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Action I: INNOVATIVE TOOLS AND SOURCES FOR TIME USE SURVEYS

Explore the reuse of new digitalised multi-mode design developed for the Household Budget Survey in a new and modernised Time Use Survey

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Summary

Due to high survey costs, a high response burden and falling response rates, we need to modernise the data collection methods and make greater use of new technology and new data sources to collect time use data. We believe that an online solution will be more user-friendly and will meet user needs better than a paper diary. With that in mind, the main objective in this report has been to *study the possibility of reusing components* developed in 2016 for the Norwegian Household Budget Survey (HBS) in a new Time Use Survey (TUS) in 2021. The report also considers the possibilities for integrating new tools and sources into the TUS 2021, and proposes a preliminary prototype for the upcoming Norwegian Time Use Survey.

In general, we found that the value of reusing the HBS applications 2016 in a TUS 2021 is limited. The changes that need to be made are so extensive that it will be more cost effective to develop new applications from scratch. It is not cost effective and, in some cases, not technically possible to reuse the solutions from HBS. Although it is not possible to reuse the technical instruments or the code, there are significant benefits to be gained from reusing the concepts of the multi-mode digitalised survey design and, not least, the experience associated with the development of the solution in 2016, experiences from piloting the design, and also the principles associated with integrating a web solution with other internal systems.

We have looked at best practices in other countries and new trends generally in terms of using new tools and sources in the TUS data collection. New technology can help improve accuracy and quality in relation to how we measure TUS, as sensor data is more accurate and can help respondents recollect the activities they have carried out. Electronic data can speed up field and reporting time. Furthermore, better case management, shorter times in the field and an increased willingness to participate will also contribute to reduced costs. Finally, digitalisation and paper-free solutions in public administration are promoted by the EU and local governments, and are expected by our participants.

On the other hand, using new sources and new technology will be a deviation from earlier methods and will impact on time series and analyses. Sensor data is big data with a big volume, which can be hard to manage, and the measuring effects can be difficult to estimate for multisource data. Lack of familiarity with smartphones and apps might reduce the willingness to participate and reduce sample representativeness for certain groups of citizens. All in all, we believe that the deciding factor for a digital transformation is the digital surroundings in each country. Further important success factors are good planning, sufficient time, adequate budgets, thorough testing and documentation of the impact of new technology and new data in time use surveys. Finally, in order to facilitate a good transition it is important to share data and empirical results to aid the integration between existing data collections and new and innovative sources.

At the end of this report, we present a prototype based on reused parts of the HBS design as well as principles and technology that can be adapted from already developed components in other countries. We have focused on a background survey and a diary. Both will be online and accessible on a PC, tablet or smartphone. For the diary, we want to use a mobile app. The idea is to utilise mobile sensors such as location, height, motion and acceleration to passively record participants' timelines. Because respondents of the paper-and-pencil diary in the old solution noted down their activity in their own words, their activities had to be recoded afterwards. This time-consuming process of activity coding is no longer required with online time-use registration. The automatization of coding is one of the main benefits of switching from paper to a mobile app; it will reduce the need for coders to a minimum without increasing the response burden disproportionately. By using an app and machine learning, we can optimise activity coding and make it faster and less burdensome.

Contents

Introduction

Norway is one of the countries in the world with the longest time series when it comes to Time Use Surveys (TUS). Statistics Norway conducted five Time Use Surveys between 1970 and 2010. Data from the last 40 years shows a great change in how we spend our time.

The five previous surveys have been based on traditional survey-based data collection methods, with paper diaries to record daily activities combined with a telephone and/or visiting interview.

However, due to high survey costs, a high response burden and falling response rates, there is now an emerging need to modernise the data collection methods and make greater use of new technology and new data sources to collect Time Use Data.

Statistics Norway's 2017–2022 strategy emphasises the need to increase the use of new technologies for data collection in order to reduce the respondent burden and data collection costs and to improve data quality. On this basis, Statistics Norway started at project in 2016 to develop a new multi-mode and digitalised data collection design for the Norwegian Household Budget Survey (HBS).

The main objective of this grant action is to *study the possibility of reusing components* developed in 2016 for the Norwegian Household Budget Survey in a new Time Use Survey.

We will concentrate our activities under subtitle 1) **Innovative tools and sources for TUS** and topics 1-3 as follows:

1) New/innovative tools and sources for data collection

2) Better integration between existing data collection and data from innovative sources

3) New methods for data entry/coding/questionnaire processing

Under topic 1, we will explore whether and how we can redesign the HBS web diary and other instruments developed for HBS data collection to fit the collection of time use data. We will also look at best practices in other countries in terms of using new tools and sources in the TUS data collection.

Under topic 2, we will explore more generally new trends in data collection, focusing on new technology and new sources, and discuss the suitability for use in a TUS with regard to functionality, usability and costs.

Under topic 3, we will describe the principles behind the automatic coding application that was developed for the Norwegian HBS and the possibilities for re-use and integration with a new TUS design. We will also generally discuss the pros and cons of using predefined activity categories and codes, as opposed to respondents' own descriptions of activity in the TUS web document with semi-automatic coding.

At the end of this report, we will present a prototype for a new web diary/mobile app, based on the possibilities for reusing parts of the HBS design as well as the principles and technology that can be adapted from already developed components in other statistics agencies.

1. Topic 1: New/innovative tools for data collection

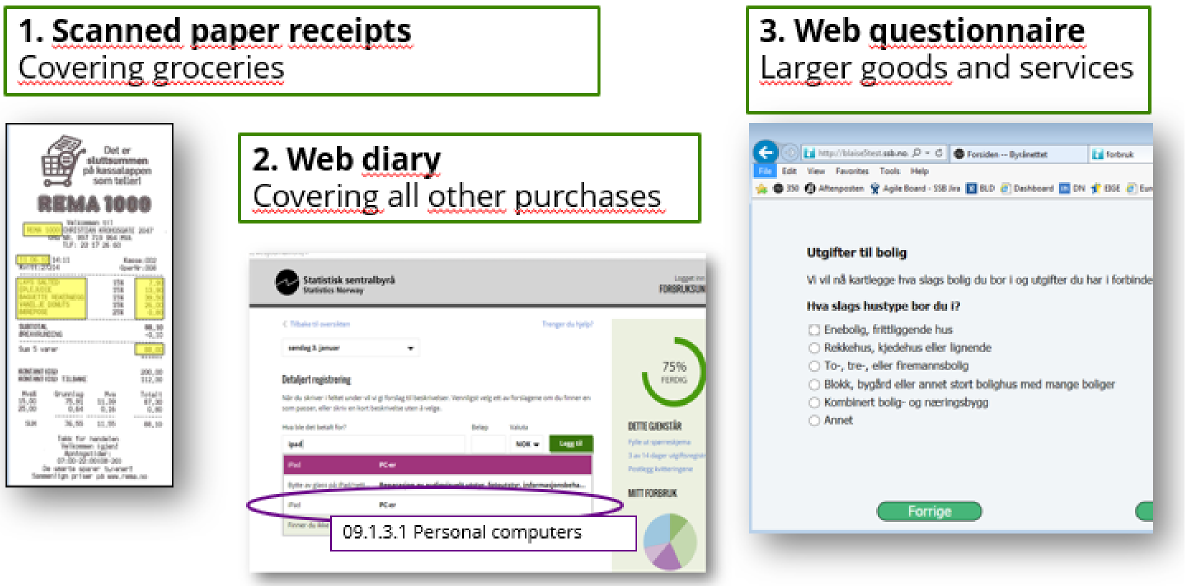
In this chapter, we will look at the possibilities for redesigning the multi-mode and digitised data collection design developed by Statistics Norway for the Norwegian Household Budget Survey (HBS) in 2016 with a view to establishing if it can be reused in a new Time Use Survey (TUS). We will also look at best practices in other countries in terms of using new tools and sources in the TUS data collection.

Many European countries have a long tradition of conducting diary-based time use surveys based on paper-and-pencil diaries and questionnaires. Most countries now face common challenges; resource-intensive data collection that results in high costs, and a large response burden that contributes to falling response rates. There is an increasing demand for modernising the survey methods, through digitisation and a greater degree of automation. There will also be a growing expectation from those that participate in surveys for digitised solutions for participation and usability. This means that most surveys will have to be transferred to a digitised platform in the coming years and that there will be a growing demand to explore and make use of new technology and new and alternative sources of data.

1.1. A digitalised HBS design in a new TUS?

On the basis of such new demands, Statistics Norway developed a new multi-mode and digitised data collection design in 2016 for a forthcoming HBS (see Figure 1). The HBS design combined a first telephone interview, a web diary and a web questionnaire, integrated into a web portal. An application that automatically categorises and encodes registered expenses into the correct codes was also developed, as one of the most time-consuming tasks in previous HBSs was the manual coding of respondents’ purchases.

Figure 1. Multi-mode set up for HBS 2016



1.1.1. *Multi-mode HBS design*

The multi-mode design for HBS was based on three elements – or sources of data:

Scanned receipts
Receipts of all grocery purchases were sent in from respondents (element 1 in Figure 1). The receipts were scanned and the text was digitally interpreted and verified. Then the data from the scanned receipts was imported into a web application that automatically coded all text lines into COICOP categories.

The reason for sending in receipts only for groceries is the vast concentration in the Norwegian market when it comes to grocery chains. Four chains cover 94 per cent of the marked.

Web diary
All other purchases were to be registered in a web diary (element 2 in Figure 1). We emphasised a user-friendly platform that can be used on a PC, tablet or smartphone. The web diary was integrated with a coding application with a library of predefined keywords. This means that if a respondent wants to register the purchase of an iPad – he/she will write iPad – choose this from the menu, and it will be automatically coded into the right code – in this case 09.1.3.1 personal computer.

Web questionnaire

A self-administered web questionnaire for entering expenses connected to housing and the purchase of rarely bought goods (element 3 in Figure 1) was integrated into the web platform with the diary. The questionnaire could be completed anytime during the two weeks of participation.

1.1.2. *Integration with other systems*

The development and use of the web portal, web diary, questionnaire and coding application was dependent on integration with several internal systems. The web diary and the web questionnaire (Blaise) were integrated with the already existing system we use for administering surveys. This proved to be quite a difficult technical task and required a lot of resources. One main challenge was the integration from a system outside the secure zone (web) to the secure zone (admin system).

1.1.3. Experiences from the HBS pilot

The pilot of the developed HBS design was carried out in the period June–July 2016 with a randomly drawn selection of 300 households.

Letters and an information brochure were sent out to the respondents in advance. After a few days, they were called by an interviewer who conducted a brief introductory interview on the telephone (CATI) with those they managed to contact and who were willing to participate. The interviewers also gave them more information about how the survey would be carried out. The respondents were then sent an email/SMS with a link and login information to the web portal. They were asked to collect all the grocery receipts from the household for 14 days, register all other purchases in the web diary and conduct the closing interview via a self-administered web form in the web portal.

Of the 300 households in the random sample, 113 households (38 per cent) were recruited to participate in the initial telephone contact. Of the 113 recruited households, 38 households dropped out along the way. This represents 13 per cent of the total, or 33.6 per cent of those recruited. This means that one in three who were recruited to the pilot did not complete all parts of the survey. The total response rate (completed all parts of the survey) was 25 per cent of the gross sample.

If we compare the drop-out rate with the 2012 survey, the figure is about double. An increase in the drop-out rate during the process was however expected, as we went from a visiting interview to a telephone interview and a self-administered survey. The commitment to complete the survey has been known to be greater when visiting interviews are used as opposed to a self-administered survey (Galesic 2006).

It is also important to mention that among those who dropped out, many completed at least one part of the survey (web diary, submitted the receipts or did the interview at the end). The part of the survey that led to most drop-outs was the registration in the web diary.

Several different measures were tried out along the way to avoid drop-out. We sent several SMSs during the reporting period (about every other day) to those who were recruited. Transmission frequency and message content varied somewhat depending on whether the respondents had completed entries in the diary and/or completed the closing interview. In general, however, they contained so-called soft reminders, which we believe is important when we send frequent reminders to all the respondents, to avoid being perceived as burdensome. At the end of the period, messages were sent as a reminder that the termination interview had to be completed and that they had to remember to post the envelope with receipts. All the respondents got a gift card of 50 Euro if all tasks were completed.

In addition, the interviewers also called the respondents to keep them motivated and make sure that they were still involved. We especially followed up those who, after one week, had not yet registered any goods in the diary, or completed the closing interview. The feedback from the interviewers was that this type of follow-up did not have much effect. The respondents that the interviewers called often wondered why they had called when they said they had saved all the receipts and were going to register it all at the end of the period. Several of the interviewers found that the follow-up talks were often perceived as unnecessary interference.

It was emphasised in all information to the respondents that they could contact Statistics Norway if they had questions or experienced problems. We had a separate telephone line for incoming support calls. The feedback from the interviewers was that there were generally few phone calls, except when there were technical problems with the web diary or the interview.

There was no special age group that dropped out and we found no gender disparities. However, the number of drop-outs was small and it is difficult to generalise on the basis of 38 observations.

Technical errors
During the pilot, there were technical errors on at least three occasions, which may have had an impact on the drop-out rate in the survey. The most serious was downtime on an internal server for a whole weekend. The result was that the respondents were not logged in at the start of the period. The server error was not detected until the respondents started calling.

In addition, some errors and bugs arose in the application (web diary) during the holiday, which took some time to rectify. There were also technical errors with Blaise.

It is very important to have a plan to manage such errors and to have a preparedness plan for monitoring and responding to technical errors that occur.

1.1.4. Reuse of HBS components in the Time Use Survey?

We will go through the different elements developed for the HBS in 2016 to establish whether some or all of the elements can be reused in a new Time Use Survey. We will look further at the architecture, technology options, coding system and design.

Architecture
It will be possible to reuse the overall architecture developed for the HBS in 2016. The concepts used for design, and survey elements such as the web diary and the web portal can be built on in the further development of a web design for TUS. The integration with the case management systems in particular is believed to have value for reuse.

Technology options
We will also most likely be able to use many of the same technologies in a new TUS that were used in the HBS design. Java was chosen with Hibernate and JAX-RS for the backend application in the HBS. Statistics Norway has experience with this kind of technology and it may be something that can be used for the backend solution for TUS. The Frontend application for HBS was made in JavaScript, including React, Backbone, Lodash and d3. These are still current technologies today, and can partly be reused in a TUS application, for example for log-in, linking to the backend application's API etc.

Code
Very little of the code can be reused. The classes and structure of the code are designed specifically for HBS's needs. In some cases, the configuration of frames and solutions for log-in, for instance, can be reused to some extent. This depends in turn on whether the requirements applicable to TUS overlap with those that formed the basis of HBS.

Layout, graphic design
Parts of the design for the HBS web portal can probably be reused for TUS. Colour selection and layout can be of value – again given that a similar application is desired.

1.1.5. Summary and recommendation

The value of reusing the HBS applications in TUS is limited. The changes that need to be made are so extensive that it will be more cost effective to develop new applications from scratch. Adapting to the old technical solution for HBS is not a good way to develop a new TUS application.

The web diary for the piloted Norwegian HBS consists of three components:

- **Web diary frontend**: Small degree of reusability. Depends on similar solution.
- **Web diary backend**: Some degree of reusability, but new application still needs to be created.
- **Code administration backend**: Small or no reusability. Recommended using more general solution.

The conclusion by Statistics Norway's IT department is that it is not cost effective and, in some cases, not technically possible to reuse the solutions that were developed for HBS in 2016. In most cases, new applications must be developed from scratch and specially adapted to the specific needs of a new project. This also has to do with the importance of user friendliness. In addition, tools and technical frameworks are being developed at a rapid pace, which means that there are now other solutions that are more suitable for use in a new project. Although it is challenging to reuse the technical solutions (tools) and codes, there is still considerable reuse value in the concepts of the design and with the principles associated with the integration with other internal systems. There is a high reuse value in how different systems and services need to interact in order to meet the needs for planning, creating, executing and administering multi-method surveys.

1.2 Review of already developed web diaries and apps

In this chapter, we will review the literature/best practices of a statistical agency (NSO) and other producers of statistics in terms of already developed web diaries and apps[1]. We will also look at best practices of modern IT tools, smart devices, smart applications and e-technologies in general for the collection of TUS data (new data sources).

According to Eurostat's Task Force members, 14 countries are planning a time use data collection in the coming years (the next two years or between two and five years). In our work to develop a new prototype to meet the needs of the TUS data collection, we have looked to other countries who have already developed/are about to develop apps/a mobile diary. We will examine MOTUS (Belgium) and XCOLA (Finland), as seen in Figure 2.

[1] See *Explaining technical terms and words* in the Appendix.

Figure 2. Tools/development for next Time Use Survey. European countries

COUNTRY	NR OF TUS WAVES	YEAR OF LAST TUS	NEXT TUS	TESTING AVAILABILITY	TOOL USE/DEV	DEV PHASE	NAME OF THE TOOL
BELGIUM (VUB)	10	2016	Current	Yes	Yes Owner	Production	MOTUS
BULGARIA	5	2009-10	In 2-5 yrs.	Yes	No	----	----
CZECH REPUBLIC	No	----	Long term	Yes	No	----	----
ESTONIA	2	2009-10	In 2 yrs.	No	No	----	----
IRELAND	1	1997	No	Don't know	No	----	----
GREECE	1	2013-14	Don't know	Don't know	No	----	----
SPAIN	2	2009-10	In 2-5 yrs.	No	No	----	----
ITALY	4	2013-14	In 2 yrs.	Don't know	No	----	----
CYPRUS	No	----	No	No	No	----	----
NETHERLANDS	15	2016	In 2-5 yrs.	Yes	Yes Partner	----	TBO LISS
AUSTRIA	3	2008-09	In 2-5 yrs.	Don't know	Yes Owner	Pilot	Zeitverwendungserhebung
POLAND	5	2013	In 2-5 yrs.	Don't know	No	----	----
ROMANIA	2	2012	In 2-5 yrs.	Don't know	No	----	----
SLOVENIA	1	2000-01	In 2 yrs.	Yes	No	----	----
FINLAND	4	2009-10	In 2 Yrs.	Don't know	Yes Owner	Production	XCOLA
FINLAND (FIOH)	1	2017	In 2 yrs.	Yes	Yes Partner	Production	AIKANI
SWEDEN	3	2010-11	Long term	Don't know	No	----	----
UK	3	2005	In 2 Yrs.	Don't know	Yes Owner	Conceptual	Online TUS
ICELAND	No	----	No	No	No	----	----
NORWAY	5	2010	In 2-5 yrs.	Yes	No	----	----
ALBANIA	1	2010-11	Long term	Yes	No	----	----

Source: Eurostat

In the feedback from the countries participating in Eurostat's Task Force (Figure 2), several report that they want to use new data collection methods in future time use surveys, such as retrospective recall registration, continuous registration and/or time-tracking registration.

Furthermore, they all state that they need to adapt to smartphones (such as GPS, accelerometer and gyroscope) for the future data collection. Many also state that they plan to develop external GPS devices and wearables.

1.2.1. Two examples of online data collection for TUS

The tradition procedure of paper-and-pencil time use surveys is, as mentioned earlier, costly, time-consuming and involves a lot of personnel for conducting the fieldwork and cleaning and inputting the data. The University of Brussels has developed an online procedure of MOTUS – a modular online time use survey with low marginal costs that is less time consuming and involves a number of automated systems that replace much of the requirement for personnel (Minnen, Glorieux, van Tienoven and Weenas, 2014, 2013).

MOTUS (Modular Online Time Use Survey) is the first online time use survey ever conducted on a population scale (Minnen et al. 2014). For time registration, they have taken a middle course when they developed it: the default time slot is set at 10 minutes, but the respondents are free to adjust the beginning time and end time to the very precise minute. In connection with the activity registration, they offer respondents two pre-coded ways of registering an activity:

- The first is a selection method that guides respondents stepwise to choosing their main category, the subcategory and their detailed activity from a 3-level tree structure.
- The second is a search method that guides respondents to entering a keyword (including the activity code) that generates a list to which the keyword is tagged and from which the most detailed activity can be selected. These activities are also sorted based on their occurrence in the registration procedure.
- Additionally, at the level of the subcategories, a free text field or category is provided, allowing respondents to write down their activity if none of the pre-coded activities suffice.

The aim of the tool is to conduct research using online questionnaires and diary surveys through an online tool in combination with an application. The domains are survey research and time diary research, both cross-sectional and longitudinal. The next data collection in Belgium will be in 2021. MOTUS is also used in other countries, for instance Germany is planning a data collection in 2022.

Statistics Finland is about to develop a TUS mobile diary, called XCOLA. It is possible to use the diary with a mobile phone/tablet or laptop. They are using their in-house software, XCola, to develop it.

The design gives the respondents the opportunity to choose time slots longer than 10 minutes, and the coding in the Finnish mobile diary is free text without drop-down menus. Unlike MOTUS, all the information from the respondents must be coded in retrospect.

Here we see two examples of online data collection that have chosen different solutions for activity coding. We can learn a lot from others if we look closer at what they have developed and what solutions they have chosen – and thus reuse different concepts that are already created. However, we have also found that it is not always easy to reuse already developed solutions – as we mentioned earlier in connection with the HBS web diary.

Inspiration outside official statistics?

We have also looked outside the NSOs for inspiration, but there are not many time use studies that we can learn from in respect of best practice or new tools. However, the media industry surveys are leading the way in the use of so-called passive measurements through specific devices like GfK's MediaWatch or other wearables, which can be studied for inspiration (see Explaining technical terms and words in the Appendix). Their purpose is not to map activity, but to capture media consumption. These kinds of data are used to plan and develop media content and formats and to set advertising prices. As media content is becoming more and more voluminous and complex to measure, the users of commercial media surveys consider passive (or automatic) measuring to be a more accurate data collection method than surveys that are known to provide socially acceptable answers and quality that depends on the respondent's memory, accuracy, engagement and honesty. The accuracy that passive measuring provides on a complex topic seems to outweigh other quality issues in the commercial industry. Time use has to consider all quality issues and combined with the time and costs it would take to adapt and produce measurement devices like the MediaWatch, it is not a likely solution for TUS.

2. Topic 2: Better integration between existing data collection and data from innovative sources

In this chapter, we will explore new trends in data collection, focusing on new technology and new sources, and discuss whether they can be used in a new Time Use Survey (TUS) with regard to functionality, usability and costs.

2.1. Alternative data sources to collect time use data

Since the last TUS in 2010, new technology and new data sources have made it possible to explore human behaviour in new ways. Today, it is feasible to use new data sources like sensor technology that can register time use activities, new data collection methods like mobile apps and wearables that can replace paper or web diaries, machine learning to improve activity coding, administrative records that can replace survey questions, etc.

New or alternative data sources are often thought of as big data and described as having a high volume, variety, velocity and veracity (the 4Vs etc.), but could comprise of anything from administrative and other records, to transactional bank data and sensor data that is collected passively or actively through different sensors and similar. Traditional sample survey-based data is not thought of as new sources but can be used in combination with new sources in a multisource setting.

With digital technology, it is not always easy to distinguish between hardware and software and between input and output. What is the data source, the detecting device and the software in the data system of detecting, collecting, processing and producing statistics? To discuss the possibilities and limitations that new data sources provide for TUS we need to understand not only new data sources but also surrounding technology and software. To explore this territory, we will look at trends and developments in measurement technology and describe new sources and new techniques for analysing and producing statistics relevant to time use surveys. (Note that an explanation of technical terms and words can be found in the Appendix.)

2.1.1 New measurement technology

The proliferation of high-speed Internet and powerful smartphones has provided easy access to the Internet and has changed how individuals and businesses access and use the Internet[2]. A decade after the smartphone was introduced, user penetration was 65 per cent in Western Europe in 2017. This is up from 23 per cent in 2011, and it is fair to assume that it is rising rapidly (Eurostat 2017). Smartphones have become an everyday commodity. Today, mobile devices are used more often than desktop computers to access the Internet, and smartphones are the preferred device for surfing the Internet. In 2018, the average time spent on the Internet on mobile devices exceeded that of desktop computers for the first time.

[2] 87 per cent of the European Union (EU-28) households had Internet access and 84 per cent (16–74 years) accessed the Internet at least once in the three last months in 2017 (Eurostat 2017). For technology-leading countries, Internet use is close to 100 per cent (98 per cent in Iceland and Norway, 2017).

The development of mobile technology also affects survey research in the general population and elsewhere. This development has forced web survey designers to produce versions that can be used on mobile devices with smaller screens, such as smartphones. Software providers have also taken this into account, as Blaise 5 has with its responsive design adapting to appropriate screen sizes (and operating system etc.) independent of device. We see in Norway that an increasing number of survey participants access web surveys on their mobile device first, regardless of whether the survey instrument is designed or optimised for mobile devices[3]. Hence the mantra in survey programming today is to design for 'mobile first'. This trend is recognised and recommended in ESSnet (Gravem, Meertens, Luiten, Giesen, Berg, Bakker and Schouten, 2019). We also learned from this project that in practice, the 'mobile first' design advice is often bypassed and instead old telephone questionnaires are copied to an online version, especially when we run mixed mode (CATI and online). This is not a good practice and has to be avoided.

Sensor technology and apps

A key part of recent technological developments is the use of sensor technology and apps in smartphones and tablets. We refer here to sensors in mobiles and wearables that can register contextual data on, for example, location, height, motion, acceleration, pressure, light, heat, moisture, pulse and other biometrics, etc. These kinds of data are often forwarded immediately when they are registered and considered to be 'true' data. One well-known example of a mobile app is the Google Maps' Route Planner. This app offers directions for drivers, bikers, walkers and users of public transport who want to take a trip from one location to another. It uses the location sensor in smartphones, data from wireless and mobile networks and the global positioning system (GPS) together with real-time traffic information and crowdsourcing to provide route planning options for different means of transport from one point to another. Anyone with a regular smartphone can access this for free. Other websites can also embed Google Maps into their own site through APIs. The user accepts sharing their private data and in return Google provides aggregated data in their service. This is a feature we often see in social media apps. We have used Google Maps as an example as the sensors it uses in smartphones and the app for route planning are not so different from the sensor data we plan to utilise in the TUS diary in Norway. In Chapter 4, we will describe our plans for a diary app – a prototype – in more detail.

We will not go through all possible smartphone sensors[4] but it is obvious that record of time, date, location, motion, height, acceleration are data that can be used to assist respondents to record time and activity. It is an obvious advantage that a mobile app can trigger reminders and measurements at set times in real time in the respondent's natural environment (ecological momentary assessment), which is hard to do with a traditional survey. Some smartphone sensors are already used in official statistics, such as image recognition of QR codes or bar codes. QR codes are used as authentication to access surveys and for scanning barcodes on consumer goods and were tested in a pilot in Norway for the Household Budget Survey (HBS) in 2016. In some countries, QR codes have already been used in large-scale HBSs. It is also worth mentioning near field communication (NFC) and Bluetooth beacons, which are examples of smart technology that could be used to trigger and guide participants' activity coding, but presently this technology would not be manageable or within budgetary constraints for

[3] 77 per cent answered an online link via their mobile in the Competency profile survey in primary education, autumn 2018, Statistics Norway. See also Toepoel & Lugtig, 2014 and Struminskaya, Weylandt & Bosnjak, 2015.

[4] See the list of sensors in Schouten and Mussmann, 2019, pp. 4–6.

TUS. Speech recognition is also widespread but would be too resource-intensive for the next TUS. However, it is probably a technology that will have to be considered in the future.

Wearables

An extension of sensors and smartphones is wearables; devices that we can wear or that are attached to our clothes. These devices are smaller than and weigh less than a mobile phone and functionality is often singular. As wearables are worn close to the user's body and 24/7, they are more suitable for measurements of a more personal nature than mobile phones, such as heart rate, calorie use, sleeping patterns, etc. (Schouten & Mussmann, 2019). Smartwatches, the most common example of a wearable, were first developed for health and exercise-related purposes, but today they can also be used to access social media, read emails, for navigation purposes, to play music, etc., in the same way as a computer. Wearables require other mobile devices to act as an interface to install settings for wearables and read data or statistics.

Wearables can also include portable TVs or people meters, such as GfK's MediaWatch, as mentioned earlier, which are used in panels designed to measure radio and/or TV audiences. As such, the people meter is a modernised version of the old stationary TV meters in audience panels, which has been improved to also capture viewing/listening away from home (i.e. wireless) and away from stationary devices (i.e. mobile devices), in both real-time media and streaming. Wearables like the MediaWatch are not designed for official statistics and adaption and production for time use surveys is not viable within reasonable time and cost restrains.

Passive versus active data collection

The intention of smart technology is to track users or participants in a passive manner that requires little of the participants. This is sometimes referred to as the Internet of things (IOT) and is the extension of Internet connectivity into physical electronic devices and everyday objects that can be remotely monitored and controlled. Examples for public use include the monitoring of weather, traffic, air pollution, etc. for a particular area and for multiple persons and not individuals. This kind of public data are collected by the government. Passive sensors are used, and citizens cannot object. The data are only used aggregated for public planning etc and not on an individual level.

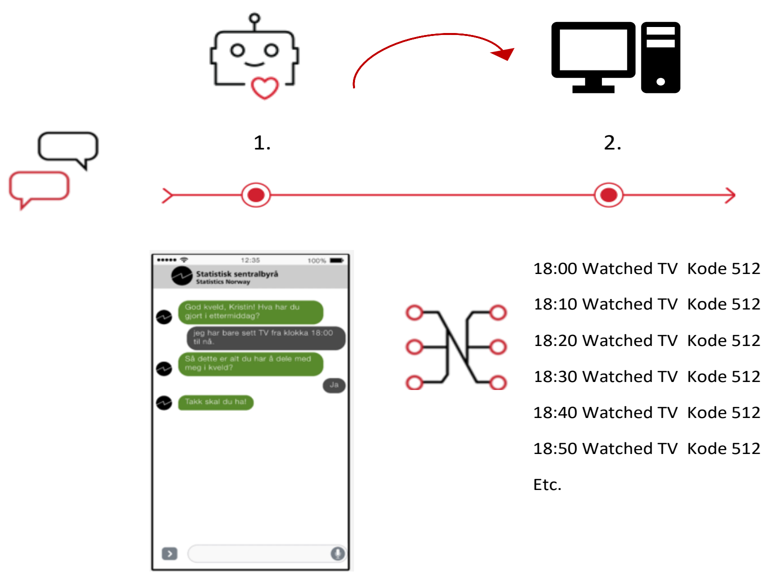
Use of mobile apps or devices to measure time use activity, scan household purchases, or track vehicles requires a greater degree of active intervention and feedback from participating respondents, and of course their consent. Required activity could entail downloading apps, registering background data and supporting data such as the classification of type of activity, or supplementing, checking, revising or accepting data, either from the respondent or the data collector. With active sensor data, the participants' level of involvement will be greater than with traditional data collection and it is assumed that this will enrich the data and increase data quality. In contrast, active data collection is more demanding than passive sensor registration, as the task of editing and making sense of real-time data can be extensive (Schouten, 2019) and it may have a detrimental effect on the willingness to participate (Jäckle, Burton, Couper & Lessof, 2017).

Chatbot – digital assistance

The technological development is also seeing the emergence of chatbots or digital assistants, which can engage in a two-way conversation, answering questions to help the respondents fill out surveys or pop up and give advice or offer help if inactivity persists. A chatbot can also be used in win-back strategies by sending text messages when the respondent has left an incomplete questionnaire.

It can also be envisaged that a chatbot could be used in the future as a digital interviewer in online surveys or mobile apps, by using a conversational interface (text or voice) to ask the questions, instead of using a traditional questionnaire format. In surveys like TUS, which use a diary, this technique can be used by having a chatbot that pops up in a mobile app a few times a day, asking questions about activities carried out in the last few hours. The idea is that answers from the conversation can automatically be transferred to a digital diary, and automatically coded if the activity is recognised (Figure 3). This design means that we would not get activities for all 10-minute intervals recommended in the TUS guidelines, and there are some challenges in relation to the timing of various activities, but this can to some extent be resolved with follow-up questions from the chatbot and confirmation from the respondents.

Figure 3. Chatbot as a digital interviewer in TUS



Over the past decade, chatbots have become a popular online support service both in the public and private sector, not only for support and customer relations that users trigger themselves, but also as a proactive approach by sales and marketing enterprises. Most chatbots communicate based on written commands and text today, but voice recognition technology is evolving and is making them even better at their jobs, as we have seen with the spread of Google Home and Siri in the last couple of years, and we expect voice to replace or be interchangeable with text in the future.

2.1.2 New data sources

We have seen that new technology provides new opportunities for data collection and measurement. New technology also provides new data sources, new ways of combining, analysing and presenting data. Traditional data like survey data can be combined with new data sources. This is often referred to as multisource statistics. Combining traditional data with real-time data from sensors and transaction data can enable more accurate data, fast data collection and a reduced response burden, but it also raises issues with regard to suitability, statistical quality and comparability with earlier time series, legal access and ethical questions about privacy. We will first look at relevant developments for TUS before we discuss the pros and cons.

Increased use of multisource data

Combining administrative records and registers with survey data is a practice that began several decades ago (Nordbotten 1966) and which has taken off in the last decade with the capability of new technology to combine and process large volumes of data. In government administration today, it is expected that records that already exist should be reused to lessen the response burden and reduce data collection time and costs. In addition to administrative records from government sources, privately held records for businesses are also interesting, if access is open or granted. Not all EU countries have access to administrative records or records that are of a sufficient quality to be interesting or relevant, but in a number of countries this has been the practice for many years. The ESSnet workshop on Quality of Multisource Statistics – KOMUSO (2015–2019) has put the topic on the agenda and encouraged more countries to evaluate possible and/or increased use. For TUS, administrative records have already substituted some of the background and household data in the background survey in Norway and we expect to further increase our use of administrative records in the future.

Alternative sources – big data

It is not only administrative or privately held record data or databases that survey data can be combined with; alternative sources could also be the Internet or media content extracted from the Internet or data from sensors or other measurement devices. Geospatial or location data has been used in official statistics for a while. This is big data, and when processed and analysed through new software, we have seen geospatial data presented in illustrative graphs in a new form that gives us information in a visual form that is easily and often dynamically presented in ways that existing statistics are not. Geospatial data has been combined with other statistics more traditionally for distributions of populations, homes and buildings etc., but also more experimentally for how crowds are traveling or commuting in and around cities, such as in the crowdsource app Google Traffic.

With regard to the TUS diary, we want to use a timeline with GPS or location data registrations (as used in Goggle Maps' Route Planner) to help participants record or reconstruct their activities and travels. Use of sensor data from other systems, like a chip or smartwatch etc., or electronic data from traffic or bank transaction systems could also be interesting data that could help respondents fill in an activity diary, but there is such an abundance of possible devices and systems that we do not consider this suitable for the forthcoming TUS.

Sensor data is big data, and the volume and speed of big data is such that new techniques for collecting, processing and analysing data are emerging, such as APIs, web scraping, and machine learning. Trials are currently underway in Norway and the ESSnet,[5] for example, to replace the HBS survey, or parts thereof, with transaction data from retailers and banking. Machine learning techniques and advanced analytics are used in this process. For HBS and TUS, machine learning in particular is expected to be of great interest in future improvements of product and activity coding.

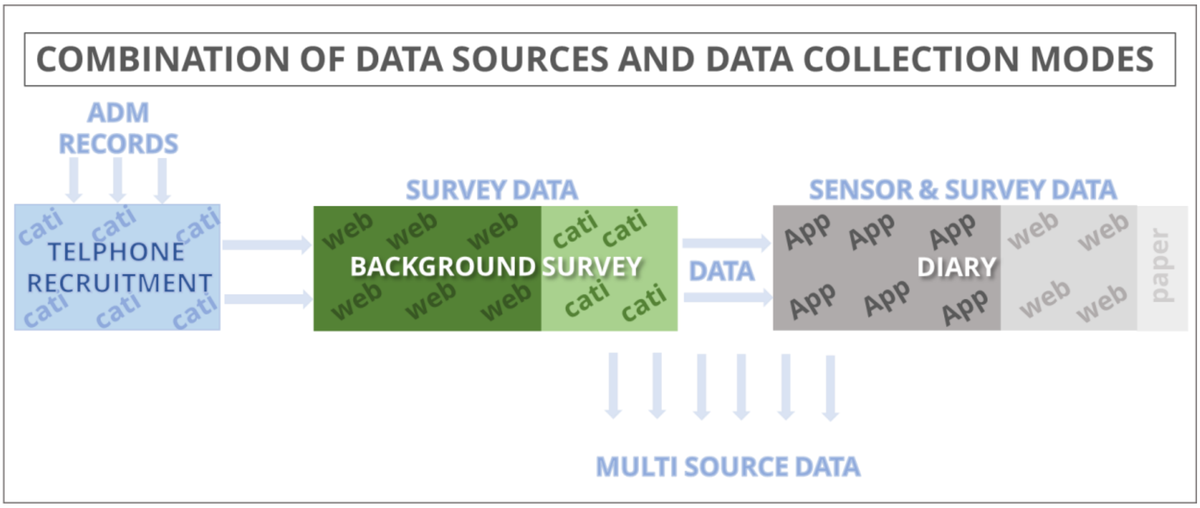
[5] Essnet: Big Data 2: On usability of financial transaction data (Webgate, 2019).

2.2 What are the possibilities and limitations of new technology and data sources?

As we have seen, new technology and alternative data sources provide many new possibilities for conducting social surveys. In particular, the spread of smartphones with their sensor technology, together with the booming growth of mobile apps is a significant development and highly interesting tools for collecting time use data. Data registration, coding and collection can all be automated to a large degree. Chatbot technology can aid the respondents when they fill out questionnaires and diaries or have questions about the survey. Modern technology in case management can provide instant and synchronised progress control and automated launches of project activities and/or reminders etc. Good automated features are important when handling complex data collection projects consisting of several activities (online link plus diary) and data collection via different modes (telephone, online and paper).

In this section, we will discuss the possibilities and limitations of new technology and data sources that we find most suitable time use surveys when we plan the new wave in Norway. The set-up we are considering is recruitment by phone. A background questionnaire will be accessed via an online link, a diary will be accessed via a mobile app utilising sensor data, and coding will be based on free activity entries utilising machine learning. For respondents that are not comfortable with responding digitally in this format, it will also be possible to respond to the background questionnaire by telephone and the diary on paper. See Figure 4 for a brief overview. A more detailed description of the set-up and the planned diary app will be described in Chapter 4.

Figure 4. Data sources and data collection mode for new set-up in Norway



There are many aspects that can be considered when evaluating the pros and cons of new ways of collecting data for TUS, such as 1) survey features; like topic, type of questions, length and type of respondents, 2) statistical quality; like measurement accuracy, non-response bias, coherence and comparability to existing data, 3) issues related to data collection and handling; such as management of data collections for several systems, integration of multiple data sources and 4) ethical and legal matters; like data access, security and privacy. We will attempt to address all of these, but the focus will be on issues related to TUS and statistical quality and comparability with previous waves.

2.2.1 Survey features

As developments bring us closer to full-scale Internet access and use of smartphones, we take data collection through online surveys for granted in many social surveys, as long as particular survey features do not prevent this. Schouten and Mussmann (2019) concluded in their recent paper that the topic and question types in TUS are suitable for mobile sensor data measurement. They reasoned that there are no complex latent concepts involved in TUS and that keeping a diary is burdensome, hence assistance from sensors can be appropriate. With respect to devices, they found smartphones to be suitable, and wearables even more so, due to their proximity to the respondent's body. Wearables will not be an option for many countries due to high costs, while smartphones are rapidly becoming a possible option.

If we use the smartphone fitness criteria developed recently in an ESSnet paper (Gravem, Meertens, Luiten, Giesen, Berg, Bakker, Schouten, 2019), it is not evident that TUS is ready for mobile use even though the topic and question types might be suitable for mobile sensors. According to the fitness criteria, several of the survey features of TUS could be in breach of best practice for small screens, such as interview length in the background survey, complexity of instructions and detailed level of time recording and coding of activities in the diary. As the background questionnaire exceeds the recommended length for online surveys, we hope to cut the length by a few minutes by replacing background questions with administrative records, where this is possible. For the diary, we hope to develop a mobile app that is intuitive and will help make it easier to complete the diary than it is on paper. If we do not achieve these goals to shorten and simplify the task, the major challenge for TUS will be, as for many other ESS surveys, the willingness to participate, and the drop-out and response rates (Galesic & Bosnjak, 2009). We call upon Eurostat to revise their HETUS recommendations to meet the online data collection trends we see across Europe today.

2.2.2 Statistical quality

Non-response bias

Online data collection is no longer a method that can be excluded as biased or in breach of ESTAT's recommendation to 'leave-no-one-behind'. Common practice in social surveys in official statistics in Europe today is often mixed mode, where traditional data collection methods like telephone interviews are combined with online surveys (Gravem, 2018). The trend is heading towards more and more online surveys and traditional modes are receding. Still; traditional modes remain to not exclude groups that do not have access to Internet yet.

Among persons aged 9–79 in Norway for instance, there is an Internet coverage of 98 per cent, 99 per cent have their own mobile phone and 95 per cent have a smartphone (Norwegian Media Barometer, 2018). Therefore, online surveys are considered to be a sound data collection method, unless sample representativeness requires more attention to older age groups, such as 70/80 years+, or the topic is sensitive towards respondents not being digitally competent. We are therefore leaning towards a mixed mode data collection to avoid non-response bias. This is what we plan to do for TUS in order not to exclude less digitally proficient respondents in the highest age groups. In Norway, this group is declining year by year. By using a mixed mode design, we attempt to safeguard sample representativeness and limit non-response bias.

Another growing concern in data collection today is a generally declining non-response trend in surveys (de Leeuw, Hox & Luiten, 2018). This is particularly apparent among young men and those with a low level of education (Lagerstrøm, Lillegård & Löfgren, 2019). If no measures are taken in the sample selection and processing, this affects the sample composition in all modes of data collection but particularly data collected online. Measures can include good case management and weighing. We will not discuss this further, as it is not a particular concern for TUS, but a general concern for all sample surveys. It is a general development that we have to monitor and evaluate on an ongoing basis for all data collection modes.

For TUS, our major concern is the response rate and partial response, as the survey topic might create bias and a study with several elements (i.e. multisource data like recruitment, background survey and diary) will have partial responses. This is no different to many of our other online surveys today and has to be met with skilled data collection management, testing and evaluation. We will not discuss this further here, but we need to address the use of a mobile app, as we know from other studies that there is a general unwillingness among respondents to download apps to participate in surveys and it is important that they use their own mobile, which they are familiar with (Jäckel, Burton, Couper & Lessof, 2017).

Lack of willingness will affect response rates and could lead to non-response bias if non-respondents differ from respondents. One important measure to control this is to monitor variables such as Internet access, ownership of smartphone, typical demographic variables like age, gender, education, etc., and mobile operating system, as we plan to have respondents use their own mobile phone. For Norway, the mobile operating system is not a particular concern presently, as 99.6 per cent of all smartphones are either iOS/ iPhone or Android, equally divided (Statcounter, 2019). It is good practice to monitor and evaluate non-response bias continuously not only for TUS, but for sample surveys in general, in order to be able to evaluate its impacts on results and take necessary measures when comparing new results with previous TUS waves.

Sampling frame

It is of course crucial to have an appropriate sampling frame to deliver a representative sample. In Norway, we have administrative records with updated contact information for all citizens, the Common Contact Register, which has been used as a sampling frame since we started producing statistics almost 150 years ago. As government administration goes digital, we are heading towards a paperless society, and tax returns must now be submitted online unless someone specifically requests to use the paper version. It is also assumed that people have digital contact information, such as email addresses and mobile phone numbers. Digital contact information is currently available in the register for 90 per cent of all citizens, and the figure is growing as the share of today's over 80s declines. This is crucial to efficient case management, high response rates and sample quality. With invitations and reminders sent as text messages and emails, survey links and mobile apps can be accessed/downloaded more easily. The good quality of digital contact information in the last five years has made it possible to maintain optimum case management in the data collection as well as acceptable response rates amid a declining trend.

Accuracy

Using sensor data in smartphones and app technology to collect activity data could potentially be of great benefit for TUS as the detailed time recording of activities is considered burdensome and hard to get right. Sensor data is more accurate than survey data if you have a sensor that can measure what you want. This does not exist for TUS and it is not possible to replace survey data with sensor data, but we can use location, motion, height, speed and acceleration sensors in smartphones to assist, prompt and remind the respondents when recording information in the diary. Exploiting the potential that such sensor data provides today can increase measurement accuracy and improve TUS. Note that sensor data is big data with a big volume, which requires competent aggregation to make meaningful output data. This can be a challenge, but we have the necessary IT knowhow, capabilities, process power and experience to handle this.

We have found little literature or evidence of findings with regard to the use of sensor data that is relevant for TUS or other social surveys in official statistics. What we did find was within medicine or engineering and has limited relevance for official statistics, as quality measures like accuracy, willingness to participate, and non-response rates depend on topics, data collection mode, country, etc. It is no surprise that little documentation exists, as this is inherent for new and innovative tools and methods.

A key issue for TUS is the activity coding. When using a smartphone app or a web solution (if a respondent declines to use their mobile) to register activities on a daily basis, we will move from free text entered on paper and coded by coders in the last wave, towards 'semi-free' text in the app using machine learning. Machine learning will be used to provide automated lists of earlier entries from previous waves for participants to select from as an alternative to free text. This may have an impact on the type and number of activity codes each respondent will use. We are planning to test this in order to gain an insight into the effects this will have on results compared to previous activity coding in a paper diary and with manual coding. We are not aware of any similar tests having been done and have no reference literature, but our hypothesis is that we will get more data and more accurate data with new technology. This has yet to be documented. We also want to study cognitive issues in regard to how respondents might report activities differently depending on diary and type of activity coding.

Measurement differences

With regard to measurement differences, the effects of switching from paper or a web diary to a diary on a mobile app is an issue for TUS. We have not yet seen any papers studying the effect of using an app for TUS. We think an app can aid accuracy, as sensor data can measure more accurately, and prompt and aid the memory better than a paper or online diary. On the other hand, we also assume that results might show device or mode effects. Registering, or confirming, activities in a mobile app may foster a higher number of entries and more detailed entries, because it is easier and faster than on paper or online and because respondents will receive recall assistance from recorded sensor data and automated push notifications. This hypothesis must of course be confirmed or disproved before accepted, and we plan to do that in 2019/2020 prior to the next launch of TUS in Norway.

Measurement differences or errors due to the use of multisource data can also be an issue as we plan to use administrative records to replace selected background variables for TUS. Norway has a long history of working with register data and has empirical results to support the notion that the results are as good as, or adequate, compared to survey data. Furthermore, using administrative records cuts down the length of interviews, which in turn reduces the response burden, and ESSnet recommends using this method when possible. In countries with little experience, we would always encourage testing the method first and to keep good paradata to monitor and evaluate the impacts of use, as insufficiently updated records can cause measurement errors. We will not discuss other multisource dilemmas related to measurement differences or errors as it is not a central issue to the set-up of the next TUS in Norway.

Neither will we dwell on measurement differences related to data collection mode, as these have been tested thoroughly over the last decade, both nationally for various statistics and at a European level in ESSnet work programs like Big Data, KOMUSO and MIMOD to serve as quality references. The experience and findings gathered from these grants in respect of other social surveys also apply to time use. First of all, there are mode effects. There are indications that electronic data collection can be more accurate, and when we go back to self-completion in social surveys (like we had before telephone interviews), we reduce the number of socially acceptable answers. On the other hand, online surveys may yield a higher share of 'Don't know' answers and strategic answering to get through the questionnaire and/or to get incentives.

Coherency and comparability

As we have stated above, the transition from traditional modes of data collection such as telephone interviews to online collections could impact on the sample as well as the accuracy, both in a positive and a negative manner. Therefore, when conducting the next TUS, we plan to do a pilot in order to track and study possible sample and measurement effects when transitioning from telephone to online and from a paper diary to a mobile app. We will compare results with previous TUS results and discuss the need for adjustments to achieve coherency and comparability across time. It is crucial to factor sufficient time into the plan to achieve this successfully, otherwise we will interrupt our time series for TUS dating back to the 1970s.

2.2.3 Data collection issues

Case management

Traditional case management applications provide the key functionalities of data collection organisation, processing of workflow, storage of data, distribution and analysis. Additional capabilities for the future are linked to the dissemination of real-time information across modes, the correlation of events and activities as they occur, instant and synchronised progress control and automated launches of project activities and/or reminders etc.

Statistics Norway has developed its own case management system (SIV), which was adopted in 2010. The system is designed to handle telephone interviewing (CATI) from a central database in addition to an offline system for CAPI interviewing.

Although Statistics Norway use the mixed mode method in several surveys, moving cases between modes in SIV requires many manual operations and cannot be fully administered from the system. Work is underway to develop add-ons that make the system more CAWI aware, and this will offer updates in real time for all cases independent of mode and give us the possibility to move cases between CATI and CAWI in real time. This will hopefully meet some of the needs in a new and digitised TUS data collection, but as seen in the HBS pilot in 2016, integrating new applications with SIV is a difficult task.

In recent years, public agencies in Norway, including Statistics Norway, have been able to access up-to-date lists of mobile phone numbers and email addresses. This means that SIV now has reliable contact information for over 90 per cent of the respondents. We use this information to send invitation letters, text messages and email reminders. The system has insufficient information on progress in online questionnaires, which makes it difficult to send reminders based on activity. Those who have only logged on to the questionnaire and those who only have a few questions left to answer will get the same notification. Manual operations can to some extent compensate for this by, for example, defining what constitutes a complete interview.

Many NSIs lack integrated case management systems for mixed mode surveys, necessitating the manual transfer of information between modes (Gravem et al., 2014). Some NSIs are presently in the process of developing new case management systems for mixed mode data collection, e.g. the Netherlands, but lack of collaboration gives differing solutions and high costs (Platt, 2019). In the coming years, the aim is to build a new case management system in Statistics Norway that takes into account the needs of new data collection technologies and sources, but this system is unlikely to be finished before the next TUS.

Chatbot

To address declining response rates and rising data collection costs, Statistics Norway wants to implement and use a chatbot as a digital assistant/interviewer in online surveys and to automate standardised processes. A chatbot is currently being tested to answer everyday questions in relation to survey participation and specific survey content questions in online surveys.

In the future, we will explore voice recognition and other areas where a chatbot can be used, for example to follow up respondents more automatically when they do not complete an online interview, and to use a chatbot to ask questions in a chat interface in online surveys or apps.

The expectation is that a chatbot can automate parts of these kinds of services and free up human resources for other tasks, as well as contribute to better user experiences and increased response rates and quality in our online surveys. However, even with integrated speech recognition, it is hard to see that it can replace skilled (human) interviewers.

2.2.4 Legal and ethical matters

The recent revision of privacy legislation means it is important to have good routines to document consent from participants/data owners, to ensure that data is anonymised, and that data combination and storage are in line with GDPR requirements. This is no different to other social surveys we conduct, and existing routines are already in place to safeguard this. For TUS, participation is voluntary, and we would document the consent both to participate and to use sensor data from mobile phones, while the use of administrative records is covered by legislation.

2.2.5 Time and budget

We have considered the possibilities that new technology and data collection methods can provide for TUS, and we have seen that there might be some quality issues and practical challenges. Now we need to consider the impacts on field time and the cost of evaluating how realistic a transition to a new set-up is for the next wave. When doing so, it is important to get a full overview of all project parts, necessary timing and cost before a decision is taken on what is the best solution within the given framework. Such an estimate will of course depend on the scale of the project, the need for new development and the range of necessary testing. Allowing for enough time is crucial for both quality and success. For the set-up we have already described for Norway, which is a conversion to an online set-up and a mobile app, we are factoring in, for example, a minimum of two years for planning and testing before launch.

With respect to field time for data collection, the set-up for 2010 with telephone interviews, a paper diary and manual coding takes longer than an online set-up with greater automatization, even if we use a mixed mode (which prolong field). The substantial reduction in interviewer costs and the greater automatization of case management and coding fields will substantially reduce costs. Nevertheless, the initial costs for a new set-up with a web portal and a mobile app will be high. For most of our surveys that are repeated, the cut in operational costs will eventually far outweigh initial costs. This is not necessarily the case for TUS, as it is only conducted once a decade and costs can hardly be spread over several waves. Ideally, we would want our development costs to be covered by reduced costs for data collection and manual coding for the new wave. From our budget planning this is feasible, but it is questionable whether the internal hours needed for testing and analysis can be provided to the extent required by a controlled transition. We also note that a change of method will build knowledge and competence in our organisation as a whole, which can then be used in other projects, such as using an app for an election diary, travel and cross-border trade and consumer expenditure. This will create synergies and aid expected digitalisation in our organisation.

2.3 Summary of evaluation

Obviously new data sources and the latest technology provide considerable possibilities, but do we really need it – will it improve our statistics?

Arguments *for* using new technology?

An online solution with a mobile app developed and tested with a focus on usability will be more user-friendly and meet user needs better than our old solution. It is old fashioned, cumbersome and time consuming to carry a paper diary with you for two days to enter your daily activities at 10-minute intervals, when it can be done more efficiently and accurately on a mobile phone with the assistance of sensor data. Easy access and easy use with a mobile app might encourage participation, provide better and more intuitive activity coding, reduce the response burden and curb the declining response rate seen in data collection since the last wave of TUS.

Just as importantly, new technology can help improve accuracy and quality in relation to how we measure TUS, as sensor data is more accurate than survey data and can help respondents recollect the activities they have carried out. Electronic data can speed up field and reporting time. Furthermore, better case management, shorter times in the field and an increased willingness to participate will also help reduce costs. Finally, we should not forget that digitalisation and paper-free solutions in public administration are promoted by the EU and local governments[6] and are expected by our participants.

Arguments *against* using new technology?

On the other hand, using new sources and new technology will be a deviation from earlier methods and will impact on time series and analyses. Sensor data is big data with a big volume, which can be

[6] The European Commission on Digital transformation 2019.

hard to manage, and the measuring effects can be difficult to estimate for multisource data. Lack of familiarity with smartphones and apps might reduce the willingness to participate and cause sample bias for certain groups of citizens. For this group, an online transition will not be user-friendly. We have previously stated that digital coding with machine learning will increase the detail and quality of activity coding, but this has to be tested empirically. Even though new technology with automatization cuts field and coding costs, there are also initial costs that can be hard for TUS to cover from reductions in data collection for one wave.

All in all, we think the deciding factors for a digital transformation are the digital surroundings in each country, Internet access and penetration of smart phones in the population, the extent of use of online solutions and mobiles in data collection in each NSI, and access to full coverage of accurate digital contact information for the population. Further important success factors are good planning, enough time, thorough testing and documentation of the impacts of new technology and new data in time use surveys. The necessary budget also has to be considered, although investment expenditure is assumed to be covered by reductions in data collection. Finally, to facilitate a good transition, it is important that the national statistic institutes in the ESSnet share data and empirical results to aid integration between existing data collections and new and innovative sources. With all this in place, a digital transition for TUS is the way to go.

3. Topic 3: New methods for data entry/coding/ questionnaire processing

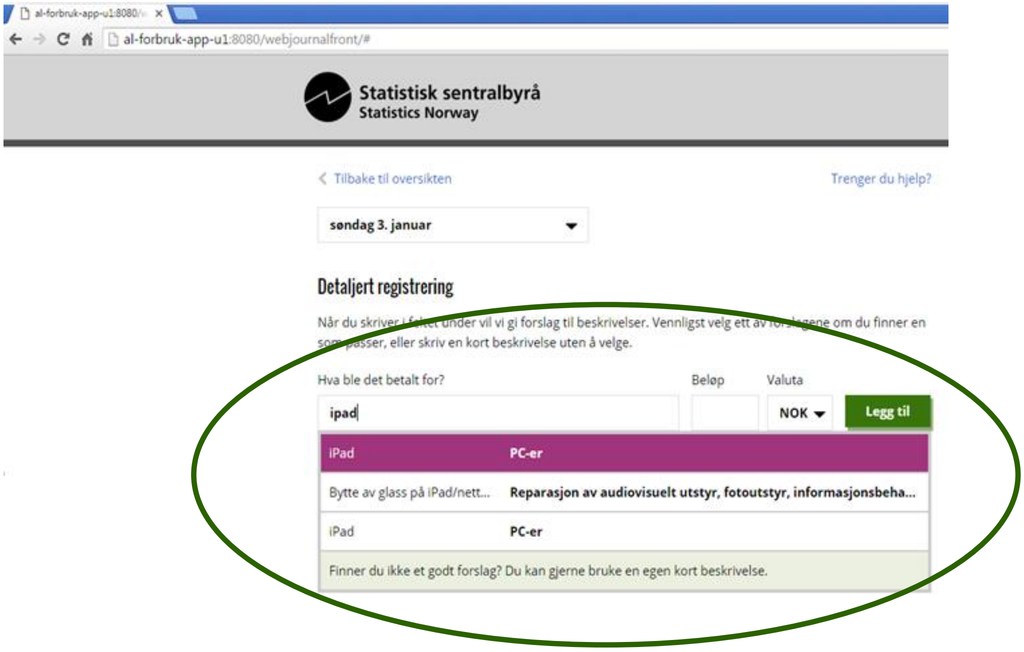
In this chapter, we will describe the principles behind the automatic coding application that was developed for the Norwegian Household Survey (HBS) and look at the possibilities for reuse and for integrating it into a new TUS design. We will also generally discuss the pros and cons of using predefined activity categories and codes, as opposed to respondents' own description of activity in the TUS web document with semi-automatic coding.

The choice of solution for the registration and coding of activities in a web diary or smartphone app is an important consideration in the development of a new tool for diary surveys, such as TUS and HBS. It is important with regard to the quality of the statistical output and it is also very important in terms of the costs associated with the processing (coding) of data. However, perhaps an even more important consideration is that the tool being developed should be user-friendly, and it must be easy and intuitive for the respondents to register their activities. In most cases, the solution that is chosen is a compromise that safeguards quality and cost reduction, and meets user-friendliness requirements.

3.1. Reuse of automatic coding application developed for HBS?

For HBS, we developed a system where the web diary was integrated with an administrative register of COICOP categories with predefined keywords (Figure 5). In the web diary, the respondents could type in the exact item that they had bought, for example an iPad, a Kindle or a reading board, then choose the right item from the list of items that appeared. This was then automatically coded into the right COICOP code (in this case 09.1.3.1 Personal computers). If the item that was typed in did not appear on the list, it was possible to register the bought item in free text. This was then coded manually in a separate coding application, but the item would later be a searchable keyword in the web diary for the next respondent. Hence, the system for coding activities was a semi-automatic coding system. The respondents did not have to choose a suitable category for their purchase but register the exact item. If the item was not pre-coded, we would code it manually once, and then the item was automatically coded for all future registrations.

Figure 5. Web diary integrated web application with pre-defined and pre-coded keywords



We initially wanted to reuse the coding application for HBS by loading the TUS activity codes into the already developed application. However, we have not been able to do this since the code and technology associated with the HBS application could not be reused without major adaptations, as concluded in Section 1.1.4.

Again, we experienced the challenge of adapting digital tools designed for a particular task or purpose for another use. With regard to both cost and time usage, the gain is small, and it is more expedient to build a new application.

3.2. Predefined codes or respondent's description of activity?

As mentioned above, the choice of registration mode is crucial when we are developing new and digital tools for collecting time use data. We have considered whether we will use pre-coded categories of activities in the TUS web diary/app, or have a solution similar to the concept of the HBS web diary with the option of choosing activities from a pre-defined list of keywords with the possibility to describe the activity in the respondent's own words. The first will mean fully automated coding, the latter will entail semi-automated coding with the use of a self-learning system (only fill in once) and text mining methods.

3.2.1 Simple and intuitive digital registration

An important consideration when replacing the traditional data collection method of paper diaries with a digital tool, is ease of use in the digital solution. The concept of the paper diary cannot be directly copied to a digital solution as this will not meet the requirement for user friendliness in the digital solution. It is very important that the digital registration is simple, intuitive and preferably done with simple keystrokes. The respondents will have an expectation of user friendliness based on their experience and use of other apps and digital tools.

The pre-coded mode for the registration of activities will definitely facilitate the code work afterwards and it will be cost efficient. However, such an approach with fixed categories to choose from can be seen as a disadvantage because the activity category list will never be exhaustive and could thus frustrate the respondent when he is not able to 'find' the activity. It can be a challenge that the same activity can be interpreted differently by different respondents.

Another disadvantage of using fully automated coding is also the break from the HETUS guidelines, which state that the respondents themselves must describe what they are doing and then the activity should be coded according to the HETUS categories.

We therefore believe that the term semi-automatic coding in TUS will be an appropriate compromise that safeguards user-friendliness, HETUS requirements and the need for simpler and more efficient coding. Several other countries that have developed web solutions for TUS have chosen this solution, including MOTUS.

4. Prototype of a new web diary/mobile app

In this chapter, we will present a prototype for a new web diary/mobile app, based on both the possibilities for reusing parts of the HBS design and principles and technology that can be adapted from already developed components in other statistics agencies.

4.1. From traditional to mixed mode data collection

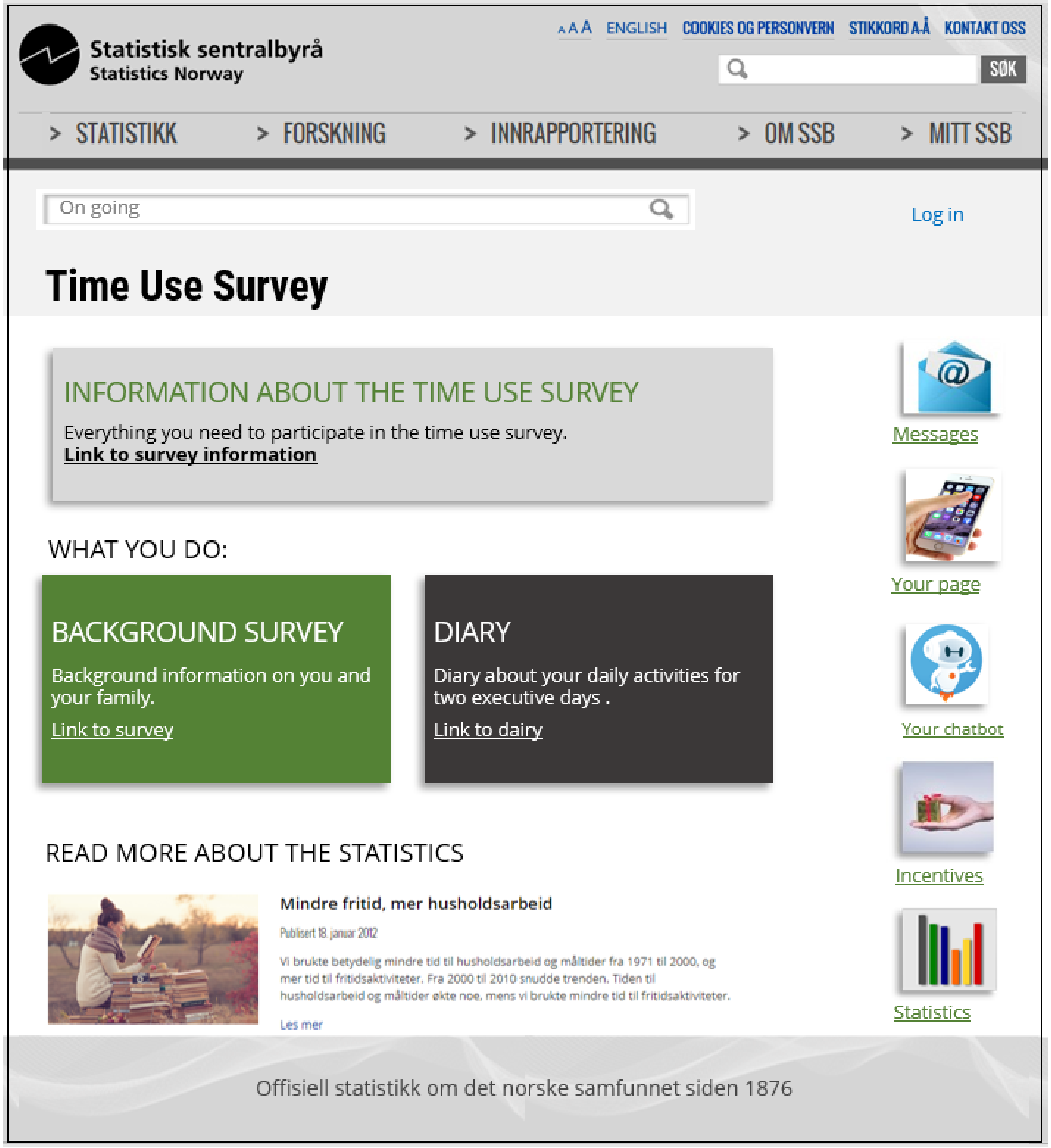
The last time use survey in Norway was conducted in 2010, and this followed general recommendations from Eurostat. Recruitment and the background survey took place using computer-assisted telephone interviewing and the time use diary was through self-completion on paper. The diary was kept over two days and in 10-minute intervals. At present there is no decision on whether a new wave will be conducted, nor what data collection set-up will be selected. Several solutions are under evaluation, but it is likely that considerations such as usability, response burden, statistical quality and cost might push towards online self-completion for both the background survey and the diary. Most likely we will create a digital solution with a web portal where respondents can access the two parts of the survey and all necessary information. We realise that a small segment of the population might not be able to participate digitally, and in order not to exclude them we will consider an alternative data collection mode with telephone interviews and a paper diary. If so, we will not only have a survey with multi elements – the background survey and the diary – but also several data collection modes, or a mixed mode, for the same survey elements. See the illustration in Figure 4 in Chapter 3. Such a design will require case management that integrates all parts in order to deliver a high-quality sample and efficient cost control.

Like any online survey, the human factor from an interviewer-assisted mode is not translatable. Good, interactive survey design can to a certain degree replace interviewer assistance for a survey with simple questions and tasks, but personal recruitment cannot be replaced with paper or electronic invitations. This factor must not be underestimated, especially for demanding surveys with multiple tasks like the TUS. For similar surveys, we have positive experiences with telephone recruitment in our first contact with the respondents. We conduct this as a short interview where we give information about the purpose and importance of the survey, explain the statistical value of participation by everyone selected, guarantee anonymity, give details of how to take part in the survey and answer questions that may arise and motivate respondents to participate.

4.2. The elements we plan to develop

For a new TUS in Norway, we are considering developing a web portal with two main features: 1) the background survey and 2) the diary, see the sketch of a web portal in Figure 6. The portal will also have information about the survey (grey box at top) and articles about earlier research papers and statistics (box at the bottom). On the right-hand side there are icons for email messages, your page, your chatbot, incentives and earlier statistics.

Figure 6. Design for a new web portal



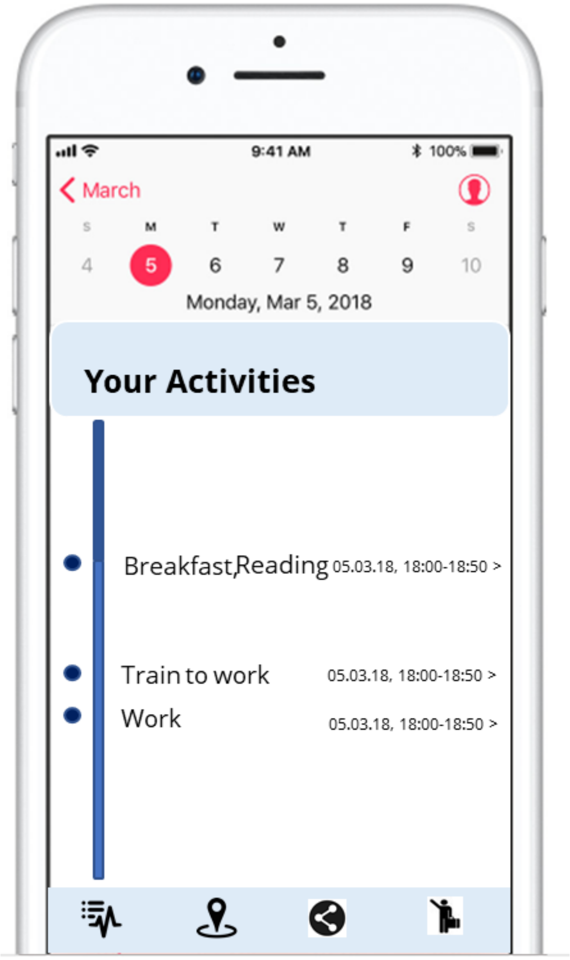
Both the background survey and the diary will be online and screen adaptive, which means that they can be accessed through a PC, tablet or smartphone. The diary will be designed as a mobile app. The background survey will likely also be possible to access from the app, but the app will primarily be designed for the diary, as it has most to gain from such a solution.

4.3 Mobile app

The idea is to enhance the detailed task of keeping an activity diary by using mobile sensors such as location, height, motion, acceleration to passively record participants' timelines, see example in Figure

7 below. The purpose of supplying respondents with a timeline based on sensor data is to provide milestones that can help 'jog' respondents' memories, so their account of activities is as accurate as possible. We can also use remote push alerts to remind respondents to record their activities, do particular tasks etc.

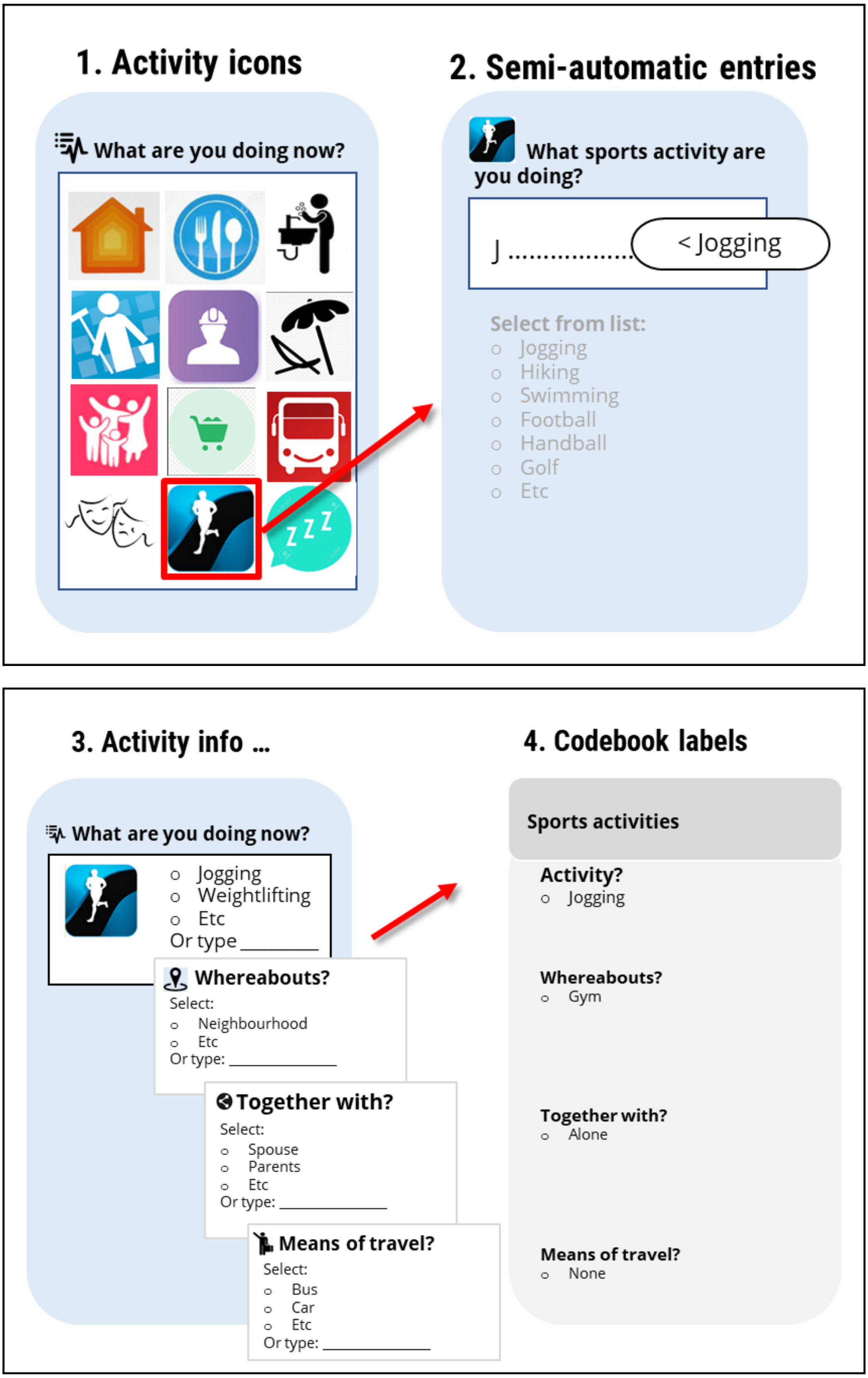
Figure 7. Mobile diary app design – timeline to assist memory



The activities from sensor data on the timeline need to be confirmed as correct, revised or supplemented by participants. For instance, features like name of location (for example work place) or means of travel (train) could be incorrect – maybe the location is actually a restaurant and maybe mean of travel is not train but bus, maybe not all activities at a certain time are recorded and need to be added, etc. Then the respondent will revise and/or add necessary activities with supporting information (e.g. activity 2, whereabouts/together with/means of travel) and the app will 'learn' or remember entries for future registrations. This means that respondents can select from a list of previous entries or those most commonly used, which are stored to facilitate responses. It is important that this process is simple and intuitive, and that it makes use of a digital format and outperforms the paper diary.

When adding or editing activities in the app, we want to use icons with images to make it easy to enter information, see Figure 8 (1 activity icons).

Figure 8. Mobile diary app – activity recording



Respondents select an activity category; start typing in the name of the activity, like in the example for 'jogging' in the figure above, a drop-down menu will suggest the most likely options and most common activities within a specific category. If a respondent is unable to find the correct activity, additional/new activities can be added using free text. After the activity is entered, additional features such as activity 2, whereabouts, together with, means of travel need to be confirmed or added as well.

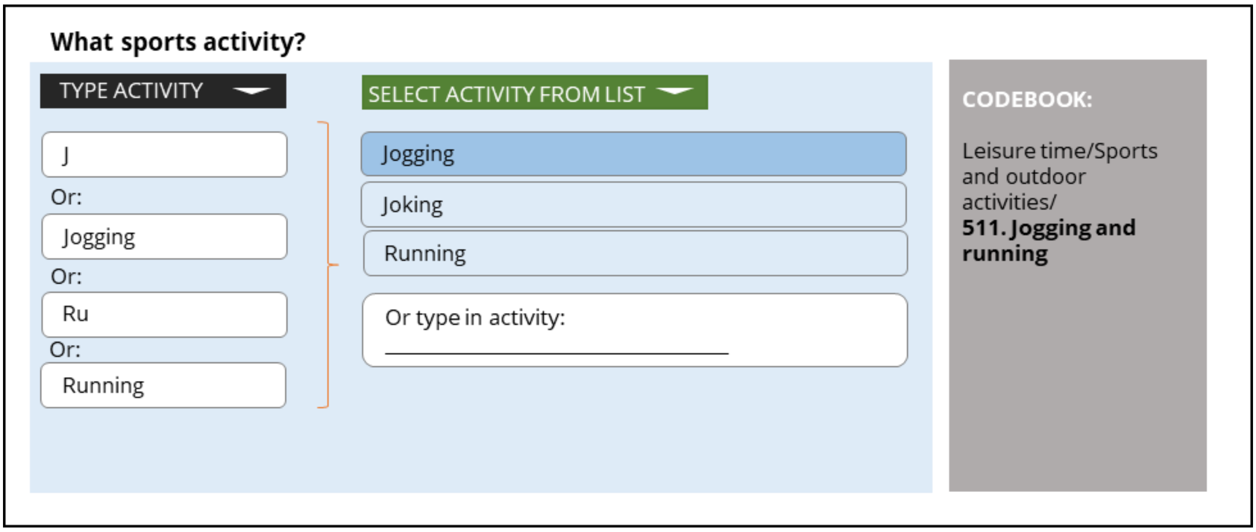
New activity names from free text will be coded centrally and added to drop-down menus with pre-coded activities. The drop-down menus will have the most commonly used and intuitive keywords for activities pre-coded from earlier studies and present wave. They will not use the code labels from the codebook, see Figure 9.

Semi-automatic activity coding

The automatization of coding is one of the main benefits of switching from paper to a mobile app. It will reduce the need for coders to a minimum without increasing the response burden disproportionately. By using an app and machine learning, we can optimise activity coding and make it faster and less burdensome.

In Figure 9, we illustrate the semi-automatic coding system described in Chapter 3.

Figure 9. Mobile diary app – semi-automatic pre-codes



Overview and revisions

A mobile app, such as web surveys on mobiles, has screen limitations. Long and complex texts with many details and requirements is not optimal for small screens (Couper, Antoun & Mavletova, 2017). Therefore, it is imperative that the app is usability tested and designed to provide an easy overview and make it easy for respondents to enter, confirm and revise diary activities. Alternatively, respondents can access the diary through the web portal and make their entries and do their revisions on their computer or tablet. The app could also have a message service that includes communications between data collectors and respondents, and possibly a chatbot for simple questions and answers.

Case management

As mentioned earlier (ref. Section 1.1.2), it is important that a new digitalised data collection system can be integrated with existing systems used for administering surveys and sending out messages in Statistics Norway.

A well-functioning multi-mode case management system is important in order to keep costs and man-hours down and to meet timeliness demands. An ideal mixed/multi-mode case management system should at any time be updated with the current and historic data collection status of all cases, as well as contact information and in which mode(s) a case is currently offered in.

The case management system should be able to interface with each respondent through push notifications and reminders of necessary tasks not yet completed. Ideally, we would want our chatbot to perform some of the push notifications. It is important to have a system that can do this automatically to a large extent, but without being too invasive.

5. Concluding remarks

The main objective of this grant action has been to *study the possibility of reusing components* developed in 2016 for the Norwegian Household Budget Survey in a new Time Use Survey.

We have concentrated our activities under the subtitle ‘Innovative tools and sources for TUS’, and the following three topics:

1) New/innovative tools and sources for data collection

2) Better integration between existing data collection and data from innovative sources

3) New methods for data entry/coding/questionnaire processing

In general, we found that the value of reusing the 2016 HBS applications for TUS 2021 is limited. However, there is still considerable reuse value in the concepts of the design and with the principles associated with the integration with other internal systems. Our prototype is based on reused parts of the HBS design and principles and technology that can be adapted from already developed components in other countries.

One important thing to be aware of in online time use registration compared to the paper diary, is the switch from writing down the activities in the respondent’s own words, to the automatization of coding in a mobile app. When we used the paper diary, the activities had to be recoded afterwards. This time-consuming process of activity coding is no longer required with online time use registration. This will reduce the need for coders to a minimum without increasing the response burden disproportionately.

New technology can help improve accuracy and quality in relation to how we measure TUS, as sensor data is more accurate and can help respondents recollect the activities they have carried out. Digitalisation and paper-free solutions in public administration are promoted by the EU and local governments and are expected by our participants. On the other hand, using new sources and new technology will be a deviation from earlier methods and will impact on time series and analyses. All in all, we think the deciding factors for a digital transformation is the digital surroundings in each country. To facilitate a good transition, it is important to share data and empirical results to better aid integration between the existing data collection and new and innovative sources. With all this in place, a digital transition for TUS is the way to go.

Appendix

COICOP administration (automated coding/creating search words/database for scanned receipts)	
The application is a backend application that integrates with other systems using REST. The application nevertheless has a simple administration interface where Statistics Norway can manage the COICOP codes.	
Framework	**Comment – background for choice**
Maria-DB	SQL database used by Statistics Norway.
Spring-Rest	Integrates well with the rest of the application especially Spring data where all repository methods are exposed as residual services.
JPA	Many good experiences from using JPA and Springdata. Avoid unnecessary configuration files.
Spring-data	Just relate to coding in java and control with database configuration. Ready-made CRUD repository that can be used by the residual services.
Spring-boot	Easy set-up and configuration. Also easy to override default configuration.
Spring batch	The most advanced framework available for automated tasks. Automatic tasks in the COICOP module are probably used for the first time at the prod setting
	However, it is easy to set up the task in Spring-boot. Spring batch is also responsible for orchestrating the task.
Web diary	
In the web diary, we go for an architecture without a framework, with only a library. Advantage:	
More likelihood of reuse in later consumption surveys where only parts of the system must be upgraded in order to be completely modern and efficient to work with.	
Less risk compared to encountering technical limitations during the project that can take up time.	
A frontend and a backend application will be created.	
Frontend technology moves extremely fast and it will therefore increase reusability in the backend code when it is not connected to front end technology.	
Generally, technology is selected that supports good code quality and minimal boilerplate. The only important choice will be React as templating language in frontend as this enables a transition to React Native if we complete web and mobile-adapted pages quickly. React Native enables native iOS and Android applications written in JavaScript.	
Web diary BACKEND - Short description	

Web diary backend offers a REST interface for web diary frontend. In addition to accessing data from the database, it also handles security and acts as a proxy against the COICOP registry and drivers working between COICOP and the web diary. The application uses no framework, but only a selection of libraries. The most important libraries are Jersey for the construction of REST API and Hibernate for database management.	
Tools backend	**Comment – background for choice**
Language: Java	The best supported language on JVM
Web server: Jetty	The best supported web server when running embedded. Possibility of replacing Tomcat.
Router: JAX-RS (javax.ws.rs)	Simple and elegant to implement and support – all we need in a REST API.
Data objects: Hibernate 4	Supports CRUD operations without writing SQL – something that saves us time. Opportunity for auto update of tables under development. Well-supported.
DB: MySQL (MariaDB)	SQL base already used in Statistics Norway.
DB update: Flyway	Makes it simple and transparent to update database tables for new versions and initiation.
Configuration: Constretto	Well-supported help library for configuration.
REST exposure: javax.json	Quickly builds JSON responses without building object structures for JSON Marshalling at the start. Possibility of marshalling library when API is more mature.
REST CONSUMPTION: JayWay JsonPath	Quickly retrieves specific values from JSON requests. The library for unmarshalling can be accessed later.
Logging: Logback	Recipient of Log4j with many exciting appendants and ability for live update of log levels.
Web diary FRONTEND Short description	
Web Diary Frontend is a separate application written in Javascript and deployed to Tomcat through Maven. It is strongly linked to the Web Log Backend application logically, but it does not share any libraries, but uses only the REST API provided.	
Tools frontend	**Comment – background for choice**
Language: JavaScript	Clean JavaScript, easiest to debug.
AJAX: Axios	User-friendly and specialised AJAX library supporting IE8.
Templating: React	Simplifies state logic in views and enables React Native at a later date.
Building tools: Webpack	Fashionable and well-supported JavaScript building tool that brings together a lot of functionality that has been scattered around in other libraries before.
Models: Backbone	Well-supported and rich functionality for building models you can move.

Explaining technical terms and words

API: An API or application programming interface is an interface with software, external databases and websites for automatically downloading or collecting data from registers or privately held records/data in a required format. See https://www.techopedia.com/definition/24407/application-programming-interface-api

App: An app or mobile application is a 'software application designed to run on mobile devices, such as a smartphone or tablet'. (TechTarget, 2019). In its simplest form, we are thinking of different calendars and booking systems with time, date, geospace, calculator or cost calculator etc., and in more advanced forms email, social media, media content, games, etc. Today, the most popular apps that are freely available are YouTube, Instagram, Snapchat, Messenger, Facebook, Bitmoji, Netflix, Google Maps, Gmail and Spotify (Apple, 2018). See

https://www.techopedia.com/definition/2953/mobile-application-mobile-app

Beacons: Beacons are low-energy Bluetooth location-based transmitters that send wireless signals to other smart devices nearby. Beacons are used commercially to inform users or potential customers of services or sales. For example, a zoo could inform its guests that the lions will be fed in 15 minutes at the waterfront, or that ice-cream is now half price. This kind of information would be sent to the guest's mobile phone when they walk by location-based beacons. See: https://www.webopedia.com/TERM/B/beacon.html

Blaise: Blaise is a software package for collecting data for computer-assisted web surveys (CAWI) from Statistics Netherlands.

Chatbot: A chatbot is a computer program that simulates a human conversational partner. The first chatbot in newer times was Siri, designed for smartphones and released in 2010. A chatbot is a virtual service often used in the first contact with customers or users to answer the most asked or simple questions in relation to an online service. It has to be preprogramed with answers or information and machine learning software is used for the bot to 'learn' from the interaction. See https://www.techopedia.com/definition/16366/chatterbot

Ecological momentary assessment: Ecological momentary assessment (EMA) involves repeated sampling of subjects' current behaviours and experiences in real time, in subjects' natural environments. EMA aims to minimise recall bias, maximise ecological validity, and allow the study of microprocesses that influence behaviour in real-world contexts. (Shiffman, 2008)

Google Home: Google Home is a smart speaker device that interacts with Google's personal assistant software, in which a large number of services, like calling, texting, listening to music, watching videos on your mobile etc., or controlling smart home appliances, like electricity, media systems etc., can be automated and initiated by voice commands.

GPS: Global positioning system.

Machine learning: Machine learning is the science of getting computers to act without being explicitly programmed. The machine is expected to 'learn' from its analysis and apply this knowledge to new problems. Machine learning, together with datamining and statistical pattern recognition is often referred to as predictive analytics. See https://www.techopedia.com/definition/8181/machine-learning

MediaWatch: GfK's MediaWatch is a portable electronic measurement device in the shape of a wristwatch that captures information on TV and radio consumption, in and outside the home. It is a passive measurement system based on sensor technology. MediaWatch was developed from stationary TV or people meters a decade or so ago when the Internet made media content accessible from anywhere and stationary measurement insufficient (GfK, 2019).

Mixed mode: In data collection, mixed mode is when more than one data collection mode is offered to the same sample to respond to a survey, and the responses from these different modes are combined. For example, when the background survey in TUS is collected through more than one data collection channel, e.g. through both telephone interviews and online (Dillman, 2014).

Multi-mode: Often used when data collection involves collecting information from survey respondents using more than one survey instrument and combining the responses, e.g. data from both the background survey and the diary of TUS. Some also use this term when one survey instrument, or element like the background survey, is collected through more than one data collection channel, e.g. telephone interviews and online, but in this paper we have called this mixed mode.

NFC sensor: NFC or Near Field Communication is a contactless tag that can start an app or identify a data channel for communication (Maycotte, 2015). Contactless payment is a good example of an NFC.

Open source: Open source means that the source code of a software application is known and available, and that the copyright holder grants users the right to study, change and distribute the software to anyone and for any purpose. See: https://opensource.com/resources/what-open-source

Open standard: Open standard in relation to data means that 'data is made available with the technical and legal characteristic necessary for it to be freely used, reused and distributed by anyone, anytime, anywhere'. Reference from the Open Data Charter (2019). *International open data charter*. See: https://opendatacharter.net/principles/

Real-time data: Real-time data is most often used about data from sensors that measures actual phenomena, like departure times in public transport, and that is passed on as soon as it occurs, without delay. It is often used about data streams that are not stored, but they could be both processed and stored. Real-time data should not be confused with dynamic or transactional data that may change over time as new information becomes available. See: https://www.techopedia.com/definition/31256/real-time-data

Sensor technology: 'A sensor is a device that detects and responds to some type of input from the physical environment.' (TechTarget, 2019). The input could be a great number of environmental phenomena and the output can be used to provide information or input to another system like a smartphone app or to guide a process, like the route planner in Google Maps. See: https://whatis.techtarget.com/definition/sensor

SIV: Statistics Norway's case management system, which was adopted in 2010. SIV is designed to handle CATI interviewing from a central database in addition to an offline system for CAPI interviewing. In addition to pure case management, Sivadm is also used to manage interviewers and interviewer payment.

The 4Vs: Refers to volume, variety, velocity, and veracity. There is a discussion about whether it is most appropriate to distinguish between 3, 4 or 5 Vs of Big Data: Volume, variety, velocity, veracity and value, see Gil (2016).

Wearable technology: Wearables are smart devices such as smartwatches, shoes, glasses etc. that rely on or send information to the processing unit like a mobile phone/tablet/PC. (Beal, 2019).

Web scraping: Web scraping is a technique employed to extract large amounts of data from websites whereby the data is extracted and saved to a local file on the user’s computer or to a database in table (spreadsheet) format. Reference from: https://www.webharvy.com/articles/what-is-web-scraping.html

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