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# Modernization of the production of time-use statistics*
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* This document has not been formally edited.

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**Modernization of the production of time-use statistics**

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## Background

Member States at the 48th session of the UN Statistical Commission in March 2017 endorsed the International Classification of Activities for Time-Use Statistics (ICATUS 2016)[2] and supported the development of methodological guidelines on how to implement/operationalize the classification to produce internationally comparable time-use data, using the latest technologies, in support of SDG monitoring, particularly in developing regions.[3] In response to this request, Since 2018, the Statistics Division and the Expert Group on Innovative and Effective Ways to Collect Time-Use Statistics have been working towards the implementation of the International Classification of Activities for Time-Use Statistics (ICATUS 2016) and the modernization of time-use surveys, in the context of updating the Guide to Producing Statistics on Time Use: Measuring Paid and Unpaid Work[4] and with the overall objective of further promoting this critical data collection across countries and over time. To date, the Group has been working on selected priority components of the conceptual framework, including this on the *modernization of the production of time-use statistics*, that, once finalized, will be at the core of the revised Guide to Producing Statistics on Time Use.

[2] https://unstats.un.org/unsd/demographic-social/time-use/icatus-2016/
[3] UN Statistical Commission-Final report 48th session-Decision 48/109 https://unstats.un.org/unsd/statcom/48th- session/documents/Report-on-the-48th-session-of-the-statistical-commission-E.pdf
[4] Available at https://unstats.un.org/unsd/publication/seriesf/seriesf_93e.pdf

## Introduction

The traditional time-use data collection approach using paper diaries is resource intensive, in particular during the collection and digitalization of information, and coding of activities. In addition to high data collection and processing costs, NSOs are also facing challenges in conducting time-use surveys due to decreasing response rates and delays in dissemination of results. In the context of modernizing their national statistical systems, NSOs are exploring alternative ways of collecting time-use data involving the use of technology, resulting in digitalization of data collections. For instance, the adoption of a mixed modes approach for time-use data collection offers respondents different options to provide the requested information, as ways to reduce non-response.

Furthermore, the use of technology is becoming an integral part of the production of time-use statistics in many countries for improved efficiency in data collection as well as increased data quality. Technology can also facilitate the operationalization of activity classifications, including ICATUS 2016, during all survey phases and in particular, it can contribute to the simplification of activity coding during data processing.

While the Expert Group recommends digitalization of time-use data collections and is exploring the use of technology, it is also identifying and assessing possible challenges, including access to/coverage of technology (for self-completed instruments) and a potential "mode effect" to be accounted for, particularly when countries are mixing modes for data collection. In this regard, it is important to mention that the Group is learning from the work undertaken by Eurostat and partners on innovative tools for Household Budget Surveys and Time-Use Surveys which is looking into solutions to lower respondents' burden, increase response rates and decrease the overall workload of NSOs.

## What does modernization mean?

Modernization of time-use surveys with the use of modern technologies should aim at addressing challenges such as: offering various options to respond; reducing the respondent's burden; improving the response rates; improving monitoring and management of data collection operations; improving contact and communication with respondents (invite to participate, provide access codes for online based self-reporting, send reminders to provide information); reducing the workload in the NSOs, improving the integration of different data sources (including georeferenced information), improving the data quality and possibly reducing the total cost of collecting time-use data in the long term.

It is important to point out that modernizing the production of time-use statistics may have different meanings in different contexts and countries. In terms of how data is collected (mode), for some countries, modernization may result in moving from paper-and-pencil interviewing (PAPI) to computer-assisted personal interviewing (CAPI), as for others, it might consist of developing and using web and mobile solutions. In general, the

Group is promoting the transition from face-to-face paper forms to self-administered digital surveys using modern technologies (moving away from paper forms).

In some settings, particularly those with low literacy rates, face-to-face interviews might still be needed, whereas in others, self-completed approaches for data collection can be a suitable solution to lower costs and reach some population groups. It is important to highlight that the presence of an interviewer might have an effect on the answers provided by the respondents, compared to those reported in self-completed surveys. For instance, several studies have shown that people tend to over report activities that are perceived as socially "important" or "acceptable" (social desirability bias) when asked about their use of time through face-to-face interviews using stylized/survey questions as opposed to self-completed diaries, thus inflating the time spent on those activities.[5]

Approaches using technology assume an initial investment/cost to develop the application/system and purchase equipment (tablets, servers, etc.) to be used. However, once the application/system is developed, many parts of the process are automated resulting in savings (less enumerators[6], minimal or no codification, automatization of the processing of the information and generation of outputs; minimal or no cost related to printing/transporting/storing paper diaries; reduced cost of data editing and processing). For example, Belgium has estimated 60% of savings thanks to the introduction of MOTUS (App) to collect time-use information in their forthcoming time-use survey.

Although many small-scale time-use studies have used observational approaches (in person observation and technology assisted observation, for example with wearable cameras or devices, such as activity trackers), in the context of producing official time-use statistics, these approaches should be considered only for data quality checks or in-

[5] For example, after comparing stylized questions with time use diaries, Hofferth (2000) concluded that parents, when asked stylized questions, exaggerated the amount of time they spend reading to children and seriously underestimated the amount of time their children spent watching television. Some other studies have reached similar conclusions with regards to the use of stylized questions. Robinson (1985) concluded that stylized questions overestimated the time spent in most activities, compared with statistics obtained from time use diary. Iiris Niemi (1993) analyzed time use data from surveys carried out by Statistics Finland, using different instruments. Comparisons of data/instruments showed that measurement error varied considerably between population groups, influencing interpretations of the results. The information on paid and unpaid work collected in the Danish time use survey in 2001 by employing diaries and questionnaires concurrently to test whether the two techniques are equally appropriate was analyzed by Bonke (2005) concluding that information on paid work at the general level does not depend on the instrument, whereas questionnaire information on unpaid work (caring for household members and domestic chores) highly underestimates the time spent on these activities, probably due to the many short-term tasks involved. Kitterod and Lyngstad (2005) analyzed unpaid domestic work data from the 2000-2001 Norwegian Time Use survey and results show only modest differences between the time use estimates obtained from diaries and stylized questions, mainly associated with age but not with sex. Kan and Pudney (2008) analyzed data from the British Home Online Survey (HoL) finding that estimates of time spent on domestic chores obtained from stylized questions are systematically biased and they developed methods to correct the estimates.

[6] Enumerators are still needed to motivate respondents to participate, follow up with respondents and guide them on the completion of the diaries, fix incomplete or incorrect responses and to interview/assist people who cannot self-respond, resulting in increased participation rate and quality of the diaries.

depth small-scale studies given the high cost they might entail (including in terms of investment in equipment).[7]

**Why modernize the production of time-use statistics?**

Household surveys are in general complex statistical operations, and time-use surveys have their own additional challenges. Time-use surveys are resource-intensive processes for the institutions collecting the data (mainly National Statistical Offices – NSOs), respondents usually see them as a burden, microdata are difficult to analyze and results are not well communicated affecting the overall utilization of the data.

Burden on respondents might be the leading cause of the low response rates in time-use surveys, which have declined over time.[8] Time-use surveys require the respondent to provide detailed information about the activities he/she was engaged in. This could lead to reluctance to cooperate due to the time that should be invested, or privacy and confidentiality concerns. Methodological decisions, such as the number of designated days for which respondents should provide data can also directly affect respondents' willingness to participate.[9]

Traditional time-use data collections with paper diaries result in high costs associated to human resources needed for the collection of data (dropping forms, monitoring completion of forms and collecting completed forms from households/respondents), to the management of paper diaries (printing paper diaries, transporting, storing and other logistical operations) as well as for data digitalization, cleaning, editing, processing, coding and formatting.[10]

In addition to the very specific challenges of time-use surveys, just like any other survey, those conducted with interviewers visiting households might suffer from inaccessibility to the households and respondents due to physical barriers (for example, security in compounds) and increased mobility of household members. Time-use surveys using phone interviews (CATI) suffer from the decrease of landlines and preference for mobile phones, screening and the unwillingness to answer to unknown phone numbers.

The use of technology can improve the mode of collecting data, but also other parts of the data collection process can benefit from its use. For example, SMS (short message service) messages could be sent to respondents as reminder and to encourage respondents to share their time-use data. The use of technology allows the almost automatic recording of a lot of paradata, such as the number of visits or calls, the time and length of the

[7] Kelly, Paul et al (2015); Kapla, Robin L. et al (2016).
[8] For example, the response rate of the American Time-Use Survey (ATUS) has declined from 57.8% in 2003 to 43% in 2018. In Canada it declined from 55% in 2010 to 38% in 2015-2016. Other surveys have also observed declining response rates.
[9] Glorieux, Ignace and Joeri Minnen (2009); Minnen, Joeri and Ignace Glorieux (2011).
[10] The cost per respondent of the 2004 Flemish time-use study was €265 (multiple visits of interviewers, entering the data, cleaning and coding). (Minnen, Joeri et al. (2013))

interview, or the times and time spent in completing the diary and the location of the respondent if using the GPS of the device. Paradata analysis is very important as it provides information on the quality of data collection, and can be used to improve the collection instrument and monitor the performance of interviewers. Paradata can also be used to understand how respondents provide information and their behavior in general.[11]

Modern technologies can also support the monitoring of the field process and allow automatic transmission of data with the possibility of accessing data almost in real time. Some countries have developed whole systems that provide detailed overview of the status of the field operation that generate reports and alerts that can trigger corrective actions by managers and supervisors while data collection is still in progress.

Modern technologies could also ease the accessibility and use of data. Although time-use data have an unlimited potential, in general, data are underutilized. Data files are very complex to analyze and use, limiting their possible users. However, with the right technology it would be possible to facilitate the communication and understanding of time-use statistics as a way to increase and promote their use. For example, tools for enhancing interactivity with data, visualizing the data, integrating with data from other sources could be developed and used to draw insights from time-use data.

Finally, statistics, including on time-use, have become an essential input for policy makers and their demand has increased, creating the need for NSOs to produce and disseminate them in a timely manner, responding to different areas of concern,[12] with limited resources. The modernization of time-use data collection will result in a more efficient production of relevant, high-quality, reliable and timely time-use statistics that are accessible and consumable by a variety of users.

**Organizational considerations for the modernization of the production of time-use statistics**

The decision of introducing a new technology to modernize the production of time-use statistics should be carefully considered. The adoption of a new technology for the collection of time-use information should be determined early in the planning stage of the production process to be able to redesign processes that consider the new technology and extensively test the new approach to ensure complete efficiency. Planning is very important, as the introduction of a new technology takes time (developing, testing, training, etc.).

[11] For example, Canada uses Responsive Collection Design (RCD) as an approach that uses paradata available prior and during data collection to adjust the collection strategy for the remaining in-progress cases. Laflamme, Francois et al (2017).

[12] Time-use data can inform a wide range of topics and guide policies and research on unpaid household service work, wellbeing, gender equality, commuting and transportation, education, health, culture, environment, sports, activity participation and the impact on quality of life, improved measurement of the distribution of household income (accounting for unpaid services as additional income), national time-transfer accounting (NTTA) and the impact of digital service production and consumption.

Given that the introduction of a new technology could be expensive and challenging affecting many steps in the production of statistics, as well as the collection of data from respondents, countries are advised to assess the national situation and the institutional capacity before any technological solution is introduced. For example, a country considering collecting time-use data nationally representative through a website in internet should check first the proportion of households with computers and access to internet, as well as the literacy rate in the case of self-reporting.

Having always in mind the objectives of the time-use survey, the decision-making process about the introduction of a new technology should be made based on relevant information that identifies and weighs possible alternatives and consequences. National context, social and cultural factors, institutional capacity should be considered as they may affect the outcomes.

Basic decision-making process steps include:

- Involve relevant stakeholders to inform them of the changes, and get their support, commitment and engagement in the implementation of the new technology
- Gather relevant information such as
    - Costs[13]: It is necessary to estimate the cost of introducing a new technology, considering direct and indirect costs of developing and implementing a particular product or system, such as human resources (software engineers), hardware and software cost including maintenance, and training.
    - What is needed to develop, test, implement and maintain the technology in terms of financial and human resources
    - Will it be sustainable?
    - Is it a scalable solution?
    - Accessibility in terms of the measures to be taken to ensure that any development complies with national or international accessibility requirements
    - Feasibility of developing the solution internally
    - Is there a need for a market engagement day if developing the solution using external agencies?
    - Implications and consequences of introducing a new technology: it is important to assess the processes that will be affected to redesign them and train staff accordingly. The introduction of a new technology can also affect the way respondents react to the data collection.
- Identify alternatives
    - Is there another internal solution that could be adapted to time-use surveys? Some countries might be able to adapt internal tools for time-use data collection. For example, Statistics Finland is adapting the software (XCola) originally used for business surveys for the next time-use survey in 2020-2021.

[13] Software cost estimation. Accessed at https://ifs.host.cs.st-andrews.ac.uk/Books/SE7/SampleChapters/ch26.pdf

    - What have other countries used or are planning to use?
- Prioritize options based on national context, social and cultural factors, and institutional capacity.

In general, small scale implementations are easier given that less resources and training are needed, but they might not cover the whole production process of time-use statistics. On the other hand, larger implementations might require additional experts with different expertise, and more planning and coordination given that they might affect several parts or the whole collection process. In any case, it will be important to ensure and train the right human resources to support the transition, implementation and smooth functioning of the new technology.

Prior experiences from the testing or application of technologies in other statistical operations such as other household surveys or censuses can help the NSO make a better decision in the context of time-use surveys, as well as overcome the challenges more easily. For example, under the 2020 World Population and Housing Census Programme, many countries are looking into the use of electronic data collection technologies.[14]

**Methodological considerations that will influence the instrument and the mode (and device/s) to be used in the data collection**

Depending on the objectives of the study, there are several basic methodological choices that will influence the development of the research instruments and affect the selection of the mode (and device/s) to be used in the data collection.

- **Research units**
  The sample can consist of (independently sampled) individuals or eligible members of the same household. Sampling households has the advantage of being able to study the household as a unit of economic production and consumption; in this case it is advisable that all members of the household register their time-use during the same days.

- **Number of days per respondent** (e.g. one day, one week and one weekend day, three consecutive days, etc.)
  The more diary days per respondent, the less time-use estimates are influenced by accidental circumstances. To avoid higher respondent burden that could lead to an increase of non-response, many countries opt for one or a couple of diary days (e.g. one week and one weekend days). However, some time-use studies involve 3 consecutive diary days or even a full week (to capture the weekly rhythm of activities) depending on the objectives.

[14] UNSD developed *the Guidelines on the use of electronic data collection technologies in population and housing censuses*, that can be accessed at https://unstats.un.org/unsd/demographic/standmeth/handbooks/data-collection-census-201901.pdf

- **Length of the field work period** (e.g. one year, several months, etc.)
  In order to take seasonal fluctuations in behavior into account, an ideal design for a time-use survey would spread the field work over 12 consecutive months. If a full year field work is not possible, the field work could be evenly spread over the year during different periods of data collection. Some time-use studies have a more limited field work period (e.g. two weeks or 3 months) during one specific period of the year.

- **Sample of designated days**
  Not only households or individuals are sampled, the days on which the time-use is to be recorded should be randomly selected. In case of a period of consecutive days, only the starting day should be sampled.

- **Start of the registration** (e.g. 4 a.m., midnight, etc.)
  Most time-use studies start the registration during the night, often at 4 a.m. since most people are sleeping at that time (so sleep is the first activity to record). Some studies start at midnight in order to cover the official day from midnight to midnight.

- **Granularity of an episode** (e.g. continuous, 5 minutes, 10 minutes, 15 minutes, etc.)
  The granularity of registration varies from study to study. In some studies, the exact starting and ending time of an episode (with the precision of a minute) is recorded. Other studies use a time grid with a precision of 5, 10, 15 minutes or even with longer intervals.

- **Registration method of activities**

  - *own wording versus activity list/taxonomy*
    The activities can be recorded in the own words of the respondent and are later coded by the interviewer or coders using a predefined activity list. Other studies use a predefined activity list from which the respondents or the interviewers select the relevant activities to register time use. In the later, (1) predefined activity lists can be organized as a taxonomy in different levels with the number of activities varying from less than 20 to a few hundreds; (2) electronic diaries can contain tags in the background, and respondents or interviewers can write down their activities in their own (key)words on basis of which the device will suggest activity entries from the precoded list;[15] or (3) in more advanced devices, the respondent might receive suggestions about his/her behavior on basis of the information collected by GPS, activity trackers or other wearables or functionalities in the registration devices (e.g. smartphone) during the designated day.[16]

[15] Natural language processing could be explored.
[16] Geofencing technologies could be explored.

- **Context questions**
  One of the strengths of time-use research is that activities are usually recorded in combination with context information (e.g. secondary activity, location, mode of transport, presence of others, use of ICT, for whom, motivation, enjoyment, etc.). Similar to the main activities, there is the need to define which context information and how they will be recorded in the diary (own wording or predefined).

- **Need to link context to activities/questionnaire information**
  In some diaries, the context questions are linked to other information collected in the diary. For example, for travelling activities the mode of transport is often recorded or for specific activities (e.g. sleep) some context questions are not asked. The context questions might even be linked with information from the background questionnaire. For example, if there is information on the number of jobs the respondent has, working activities might be linked with a specific job.

- **Validity checks**
  The diary may contain validity checks to ameliorate the quality of the data collection and/or to avoid registration errors.

  *Direct checks* are linked with the activity that is registered and check the consistency of the registered information, such as warnings when attempting to register activities in the future, reporting change of place without transportation or recording inconsistencies such as travelling at home, sleeping with reading as a secondary activity or overlap in time.

  *Indirect check* can only be done after a predefined period of registration for which a certain behavior is expected, for example, reporting a minimum number of activities during the specific time period (e.g. 5 activities in a day), reporting undefined time for a maximum time during the specific time period (e.g. 2 hours per day), reporting no sleep or eating time in the specific time period.

It should be clear from the above that some of these decisions might influence the choice of the registration device. The validity checks, linking context questions to information from the pre-questionnaire or the use of tags for example, cannot be implemented in a self-completed paper (PAPI) diary. The import of information from external sources (GPS, trackers, etc.) implies the use of high standard technical devices. It is clear that the use of ICT via personal computer, tablet or smartphones opens up new possibilities for collecting time-use information, not only to improve the quality of the collected data but also to decrease the costs and the respondent burden (and as such increase the response rates) in time-use research. In the paragraphs that follow, some of the current options in terms of devices (PC, tablet and smartphone) to collect time-use data, the choices to make and the different implications of these choices are listed.

**The use of modern technologies to improve how time-use data are collected**

From this section onwards, the document will only focus on the mode of collecting time-use data.

Data collection mode generally refers to the approach adopted to collect information from the respondents. Collecting time-use data has traditionally been achieved through three main approaches: (1) direct observations; (2) recall interviews by an interviewer; and (3) self-reporting by respondent. Each of these options can benefit from the use of modern technologies resulting in more effective and cost-efficient collection of time-use data.

1. In the direct observation method, the time use of the respondent is observed and recorded by the survey enumerator or device (video or/and audio). The observation can be carried out continuously (the respondent is observed and recorded throughout the recording period), or randomly (the respondent is observed and recorded only at random points in time during the recording period).

With observational methods, respondents do not have to remember all the activities. With new technologies, it is possible to recreate all the activities undertaken by a person by reviewing video or audios, ensuring proper recording of the activities.

Observational approaches should be considered only for data quality checks, in-depth small-scale studies or studies of activities in certain location, given the high cost they entail – in terms of labor and equipment – and their intrusive approach. There could be changes in respondents' behavior given they know they are monitored. However, it is getting more common for people to use devices that are continuously recording their behavior, including their location with GPS, or physical activity with accelerometers, etc. Less intrusive methods have been used, such as programs tracking the use of time in computers at work or school (time spent checking email, time spent in applications, time spent on the web, etc.).

2. Another way of collecting time-use data is through an interview by asking the respondent about their time use during a specified period of time (yesterday, last seven days, etc.). The interview may be conducted face to face or over the network (telephone). Both cases have incorporated modern technologies for fast and reliable data collection.

Experiences from countries have shown that paper questionnaires/forms (PAPI) are still needed in some settings where there is lack of infrastructure such as electricity and cellular connection or insecurity is high (for example, in Mexico they are still used in insecure regions where it is not possible to bring laptops or tablets). For a faster data capture from paper questionnaires, the use of automated data entry technologies, such as **Intelligent Character Recognition (ICR)**, and **Optical Mark Recognition (OMR),** are still valuable solutions. ICR is an advanced optical character recognition technology that has the capability to recognize and convert handwritten texts into machine readable characters, whereas OMR is a technology that has the capability of identifying optical markers and check marks made by the users in the specially printed questionnaires and is

transformed into the appropriated digital data. Regardless of the technology chosen, a further data validation should be conducted to ensure the accuracy of the converted data.

Recording data during interviews has been improved with the use of portable, electronic devices like laptops, smartphones, tablets, where interviewers follow on-screen prompts to ask the questions in a retrospective way to obtain the time-use data (Computer Assisted Personal Interview – CAPI). Skip patterns can be programed facilitating the conduction of the interview. This solution can enforce data entry validations for the collection phase, thus reducing coding error and generating better quality of data. Devices can automatically capture auxiliary data (paradata) like geolocations and duration of the interview, for example, that could help further improve the survey and data quality. There are several free and proprietary software solutions that could help in designing and conducting CAPI data collection, such as "CSPro", "ODK", "Survey Solution" and "Blaise", among others.

In general, the use of devices to collect time-use data can help bridge the time gap between data collection and reporting phase by automatically/manually uploading the data to the server when it is in network and eliminating the additional digitization process as in PAPI approach. The automation of post interview processes, like processing, cleaning, and digitization of data, reduces the cost of the operation. In addition, devices can be used for other statistical operations, such as other household surveys and censuses.

Interviews can also be conducted via telephone (Computer assisted telephone interview – CATI), where respondents are asked to recall their activities during a specific period of time. Interviewers follow on-screen prompts to obtain the use of time from the respondent. Just like in a CAPI, the CATI software allows validation of answers (activities, codes for contextual information) while an interview is ongoing so that the interviewer is notified when a value given by the respondent falls out of a valid range of answers or when a response is inconsistent with recorded responses to other prior items. Telephone interviewing costs much less than face-to-face interviewing as neither travelling time nor travel expenses must be paid; however, response rates tend to be lower than face-to-face interviews.

Interactive voice response (IVR) technology could support the telephone interviews. In this case, respondents would be able to call a number and provide information using voice to a system that could record automatically the answers into a database.

3. In the self-reporting method, the respondent personally records the time-use information on the survey instruments. If the instrument is a paper diary, automated data entry technologies like **Intelligent Character Recognition (ICR)**, or **Optical Mark Recognition (OMR)** as discussed above could be implemented. Digital instruments have been also developed for self-reporting using the internet (CAWI) or mobile applications.

CAWI in time-use surveys is an internet surveying technique where the respondent follows on-screen questions and complete the time diary. Using similar notification strategies as other modes, participants are informed about the survey, and along with it

the web link to access the web application and instructions on its use. The respondents, at their convenience visit the link and complete the survey. Canada, Serbia and Japan have developed websites for the self-reporting of activities for time-use statistics.

Mobile applications could become a great alternative for data collection of self-reported time-use as opposed to paper diaries or web applications (CAWI). Research conducted by Dutch researchers found that it is feasible to conduct time use surveys using mobile app and their data quality is in line with previous time use studies (Sonck and Fernee (2013)). Respondents carry their smartphones with them most of the time making it possible to record time use in more or less real time. It is also possible to send notifications to respondents to implement experience sampling (ESM)[17] techniques. In addition to the time-use data, paradata on how the respondents complete the diary can be captured. A recent example of using a mobile app to collect time-use data is the survey undertaken in Shanghai, China, in 2018.[18] Furthermore, the research Group Tempus Omnia Revelat has conducted several studies in Flanders, Belgium, using MOTUS (online app) to collect time-use information from university professors (2016), people working in public administration (2017), school teachers in Flanders (2018), a longitudinal time-use survey among employees from a women's organization transitioning to a 30-hour week in 2019 (twice in 2018, twice in 2019 and one survey to be organized in 2020).

The section below provides a detailed description of the use of computers and smartphones for the collection of time-use data.

Using open sources (free) for the development of CAPI, CATI and CAWI instruments is important to lower software costs, reduce application development and testing time, avoid vender lock-in and facilitate scaling.

*Table 1 Comparison of different modes to collect time-use data*

| | **Advantages** | **Challenges** | **Options** |
|---|---|---|---|
| Self-reporting | • Not biased or influenced by an interviewer | • Literacy of population<br>• Understanding time/time sense<br>• Respondent burden<br>• Details of activities reported | • Paper<br>• Electronic/digital (cellphones, computer, tablets in web or mobile applications) |
| Interview | • Enumerator can probe to record the necessary details | • Respondent burden<br>• Interviewer-effect: over or | • Face-to-face (PAPI, CAPI)<br>• Telephone (CATI) |

[17] In "Experience Sampling Method" (ESM) or "beeper" studies, respondents are prompted by a beeper to record specified objective information, and possibly subjective information as well, on what they were doing at the time the beeper sounded.

[18] Paper questionnaire was used in 10 provinces and an ad-hoc app was used in Shanghai.

| | Advantages | Challenges | Options |
|---|---|---|---|
| | | underreporting of time (social desirability) | |
| Observational methods | • Respondents do not have to remember all the activities | • Too expensive<br>• Intrusive<br>• Not sustainable | • Enumerator observing<br>• Using devices for recording video and/or audio (wearable cameras, wearable devices such as activity/movement trackers) |

Many countries have been exploring the use of mixed-mode approaches. For example, Denmark (HETUS 2008-09) collected data with paper and web application. In Serbia in 2015, respondents had the option of providing data through a paper diary, a web application or a mobile application. In Canada in 2015, CATI and an electronic questionnaire, as web application, were used for the collection of time-use data as part of the Canadian General Social Survey program (GSS).

The use of mixed modes in the collection of time-use data could help address many of the challenges discussed, as different groups of a population would be targeted with a different/suitable mode. As an example, the table below shows population sub-groups and associated instruments and modes to be used for a hypothetical country. Sequential or concurrent strategies in mixing the modes could be selected for effective data collection design based on sample, time, questionnaire, or all of them.

The use of technology is bringing new data comparability issues due to the effects of the use of different data collection modes and also in terms of the quality of the data (e.g. use of technology may produce more episodes or affect the response rates[19]).

*Table 2 Different groups of a population targeted with a different/suitable mode*

| Population subgroup | Instruments[20] | Mode | First contact method |
|---|---|---|---|
| High literate urban high-tech working age population | Full or light time diary | CAWI or Mobile application (concurrent mode) | Mail / e-mail / SMS |
| High literate urban high-tech working age population, who | Full or light time diary | CAPI or CATI | Mail |

[19] Elevelt, Anne et al (2019).

[20] Please refer to the "Concepts and Definitions" background document available at https://unstats.un.org/unsd/statcom/51st-session/documents/BG-Item3m-Concepts_and_definitions-E.pdf

| Population subgroup | Instruments[20] | Mode | First contact method |
|---|---|---|---|
| has lost trust in technology (data protection, confidentiality, etc.) | | | |
| Low literate rural population | Full or light time diary | CAPI | |

**Modern options for self-reporting time-use studies**

Since the start of time-use studies, more than a century ago, the tools to collect time-use data have not changed fundamentally. Respondents were interviewed on their time-use or were asked to register their time-use in a paper diary or in a grid. Researchers coded and organized these data afterwards in data files. The spread of the Personal Computer, internet and above all smartphones has opened new possibilities for data collection in general and for collecting data on time-use more particularly. The smartphone as a personal computer that people wear with them almost all day, offers many new possibilities to register time-use on the go and to make the registration much easier, more reliable, faster and cheaper.

The most commonly used devices are personal computers, laptops, tablets and smartphones. Smartphones are easy to carry and also suitable to keep a diary at regular intervals, while a PC usually has a fixed place and is not taken along during the day. Laptops and tablets (or phablets), depending on the size, tend to be used as a PC or a smartphone and as such can be seen as an intermediate between both. In the comparison below (see Table 3) laptops will be treated as PC, and tablets as smartphones. Time diaries programmed for a PC (or laptop) will be called computer-assisted personal agenda (CAPA), diaries developed for smartphones (or tablets) will be called smartphone-assisted personal agenda (SAPA).

Both on a PC and a smartphone it is quite easy to fill in activities and context variables by means of a predefined list, but on a PC, it is much easier to type in text if the input has to be done in own words. For both devices it is possible to program tags that lead to suggestions in the predefined list of activities, and since tags usually refer to short words or even a part of a word, typing tags on a smartphone is for most respondents not an issue. Smartphones are better adapted to the more advanced means of input such as an external GPS and wearable sensors and of course also smartphone applications itself (GPS, camera, user statistics, etc.) can be used as input for the diary. All this is not available on a PC, or not useful if the device is not carried all the time by the respondent. Speech recognition on the other hand can in principle be programmed for both a PC and a smartphone.

*Table 3 Comparison of advantages (+) and disadvantages (-) for CAPA and SAPA*

| | **CAPA** (PC / Laptop) | **SAPA** (Smartphone / Tablet) |
|---|---|---|
| **Input** | | |
| • Own wording | + | - |
| • Selection (predefined list) | + | + |
| • Keywords / tags | + | + |
| • Speech recognition | + | + |
| • Use of smartphone applications (GPS, camera, user statistics, etc.) | **N/A** | + |
| • Connected devices (external GPS, wearable, sensors, etc.) | **N/A** | + |
| **Registration** | | |
| • Continuous self-registration (always available) | - | + |
| • Time Tracker | **N/A** | + |
| • Experience Sampling Method (push notifications) | **N/A** | + |

Note: (+) Easier; (-) More Difficult; N/A Not applicable

One of the main advantages of a smartphone is that most people carry it with them all the time. As such, the smartphone is always available to register activities on the go, while a PC is only available when the respondent is around. Since the smartphone is constantly available, it is possible to program a time tracker in the diary or send push notifications to the respondent with reminders or specific questions (e.g. questions on the mood or stress level at random occasions during the day, as it is done in Experience Sampling Method).

The advantages of the smartphone that go with its constant availability are dependent on one important condition: the battery. If the battery is low, the device is no longer available for input and registration. A PC is usually connected to the electricity network and us such the availability of energy usually poses no problems. Most PC's are also connected to the internet, so the input and synchronization of the diary data generally cause no problems. Smartphones are not always connected; this could possibly be a problem for the time-use registration.

**Computer-assisted personal agenda - CAPA (PC / laptop)**

A CAPA is usually programmed as a website on which respondents log in and fill in their diary during the registration day(s). As mentioned before, one of the advantages is that validity checks can be built in in the diary. It is important that the CAPA be compatible with different operating systems (MacOS, Windows, Linux, etc.) and browsers (Internet

Explorer, Microsoft Edge, Mozilla Firefox, Google Chrome, Safari, Opera, etc.) and versions, including older versions of these platforms and browsers.

### Smartphone-assisted personal agenda - SAPA (tablet / smartphone)[21]

A SAPA can be programmed both as a website or an app (or both). Below the main differences between a website-based diary and an app are explained. Developing an app for time-use data registration involves the choice between the type of app: Native app, Hybrid app or Progressive app. Each of these has advantages and disadvantages that will be also explained.

### Website or app?

| Website | App |
|---|---|
| Only accessible online | Can be used offline |
| Synchronized between different devices | Better performance |
| Cost-effective | Better user experience |
| Don't need an app store | Has to be accepted in different app stores |

A smartphone can run a website-based diary as well. Programming a website-based diary is relatively simple, as there is no need to develop different apps for different platforms (Android, iOS, Windows) and as such it is more cost-effective than an app. A website-based diary has also the advantage that it is easy to synchronize between different devices; a respondent can keep the diary on the go on a smartphone and continue at home on a PC without many complications. An app can be synchronized with other devices as well, but in general this is technically somewhat more complicated. On the other hand, an app can be used when the respondent is offline, which is not possible for a website-based diary. In general, an app offers more possibilities, has a better performance and a better user experience.

### Which kind of app?[22]

### Native app

A Native app is specifically developed for a platform (Android, iOS, Windows Phone) in its own coding language. A Native app is an application that is offered in the App store for smartphones or tablets.

[21] Research in the UK has indicated that an increasing number of users would like to use a smart device over a PC or laptop. Furthermore, design approaches now take a 'mobile first' principle when designing solutions.

[22] It is important to inform respondents clearly about the study objectives and the reason an app is used to create confidence to download and use it.

Native apps are built with specific technology and language for specific platform like Java for Android, Swift for iOS. Since a Native app is specifically designed for iOS and/or Android, the experience within the native app is tailor-made to each platform. Developers have to worry less about cross-browser or -platform compatibility. The main advantage of this is that Native apps are well-integrated in the device: they are better integrated with the other apps on the device which makes the maximum use of device functionalities (microphone, GPS, camera, pedometer, etc.) and makes push notifications possible. As Native apps are written in the programming language natively supported by the platform, they work faster, are more reliable and most responsive and consume less battery power. Native apps can make full use of offline mode capabilities making offline input possible.

The main disadvantage of a native app is that is it less flexible. The app has to meet all the criteria to be accepted to the app store and the acceptance can take some time.
To get a Native app published in an app store, it has to be authorized by either Apple or Google. Apps that present clear security issues for users are highly unlikely to get accepted. The advantage of this is that Native apps are more secure for both the app owner and users.

Furthermore, another disadvantage is that any change or update in the platform software may lead to adaptation in the app and for every platform different apps need to be developed and maintained.

| **Advantages** | **Disadvantages** |
|---|---|
| Better integration with other apps | Not easy to include in the store (Google Play, App Store, etc.) |
| Maximum use of device functionalities (microphone, GPS, camera, etc.) | Any change / update in the platform software may mean that the app needs to be adjusted |
| Possibility to send push notifications | For every platform (Apple iOS, Android, Windows mobile) a different app needs to be developed |
| Higher speed | |
| Works offline | |

**Hybrid app**

A Hybrid app is a website that behaves like a mobile app. It combines a Web app with capabilities of a Native operating system. Hybrid apps are built using web technologies like HTML, CSS and JavaScript. Just like Native apps, you can download Hybrid apps from an app store. At first glance, the app looks like a Native app, but appearances are deceptive. In fact, the browser is started and displayed without navigation.

| Advantages | Disadvantages |
|---|---|
| Flexibility in keeping the content up to date | An internet connection is needed |
| Uses the possibilities of the operating system and local functionalities | Plugins are needed to access the features of a device |
| Low development costs | Not recommended for complex apps |
| | Slower |
| | Lower user experience |

A Hybrid app is much more flexible than a Native app; it is much less dependent on the platform and changes in the platform since it uses the possibilities of the operating system and local functionalities. As such it is much cheaper to develop a Hybrid app than a Native app.

Hybrid apps rely on plugins to access the built-in features of the device. The disadvantage of this is that plugins can be outdated or unreliable. Since a Hybrid app is in fact a website, it requires a constant internet connection to deliver the full range of features; there may be difficulties to implement offline access to parts of its functionality. A Hybrid app is slower, since more time is needed to load all its elements. The user experience of a Hybrid app in general is lower since the interface should be adapted for both Android and iOS (and eventually Windows). If developers adapt the app too much for Android, the experience will be worse for iOS users and vice versa.

**Progressive app**

Progressive apps take an approach that is midway between mobile websites and mobile apps. They are mobile sites built with JavaScript, and aim to work just like a Native app. This form of app does not have to be accessed via the store of Apple, Google or Microsoft. You can add a Progressive app from your browser to your home screen. Once installed, the app will appear with a recognizable icon on the respondent's home screen.

| Advantages | Disadvantages |
|---|---|
| Possibility to send push notifications *(not in iOS)* | Remains a Web app with a number of limitations in comparison with a Native app |
| Works offline *(with limitations)* | Cannot be found in the App store |
| Accessible to everyone (not dependent on an operating system) | Progressive apps and their compatibility with (mobile) browsers and operating systems are still in the development phase. So far, it is not yet clear which further usage functions will be supported in the future |
| Always up to date: updates don't have to be downloaded from a website | Not all browsers and operating systems support all functions of Progressive Apps. |

| | |
|---|---|
| | A lot depends on whether iOS devices will support this technology |

Once a Progressive app is installed its features can be used offline utilizing cached data. However, a Progressive app cannot serve all parts of the app offline, anything that is not part of the caching system will be offline without an internet connection. Push notifications are possible with Progressive apps but are not available on iOS. Progressive apps can make connections to other features of the device but is much more limited as compared to Native apps. If the app heavily relies on other device features (camera, GPS, Geofencing, etc.), a Native app is still the most appropriate choice.

Just as with a Hybrid app, the interface should be adapted for both Android and iOS (and eventually Windows) and as such the personal user experiences in general is lower than with a Native App. Progressive apps are quite recently introduced, and get more and more the benefits that Native apps have, however these benefits are still limited, particularly in iOS.

**Other considerations**

- Websites and apps, especially Hybrid apps, can appear very differently according to the screen size of the devices. It is important to test the compatibility of website or app with different screen sizes (small smartphones (5 inches), bigger (5 – 6.8 inches), small tablets (6.9 – 9 inches), bigger tablets (9.1 – 10.2 inches), larger tablets/small laptops (10.3 – 12.9 inches), middle size laptops/computer screens (13 – 15.6 inches), large laptops/computer screens (> 15.6 inches).
- Normally the diary is preceded by a questionnaire and is usually followed by questions too. Although each can be completed independently, it is much more efficient to link all phases of the field work. Therefore, it is important to think how the questionnaire(s) and diary will be linked and organized, in terms of sequence, transition and linkage of the information.
- The front office as it appears on the screen of the respondent is only one aspect of the use of new technologies in collecting time-use data. A well-developed back office can be a very powerful tool to organize the flow of the field work efficiently: inviting and reminding respondents, transition from pre-questionnaire to diary on the assigned day, transition from diary to post-questionnaire, reminders in case of interrupting the registration, overview of response rates, overview of respondents in different stadia of the research, etc.
- The use of new technologies offers the possibility to collect paradata: when do respondents fill in the diary, how many times a day do they record activities, how long does it take to record one episode, etc. It is important to think on which paradata to collect during the field work.
- The field work should not be restricted to the use of one device or even one type of software. Most often it will be better if respondents themselves can make the choice between a PC (with a website) or a smartphone (with an app), or to use both (e.g. the

smartphone during the day and the PC in the evening) to enter their data. To make this possible it is important to enable smooth synchronization between the different devices.

- It is important to think on how the data will be transferred from the devices to the data files. The most efficient way is automatic synchronization over the internet.
- An important issue in collecting, synchronizing, transferring and storing personal data is of course security and confidentiality. It is important to act according to the local and international regulations and be aware that some easy and cheap solutions (such as Dropbox, Microsoft, etc.) often do not meet these requirements.

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