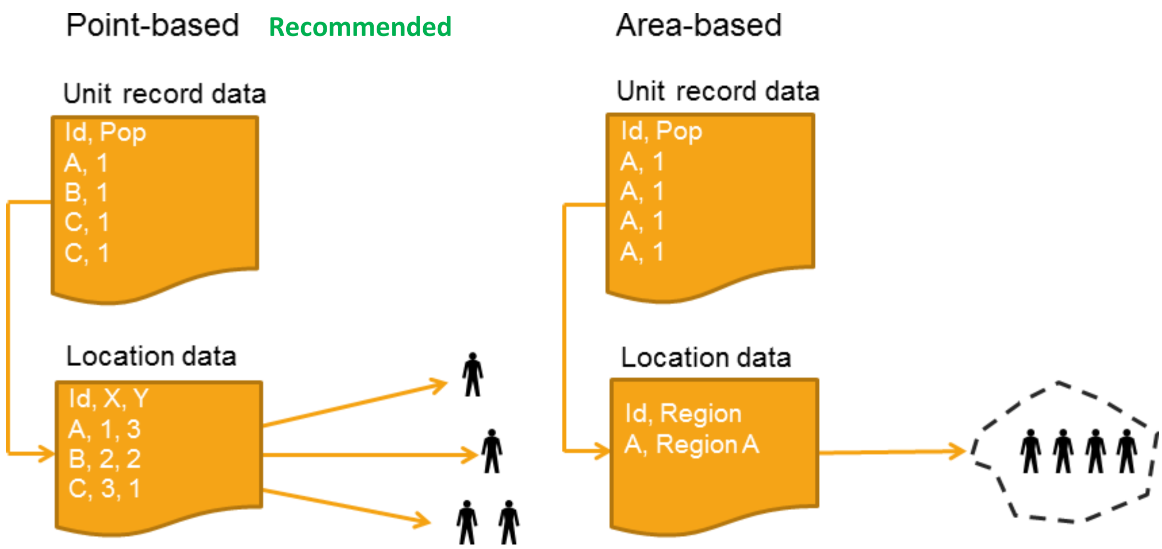
However, reliable registers of addresses or up-to-date cadastral data are not always available in countries. Often, it is necessary to conduct field work for map updating or household listing largely in advance of the period of the census enumeration, to identify, number and classify buildings and dwellings with GNSS enabled handheld devices and Earth Observation data as base maps, for geocoding with geographic coordinates.

Even though this requires resources and technical capabilities, many countries developed and implemented in the 2020 census round an integrated electronic system strategy for census mapping, composed of GIS tools, GNSS, high-resolution satellite imageries as EO data and handheld devices synchronised with a cloud-based dashboard. Such systems are used for map updating activities, EA

[53] UN Principles and Recommendations provides a list of recommended topics to be investigated in population censuses. While “core topics” should be collected directly, “derived core topics” are obtained indirectly from questionnaire variables. Non-core or additional topics are such topics which are not regarded to have the highest priority but which some countries may find useful to include in their census.

boundaries delineation, numbering of buildings and listing of households. These systems are also integrated with the Computer Assisted Personal Interviewing (CAPI) applications used in the enumeration process, and with field management and monitoring activities.

Figure 4.5 – Point-based versus area-based geocoding



One of the main characteristics of these systems are that the integration between geospatial and census data occur at point-based level, geocoded through unique identifiers and geographic coordinates. Such characteristics allow the aggregation of census data in any spatial dimension and allow integrating spatial data from different sources (figure 4.6).

Figure 4.6 – Example of integration of geospatial data sources

Once disclosure control is ensured, geocoded census small area data can be used by the government and development partners at any level for planning and policy purposes, and for support computing some SDG indicators, or for their monitoring and dissemination.

4.5 Measuring SDG indicators with the support of geospatial and census data

This section provides detailed analysis for each of the four SDG indicators listed earlier in this chapter:

- 9.1.1 Proportion of the rural population who live within 2 km of an all-season road
- 11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
- 11.3.1 Ratio of land consumption rate to population growth rate
- 11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.

It discusses how integrating PHC data, preferably geocoded at point-based level, with geospatial data can enrich the methodological design and procedures in generating and disaggregating SDG indicators that have geographic characteristics, providing specific contributions to the metadata information already available in the SDG metadata repository[54].

For each of the four indicators under consideration, the following aspects are discussed:

- Review of concepts and definitions
- Review of data sources, focusing on the role of PHCs
- Method of computation, focusing on the role of geospatial information
- Data disaggregation
- Comments and operational suggestions

The objective is also to advice the bodies of National Statistical Systems (NSSs), as the main producers of SDG indicators, on the limitations in the use of geospatial data in terms of spatial data availability and needed resources, and to make suggestions for the design of census questionnaires, particularly for location-based variables, in order to better measure SDG indicators.

SDG 9.1.1 - Proportion of the rural population who live within 2 km of an all-season road

Goal: 9 Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Target: 9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all

a) Review of concepts and definitions

This indicator, also known as Rural Access Index (RAI), measures the share of a country's rural population that lives within 2 km of an all-season road. The RAI, originally developed by the World Bank[55] in 2006, is an important indicator for the transport sector especially in rural areas of developing countries, were transport connectivity limits economic and social development.
It is recognised that when road conditions are good, travel time and costs are reduced, agricultural products get to market faster and at lower prices, more jobs can be created, and poverty could be

[54] https://unstats.un.org/sdgs/metadata/
[55] The World bank is the responsible agency for this SDG indicator.

reduced in a long-term perspective. The access to social and administrative services improves, especially in rural and remote areas where sometimes most poor people live.
The indicator is measured by combining sets of geospatial data on rural population distribution, road network, and road conditions. The spatial distribution of the rural population is usually derived from a population and housing census when it is geocoded. Data on road networks should come from national data or can be derived from global spatial datasets such as OpenStreetMap or from EOs, with some approximation. The concept of "all-season" road network remains central to the original concept of measuring the RAI. An "all-season road" is defined as a road that is motorable all year round by the prevailing means of rural transport (often a pick-up or a truck which does not have four-wheel-drive). Temporary interruptions due to weather conditions (e.g., heavy rainfall) are accepted, particularly on low volume roads. A road that it is likely to be impassable to the prevailing means of rural transport for a total of 7 days or more per year is not regarded as all-season.

b) Review of data sources, focusing on the role of PHCs

From a geospatial perspective, the indicator requires two types of geospatial data georeferenced in the same coordinate system:

- delimitation of rural areas
- road network

From a statistical perspective, the indicator requires:

- rural population
- classification of road network by road conditions

From the perspective of integrating geospatial and census data, the indicator requires:

- geocoded rural population data
- all-season roads georeferenced in the same geographic coordinate system used by the geocoded rural population data

c) Method of computation, focusing on the role of geospatial information

As pointed out in the SDG metadata repository, the measurement of the rural access index requires the identification and location of the rural population, that is usually implemented on the basis of the definition of urban and rural areas, and then excluding from the computation the population living in urban areas. The road network may be available at national level, or derived from open-source data, such as OpenStreetMap, or from transport services. More difficult may be the identification of "all-season" roads. An "all-season road" is defined as "a road that is motorable all year round by the prevailing means of rural transport (often a pick-up or a truck which does not have four-wheel-drive). Predictable interruptions of short duration during inclement weather (e.g., heavy rainfall) are accepted, particularly on low volume roads. A road that it is likely to be impassable to the prevailing means of rural transport for a total of 7 days or more per year is not regarded as all-season".

The defined method of computation indicates three steps to generate this indicator:

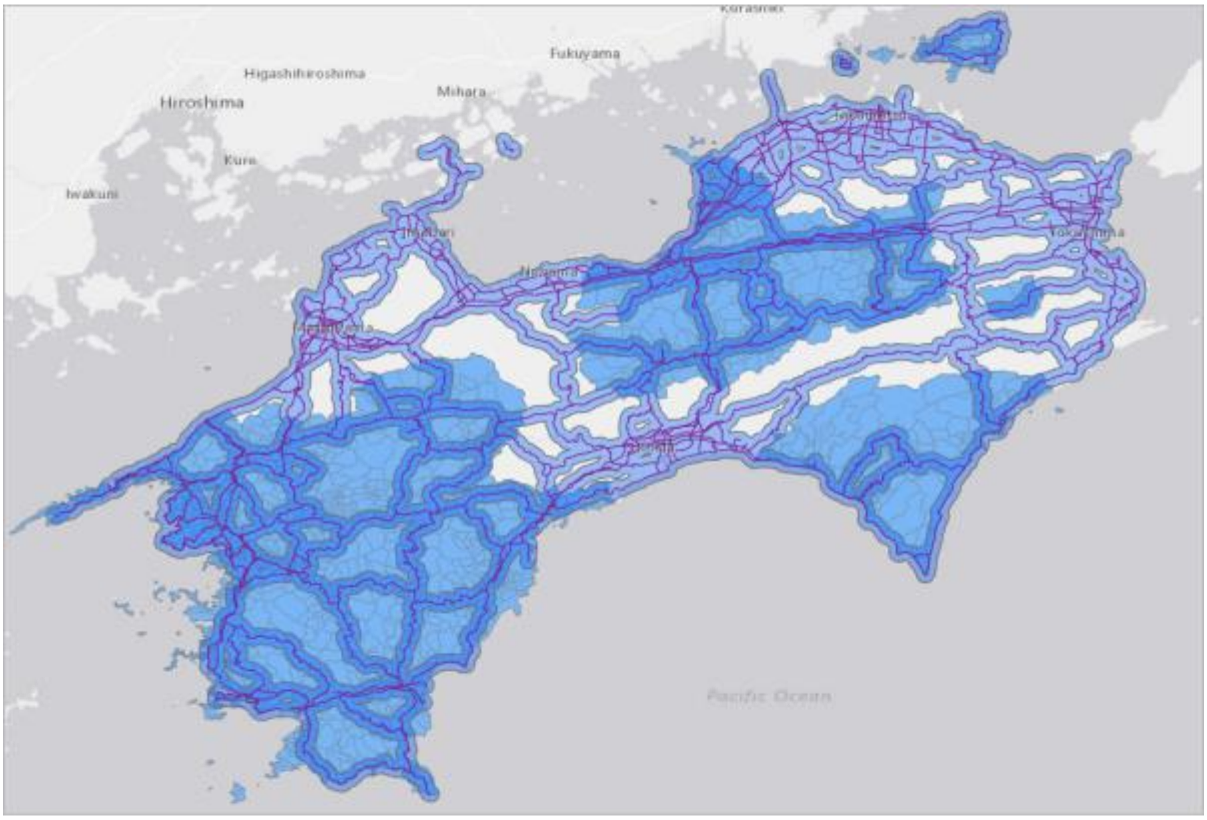
(i) Delimitation of the rural areas and identification of the rural population, usually from PHCs or, less recommended, from global spatial datasets. In this respect, it is important that population data is geocoded at point-based level, or by very small area level, or by small cell size grids. Census EAs in rural areas are often large and would not allow the calculation of distances of 2 km from the road network
(ii) Inventory and mapping of all-seasons roads and implementation of a geospatial data set in a GIS environment with the same coordinate system used for the spatial dataset of the rural population distribution as in (i) above

(iii) Using GIS tools, generating a 2 km buffer around the road network identified as in (ii) to calculate the rural population within the threshold. The final RAI is determined by dividing the identified portion of the rural population with the total rural population. The indicator can be calculated at national and/or sub-national levels.

d) Data disaggregation

Although this indicator is internationally required at national level only, countries may decide to generate it at sub-national levels as well, using the same methodology indicated above.

Figure 4.7 – Rural population served by all-seasons roads within 2 km, Shikoku region, Japan



Source: ESRI

e) Comments and operational suggestions

The quality of the SDG indicator 9.1.1 is highly dependent on the availability of geocoded population data living in rural areas. The best data source is PHCs, if the following conditions are met: i) census data is geocoded at point-based level (e.g., dwelling/household or building levels, or by small size cells grid); ii) rural areas are defined according to statistical methods, using the Degree of Urbanisation approach (DEGURBA)[56].

The indicator depends heavily on the quality and extent of the underlying spatial data as well. Verification against open-source data and EO satellite data where possible is recommended.

[56] https://ghsl.jrc.ec.europa.eu/degurba.php

Also, available spatial datasets of road networks should be verified in the field to ensure that the all-seasons roads are identified and mapped in a GIS environment according to the internationally agreed methodology. This is possible by driving along the identified all-seasons roads with GNSS devices operating in tracking mode and transferring the corresponding geospatial data into a GIS environment. Digital Elevation Models (DEM) could be also used in mountainous terrains, in conjunction with EO data.

Although the method of computation of this indicator is conceptually simple, it requires some specialised technical capacity in the use of geospatial technologies that are not always available in countries. Many developing countries are able to geocode only at EA area levels, and this may introduce relevant statistical bias in the computation procedure. Also, the often use of administrative classification of urban and rural areas does not correspond to the actual situation in many rural environments, and such element may interfere with the overall quality of the indicator.

SDG 11.2.1 - Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities

> Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable
>
> Target 11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.

a) Review of concepts and definitions

As stated in the SDG metadata repository, this indicator, under the custody of the UN-Habitat (United Nations Human Settlements Programme), aims to "measure and monitor the use of and access to the public transportation system of citizens, improving the access to areas with a high proportion of transport disadvantaged groups such as older persons, persons with disabilities, and low-income earners or areas with specific dwelling types such as high occupancy buildings or public housing and reducing the need for mobility by decreasing the number of trips and the distances travelled".

This indicator is monitored by the proportion of the population that has convenient access to public transport in terms of pedestrian walks from the origin of the trips to public transport stops and from public transport stops to the destination of the trips. The access to public transport is considered convenient when an officially recognized stop is accessible within a walking distance along the street network of 500 m from a reference point such as a home, school, workplace, market, etc. to a low-capacity public transport system (e.g. bus, Bus Rapid Transit) and/or 1 km to a high-capacity system (e.g. rail, metro, ferry). Additional criteria for defining public transport that is convenient include:

(i) Public transport accessible to all special-needs customers, including those who are physically, visually, and/or hearing-impaired, as well as those with temporary disabilities, the elderly, children and other people in vulnerable situations
(ii) Public transport with frequent service during peak travel times
(iii) Stops present a safe and comfortable station environment.

b) Review of data sources, focusing on the role of PHCs

From a geospatial perspective, the indicator requires four types of spatial information:

- location of the population
- point location of public transports stops
- paths that the population should cover between locations (place of the origin of the trip, transport stop, place of the destination of the trip)
- boundaries of cities and urban areas, being an indicator classified under Goal 11

From a statistical perspective, the indicator requires:
- urban population
- urban population disaggregated by sex, age, and disability status
- quality of transport stops

From the perspective of integrating geospatial and census data, the indicator requires:
- urban population geocoded by location
- classification of the public transport (e.g., bus, metro, rail, ferry and their quality) by location of stops

c) Method of computation, focusing on the role of geospatial information

Although the indicator should also consider the quality of the access with a focus on special-needs customers, such as people with disabilities, elderly, children, and other people in vulnerable situations, it is nowadays internationally agreed that convenient access in terms of distance is 500 m or 1 km walking distance to a public transport stop. Also, the SDG metadata repository specify that the indicator should consider the frequency of public transport and the quality of the stops in terms of safety and comfort. Data should be reported in an interval of three-to-five-year, based on availability of new data.

The defined method of computation indicates five steps to generate this indicator:

(i) Delimitation of the city or urban area where the indicator should be generated, using GIS tools applied to the concept and methodology developed for the calculation of the Degree of Urbanisation (DEGURBA)[57].

(i) Inventory and mapping of the public transport stops in the city or the service area provided by Local Administrations or by transport service providers. If data is not available or of poor quality, location and quality of public transport stops can be derived from open spatial data sources such as OpenStreetMap or Google, EO high-resolution satellite images, or collected in the field with GNSS devices.

(ii) Network analysis based on street network to measure walkable distance of 500 m and/or 1 km to nearest transport stop. The analysis requires specific GIS tools available in some GIS suites to create “service areas” and assume that a well-defined street network is available. If it is not the case, other spatial data sources such as OpenStreetMap could be used in combination with EO and GNSS data. Field verifications may be necessary to verify that no barriers along the streets are present, and that streets are walkable. If not possible, the major assumption in creating the service areas is that all streets are walkable.

(iii) Estimation of population within the walkable distance to public transport. The “service areas” are overlayed with GIS tools and functions with demographic data. The best source of population data is point-based data at dwelling, building or city block levels usually derived from population and housing censuses. If not available, countries are encouraged to create population grids of small cell size[58].

(iv) Estimation of the proportion of the population with convenient access to public transport out of the entire city population or urban areas and disaggregated by intra-urban locations. Since the “service areas” can intersect more than one “population area” (e.g., dwelling, building, city block,

[57] https://unstats.un.org/unsd/statcom/51st-session/documents/BG-Item3j-Recommendation-E.pdf
[58] https://ec.europa.eu/eurostat/statistics-explained/index.php/Population_grids

enumeration area), the served population that has convenient access to public transport is the sum of all the “population areas” that are within, partially or completely, the “service areas”.

d) Data disaggregation

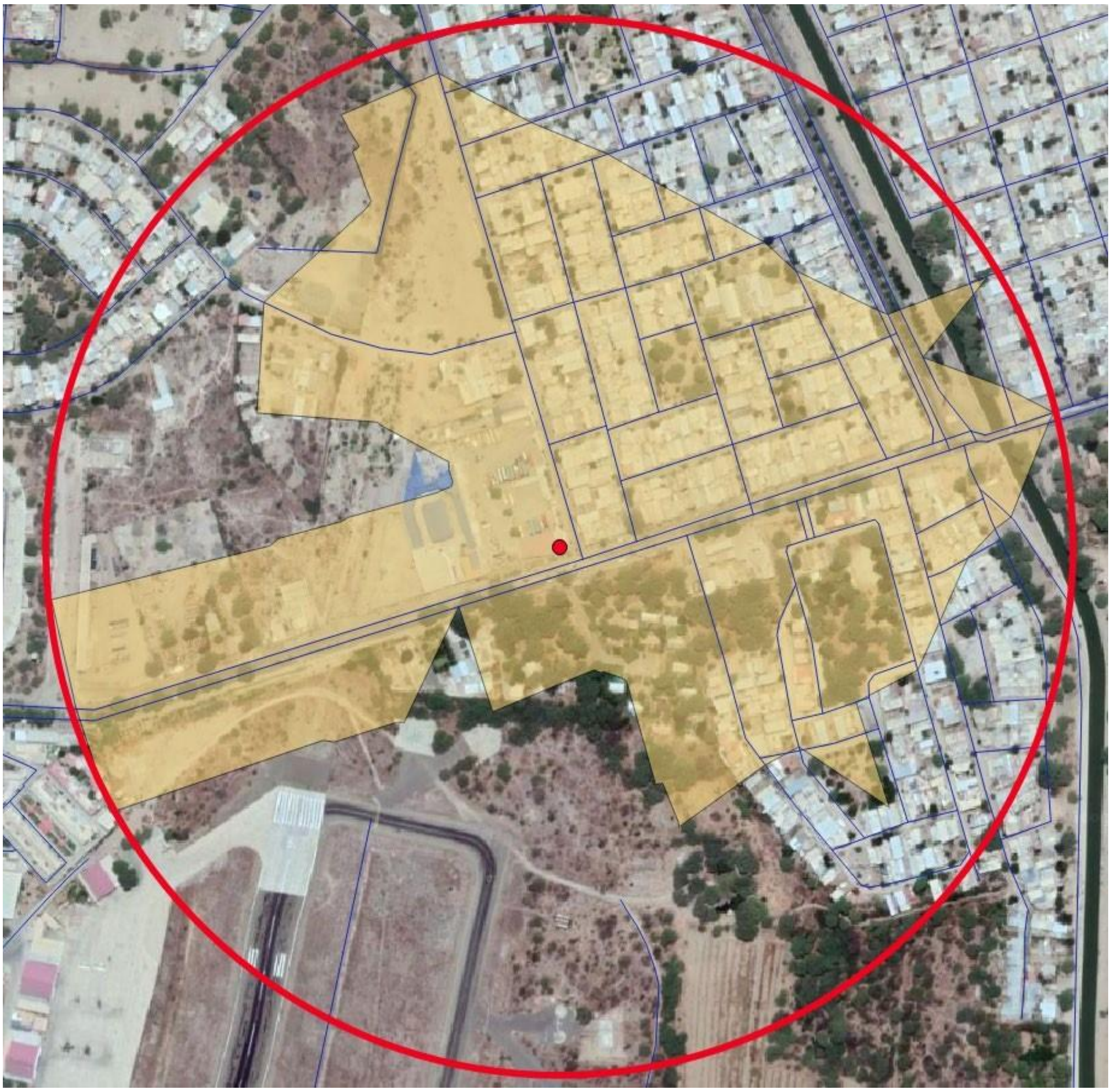
According to the SDG metadata repository, typical types of disaggregation include:

- Disaggregation by location (intra-urban)
- Disaggregation by income group
- Disaggregation by sex (female-headed household)
- Disaggregation by age group
- Disaggregation by type of public transport system (low-capacity vs high-capacity systems)
- Disaggregation by formality of public transport carrier (formal vs paratransit transport modes)
- Disaggregation by mode to reach public transport (walking vs cycling)

From such data disaggregation, it is possible to derive the following sub-indicators. Most of them could benefit from the PHCs data integrated with geospatial information.

- Proportion of urban area that is served by convenient public transport systems
- Proportion of population/urban area that has convenient access to public transport stop with universal accessibility for people with disabilities
- Proportion of population/urban area that has frequent access to public transport during peak hours
- Proportion of population/urban area that has frequent access to public transport during off-peak hours
- Proportion of population with access to low-capacity systems (e.g. bus) and high capacity systems (e.g. metros), access by walking vs. biking, etc.
- Proportion of population with access to formal vs paratransit transport modes
- Share of population using different transport modes (modal share)

Figure 4.8 – Population that has convenient access to public transport, street network (yellow transparent) and buffer of 500 m (red circle)



Source: UN-Habitat

e) Comments and operational suggestions

The SDG indicator 11.2.1 has relevant spatial characteristics since it is based on the measure of physical distances that requires the use of geospatial data, GIS tools and EO data.

Because it measures short distances (500 m and 1 km) in urban environments, geospatial data and demographic data need high-resolution spatial detail.

In countries where a reliable address system and a population register linked to a register of buildings and dwellings is not available, PHCs are the main data sources of population data and their disaggregated population groups. However, census data should be geocoded at point-based level or by small cell size grids (e.g., 100 m), census data aggregated at EA level are not appropriate to generate representative data of the indicator.

In addition to the place of usual residence of individuals, PHCs may collect locations of collective living quarters, places of work and schools or universities, thus making it possible to compute this SDG indicator also for locations other than the place of residence and to perform spatial data analysis to generate information on “access to opportunities”.

Considering the number and quality of necessary geospatial data (location data on transport stops, street network, definition of urban limits) to perform spatial analysis together with the availability of PHC data geocoded at the level of dwellings and buildings, the computation of this indicator may be possible only in some countries, where appropriate geospatial data, capacities, and resources are available.

SDG 11.3.1 - Ratio of land consumption rate to population growth rate

> Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable
>
> Target 11.3: By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries

a) Review of concepts and definitions

This indicator, under the responsibility of the UN-Habitat, shows the progressive spatial expansion of a city and requires defining the rates of the two components: population growth and land consumption. While population growth - increase in the number of individuals in a population, generally in one year – is a well know measure, the concept of land consumption required several debates at the international level to reach a general agreement on its definition, to be applied in the framework of the 2030 SDG Agenda. Nowadays, it is accepted that the percentage of current total urban land that was newly developed (consumed) is the measure of the land consumption rate.

The land consumption rate is the rate at which urbanized land or land occupied by a city or urban area changes during a period of time (usually one year), expressed as a percentage of the land occupied by the city/urban area at the start of that time. Built up area within the context of indicator 11.3.1 is defined as all areas occupied by buildings.

The city or urban area is nowadays defined according to the methodology of the Degree of Urbanisation (DEGURBA), following its endorsement in March 2020 by the United Nations Statistical Commission, in its 51st Session. This methodology combines population size and population density thresholds to classify the entire territory of a country along the urban-rural continuum, and captures the full extent of a city, including the dense neighbourhoods beyond the administrative boundaries of cities.

Data for this indicator combines Earth Observation, geospatial analysis and population data from censuses and surveys. Input data for computation of the land consumption rate can be derived from satellite imagery through remote sensing and geospatial analysis processes applied to high to medium resolution satellite images. High-resolution satellite images can provide better data quality.

b) Review of data sources, focusing on the role of PHCs

From a geospatial perspective, the indicator requires two types of spatial information:

- identification of the built-up area

- delimitation of the urban agglomeration and eventually of intra-urban locations and urban typologies[59]

From a statistical perspective, the indicator requires:

- population numbers of the city defined with the DEGURBA methodology and eventually of intra-urban locations and urban typologies, which form the urban population

From the perspective of integrating geospatial and census data, the indicator requires:

- urban population geocoded by location, preferably using the point-based approach, in order to develop population grids used by the DEGURBA methodology.

c) Method of computation, focusing on the role of geospatial information

The defined method of computation indicates four steps to generate this indicator:

(i) Defining the period of the analysis. This is usually a period of 5 or 10 years, allowing comparison between two consecutive PHCs.

(i) Calculation of the population growth rate as a percentage change in the size of the population in a defined period. It is calculated by dividing the number of people added to a population in the reference period (Natural Increase + Net In-Out Migration) by the population size at the start of the period.

(ii) Calculation of the land consumption rate as the percent of the total area of the urban agglomeration in sq km for the current year divided by the total area of the urban agglomeration in the past/initial period.

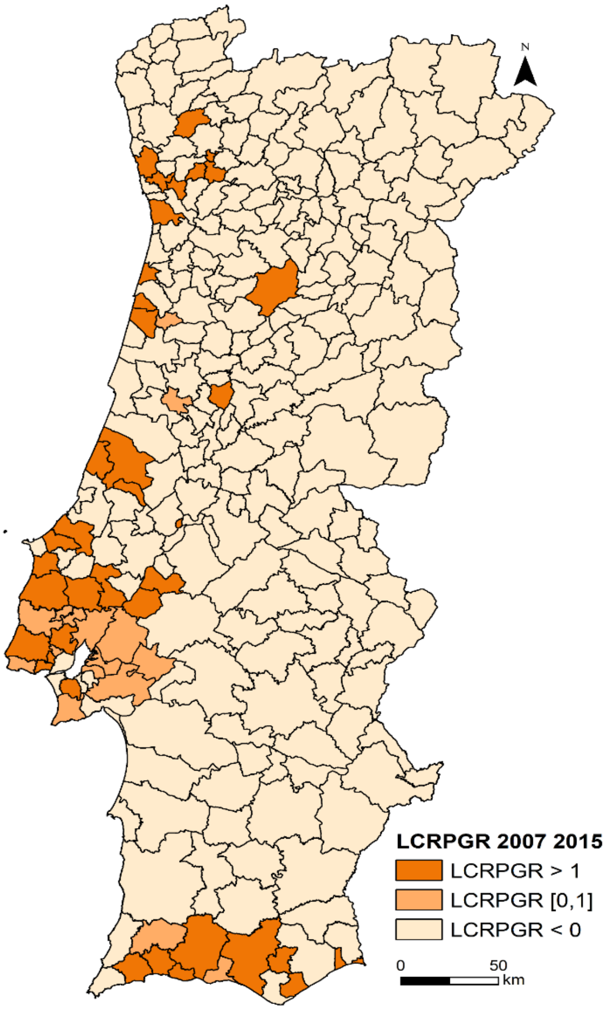
(iii) Calculation of the ratio of land consumption rate to population growth rate by dividing the land consumption rate by the annual population rate.

d) Data disaggregation

As indicated in the SDG metadata repository, the indicator should be spatially disaggregated by location (intra-urban), income level and urban typology. The periods considered in the computation of the indicator for both urban expansion and population growth should be comparable, and it should be revised every 5 years.

Figure 4.9 – Example of ratio of land consumption rate to population growth rate (LCRPGR), Portugal

[59] https://ghsl.jrc.ec.europa.eu/degurba.php



Source: UN-GGIM

e) Comments and operational suggestions

The SDG indicator 11.3.1 is an example of integrating land use with population data.

The identification of built-up areas and the delimitation of urban agglomerations require the availability and use of EO data and GIS tools.

When PHC data is geocoded at point-based level, it is possible to identify both the urban population for the area analysed, and the extension of the urban area where such population is living. This can be achieved by applying the methodology to construct population grids, developed in the framework of the concept of Degree of Urbanisation implemented by the UN-Habitat Global Human Settlement Layer (GHSL) project.

Conceptually, the definition of urban areas/cities and built-up areas are central for a correct calculation of this indicator. Urban areas and cities should be identified based on a statistical definition, instead of an administrative definition, at the national level. Built-up areas should also be better defined, for instance by excluding public spaces including parks, gardens, and roads.

The computation of this indicator should involve not only NSOs where capacity and experience in EO and GIS is limited, but also other specialised institutions with expertise in geospatial data and technologies, such as national Mapping Agencies or Academia.

SDG 11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Target 11.7: By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

a) Review of concepts and definitions

This indicator, also linked to the previously discussed items 11.2.1 and 11.3.1, requires the definition of relevant spatial-related concepts including built-up areas, cities, and open spaces for public use. They have been recently further discussed internationally within the UN-Habitat as the custodian agency for this SDG indicator, together with researchers and other partners. The main results of the discussion are reported in the SDG metadata repository and summarised below.

- **(i) Built-up area of cities:** Conventionally, built up areas of cities are areas occupied by buildings and other artificial surfaces. For the indicator 11.7.1, built up areas have the same meaning of cities (see definition of city below).
- **(ii) City:** Definitions of cities largely vary across countries, and they can be based on the characteristics and extent of built-up areas and population data, or by administrative boundaries or by functional criteria. In order to define standard criteria for the SDG global monitoring and reporting processes, the United Nations Statistical Commission, in its 51st Session of March 2020, endorsed the Degree of Urbanisation (DEGURBA) as the recommended method to delineate cities, urban and rural areas for international statistical comparisons.[60] For the computation of indicator 11.7.1, countries are encouraged to adopt the degree of urbanisation to define the analysis area (city or urban area).
- **(iii) Public space:** Public Space is defined as all places that are publicly owned or of public use, accessible and enjoyable by all, for free and without a profit motive, categorized into streets, open spaces and public facilities. For monitoring and reporting on indicator 11.7.1, public space is defined as all places of public use, accessible by all, and comprises open public space and streets.[61]
- **(iv) Open public space** is any open piece of land that is undeveloped or land with no buildings (or other built structures) that is accessible to the public without charge, and provides recreational areas for residents and helps to enhance the beauty and environmental quality of neighbourhoods. Open public spaces are broadly classified into six categories: national/metropolitan open spaces, regional/larger city open spaces, district/city open spaces, neighbourhood open spaces, local/pocket open spaces and linear open spaces. Classification of open public space by typology is described by the function of the space and can include: green public areas, riparian reserves, parks and urban forests, playground, square, plazas, waterfronts, sports field, community gardens, parklets and pocket parks.
- **(v) Potential open public space:** the identification of open public spaces across cities can be implemented through, among other sources, analysis of high to very high-resolution satellite imagery, from base-maps provided by different organizations (eg OpenStreetMap, Esri, etc) or as crowd-sourced and volunteered data. While these sources provide important baseline data for indicator 11.7.1, some of the identifiable spaces may not meet the criteria of being "accessible to

[60] A recommendation on the method to delineate cities, urban and rural areas for international statistical comparisons. https://unstats.un.org/unsd/statcom/51st-session/documents/BG-Item3j-Recommendation-E.pdf
[61] https://unhabitat.org/sites/default/files/2020/07/indicator_11.7.1_training_module_public_space.pdf.

the public without charge". The term "potential open public space" is thus used to refer to open public spaces which are extracted from the above-mentioned sources (based on their spatial character), but which are not yet validated to confirm if they are accessible to the public without charge.

(vi) Streets are defined thoroughfares that are based inside urban areas, towns, cities and neighborhoods most commonly lined with houses or buildings used by pedestrians or vehicles in order to go from one place to another in the city, interact and to earn a livelihood. The main purpose of a street is facilitating movement and enabling public interaction. The following elements are considered as streets space: Streets, avenues and boulevards, pavements, passages and galleries, Bicycle paths, sidewalks, traffic island, tramways, and roundabouts. Elements excluded from street space include plots (either built-up), open space blocks, railways, paved space within parking lots and airports and individual industries.

(vii) Land allocated to streets refers to the total area of the city/urban area that is occupied by all forms of streets (as defined above). This indicator only includes streets available at the time of data collection and excludes proposed networks.

b) Review of data sources, focusing on the role of PHCs

EO data of high-resolution satellite imageries, open-source datasets such as OpenStreetMap, documentation outlining publicly owned land and community-based maps are the main sources of geospatial data. Data derived from PHCs are the main information for identifying the share of the urban population with access to public open spaces.

From a geospatial perspective, the indicator requires two types of spatial information:

- identification of the urban areas or city extent that can be extracted by EO high-resolution data
- inventory of public spaces that can be derived by documentation already available, or extracted from EO data, or by other spatial datasets
- the share of land occupied by public open spaces in the overall urban area
-

From the statistical perspective, the indicator requires:

- population numbers of the city and eventually of intra-urban locations and urban typologies

From the perspective of integrating geospatial and census data, the indicator requires:

- population numbers geocoded by location, preferably by point-based location

c) Method of computation, focusing on the role of geospatial information

The computation of the indicator is a four-step process:

(i) **Spatial analysis to delimit the city/urban area**: the first step aims at identifying the urban area following the DEGURBA methodology as endorsed in March 2020 by the United Nations Statistical Commission, in its 51st Session[62].

(ii) **Spatial analysis to identify potential open public spaces**: an inventory of open public spaces may be available from local administrations. If it is the case, the use of GIS and other geospatial tools can be used to compute or verify the location and size of such areas. Field activities can also be used to validate the calculations made from the available inventory data. If an inventory of open public spaces is not available, EO data and GIS functions are very useful tools to identify and locate them and to calculate the geographic extension of such areas. Also in this case, field activities can be extremely important to validate the results obtained by using high-resolution satellite images and GIS software. For instance, there may be the need to remove from the computation areas that are not open to public access, or to add areas that were initially classified

[62] https://unstats.un.org/unsd/statcom/51st-session/documents/BG-Item3j-Recommendation-E.pdf

as non-open public spaces. Interactive and user-friendly modules for this kind of spatial analysis are available in most of the GIS packages. UN-Habitat, in consultation with partners, experts and data producers have developed a free tool to facilitate the verification of each space and collection of additional data on the space quality and accessibility.[63]Once all public open spaces have been identified, calculated in terms of area, their sum is divided by the total area of the city, in percentage.

(iii) **Estimation of the total area allocated to streets**: where the length and width of streets are available from administrative data sources, the area allocated to streets can be easily calculated. Otherwise, GIS functions could be also useful to identify and calculate the length and with of streets, sometimes with the help of high-resolution satellite images, or by using free online spatial datasets such OpenStreetMap. The share of the built-up area of cities that is open space for public use is then calculated by the sum of open public spaces a) and areas allocated to streets b), divided by the total area of the city.

(iv) **Estimation of share of population with access to open public spaces**: after an extensive consultation of stakeholders organised by UN-Habitat, it was agreed that a walking distance of 400 meters - equivalent to 5 minutes' walk is a practical and realistic threshold to estimate the share of population that has access to open public spaces. Based on this, a street network-based service area is drawn around each public open space, using the 400 meters access threshold. Therefore, all populations living within the service areas are in turn identified as having access to the public open spaces, based on the following key assumptions:
   - Equal access to each space by all groups of people - i.e. children, the disabled, women, elderly can walk a distance of 400 meters (for 5 minutes) to access the spaces (in actual sense, these will vary significantly by group)
   - All streets are walkable - where existing barriers are known (e.g. un-walkable streets, lack of pedestrian crossings, etc), these can be defined in the delimitation of the space service area
   - All public open spaces have equal area of influence - which is measured as 400 meters along street networks; in real life situations, bigger spaces have a much larger area of influence.
   - All buildings within the service area are habitable, and that the population is equally distributed in all buildings/built up areas

The 400 meters walking distance service area from the identified open public spaces can be developed by GIS functions that include network analysis tools. In principle, it is recommended to develop separate service areas for each open public space and then merge all of them in a single GIS layer. Finally, the merged service areas have to be overlayed to geocoded population data, also using GIS overlay tools. The share of the population having access to open public space is then calculated in percentage by dividing the population located within the 400 metres service areas, by the total population of the city or of the considered urban area.

d) Data disaggregation

Based on availability of high-resolution population data, population with access to open public spaces should be disaggregated by age, gender and persons with disabilities.

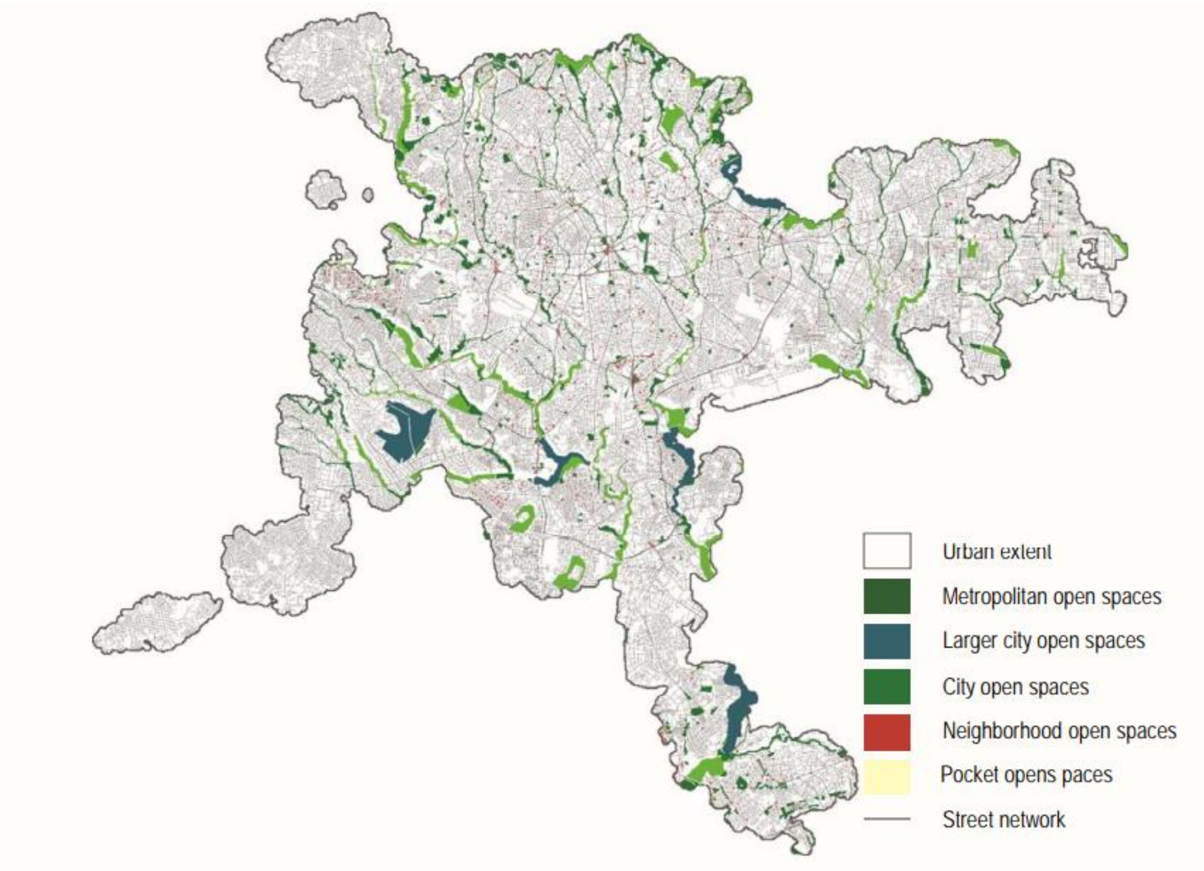
Wherever possible, it would also be useful to have information disaggregated by:
- Location of public spaces (intra-urban)
- Quality of the open public space by safety, inclusivity, accessibility, greenness, and comfort
- Type of open space as a share of the city area

[63] https://ee.kobotoolbox.org/x/IGFf6ubq

- The share of open spaces in public use which are universally accessible, particularly for persons with disabilities.
- Type of human settlements

The best source of population data for the analysis is point-based individual dwelling or block level total population which is collected by National Statistical Offices through censuses. Where this level of population data is not available, or where data is released at large population units, countries are encouraged to create population grids, which can help disaggregate the data from large and different sized census/ population data release units to smaller uniform sized grids.

Figure 4.10 – Example of public open spaces in urban areas, Addis Ababa, Ethiopia



Source: UN-Habitat

e) Comments and operational suggestions

At the global level, the harmonization of data sources is proposed to ensure more consistent reporting on this indicator.

For estimating the total surface of built-up area, it is proposed the use of existing layers of satellite imagery ranging from open sources, such as Google Earth and US Geological Survey/NASA Imagery Landsat, to more sophisticated and higher resolution land cover datasets.

For the Inventory of open public space, information can be obtained from legal documents outlining publicly owned land and well-defined land use plans. In some cases, where this information is lacking, incomplete or outdated, open sources, informants in the city and community-based maps, which are increasingly recognised as a valid source of information, can be a viable alternative.

The share of land in public open spaces cannot be obtained directly from the use of high-resolution satellite imagery because it is not possible to determine the ownership or use of open spaces by remote sensing. However, fieldwork to validate and verify the open spaces derived from satellite imagery helps to map out land that is for public and non-public use.

At national level, PHCs can play a relevant role in identifying and mapping population at small-area level. Also, a relevant contribution can derive from point-based geocoded census data for the definition of built-up areas and for locating and classifying open public spaces when the census operation is associated to an ambitious census mapping programme.

However, generating this indicator by integrating census data and geodata information requires specific technical capacities that are not always available in NSOs. An institutional cooperation with national Mapping Authorities may be required.

4.6 Spatial disaggregation of SDG indicators

The SDG global indicator framework was adopted by the UN General Assembly on 6 July 2017[64], emphasizing the importance of geographical disaggregation of the indicators, along with sex, age, income, race, ethnicity, migratory status, and disability. Nowadays, it is globally recognized that the implementation and monitoring of the 2030 Agenda for Sustainable Development requires the collection, analysis and availability of data and indicators not only at global, regional, and national levels. The main challenge is the availability of data at subnational and small territorial levels that mostly national PHCs can provide. National data sources, and especially PHC data, can provide detailed and high quality integrated statistical and geospatial data for greater territorial disaggregation of the indicators, thus ensuring qualitative computing of a relevant number of SDG indicators, and their measure of progress over time at small territorial levels.

To develop a common framework for SDG data disaggregation, the IAEG-SDGs had defined the concepts of disaggregation dimensions and their corresponding categories[65]:

- **Disaggregation dimensions**: the characteristics by which data are to be disaggregated.
- **Disaggregation categories**: the different characteristics under a disaggregation dimension.

As mentioned above in this sub-chapter, the dimensions are:

- Sex
- Age
- Income
- Race
- Ethnicity
- Geographical Location
- Migratory, and
- Disability Status

The categories are:

[64] Resolution adopted by the General Assembly on 6 July 2017 on Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313).
[65] IAEG-SDGs. 2019. Data Disaggregation and SDG Indicators: Policy Priorities and Current and Future Disaggregation Plans.

- Category 1. Dimensions mentioned in the goals or targets (also referred to as the minimum set of data disaggregation)
- Category 2. Dimensions for which data are currently available (includes other dimensions in addition to the minimum set)
- Category 3. Dimensions for which the international custodian agencies may introduce in the future (includes other dimensions in addition to the minimum set)

PHCs and sample surveys are traditionally the two main data sources of national statistical systems for data on population that are disaggregated at different geographical levels. PHCs can provide data to directly calculate indicators on census topics disaggregated by sex, age, ethnicity and race, disability and migrant status, education level, and geographic location. At the same time, they can be used as inputs for small area estimation modeling to produce disaggregated data derived from sample surveys, in connection with the use of detailed and geocoded statistical data.

Indeed, recent developments in the use of high-resolution EO data for statistical surveys, statistical methods for the use of grid statistics and GIS tools are facilitating the enhancement and use of methods that can estimate more granular population scales across countries, in cases where population and housing censuses cannot be conducted, or during the intercensal periods. This method is usually implemented by conducting full surveys in selected sample areas and applying statistical models for non-sampled areas based on the data gathered from the sample areas. This approach cannot fully replace the data produced by a traditional population and housing census, but under some circumstances can generate population estimates for small areas[66,67].

The generation of the four SDG indicators discussed above in this chapter shows that when population data is collected at point-based territorial level providing geocoded statistical data at dwelling or building levels, SDG indicators can be computed at high quality, and then aggregated at higher territorial levels, such as for intra-urban areas or cities or for regions. Statistical data geocoded at the level of census enumeration area or by grid, also offer valid data sources, although the results are generally less accurate when compared to the results that can be obtained in terms of spatial disaggregation, if statistical data is geocoded at dwelling or building levels.

The “Practical guidebook on data disaggregation for the sustainable development goals”[68], published in May 2021 by the Asian Development Bank (ADB) and UNSD, with relevant inputs from other UN Agencies and stakeholders, provides a framework for statisticians and data analysts of National Institutes of Statistics and sectoral ministries for data disaggregation of SDG indicators, although focusing mainly on the monitoring of progress of the SDGs.

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[66] UN Population Fund. 2017. New Methodology: a hybrid census to generate spatially disaggregated population estimates—Technical Brief.

[67] N. A. Wardrop, W. C. Jochem, T. J. Bird, H. R. Chamberlain, D. Clarke, D. Kerr, L. Bengtsson, S. Juran, V. Seaman, and A. J. Tatem. 2018. Spatially disaggregated population estimates in the absence of national population and housing census data. Proceedings of the National Academy of Sciences Apr 2018, 115 (14) 3529-3537.
Geo-referenced Infrastructure and Demographic Data for Development. 2020. High resolution population estimates. B. Hellali. 2018. Hybrid census to generate spatially disaggregated population estimates.

[68] Practical guidebook on data disaggregation for the sustainable development goals. 2021. Asian Development Bank, Manila, Philippines.

5. Conclusions and recommendations

5.1 Conclusions and recommendations for SDG indicators that can be measured through PHCs and CRVSs

The analysis carried out in the previous chapters demonstrate the potential usefulness of PHC and CRVS data for the monitoring of the SDG indicators. In all, 40 indicators can be credibly estimated, at least to some extent, with the help of such data and for half of these indicators, census and CRVS data are actually the natural source. In addition, population data from censuses are useful for estimating and projecting the denominators for many population-based indicators. Finally, census, and, to a lesser extent, CRVS data present considerable advantages over surveys in terms of their potential for disaggregation by different population characteristics as they do not suffer from the restrictions of limited sample sizes that surveys have.

Detailed discussions on the possibilities for disaggregation of the indicators by the various population groups, urban/rural areas of residence, and by age, sex, education group, migration status and disability stress the value of these sources in monitoring the SDGs at subnational level. Linking relevant SDG indicators with the needs of national and sub-national governments can offer a greater capacity to inform policy by examining relevant disparities in population groups. The ability to analyse and compare the indicators by subgroups and subnational level can provide insights into measuring performance, driving policy reform and allocating resources effectively to socioeconomic development of a country.

The analysis of SDG indicators also indicates some challenges in the use of PHC and CRVS data. One of the concerns that has been raised is that these sources can suffer from under-count which might affect the quality of the results. Census under-count is only a problem to the extent that it occurs selectively in the population sub-groups relevant to the construction of the indicator. A more or less uniform under-count will not affect the estimation of the SDG indicators and disaggregation by different groups of population for example for people living in slums. But of course, if the under-count is mostly concentrated in particular population groups such as slum settlements, it will lead to under-estimation.

In the case of CRVS data, under-registration can be a problem, as it is usually not uniform throughout the population. However, there are ways to correct for this, as is most vividly illustrated by the case of maternal mortality. CRVS data on maternal mortality are known to be substantially under-stated even in the best of registration systems. Nevertheless, correction mechanisms have been devised and CRVS systems of sufficient quality are still considered the good standard for maternal mortality estimation.

As discussed in previous chapters, about half of the indicators that were identified can be estimated directly based on PHC or CRVS data. The others are proxy data that require statistical manipulation to approximate the desired concept or only contribute ancillary information that may be relevant to the indicator, but that by itself is insufficient for its calculation. To some extent this situation can be remedied by adding or fine-tuning some of the questions asked in future censuses.

For using PHC data for the global SDG monitoring, the most serious challenge is the heterogeneity in national census practices. Despite the best efforts of the international statistical community to unify concepts and homogenize the contents of census questions, there are still major variations in the questions that are asked and the categories used to code the responses. In the case of the CRVS there is greater homogeneity, but in most countries the system is incomplete and the quality of cause-of-death data is often deficient. Moreover, the information is often insufficient to produce all the relevant disaggregations. It is hoped that this report may provide additional motives for the further unification of national census practices, as national census authorities pay more systematic attention to the value of particular census questions for the estimation of SDG indicators.

In the previous section, the availability of PHC and CRVS data for the computation of the SDG indicators has been assessed primarily in terms of the recommendations included in the P&R and P&RVS and, to some degree, the national practices adopted in the 2010 census round. The fact that a a given question is part of the P&R core topics does not guarantee that the information will be available in every single country, but according to assessments of the 2010 census round made by UNSD, most of the recommended census topics were found to be relevant to all regions and covered by the majority of countries in their censuses.

Some specific recommendations have already been made in the discussion of specific indicators in chapter 3. The following lists some of the major areas in which PHC data could be extended, in order to cover a larger number of SDG indicators.

- One of the major deficiencies of PHC data is that most censuses do not provide income data. There are good reasons for this as the collection of income data from the census may require several questions and the quality of the data tends to be inferior to that of living standards or household expenditure surveys. Nevertheless, several of the SDG indicators (1.1.1, 1.2.1, 10.2.1 and others) depend on this information, which would allow much finer disaggregation than is currently possible with survey data.

- Even if no actual income data are collected, a list of potential income sources that contains all the relevant categories of indicator 1.3.1 (Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons, persons with disabilities, pregnant women, newborns, work-injury victims and the poor and the vulnerable) with a yes/no categorization would be very helpful to assess the coverage of social security systems in different population groups and would have significant advantages over the use of administrative data.

- The quality of coding practices for occupational data in census data processing (e.g. the level of detail provided) should be improved in ways that give priority to the identification of certain occupational groups relevant from the viewpoint of the SDG indicators, such as ISCO-08 codes 221, 222, 2261 and 2262 for identification of health worker density and distribution (3.c.1.) the characterization of managerial positions and the level of management (for 5.5.2), as well as the correct identification of teachers at the pre-primary, primary, lower secondary on upper secondary levels (for 4.c.1).

- In countries that do not have reliable child mortality data from the CRVS, the questions on the date of birth and the survival of the last live-born child can provide information relevant to the indicators of infant, child and neonatal mortality. Similarly, in countries with significant under-registration of births, should consider including the question on whether the births of children under age 5 have been registered.

- In countries that do not have reliable maternal mortality data from the CRVS, the census question on deaths in the household during the past 12 months, combined with questions on the age and sex of the deceased and whether the death occurred during pregnancy, childbirth, or 42 days after childbirth provides valuable information on maternal mortality. In the 2010 census round, about 30 countries asked this question, but it is hoped that this number will increase in the 2020 round.

- In countries with a high incidence of child marriage, it would be beneficial to include the question on age at first marriage or age at first consensual union, particularly in the case of women. Some PHCs already have this question, but a greater number could follow this example.

- Data on literacy should be extended to distinguish broad levels of literacy skills. Simple questions with response categories that reflect different levels of literacy skills should be used. In addition, since literacy is an applied skill, it needs to be measured in relation to a particular task, such as reading, with understanding, personal letters and newspapers or magazines, or writing a personal letter or message. Respondents may be able to do so easily, with difficulty or not at all, reflecting the different levels of literacy skills. Reading and writing may be measured separately to simplify the questions.

- Compliance with the standard format of the Washington Group questions on disability is still uneven. A more uniform application of this methodology would improve the international comparability of disability data for the disaggregation of several of the indicators in this report.

- The introduction of questions on access to and use of the internet is still relatively new and countries have approached the subject in different ways. In order to guarantee better alignment with the SDG indicators, consider the possibility of an individual level question about internet use, with an explicit time limit of three months, in addition to asking if an internet connection is available in the household. This also applies to the use of cell phones. Also, consider the possibility of assessing the availability of broadband internet (distinct from other types of internet service) at the household level, rather than just generic individual internet access at home or outside. Asking for the speed of the internet connection would further improve the usefulness of the question, although this may run into problems as household members may not know the speed of their internet connection.

- Generally, it would be adviseable to review all the categories of questions on issues such as the sources of drinking water, basic sanitation and the use of cooking and lighting fuels to make sure that all the categories relevant for the construction of the SDG indicators can be identified. In the case of sources of drinking water, this means not conflating safe with unsafe sources. In the case of lighting and cooking fuels, it means not mixing clean and non-clean fuel categories.

- For countries with a high level of child labour, it is recommended that the question on economic activity be extended to children over age 5, rather than 10, 12 or 15, so as to allow the measurement of child labour.

- It is suggested to extend the question on educational attendance to include alternatives pertaining to young people enrolled in informal and non-formal training programmes would help with the estimation of indicator 4.3.1 (participation rate of youth and adults in formal and non-formal education and training). Also, considering that adult education plays an important role in developing new skills and improving the career, education questions can be extended for collecting data on participation of adults in training.

- In the case of the CRVS, ensure the implementation of the item regarding attendance at birth in the CRVS, for the computation of indicator 3.1.*2* (proportion of births attended by skilled health personnel).

- It is recommended that geospatial information system be set up in such a way that it can be used for analytical purposes, to quantify the distance of population from service points, in addition to its standard role of guiding the organization of the census field work. In particular, this means that the census results need to be geo-referenced.

A final recommendation relates not to the data sources, but to the description of the methods used to construct the SDG indicators themselves. The current description of these methods in the SDG meta-data is primarily directed at the scientific justification of the process by which these indicators were obtained. In theory this allows independent researchers to replicate the entire process. However, NSOs that have no interest in the methodology of the global estimates, but that merely want to compute or disaggregate specific indicators for their countries may need more operational instructions to this end. It is recommended therefore that, in addition to the methodology of the global estimates, more attention be paid to mechanisms by which NSOs can reproduce and disaggregate these estimates at the national and sub-national level.

5.2 Conclusions and recommendations for SDG indicators that can be measured through geospatial information and geocoded census data

Integrating geospatial and census data allow the measurement of some of the SDG indicators, sometimes in combination with other data sources, and sometimes only as proxy information. It seems to be a promising area of study that would need further investigation in terms of the measurement, disaggregation and visualization of SDG indicators with geographic relevance.

For this potential to be realized, many aspects would require improvements, including: the harmonisation of spatial datasets at national and international levels; the development of specific capacities within NSOs and national Mapping Authorities in geocoding of statistical data and their integration with geospatial data; the harmonisation of concepts and definitions pertaining to geoinformation; and, the development of a common spatial framework for the visualization of SDG data.

The following are specific recommendations addressed to census managers and geospatial specialists at NSOs. The recommendations are based on the outcomes and findings of the analysis carried out on a selected number of SDG indicators with a spatial component and are aimed at enhancing the contribution of geospatial data analysis data towards the effective measurement, disaggregation and visualization of spatial-related SDG indicators.

- Taking advantage of national census operations, NSOs should harmonize census geography with relevant geospatial data themes at the national level (e.g., in terms of built-up areas and cities, buildings, addresses, land cover, and cadastral data) in line with the ongoing harmonization at the global level.

- Create capacity building initiatives in the NSO to take full advantage of Earth Observation based data to produce new statistical indicators and to increase territorial disaggregation of traditional indicators already reported.

- Design census questionnaires of national PHCs having in mind the requirements for measuring relevant SDG indicators. Census data can be a relevant source of information for improving the quality of SDG indicators and for disaggregation purposes.

- Geocode census data at point-based level (e.g., building, housing unit, or address level) instead of at area level. This allows the construction of population grids and grid statistics that can be used for statistical definition of urban and rural populations and for international comparability of SDG indicators.

- Promote the use of census data for building registers of buildings and dwellings, as a future statistical framework for collecting census statistics as well as for the computation of SDG indicators. This will require a solid and consistent national codification of spatial units to ensure integration between geocoded census data and cadastral data, and with civil registries and population registers.

- Adopt harmonised and comparable concepts, definitions and classifications and build consensus in common thematic and technical domains within the statistical and geospatial communities.

- Develop initiatives that promote the availability, accessibility and usability of geospatial data by making use of standard metadata and quality reference frameworks aligned with the requirements of the Generic Statistical Business Process Model and Metadata Reporting Standards for statistical production.

- Enhance collaboration with researchers and data providers to take full advantage of geocoded census data and for tuning operational workflows and regular computation of SDG indicators.

- Increase cooperation with Geospatial Agencies for the calculation of SDG indicators in order to better address the spatial dimension of census data in the national context.

- Georeferenced cadastral data can provide good data coverage for a more detailed territorial disaggregation and a more consistent and stable classification for measurements over time of SDG indicators.

Appendix

I - List of SDG Indicators

Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development
https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202019%20refinement_Eng.pdf

II - Additional SDG Indicators that can be generated from CRVS

3.9.1 Mortality rate attributed to household and ambient air pollution

a) Concept and definition

Assessments of the mortality resulting from exposure to ambient (outdoor) air pollution (AAP) and household (indoor) air pollution (HAP) from polluting fuels use for cooking have shown that exposure to air pollution is linked, among others, to the following important disease categories:

Acute respiratory infections (ALRI) in young children (estimated under 5 years of age) (J20-22 of ICD-10);
Cerebrovascular diseases (CVD) (stroke) in adults (estimated above 25 years) (I60-69);
Ischaemic heart diseases (IHD) in adults (estimated above 25 years) (I20-25);
Chronic obstructive pulmonary disease (COPD) in adults (estimated above 25 years) (J44); and
Lung cancer (LC) in adults (estimated above 25 years) (C34).

Ambient air pollution results from emissions from industrial activity, households, cars and trucks which is a complex mixtures of air pollutants, many of which are harmful to health. Of all of these pollutants, fine particulate matter has the greatest effect on human health. By polluting fuels is understood kerosene, wood, coal, animal dung, charcoal, and crop wastes. The majority of the burden is borne by the populations in low and middle-income countries.

An approximation of the combined effects of outdoor and indoor air pollution is possible if independence and little correlation between risk factors with impacts on the same diseases can be assumed. There are some limitations to estimate the joint effects: limited knowledge of the distribution of the population exposed to both household and ambient air pollution, correlation of exposures at individual level as household air pollution is a contributor to ambient air pollution, and non-linear interactions. In several regions household air pollution remains mainly a rural issue, while ambient air pollution is predominantly an urban problem. Assuming independence and little correlation, a rough estimate of the total impact can be calculated, which is less than the sum of the impact of the two risk factors.

b) Possible data sources, particularly CRVS, and their relative advantages/ disadvantages

The basic data on deaths in the five cause-of-death categories identified in the previous section would normally be obtained from a CRVS with reliable coding of cause of death. The numerators for the relevant population numbers are normally derived from population censuses or population projections based on population censuses.

In order to quatify exposure to household air pollution, indicator 7.1.2 can be used. Annual mean concentration of particulate matter of less than 2.5 µm can be used as exposure indicator for ambient air pollution, according to methods used for Indicator 11.6.2.

Data availability is limited to countries with reliable cause-of-death registration by age and sex that identifies the cause-of-death categories mentioned in section a). In addition, indoor and outdoor pollution data should be available in the form of assessments of indicators 7.1.2 and 11.6.2.

c) Method of computation

The methodology for the integrated exposure-response functions (IER) developed for the Global Burden of Disease 2010 (Burnett et al, 2014) and further updated for the Global Burden of Disease 2013 study is described by Burnett et al. (2014) and Forouzanfar et al. (2015).[69] Estimating the burden of disease attributable to long-term exposure to fine particulate matter ($PM_{2.5}$) in ambient air requires knowledge of both the shape and magnitude of the relative risk (RR) function. However, adequate direct evidence to identify the shape of the mortality RR functions at the high ambient concentrations observed in many places in the world is lacking.Therefore, Burnett et al. developed RR functions over the entire global exposure range for causes of mortality in adults: ischemic heart disease (IHD), cerebrovascular disease (stroke) (CVD), chronic obstructive pulmonary disease (COPD), and lung cancer (LC). They also developed RR functions for the incidence of acute lower respiratory infection (ALRI) that can be used to estimate mortality and lost-years of healthy life in children under 5 years of age.

Burnett et al. fitted an integrated exposure–response (IER) model by integrating available RR information from studies of ambient air pollution (AAP), second hand tobacco smoke (SHS), household solid cooking fuel (household air pollution, HAP), and active smoking (AS). Only the AAP and the HAP components are relevant here. The authors selected a mathematical form of the RR function with a $PM_{2.5}$ concentration that could describe the observed relationships between RR and exposure for the five outcomes examined, as follows:

$$\text{for } z < z_{cf}, \quad RR_{\mathrm{IER}}(z) = 1$$

$$\text{for } z \geq z_{cf}, \quad RR_{\mathrm{IER}}(z) = 1 + \alpha\,\{1 - \exp[-\gamma\,(z - z_{cf})^{\delta}]\}$$

where z is the exposure to $PM_{2.5}$ in micrograms per meter cubed and z_{cf} is the counterfactual concentration below which it is assumed that there is no additional risk. For very large z, RR_{IER} approximates $1 + \alpha$. The power δ of $PM_{2.5}$, was included to predict risk over a very large range of concentrations. Further, $RR_{\mathrm{IER}}(z_{cf} + 1)$ approximates $1 + \alpha\gamma$. Thus, $\gamma = [RR_{\mathrm{IER}}(z_{cf} + 1) - 1]/[RR_{\mathrm{IER}}(\infty) - 1]$ can be interpreted as the ratio of the RR at low-to-high exposures.

This model was fitted for cause-specific adult mortality for four causes of death—ischemic heart disease (IHD), stroke (CVD), chronic obstructive pulmonary disease (COPD), and LC—using RR information from epidemiologic studies of long-term exposure to particulate matter from AAP and HAP.[70] The relationship between $PM_{2.5}$ exposure and the incidence of acute lower respiratory infection (ALRI) in infants was

[69] Burnett et al (2014). *Environmental Health Perspectives* Vol 122, Issue 4; Forouzanfar et al. (2015). *The Lancet* 386: 2287-323.

[70] The data also contain some data points derived from SHS studies, but these are very few and have little effect on the estimated parameter values.

investigated separately. Because infants and young children are non(active)-smokers, the largest $PM_{2.5}$ exposures considered for ALRI are from HAP. The IER model was a superior predictor of RR compared with seven other forms previously used in burden assessments.

The actual fitted parameter values for each of the health impacts were as follows:

IHD:	$z_{cf} = 7$	$\alpha = 1.378$	$\gamma = 0.0667$	$\delta = 0.37$
CVD:	$z_{cf} = 7$	$\alpha = 1.225$	$\gamma = 0.0121$	$\delta = 1.0675$
COPD:	$z_{cf} = 7$	$\alpha = 15.35$	$\gamma = 0.00125$	$\delta = 0.667$
LC:	$z_{cf} = 7$	$\alpha = 105.6$	$\gamma = 0.000193$	$\delta = 0.729$
ALRI:	$z_{cf} = 7$	$\alpha = 2.082$	$\gamma = 0.00367$	$\delta = 1.135$

Not all mortality due to the forementioned causes can be attributed to either outdoor or indoor air pollution. Therefore, it is necessary to first calculate attributable mortality by combining information on the increased (or relative) risk of a disease resulting from exposure, with information on how widespread the exposure is in the population (e.g. the annual mean concentration of particulate matter to which the population is exposed, proportion of population relying primarily on polluting fuels for cooking). The result is a 'population attributable fraction' (PAF), which is the fraction of disease seen in a given population that can be attributed to the exposure (i.e. both the annual mean concentration of particulate matter and exposure to polluting fuels for cooking). Burnett et al. used the models specified above to estimate the percentage of PAF associated with exposure to ambient $PM_{2.5}$ for each of the 187 countries included in the GBD 2010 project. The percent PAF attributable to AAP exposure varied among countries from 2 to 41 for IHD, 1 to 43 for stroke, < 1 to 21 for COPD, < 1 to 25 for LC, and < 1 to 38 for ALRI.

Applying this fraction PAF to the total burden of disease (e.g. cardiopulmonary disease expressed as deaths), gives the total number of deaths that results from exposure to that particular risk factor (in the example given above, to ambient and household air pollution). The mortality associated with household and ambient air pollution is estimated based on the calculation of the joint population attributable fractions assuming independently distributed exposures and independent hazards as described in (Ezzati et al, 2003).[71]

The PAF for AAP and HAP were assessed separately, based on the Comparative Risk Assessment (Ezzati et al, 2002) and expert groups for the Global Burden of Disease 2010 study.[72]

The input for the exposure to ambient air pollution (AAP) are annual mean estimates of particulate matter of a diameter of less than 2.5 µm ($PM_{2.5}$), as described by WHO,[73] or for Indicator 11.6.2. The input for exposure to household air pollution (HAP) is the proportion of population with primary reliance on polluting fuels use for cooking (see Indicator 7.1.2 [polluting fuels use = 1 - clean fuels use]).[74]

The percentage of the population exposed to a specific risk factor (here AAP, i.e. $PM_{2.5}$) needs to be specified by increment of 1 µg/m^3; relative risks are then calculated for each $PM_{2.5}$ increment, based on the IER. The counterfactual concentration can be selected to be between 5.6 and 8.8 µg/m^3, as described by Ezzati et al. (2002) and Lim et al. (2012). The country population attributable fraction (PAF) for ALRI, COPD, IHD, CVD and LC can then be calculated using the following formula:

[71] Ezzati et al. (2003). *The Lancet* 362: 271-80.

[72] Lim et al. (2012). *The Lancet* 380(9859):2224-60; Smith et al. (2014). *Annual Review of Public Health*, Vol 35.

[73] WHO (2016). Air pollution: a global assessment of exposure and burden of disease, WHO Geneva.

[74] Details on the model are published in Bonjour et al (2013). *Environmental Health Perspectives*, doi:10.1289/ehp.1205987.

$$\mathrm{PAF} = \frac{\sum_{i=1}^{n} p_i(\mathrm{RR}_i - 1)}{\sum_{i=1}^{n} p_i(\mathrm{RR}_i - 1) + 1}$$

where i is the level of $PM_{2.5}$ in µg/m^3, and p_i is the percentage of the population exposed to that level of air pollution, and RR_i is the relative risk associated with level i.

The calculations for household air pollution (HAP) follow the same logic, and are explained in detail elsewhere (WHO 2014a).

The joint population attributable fraction (PAF) is calculated as:

$$\mathrm{PAF} = 1 - \prod_{r=1}^{R} (1 - \mathrm{PAF}_r)$$

a)

where PAF_r is PAF of individual risk factors (AAP, HAP).

d) Challenges in measuring in CRVS and PHC

Underlying differences between country produced and internationally estimated data may due to:

Different exposure data (annual mean concentration of particulate matter of less than 2.5 µm of diameter, proportion of population using clean fuels and technology for cooking);
Different exposure-risk estimates;
Different underlying mortality data.

The assessment of the indicator requires not only cause-of-death data, but also detailed data on the distribution of particulate matter, both in the general environment and within households. The former requires a well-organised monitoring system, to detect different levels of PM pollution in a variety of locations. Not many countries have such a detailed system and as a consequence much of the estimation may have to be based on extrapolation. As for household pollution, the census only provides data on the kind of fuel used, but the actual levels of PM pollution generated by these fuels can only be assessed indirectly and depend on several other factors, such as the amount of these fuels used, the amount of ventilation available in the places where they are used, and the separations inside the dwelling which may protect some of the household members against the smoke as others are cooking.

e) Data disaggregation

Due to the complexity of the methodology, it is difficult to disggregate this indicator. The proposed disaggregations concern age and sex differentials and disggregations by type of pollution and cause of death. However, the disaggregation by age must be treated with caution because the methodology for the determinantion of the IER and PAF is not age-invariant. Another possible disdaggregation concerns specific geographical áreas, particularly areas that display significant differences in terms of their levels of ambient air pollution (AAP).

3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)

a) Concept and definition

The indicator expresses the number of deaths from inadequate water, sanitation and hygiene (with focus on WASH services) which could be prevented by improving those services and practices, expressed per 100,000 population. It is based on both the WASH service provision in the country, as well as the related health outcomes, and therefore provides important information on the actual disease caused by the risks measured in 6.1.1, 6.2.1, 6.3.1 and 6.3.2. Deaths attributable to unsafe water, sanitation and hygiene focusing on inadequate WASH services include the WASH attributable fractions of the following disease categories:

Diarrhoea (ICD-10 code A00, A01, A03, A04, A06-A09);
Intestinal nematode infections (ICD-10 code B76-B77, B79); and
Protein-energy malnutrition (ICD-10 code E40-E46).

b) Possible data sources, particularly CRVS, and their relative advantages/ disadvantages

Data rely on (a) statistics on WASH services, which are well assessed in almost all countries, and (b) data on deaths, primarily based on CRVS systems. The main limitation is that not all countries do have cause-specific CRVS registration systems of sufficient quality, and data need to be completed with other type of information. In some countries, alternative data sources are available, such as verbal autopsy data. An example is the INCAM (National Inquiry on Causes of Death) that was carried out in Mozambique after the 2007 census, in which households that reported a death during the past 12 months were revisited for a verbal autopsy.

Another possibility is the collection of information through population-based surveys such as DHS or MICS, but these typically only collect data on children.

Apart from child mortality, data availability is limited to countries with reliable cause-of-death registration by age and sex that identifies the cause-of-death categories mentioned in section a). In some countries that do not have complete CRVS systems, it may be possible to obtain reliable data from sample registration systems.

c) Method of computation

The methods with agreed international standard have been developed, reviewed and published in various documents. The method explained by Prüss-Ustün et al.[75] strictly speaking only applies to diarrhoeal disease, but can be extended to the other disease categories. It attributes different risk reduction factors associated to different levels of water treatment and other hygienic methods. For example, a basic improved water source other than piped water brings about an 11% reduction of risk. If, in addition, the water is piped, this results in a further reduction of 14%. Finally, if the water is filtered and safely stored, the contamination risk is reduced by another 28%. Although there is some doubt regarding the statistical significance of the finding on handwashing, a 23% reduction in diarrhoeal disease risk is considered the best estimate of the effect of handwashing promotion.

For each risk factor, the population-attributable fraction (PAF) was estimated by comparing current exposure distributions to a counterfactual distribution, for each exposure level, sex and age group, and by country:

[75] Prüss-Ustün et al. (2014). *Tropical Medicine and International Health* 19 (8): 894–905.

$$\mathrm{PAF} = \frac{\sum_{i=1}^{n} p_i(\mathrm{RR}_i - 1)}{\sum_{i=1}^{n} p_i(\mathrm{RR}_i - 1) + 1}$$

where p_i and RR_i are the proportion of the exposed population and the relative risk at exposure level i, respectively, and n is the total number of exposure levels.

Exposure to inadequate WASH is related by similar mechanisms and policy interventions. The following formula has been proposed for the estimation of burden attributable to a cluster of risk factors:

$$\mathrm{PAF} = 1 - \prod_{r=1}^{R} (1 - \mathrm{PAF}_r)$$

where r is the individual risk factor and R the total number of risk factors accounted for in the cluster. This formula assumes that risk factors are independent. This assumption is likely to be an oversimplification for WASH as, for instance, handwashing promotion is unlikely to be effective if water quantity is limited. However, this approach has been applied in the assessment for ease of interpretation of the results, and in the absence of a more suitable approach.

The burden of disease attributable to each risk factor (AB), or to the cluster of risk factors, in deaths or disability-adjusted life years (DALYs), can be obtained by multiplying the PAFs by the total burden of disease of diarrhoea (B):

$$\mathrm{AB} = \mathrm{PAF} \times \mathrm{B}$$

The PAFs can be applied equally to burden of disease in deaths and DALYs, assuming that the case fatality of other causes related to WASH is the same as the mean case fatality of diarrhoeal diseases.

d) Challenges in measuring in CRVS and PHC

The assessment of WASH services relies on four indicators: 6.1.1, 6.2.1, 6.3.1 and 6.3.2. While 6.1.1 and, to a lesser extent, 6.2.1 can be assessed based on PHC data, 6.3.1 and 6.3.2 cannot. A suggestion is to include this indicator as proxy and only covering the household level. This would be a complementary indicator related to the discharge of the toilet into sewers or septic tanks. This may limit the possibilities of accurately assessing risk reduction factors. While almost all censuses ask a question about the origin of the water used for consumption, questions about the use of filters, the modalities of storage, and about hand washing are much rarer. These questions are more typical of household surveys specifically aimed at assessing health behaviors.

e) Data disaggregation

Since this indicator is population-based, geographic location is the most natural disaggregation. Data also exists for age group and sex. Disaggregation by wealth quintile has also been proposed, but this is difficult if the mortality data are obtained from the CRVS, unless the CRVS provides socioeconomic status data (P&RVS, Par. 189-190).