Modernization of the Production of Time-use Statistics*
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in collaboration with the *Expert Group on Innovative and Effective ways to collect Time-Use Statistics*.[1]

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* This document has not been formally edited.

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Table of Contents

Table of Acronyms

Acronym	Definition
ATUS	American Time-use Survey
CAPA	Computer Assisted Personal Agenda
CAPI	Computer Assisted Personal Interview
CATI	Computer Assisted Telephone Interview
CAWI	Computer Assisted Web Interview
DIPA	Data Protection Impact Assessment
EG	Expert Group on Innovative and Effective Ways to Collect Time-use Statistics
ESM	Experience Sampling Method
EU	European Union
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation, European Union
GPS	Global Positioning System
GSBPM	Generic Statistical Business Process Model
GSS	General Social Survey, Statistics Canada
HETUS	Harmonized European Time-use Surveys
ICATUS	International Classification of Activity for Time-use Statistics
ICLS	International Conference on Labour Statistics
ICR	Intelligent Character Recognition
ICT	Information and communication technology
ILO	International Labour Organization
IVR	Interactive Voice Response
LFS	Labour Force Survey
MHI	Minimum Harmonized Instrument
NSO	National Statistical Organization
NTTA	National Time Transfer Accounting
OMR	Optical Mark Recognition
PAPI	Paper and Pencil Interviewing
PC	Personal Computer
RCD	Responsive Collection Design
SAPA	Smart phone Assisted Personal Agenda
SDG	Sustainable Development Goals
SMS	Short Message Service
SNA	System of National Accounts
TUS	Time-use Survey
UNSD	United Nations Statistical Division
UNECE	United Nations Economic Commission for Europe
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UN Women	United Nations Entity for Gender Equality and the Empowerment of Women

1. Background

Member States at the 48th and 50th sessions of the UN Statistical Commission 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.[3] In response to this request, since 2018, the United Nations Statistics Division (UNSD) and the *Expert Group on Innovative and Effective Ways to Collect Time-Use Statistics (*hereafter*, EG)* have been working towards the implementation of 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] (hereafter, *Guide*). The overall objective is to promote this critical data collection across countries and over time. To date, the *EG* 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*. This report builds on an earlier draft prepared for the 51st session of the UN Statistical Commission.[5]

For both developed and developing countries modernisation is a journey across multiple steps requiring decisions about the main methods of registering activities, discussion of the role of data protection and privacy specific to modernised tools, and elaboration of the potential of geolocation tools.

The National Statistics Offices (NSOs) are facing challenges in conducting time-use surveys, and social surveys in general, due to decreasing response rates, increasing costs, 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, as a way to reduce non-response, offers respondents different options to provide the requested information.

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.

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. These include access to and coverage of technology. In addition, biases may emerge when countries are mixing modes for data collection. In this regard, it is important to mention that the *EG* is learning from the work undertaken by Eurostat and partners on innovative tools for Household Budget Surveys and Time-Use Surveys. This work is looking into solutions to lower respondents' burden, increase response rates and increase the efficiency of NSOs across the world.[6]

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[2] https://unstats.un.org/unsd/gender/timeuse/23012019%20ICATUS.pdf

[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

[5] https://unstats.un.org/unsd/statcom/51st-session/documents/BG-Item3m-Modernization-E.pdf

[6] See Eurostat's inventory of innovative tools and sources for smart Time Use Household Budget Surveys at https://coms.events/NTTS2021/data/x_abstracts/x_abstract_36.pdf

2. Why modernize the production of time-use statistics?

2.1. Modernization trends in collection of official 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 NSOs. Respondents usually see them as a burden, microdata are difficult to analyse, 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.[7] Time-use surveys require the respondent to provide detailed information about the activities they were 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.[8]

A number of modes of data collection have been used in various surveys but these more traditional methods are becoming less effective. Surveys based on paper diaries are very costly due to associated production, distribution, management, and digitalization tasks.[9] Surveys 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, short message service messages (SMS) 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 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 behaviour in general.[10]

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 field operations. These generate reports and alerts that can trigger corrective actions by managers and supervisors while data collection is still in progress.

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[7] 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.

[8] Glorieux, Ignace and Joeri Minnen (2009); Minnen, Joeri and Ignace Glorieux (2011).

[9] 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)).

[10] 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).

Modern technologies could also ease the accessibility and use of data. Although time-use data has a large amount of potential, in general, data are underutilized. Data files are complex to analyse 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, and integrating with data from other sources could be developed and used to draw insights from time-use data.

Finally, statistics including time-use have become an essential input for policy makers. Demand has increased creating the need for NSOs to produce and disseminate data in a timely manner responding to different areas of concern[11] 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.

Modernization of statistical systems and processes is a priority for the statistical community. For instance, the High-level Group for the Modernisation of Statistical Production and Services[12] (HLG-MOS) was created to oversee the development of frameworks, and sharing of information, tools, and methods, which support the modernisation of statistical organisations. The aim is to improve the efficiency of statistical production processes and the ability to produce outputs that better meet user needs, as well as to advise the Bureau of the Conference of European Statisticians on the direction of strategic developments and ensure that there is a maximum of convergence and coordination.

Furthermore, under the governance of the UN Committee of Experts on Big Data and Data Science for Official Statistics (UN-CEBD),[13] the United Nations Global Platform[14] was established as a collaborative environment to work together as a global statistical community and to learn together sharing knowledge, data, and methods for all countries in the world. The Global Platform has a built-in a cloud-service ecosystem to support international collaboration in the development of Official Statistics using new data sources and innovative methods and to help countries measure the Sustainable Development Goals (SDGs) to deliver the 2030 Sustainable Development Agenda. It is noted that as the platform has matured and the value it delivers has increased, the demand for access to the tools, data, and methods from Task Teams around the world has increased dramatically.

2.2   Social trends in communication

NSOs operate in the current environment of social communication and media use. Information and communication technology use is pervasive world-wide. Citizens now expect easy access to all public services including official data collection programs. This is particularly true for younger respondents, or for people in countries with higher adoption rates for internet and mobile technologies. With these trends

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[11] 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.

[12] https://unece.org/statistics/networks-of-experts/high-level-group-modernisation-statistical-production-and-services

[13] https://unstats.un.org/bigdata/

[14] https://unstats.un.org/bigdata/un-global-platform.cshtml

increasing across many countries across the world, such expectations are set to grow. In this sense, digital technology for surveys is not so much modern as barely keeping pace.

Furthermore, there are global trends to make government statistical agencies more efficient by moving production of official statistics towards use of administrative data (such as tax records) and away from traditional statistical processes and methods. Both trends align with the move to take advantage of modern techniques and with the expectations of both survey respondents and data users that this trend is being adopted as a standard by government agencies.

2.3   Traditional methods in a modern world

A number of modes of data collection have been used in various surveys but more traditional methods are becoming less effective, as mentioned above in section 2.1. Traditionally, 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 in particular. The smartphone, as a personal computer that people have 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. Options for implementing information technology involve choosing devices (computer or smartphone), selecting the point of access of the system (web or app), implementing geo-location aids, and resolving a number of other details/issues.

Before considering modernisation options in detail, it is worth recalling the benefits and trade-offs of more traditional collection modes, namely paper and telephone diaries. These are summarised in Table 1.

Table 1

Benefits and trade-offs of more traditional collection modes

Mode	Benefits	Drawbacks
Paper diary	• Tried and tested method used in many countries for several decades • Accessible to people with no smartphone or internet connection • Can be used as 'full-diary' or 'light diary,' that means allowing for different methods of recording activities — either free-text entry of activities or using pre-defined list of activities, which is the light diary option • Allows for collection of multiple diary days • Allows for flexibility in timing the distribution of	• Requires reasonably high level of literacy to participate • Requires either mail infrastructure to mail-out/receive paper diaries or requires interviewers to hand-out/collect diaries • Requires staff to enter data and code responses • May be difficult to be used by people with disabilities such as those with vision impairment • No immediate checks on the data being recorded by respondents as they are filling in their diary • More expensive to run if require use of interviewers to drop off and pick up diaries • For mail back, relies on respondents to return diaries

	diaries (compared with telephone interviews) • Allows for granular data on time-use	• Environmental impact – materials need to be manufactured, paper needs to be printed and distributed, left over materials to be destroyed • Completed diaries require storage space
Telephone diary	• Interviewer can perform checks on the data being recorded • Interviewer can ask probing questions to collect more information, such as transport activities, which are traditionally problematic to capture • Interviewer can continuously motivate the respondent to continue participating • Does not require high level of literacy to participate • Lower cost compared with face-to-face interviewers due to interviewers not having to travel	• Respondents may provide more socially desirable responses as they are directly interacting with an interviewer • Cannot be used by some people with disabilities • Requires interviewers to record activities • Excludes respondents without telephones • Usually limited to collecting activities for one diary day only • Usually requires making timely contact with respondent to collect responses (usually about the previous day only) • Potentially a lengthy survey resulting in respondent burden (and increased interviewer pay)

2.4   New functionality enabled by digitalisation

A couple of beneficial examples are highlighted here. Note, with technological developments and more countries' experiences, further functionalities may be enabled that will improve the modernised time-use survey as a whole. These could not have been envisioned with more traditional methods. Some of these potential future directions are covered later in the report. The general principle of the ease of editing and of amending survey instruments should be highlighted.

First, the electronic diary may contain validity checks to improve the quality of the data collection and/or to avoid registration errors. These are most flexible and effective with web or online technologies. Direct checks are linked with the activity that is registered and check the consistency of the registered information, such as warnings, which may be posted when attempting to register activities in the future, reporting change of place without transportation, or recording inconsistencies such as travelling at home or gaps and overlaps in time.

Indirect checks can only be done after a predefined period of registration for which a certain behaviour is expected. For example, respondents may be directed to amend diaries reporting fewer than a minimum

number of activities during the specific time period (three activities a day are recommended.[15]), reporting undefined time for more than a maximum (12 hours per day are recommended.[16]), or reporting no eating time in the specific time period. These checks may also improve quality and lower costs as responses can be checked automatically in digital modes of collection and targeted messaging given to respondents.

Another big benefit to using a modernised mode of collection is the potential to capture more question-specific information from respondents. Having specific questions related to the associated demographic/background questionnaire typically conducted for time-use surveys is also enabled by digitalization. For example, for those with multiple jobs, a modernized tool can ask for clarifications of work activities to link to these specific jobs. The tool could ask more targeted questions on location or co-presence, some of which may even be partially automated allowing for a smoother respondent experience and lower burden, or could probe for details about with whom or for whom an activity was performed. These opportunities enable researchers and organisations to answer questions they may not have considered with more traditional time-use data collections, as well as improve the quality of such collections.

Finally, several types of questions relating to the diary day and giving a more complete picture of time-use across both activities and related information (enjoyment, location, activity-specific follow-ups etc.) are more naturally integrated into an online or mobile-based tool. The information to be filled in can be presented more sequentially for respondents so as to avoid cognitive overload by using links, shortcuts, and inference of related categories. For example, activities related to computer would not require asking if an ICT device was used. Hence researchers do not have to restrict collection choices as much as they may do when using limited space in physical paper diaries.

3. What does modernization mean?

3.1   Introduction

Modernization of time-use surveys using digital technologies addresses a number of problems cited above. These include offering various options to respond, reducing the respondent's burden, improving the response rates, improving monitoring and management of data collection operations, and improving contact and communication with respondents (such as sending invitations and reminders). Information technology can reduce costs of survey programs, improve data quality, address certain sampling problems, and allow deeper survey questioning by integrating different data sources. This section discusses these issues as they relate both to digital and traditional survey methods.

It is important to point out that modernizing the production of time-use statistics may have different meanings in different contexts and countries. It should be seen as a journey for which the most important question for each country is what its next step may be. For some countries, modernization may result in moving from paper-and-pencil interviewing (PAPI) to computer-assisted personal interviewing (CAPI). For others, it might consist of developing and using web and mobile solutions. Importantly, a target that

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[15] See the report *Quality Considerations for Time Use Surveys,* prepared by the Expert Group and available online as a background document to the Secretary General's report on gender statistics at https://unstats.un.org/unsd/statcom/53rd-session/
[16] Ibid

may be more achievable for many countries would be the use of mixed-mode and mixed technology solutions. In the longer-term, countries and their statistical agencies may get the benefits modernisation allows by stretching out the costs across time. In general, the guidance provided here focuses on the transition from face-to-face or telephone-interview data collection modes to self-administered digital surveys using modern technologies or mixes of interviewing and self-administered modes.

There are multiple stages of digitalisation, with differing considerations that organisations would have to weigh up. These relate to the mode of collection, naturally, but also to other considerations about the depth, scope and quality of data required for the organisation's purposes and users. These are elaborated in the next section.

Focusing on the different collection modes first, the considerations are summarised in Table 2 below, in terms of probable cost and quality impacts.

Table 2
Considerations when implementing differing modes of collections

Mode	Initial investment cost	On-going Cost	Representativeness
Paper	Lower	Higher	Higher (due to fewer access issues)
Telephone	Lower	Higher	Lower
Online (Web based app and CAPI)	Higher	Lower	Higher (due to additional functionality to help)
Mobile app	Higher	Lower	Lower
Mixed	Lower	Lower	Higher
Online and Augmented	Higher	Higher	Higher (due to recall help)

This table is based on the assumptions of a certain level of access to internet and technology across the target population, as well as feasible sampling strategies being available. Please see section 4.1 for more cost considerations.

3.2   What can modernisation look like – with digital tools

The most commonly used devices are personal computers (PCs), laptops, tablets, and smartphones. Smartphones are easy to carry and suitable for updating 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 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), and diaries developed for smartphones (or tablets) will be called smartphone-assisted personal agenda (SAPA). However, PC or laptop-based diaries are almost exclusively linked to the internet, and even if there is a desktop version, it also exists as a web version.

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 into the diary. It is important that the CAPA be compatible with different operating systems (MacOS, Windows, Linux, etc.) and browsers (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).[17]
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 are also explained.

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-native applications (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 and is native in later mobile and PC operating systems.

Table 3
Comparison of advantages and disadvantages for CAPA and SAPA self-administered web-based TUS applications

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

[17] 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.

Note: N/A Not applicable CAPA or computer-assisted personal agenda are time diaries programmed for a PC (or laptop).
SAPA or smartphone-assisted personal agenda are time diaries developed for smartphones (or tablets).

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. Since the smartphone is frequently available, it is possible to program a time tracker in the diary or send push notifications to the respondent with reminders or questions on their 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 PCs 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. However, if built with the functionality, smartphone tools can be completed 'offline' – without a constant internet connection. The data subsequently get uploaded once the smartphone reconnects to the internet.

3.3   What can modernisation look like with traditional collection modes

Collecting time-use data has traditionally been achieved through two main approaches: recall interviews by an interviewer; and self-reporting by respondent. In addition, direct observation has been used but this is now almost exclusively used for in-depth small-scale studies or data quality checks. Both main options can benefit from the use of modern technologies resulting in more effective and cost-efficient collection of time-use data. In practical terms, most national time-use survey programs are tailored to the specific capabilities of their populations and sub-populations and employ mixed modes and more than one technology.

A traditional mode of data collection is to interview respondents about their time-use during a specified period of time. The interview may be conducted face to face or over the telephone. Both cases have incorporated modern technologies for fast and reliable data collection.

Recording data during interviews has been improved with the use of portable, electronic devices like laptops, smartphones, and tablets, where interviewers follow on-screen prompts to ask the questions in a retrospective way to obtain the time-use data (CAPI or CATI). Skip patterns can be programmed 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), geolocations, as well as interview duration for example, which 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. An example of CSPro given data entry is in Annex 2.

4. How can we modernise?

This section discusses the contributions of digital technology to survey planning and design, content, the selection of application options, surveys based on mixed modes, and survey management. Country experience is cited and NSOs are recognized as beginning at different stages of technological adoption. This section, as the rest of the report, assumes that the *Minimum Harmonized Instrument*[18] is used, and the reader is encouraged to review the detailed guidelines there.

4.1   Considerations during planning and design phases

Cost considerations
The critical considerations of cost can be addressed along two dimensions – initial investment to set up the survey, and on-going costs of collection. These latter on-going costs may also need to reflect whether the time-use collection is planned for a one-off or regular collection. Initial investment costs for modernised tools entails developing a survey collection tool (either in-house or outsourcing this), upskilling survey teams, testing the platform, user testing and ideally accessibility testing to ensure the platform can be used robustly and efficiently by respondents to not be put off the collection. The iterative testing of the platform has the additional cost of time, which should also be considered. A viable alternative to lower initial investment may be to take on an existing modernised tool and re-purpose for a country's use case. There are several existing and developing tools,[19] which should cut down on substantial initial considerations of design, accessibility, and functionality, though there is some offset from carefully investigating existing options.

On the other hand, on-going costs are typically lower with modernised tools, whether a mobile-based or web-based solution. This is due to the much simpler process to make changes to the tool in response to testing, analysis of results, and modification for differing purposes. Section 4.3 examines the pros and cons of online modes. Paper-based tools require to be re-printed for any changes. In addition, costs during collection tend to be smaller, for several reasons. There are smaller printing and postage costs required for the smaller amount of information to be sent (or non-existent in the case of mobile tools potentially). Typically, web-based solutions may have smaller on-going costs than mobile app-based solutions, due to the more specific expertise required to modify and maintain mobile apps.

For a breakdown of the initial investment cost, on-going cost, and the representativeness of the data collection by the mode of collection, please see Table 2 in section 3.1.

There are also smaller costs to follow up respondents or help them with filling in their diaries, through internet-based communication, rather than sending further physical information or having a telephone response unit. The collection of the data itself tends to be smoother, less error-prone particularly from manual intervention, and can be designed to be used upon filling in, rather than having to transpose the data from a physical to digital medium. Finally, on-going storage costs of digital results tend to be

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[18] See the report *Minimum Harmonized Instrument for the production of Time Use Statistics,* prepared by the Expert Group and available online as a background document to the Secretary General's report on gender statistics at https://unstats.un.org/unsd/statcom/53rd-session/

[19] See Eurostat's **inventory** of innovative tools and sources for Time Use Survey at https://webgate.ec.europa.eu/fpfis/wikis/display/ISTLCS (access upon request at ESTAT-F4-INNOVATIVE-TOOLS@ec.europa.eu)

minimal in comparison to having to keep the raw returned physical diaries, given the results were filled in digitally in the first place. These factors tend to hold for mixed mode, particularly if the mode is split between digital and telephone as was found in the United Kingdom 2020-2021 Online Time-Use Survey.

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 is developed, many parts of the process are automated resulting in savings. These include fewer enumerators,[20] minimal or no codification, automatization of the processing of the information and generation of outputs, minimal or no cost related to handling paper diaries, and reduced cost of data editing and processing. For example, Belgium has estimated 60% of savings thanks to the introduction of the MOTUS app to collect time-use information in their forthcoming time-use survey in spring 2022.

Although many small-scale time-use studies have used observational approaches in the context of producing official time-use statistics, these approaches should be considered only for data quality checks or in-depth small-scale studies given the high cost they might entail.[21]

Quality considerations

Quality considerations as they relate to modernization and technological applications focus on the flexibility and ease of use for respondents and the depth of detail that may be asked given the speed and reliability of digital applications. Quality considerations for time-use surveys in general include representativeness of a target population, days and seasons, granularity of episodes and activities, accuracy of responses, management of data during the collection and distribution process, and level of detail in background descriptions and episode contexts. These issues are discussed in detail in the Expert Group report, *Quality Considerations for Time-use Surveys*.[22]

Considering the quality of individual responses, generally modernised tools allow more flexibility for individuals to fill in their time-use diary, which should enable higher quality responses. For example, some respondents may choose to fill in their diary day 'on-the-go' either with online or mobile tools, and so can accurately record each activity. Mobile tools can be built to not be reliant on a continuous internet connection, further empowering respondents to use the tool when they choose. In addition, there may be benefits in lowering respondent burden or augmenting the user experience. These are further elaborated in the quality consideration report.[23] In all cases, countries should conduct testing of selected tools and survey design with potential respondents to optimise these elements before implementing them.

A mix of telephone, online and mobile solutions also enables further quality improvements. In particular, prompts for recall can be embedded in the tool and used by telephone interviewers consistently when filling in the information digitally during the call. Prompts which are activity-dependent can be built-in into online and CATI applications. For example, such checks may ask people who have changed location

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[20] 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.
However, less engagement with enumerators likely means less bias brought into data from such interactions.
[21] Kelly, Paul et al (2015) ; Kapla, Robin L. et al (2016).
[22] See the report *Quality Considerations for Time Use Surveys,* prepared by the Expert Group and available online as a background document to the Secretary General's report on gender statistics at https://unstats.un.org/unsd/statcom/53rd-session/
[23] Ibid.

how they travelled to and from that location and if they have missed reporting travel explicitly. This is a known weakness of self-completed time-use surveys.

When asked about their use of time through interviews using stylized survey questions as opposed to self-completed diaries, time spent on activities thought more desirable have been over-estimated and under-estimated, as reported by Hofferth (2000). Bonke (2005) found that respondents systematically reported more unpaid work in diaries than in questionnaires, perhaps due to the fact there are many short bursts of activity which are more likely to be forgotten in a stylised question.

Security and data protection

Data collection, storage, processing, and dissemination must respect the data protection laws, regulations and rules as described in national law and, for EU countries, the General Data Protection Regulation (GDPR). Countries may have their own specific regulations, such as New Zealand's data protection within its 2020 Privacy Act[24], or Mexico's LSNIEG[25].

Data protection laws, such as GDPR, require a Data Protection Plan (DPP) to be completed to assess proposed measures that pose particular risks relating to how personal data is used. These may include a full Data Protection Impact Assessment (DPIA).

The GDPR does not define which method has to be used to perform a DPIA. The European Data Protection Supervisor (2018) points to the Bieker et al. (2016) method as a reference. Hoorn & Montager (2018) uses the Bieker et al. method as a starting point because it gives a parsimonious model with privacy and security protection goals (confidentiality, integrity, availability, unlink ability, intervenability and transparency). These protection goals are aligned with the data protection principles defined in article five of the GDPR. Those principles are lawfulness, fairness and transparency, purpose limitation, data minimization, accuracy, storage limitation, integrity, confidentiality, and accountability. Hoorn & Montager (2018) added data minimisation as an additional protection goal. A table, taken from Hoorn & Montager (2018) that outlines protection goals and some generic measures for the implementation of these goals is presented in Annex 1. This table could be used as a starting point to further discuss issues on data protection and privacy related to the digitalization of time-use studies.

4.2   Considerations of survey content

Survey content depth and context questions

As well as the above considerations, countries and organisations considering modernisation should consider what depth of collection would meet their purposes, and how different modes may enable and extend this.

One of the strengths of time-use research based on diary instruments is that each activity episode may be recorded in combination with context information. Any descriptor of an activity episode may be used. Most common are secondary activity, location, mode of transport, presence of others, use of devices, for whom the activity is undertaken. Survey managers need to define which contexts are necessary and how they will be recorded in the diary (own wording or predefined). Other guides describe in more detail the

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[24] Privacy Act 2020 No 31 (as of 28 October 2021), Public Act Contents – New Zealand Legislation
[25] Ley del Sistema Nacional de Información Estadística y Geográfica (snieg.mx)

benefits and drawbacks of the different levels of diary-related information (e.g., UN (2018a)). The *Minimum Harmonized Instrument.*[26] and the accompanying data *Quality Considerations* report[27] are the most recent guidelines on the minimum level of detailed information that should be collected.

Core aspects of time-use, such as main activities, secondary activities, location, and co-presence can be captured in traditional time-use surveys. However, allowing for flexible adjustment of questions related to responses requires a degree of digital modernization. In some diaries, the context questions are linked to the activity. For example, for travelling, the mode of transport is presented in place of location options. For specific activities, such as 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

As another example, the United Kingdom has been testing in its 2020-2021 online time-use survey the potential to capture a more complete measure of paid work than through traditional 'work' related activity categories. This is particularly relevant in a world where the boundary between work and social life blurs, but also in the context of higher access to working from home or remote locations. Some activities may be less likely to be recalled (e.g., checking work emails in the evening, reading, or researching about a work problem, conducting some informal market research on products or competitors, etc.). To explore this, the survey asked specific follow-up questions on whether people were conducting certain activities for paid work or if they were paid for an activity, which they may not consider in the more traditional bounds of work contracts. Combining these more specific activities and follow-up questions provided around 5% of total work time - a meaningful minority of work time that could then be analysed to understand barriers to work-life balance and the types of individuals undertaking this extra work.

Registration method of activities

Activities can be recorded in the words of the respondent and later coded by the interviewer or coders using a predefined activity list. Alternatively, the survey provides a predefined activity list from which the respondents or the interviewers select the relevant activities to register time-use.

Predefined lists can be organized as a taxonomy in different levels with the number of activities varying from less than 20 to a few hundred. Electronic diaries may also be designed with tags in the background. As respondents or interviewers write down their activities in their own words, the device will suggest activity entries from the pre-coded key word list.[28] In more advanced devices, the respondent might receive suggestions about his/her behaviour on the basis of information collected by GPS, activity trackers or other wearables or functionalities in the registration devices (e.g., smartphone) during the

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[26] See the report *Minimum Harmonized Instrument for the Production of Time Use Statistics,* prepared by the Expert Group and available online as a background document to the Secretary General's report on gender statistics at https://unstats.un.org/unsd/statcom/53rd-session/

[27] See the report *Quality Considerations for Time Use Surveys,* prepared by the Expert Group and available online as a background document to the Secretary General's report on gender statistics at https://unstats.un.org/unsd/statcom/53rd-session/

[28] Natural language processing could be explored.

designated day.[29] The benefits and trade-offs of the main types of registration methods are summarised in table 4.

Table 4

Benefits and trade-offs of the main types of registration methods

Registration method	Benefits	Drawbacks
Free text	• Creates freedom for respondents to provide limitless variety of activities – able to capture activities that may be new or unusual • Respondents do not have to look through large list of activities/remember a list of activities • Provides a good indication of how respondents think about how they spend their days and what they define as an activity	• Respondents may record more than one main activity – forcing staff to decide on what to include/exclude • Requires staff to data enter and code activities (or for modernised tools, to invest in automatic natural language processing categorisation methods) • Respondents may not describe the activity in sufficient detail or may describe it with too much detail, that needs to be removed
Pre-defined list	• Does not require staff to code activities – self-coding by respondents (this may still be an issue for people filling in paper diaries if they do not stick to the list) • The list can prompt or remind respondents to record activities that are easily missed such as transport activities • Depending on the size or scope of the list, it can assist respondents to understand the level of detail that is desired	• Can limit the variety of activities that can be collected, due to the space on the page or screen • Can result in not accurately capturing the nature of an activity as respondents may just select a category that is 'close enough' • Does not allow for social, cultural, or geographical linguistic differences between respondents

4.3   Considerations for technology selection

Current modern technology choices for survey data collection are web-based and smartphone-based applications. Both have distinct advantages, taking account of functionalities that could not exist through paper-based or telephone diaries, as well as making savings and efficiencies in some cases. Such applications can:

• cater for some people with disabilities by including functional testing at the design phase (e.g., screen readers)

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[29] Geofencing technologies could be explored.

- be programmed for both methods of recording activities, as well as accentuating the experience with a pick list or predictive text coders to assist respondents
- automatically gather some contextual information, like physical location, and paradata, such as how often respondents access the diary
- allow for soft and hard checks of the date being entered to improve accuracy
- eliminate data entry staff as the data is being electronically recorded
- provide visualisations such as graphs of the data being recorded can be shown
- be accessed on the go throughout the day
- be less likely to lose personal data than paper diaries (though there is potential for digital data breaches)
- meet expectations of respondents to have the option for an electronic diary
- potentially lower cost as interviewers are not involved, which is a large cost in traditional survey collection methods

There are trade-offs common to web-based and smartphone-based applications that organisations should be aware of if considering modernising. As highlighted above, there may be an initially higher cost for set-up, which includes not just the cost to build and test the tool, but higher levels of testing up-front and continuously if the tool is being created for multiple waves of collection. In addition, there may be a level of investment in human capital in the organisation if the tool is being developed and maintained in-house, to have a regular supply of specialist skills such as coding software and hosting the website with related infrastructure. Finally, there is the clear concern around participation from respondents – requiring not just the literacy skills that most time-use surveys require but also a degree of digital literacy and access to technology. A potential solution may be to leverage higher levels of digital literacy within the household and community (e.g., through younger populations in tandem with other members of the household) though it is worth considering potential knock-ons to privacy issues and consent. Finally, it may be difficult to convey to respondents the level of detail required for activity reporting unless further communications are sent.

Using an app.[30]
An app-based diary has further considerations to weigh up (see Table 5). Some of these are a larger priority for differing countries with different needs, existing infrastructure, and expertise, as well as where they are on their journey towards modernisation of data collections.

Table 5
Considerations when choosing a website or app for collecting time-use data

Website	App
Only accessible online	Can be used offline
Synchronized between different devices	Better performance
Cost-effective	Better user experience
Do not need an app store	Must be accepted in different app stores

Extra functionalities enable new opportunities. For example, communicating with respondents can be done directly through the smartphone to prompt them to complete the diary, as well as other reminders or prompts. Extra information can be gathered automatically from each respondent, such as the time spent

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[30] 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.

on the device, time using certain categories of apps such as social media, banking etc., subject to full transparency to the respondent and their consent. Finally, the app can be tailored to suit the operating system of the user's device more accurately than with a web-based solutions, allowing for a cleaner user experience.

Extra functionalities also provide some new types of risks. An app would typically have to be downloaded through an app store, which may be confusing for some users, as well as requiring approval from the app store in order to make sure that the proposed app abides by its terms and conditions. This may cause privacy concerns depending on the restrictions of these terms. In addition, the development of the app would likely require specialist skills such as programming on iOS or Android. In fact, multiple versions of the app may be required to cater for users across the multiple operating systems. In addition, as these operating systems change, more regular updates may be required to ensure the app still functions. Finally, there may be further specialist skills required by the tool developers in the form of data security relating to mobile data storage and transfer.

If an app is the selected modernised solution for the country, there are several approaches to consider. These are described in Annex 3.

4.4   Considering a mixed mode collection

Many countries have been exploring the use of mixed-mode approaches. For example, Denmark (HETUS 2008-09) and Finland in 2020-21 collected data with paper diaries and a 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 in a web application were used for the collection of time-use data as part of the Canadian General Social Survey program (GSS). In Australia in 2020-21, CAWI, CATI and CAPI were options for collecting the background questionnaire and paper or electronic diary for the time-use component.

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. For example, highly literate, working age, urban population might be best interviewed through CAWI or Mobile application, with an initial contact via mail, e-mail, or SMS, while low literate or rural populations with poor internet coverage may be best interviewed via CAPI, with an initial contact via postal mail. Meanwhile, highly literate, working age, urban population that has lost trust in technology might be best interviewed via CAPI or CATI, with an initial contact by mail. 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 because of the use of different data collection modes and in terms of the quality of the data. For example, use of technology may produce more episodes or affect the response rates.[31]

Offering respondents a variety of options for participation (i.e. having a mixture of paper, telephone, and web-based data collection) is likely to improve the response rate and diary quality. Multiple options can also reduce potential bias arising from differing access to internet and technology in the population, since respondents can select their preferred mode. An example of this could be having both CATI and CAWI to

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

allow inclusion of those with and without internet access, such as was done in the UK for their 2020-2021 collection.

Digital collection mode effects on representativeness

Population representativeness is another key factor that organisations should weigh when considering digitization and modernisation goals. While an online option may be thought to bias response towards persons with good internet and device access, as a mixed mode it can enable additional functionality to ensure respondents can report. The lower respondent burden can offset the more universal access of a paper diary, since it may encourage more people to fill in the diary.

A modernised tool may engage a wide group of people. As is also well documented, internet access is becoming more prevalent in many countries, particularly mobile internet access, so a mixed mode approach combining populations willing to fill information online with more traditional collection still represents a path to modernisation.

In some settings, particularly those with low literacy rates, face-to-face or telephone-monitored 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. In such an instance, the NSO or agency should also consider the potential of bias from telephone and face-to-face interviews when stemming from communities' higher non-response, as it is plausible that they may have trust issues with their government.

Sample survey data is intended to represent the target population. Any data collection program must control for the effects of biased responses from certain types of individuals arising from the sampling design. Assuming a representative sampling frame can be applied with modernised collection methods then the different stages of engaging with respondents need to be considered to optimise representativeness at each stage. These can be split into topics of initial communications, access to technology, engagement, and accessibility of equipment. Developing the sampling frame may be considered one of the key methodological steps but is not dealt with here.

4.5   Digital roles and issues in survey management

Initial communication

Initial communication may be more challenging with modernized time-use collection, if email address lists are unavailable or internet access is restricted. Some online survey programs have continued to initially reach out to households' addresses, before providing log-in information bypassing the requirement for an email address, or even permanent internet access. If the initial reach is through physical addresses, there are more general issues that several countries have been facing across their social survey portfolio, with further bias and disengagement in recent years (Koen et al., 2018). For example, young people tend to respond less frequently to surveys, as do those of ethnic minorities and persons with the country's official language as their second language.

Access to technology

Starting respondents with modernised tools presumes adequate levels of technology access, particularly if equipment such as tablets or GPS trackers need to be provided. Additionally, there are accessibility considerations when accessing tools online. There are also data protection requirements to make sure

individuals' access is specific to them and other individuals cannot see their data. This is the case if the whole household is filling in their individual information.

Engagement

Once a respondent is engaged, organizations should test differential rates of completion to ensure there is no bias in keeping them engaged. It is important to consider if functionality prevents people with differing abilities to respond to the burdensome task of reporting 24 hours of time-use, particularly those who may have short attention spans or deficits with short or long-term memory. If a certain design has a disproportionate impact on such groups of individuals, additional functionality may be provided, such as presenting information for people to recall what they have filled in already, or tips on how to better recall events using other guides such as calendars or speaking to relatives. In addition, the tool may need to accept partial completions throughout several logins rather than simply allowing individuals to fill in their entire day at once. The concept of cognitive load theory (Sweller, 2011) may be particularly relevant, especially for younger respondents and children. Asking individuals to concentrate on filling in one element at a time may improve engagement.

Usability in terms of reliable connectivity is also worth considering as an engagement problem. For example, should the page need to re-load every time a new entry is submitted, should it only send across one item at a time? Similarly, what element of automatic time-out (both for online and mobile tools) should be considered, trading off potential security exposure to personal data with certain people who may have certain abilities that mean they are slow to fill in. These are examples of considerations that survey teams should explore with their IT departments. Some of these considerations may interact with the considered costs for server usage during collection as typically the hosted tool would have an expected level of activity from multiple respondents being logged on to the tool at the same time.

Accessibility of equipment

Accessibility remains an issue to consider once individuals start their diary day and functionality should reflect all abilities. This may mean testing an online tool to see how respondents using screen readers interpret the information, or those who may only use a keyboard and not a mouse. In general, considering different user experience with the modernised tools would allow for systematic testing of areas of functionality that may have been overlooked for non-disabled people. Within the European Union, there is the *Web Content Accessibility Guidelines* (WCAG 2.1) in line with EU Directive on Web Accessibility (EN 301 549) and there may be other accessibility guidelines for specific countries or other statistical unions of countries. For example, the New Zealand equivalent set of guidelines can be found online[32]. Hence, elements that may need to be avoided include drag and drop, which is difficult or impossible for keyboard-only users to navigate easily, as may be certain hover options. In general, having interactive elements as a core standard of the collection should be avoided for people with cognitive impairments. Positioning of the least amount of information necessary, and general design choices for a clear user experience, may also help dyslexic individuals and those with vision problems. This may lend itself to avoiding simultaneous multiple field collection on a screen/mobile page, as well as having timelines for the diary integral to collection rather than for simply representing more traditional collection approaches. In a related manner, relying purely on shapes or colours to convey information to users would disadvantage blind and visually impaired respondents.

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[32] https://www.digital.govt.nz/standards-and-guidance/design-and-ux/accessibility/

It is important to highlight that some of these accessibility issues affect more traditional forms of collection. Being able to hold a writing implement or telephone (if reporting through an interviewer) would be a particular concern for those with arthritis. Telephone mode may also impact on those with hearing problems, unless there is equipment or help already provided, so a modernised online-based tool may actually enable greater response rates from such vulnerable groups. These factors point to the importance of accommodating mixed modes of data collection.

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 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 the sections 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.

Modernising tools for paper and interview-based 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.

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 the 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 are much lower 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.

Self-reporting

In the self-reporting method, the respondent personally records the time-use information on the survey instruments (see table 6 for a summary of advantages and shortcomings of self-reporting TUS collections). 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 computer assisted web interviews (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 visit the link to access the survey but should be given some direction as to when and how to complete it. Austria, France, Hungary, Poland, Norway, Belgium, Luxembourg, Germany, Canada, Serbia, and Japan have developed websites for the self-reporting of activities for time-use statistics.

Mobile applications are a feasible alternative for data collection of self-reported time-use as opposed to paper diaries or 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).[33] 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 mixed mode with paper and a mobile app to collect time-use data is the survey undertaken in Shanghai, China, in 2018.[34] Furthermore, the research Group Tempus Omnia Revelat has conducted several studies in Flanders, Belgium, using MOTUS (web app and smartphone application) to collect time-use information from university professors (2016), people working in public administration (2017), schoolteachers (2018), as well as 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 once in 2020).

Using open sources which are 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.

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[33] 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.

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

Table 6
Comparison of different modes to collect time-use data

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

5. Future considerations

5.1 Potential future technologies or use of existing technologies not applied to data collection

Geolocation

Geolocation data holds information on the longitude and latitude of an internet-connected electronic device, such as a smart phone or smart watch. This information comes along with a time stamp tracing the device through time. More and more individuals carry multiple devices at a time. According to an international survey in 2020,[35] the average German has access to more than seven internet-connected devices while the average American has access to more than ten devices. With the number of smartphone users reaching worldwide over 6.3 billion in 2021, and expected to exceed 7.5 billion by 2026,[36] geolocation technologies will become more and more pervasive.

The best-known and most precise way to determine the location of a device is through GPS. In fact, many smartphones and other devices can detect location via satellite GPS, independent of reception or internet. However, being a satellite-based system, GPS does not work as accurately indoors and can be affected by the weather or a physical interference. For these reasons, most devices use GPS in combination with other

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[35] Average number of devices residents have access to in households worldwide in 2020, by country | Statista
https://www.statista.com/statistics/1107307/average-number-connected-devices-households-worldwide/
[36] Number of smartphone users from 2016 to 2021 | Statista
https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide

forms of location signals like Wi-Fi networks, cell towers, and Bluetooth to create a more accurate location picture.

The inclusion of sensor data will make the time-use survey a so-called 'smart survey.' The transition to a smart survey will make it necessary to rethink various elements/concepts/stages within the survey itself. Not the least, there is an impact on:

- how to contact and communicate with the respondent (General Data Protection Regulation GDPR,[37] right to consult, differential privacy, …)
- how sensor data is collected and processed (software, front/back office, database, server side, algorithms, …)
- how the (derived) sensor output is provided to the respondent (interface designs, business logic, decision models, etc.)
- how various devices are used and need to be inline which each other (smartphone, wearables, smartwatch, multi-mode setup, synchronization/interplay, business logic, etc.)
- how the respondent can confirm, adapt, enrich passively acquired information (multi-mode setup, synchronization/interplay, business logic, etc.)
- how does this new and extra information integrates/impacts the traditional registration logic (multi-mode setup, synchronization/interplay, business logic, etc.)
- the role of the respondent (data supplier, data controller, feedback, etc.)
- the representation of the population (capability gap, device ownership, internet/data plan, device configuration, platform specifications, costs, etc.)
- how this new way of data collection affects the comparison of historical data, and the effect on mixing modes

There may be a potential for other future technologies to enable the above benefits too but are yet to be tested. These may include Google Glasses or similar technology; sensors being developed from the Internet of Things (IoT) sector. Smart TVs and smart speakers may be the first step in trying to link to this wider set of technologies for further data collection on time-use and its integration among other more traditional solutions.

Further use of automating technologies

The field of artificial intelligence (AI) and machine learning in general is undergoing a revolution, driven by a mixture of faster computation, new techniques, wider interest, and a burgeoning of available data for training models. This may end up being used in potential different ways.

Automatic categorisation of free text-based activities along activity hierarchies such as ICATUS 2016 may be enabled. Currently, such models do not have enough modelled data to create predictions on other free text completion of diaries, and so would only be able to categorise text in fairly generic ways, rather than specific taxonomies. However, in time, other models that do not require as much data for training may be enabled.

A second possible option is to use AI technologies to improve the collection process end-to-end, rather than specifically at the diary response side. For example, methods to infer optimal times of the day to text or email respondents to remind them to fill in their questionnaire may be inferred from the general-purpose machine learning methods available, based on existing survey responses. Similarly, optimal

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prompts and guidance from telephone interviewers during the collection period, resulting in lower respondent drop-off or faster completions may be imagined.

There may be more potential to use voice recognition software founded on AI methods in training the original models. This may enable faster respondent collection as well as the potential to fill in diaries in potentially differing ways altogether (e.g., automatically perceiving speech as text and automatic categorisation from a narrative-style response to activity information). Relatedly, 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 the answers automatically into a database. However, this has not been implemented in any national statistical context, and there may be wider challenges of data protection, as well as representability, that are yet to be explored by the research community. Hence, no strong recommendation is made on this software.

The aspect of using auto-completion technology when people are writing free text information has benefits and drawbacks, so it still requires more research before full implementation. The obvious potential benefit is that respondents will be able to complete their diaries and questionnaires more quickly. However, there is evidence that it can also trigger errors, or guide respondents too much and hence cause lower data quality.

Things that would not be recommended for application at this stage include using technologies for pre-filling information and getting people to validate it through machine learning methods that can supposedly infer activity information. At this stage, this may have more drawbacks, than the potential benefits saving time to fill in, as survey respondents may want to finish the survey they are answering as quick as possible (and hence not actually review and leave pre-filled information as is, even if wrong).

The field is still evolving and expanding at a fast pace, as of 2021, and there may be new technologies and applications in the future that are not discussed here.

Video conferencing and social media
There may be a potential in using video conferencing technology to retain some of the more personal human touch from interviewers, while enabling remote collection. This may further enable a secondary collection of data – namely the video itself. However, this has not been applied in any country context yet and would need to consider the further complexities of data protection and security to add value.

Similarly, there have been suggestions of engaging users through social media and creating more bespoke collections directly through existing platforms as a way to reach audiences not otherwise reached through more traditional collection. This may enable different sampling frames to supplement other approaches, or a new channel of engagement and communication. This has not been tested in a time-use context specifically, and so its viability is still an open research question, particularly as it pertains to data protection, commercial sensitivity, and available technological solutions.

Outstanding issues with time-use collection
A number of problems have faced time-use survey operations and still remain. Two are discussed here.

The first is the generally high burden of data collection. With all the solutions proposed above, and implemented through various countries, collecting time-use diary data remains more burdensome than

typical social survey questionnaires. The hope is that by using the *Minimum Harmonized Instrument*,[38] the burden may be lessened with some of the approaches. However, further technological improvements may be needed to envision a quick collection of people's time, as referred to with the potential future approaches above.

The second is travel time. It is difficult to capture accurately with reasonable respondent burden. There seem to be fundamental trade-offs in automatic recall vs quality of such data. Either a more costly and intensive approach requiring human interviewers as prompters is needed or the potential of some of the geolocation technologies above may be required to create data ready for more meaningful analysis of travel time.

There are additional problems relating to the digitalisation of time-use surveys due to internet availability. Research from ITU 2021 suggests 37% of the world population still has never used the internet. This should be a more obvious consideration for developing countries. Additionally, there are demographic differences that would need to be taken into account in some cases. Looking at age, 71% of the world's population aged 15-24 is using the internet, whereas only 57% of all other age groups are doing so. There are also gender differences: 62% of men compared with 57% of women. It is important to note there are alternative methods of modernization that do not all rely on good access to the internet, as outlined in section 3. In situations whereby a modernization approach is chosen that requires internet availability, and this differs by demographic, survey design would have to be adjusted for this fact, with the possibility of targeted incentives being used.

6. Conclusion

The move towards modernisation is driven by many factors, some of which are global, while others may be more country specific. However, the trend and expectation from both respondents, users of data, and UN and international experts is in the direction of digital tools being embedded in all stages of the time-use data collection process. The benefits of doing so may mean the difference between collecting time-use survey data or not, in particular country contexts.

The decision to introduce any of a number of technologies and tools to modernize the production of time-use statistics should be carefully considered. However, there are many benefits and the trends in survey and census data collection across the globe is towards modernisation and digitalisation, as highlighted in the 'why modernise' section. The adoption of a modern 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. Planning is very important, as the introduction of a new technology takes time and resources.

Countries are advised to assess the national situation, social and cultural factors, the availability of sampling frames and the institutional capacity before any technological solution is introduced. This is since to the introduction of a new technology may be potentially expensive and challenging, affecting many steps in the production of statistics, as well as the collection of data from respondents. For example, a country considering collecting time-use data that are nationally representative through a

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[38] See the report *Minimum Harmonized Instrument for the production of Time Use Statistics,* prepared by the Expert Group and available online as a background document to the Secretary General's report on gender statistics at https://unstats.un.org/unsd/statcom/53rd-session/

website must first check the proportion of households with computers and access to internet and the feasibility of sampling strategies, as well as the literacy rate in the case of self-reporting.

However, this report considers modernisation as a journey. Every NSO or agency must consider their useful next step in that journey, whether that is incorporating new technologies into existing collection processes or switching more traditional processes with digital tools. The time-use research community continues to research potential further avenues of modernisation, but even if these seem to be out of reach for specific national contexts, the authors of this report believe there are useful steps that can be made in improving or enabling data collection for time-use across the world.

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Annex 1: Sample data protection goals and measures

Taken from Hoorn & Montager (2018)

PROTECTION GOALS	GENERIC MEASURES FOR THE IMPLEMENTATION OF THE PROTECTION GOALS
Data minimization is the requirement to collect, process and use only personal data than are necessary for the achievement of the purpose of the processing.	• Reduction of collected attributes of the data subject. • Preference for automated processing operations (not decision-making processes), which make the use of processed data unnecessary and limit the possibility of interference, compared to dialogue-controlled processes. • Procedures for pseudonymisation and anonymisation.
Availability is the requirement that personal data must be available and can be used properly in the intended process. Thus, the data must be accessible to authorised parties and the methods intended for their processing must be applied.	• Preparation of data backups, process states, configurations, data structures. • Protection against external influences. • Implementation of repair strategies and alternative processes.
Integrity refers, (i) to the requirement that information technology processes and systems continuously comply with the specifications that have been determined for the execution of their intended functions. (ii) the data to be processed remain intact, complete, and up to date.	• Restriction of writing and modification permissions. • Documented assignment of rights and roles. • Specification of the nominal behaviour of workflow or processes and regular testing of the detectability respective determination of the current state of processes.
Confidentiality refers to the requirement that no person be allowed to access personal data without authorisation. It ensures the protection against unauthorized and unlawful processing.	• Definition of a rights and role concept according to the principle of necessity based on identity management by the controller. • Implementation of a secure authentication process. • Limitation of authorized personnel to those who are verifiably responsible. • Specification and control of organisational procedures (obligation to data secrecy, confidentiality agreements, etc.). • Encryption of stored or transferred data.
Unlink ability refers to the requirement that data shall be processed and analysed only for the purpose for which they were collected.	• Restriction of processing, utilization and transfer rights. • Separation in organisational / departmental boundaries. • Approval of user-controlled identity management by the data processor. • Using purpose specific pseudonyms, anonymisation services, anonymous credentials, processing of pseudonymous or anonymous data.

Transparency is necessary for the monitoring and control of data, processes, and systems from their origin to their erasure and is a prerequisite for lawful data processing. Transparency of the entire data processing operation and of the parties involved can help ensure that data subjects and supervisory authorities can identify deficiencies and, if necessary, demand appropriate procedural changes.	• Documentation of procedures, in particular including the business processes, data stocks, data flows and the IT systems used, operating procedures, description of procedure, interaction with other procedures. • Documentation of the contracts with external service providers and third parties, from which data are collected or transferred to. • Documentation of consents and objections.
Intervenability refers to the requirement that data subjects are effectively granted their rights to notification, information, rectification, blocking and erasure at any time, and that the controller is obliged to implement the appropriate measures.	• Differentiated options for consent, withdrawal, and objection. • Creating necessary data fields, e.g., for blocking indicators, notifications, consents, objections, right of reply. • Disabling options for individual functionalities without affecting the entire system. • Traceability of the activities of the controller for granting the data subject's rights. • Establishing a Single Point of Contact (SPoC) for data subjects. • Operational possibilities to compile, consistently correct, block, and erase all data stored regarding any one person.

Annex 2: Example of Online Data Entry Screens (CSPro)

The Screenshots below illustrate what data entry in CSPro looks like, in this case, for a survey assessing the impact of COVID on time use.

Annex 3: Online Applications – Web versus Smartphone

In selecting an online data collection application, the main options are native, hybrid or progressive.

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.

Native apps are built with specific technology and language for specific platform like Java for Android, and 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 cross-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 it is 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.

Table A3-1
Comparison of advantages and disadvantages of Native apps

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.

Table A3-2

Comparison of advantages and disadvantages of Hybrid apps

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.

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.

Table A3-3

Comparison of advantages and disadvantages of Progressive apps

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 do not 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

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 for online tools

- 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.