# Age and Gender Difference in ICT Literacy and Biometrics Knowledge[1]

Tomáš Doseděl, Marcela Petrová Kafková, Lucie Vidovićová

ABSTRACT Accelerated digitalization during the COVID-19 pandemic and the transition from mobile phones to smartphones have increased the need for ICT literacy among the general public, including knowledge of the potential risks and their management. Generally, it is assumed that some population groups are more at risk of being left behind. Original empirical data collected in autumn 2020 as part of the PRECOBI project were used to identify the sociodemographic groups at risk of insufficient knowledge of biometrics and ICT safety. The novelty Biometrics Knowledge and ICT Safety Index (BIKIS index) was constructed to identify these and analyzed in the context of the Czech Republic. The OLS regression shows that the combination of higher age and lower education is associated with the highest risk of digital illiteracy, potentially resulting in digital exclusion. Regarding biometrics and ICT safety knowledge, the age of 50 is the cut-off point, with those with elementary and lower secondary education at a disadvantage compared to those with higher levels of education. The results show that in terms of ICT literacy, old age starts considerably earlier than in other societal contexts, which is important to note when designing ICT and biometrics-related risk mitigation strategies. The role of early life educational attainment should be supported to ensure ICT literacy in later life.

KEYWORDS digital divide, digital exclusion, ICT literacy, biometrics, information security

## Introduction

Information and communication technology (ICT) is increasingly pervasive in all spheres of human society. The COVID-19 pandemic, with its emphasis on physical distancing, has rapidly increased the adoption of these technologies in all areas of life. ICT was recommended as the safest possible way to meet with others, shop, and learn, to obtain health advice and medication, and to deal with local government and the state. Some authors claim that the resulting accelerated uptake in usage is one of the few positive impacts of the pandemic (Delloitte 2020; Giralt 2020; Nguyen 2021). Others argue that the issues

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of the digital divide[2] and digital exclusion[3] have worsened because some social groups at risk of digital exclusion have not had the resources or abilities necessary to benefit from increased digitalization, and this gap could even increase (Oldekop et al. 2020; Ramsetty and Adams 2020; Martin Van Jaarsveld 2020; Xie et al. 2020). Digital exclusion has serious negative consequences, not only for individuals but also for society since solidarity may be disrupted. A society attempting to provide equal opportunities for everyone could change into a two-tiered society with citizens in the first tier having access to digital governmental services, digital shopping, digital medicine etc. and second tier citizens lacking access. There is the risk of lowered equality of opportunity among people and changing society for the worse. In addition to knowledge and use of ICT, another important issue is users' understanding of the security risks associated with the new technology. Moving substantial parts of everyday life online makes things like privacy, location history, financial transactions, health information, home security, and even children's toys much more vulnerable to cyber criminals. Knowledge of ICT safety is more important than ever before. Although users consider security when using ICT, their feedback indicates that they lack the necessary knowledge to handle information security issues (Kaur and Mustafa 2013). Women are more concerned about privacy security in using ICT than men, and are more likely than men to take pro-active self-protective measures when using social network sites (McGill and Thompson 2018; Hoy and Milne 2010; Laric et al. 2009). Given the risks of ICT use, adequate security knowledge is important. For this reason, we surveyed the Czech population to determine the level of ICT security knowledge, as a first step toward setting appropriate educational policies to reduce the risks associated with the misuse of ICT and to narrow the digital divide. Some individuals are more at risk of falling into digital exclusion than others, and risk characteristics tend to combine and multiply risk, a principle known as cumulative dis/advantage (Dannefer 2003). Although fundamental access to technology may be a problem among some groups, especially those in more deprived communities, Internet access rates are generally relatively high, especially in Western countries. Studies have shown that the cost of or access to technology play only a small role in the lack of usage by older individuals.[4] Instead, research suggests that the main determinants of this divide are low motivational access and a general skills deficit (Friemel 2016).

Our article aims to identify the sociodemographic groups most lagging in ICT safety and biometrics-related knowledge and therefore at risk of digital exclusion. Using data collected specifically for this reason during autumn 2020 in the Czech Republic, we analyze the relationships between age, gender, education, and other characteristics of the respondents and knowledge of ICT and biometrics safety.

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2 The "digital divide" reflects the difference in how different groups of people access digital services.

3 "Digital exclusion" refers to a situation where a certain segment of the population cannot access services because they are unable to use ICT.

4 We approached the research without prejudice and deliberately used the general term "older adults" without mentioning a specific age group. As the results of the analyses showed, this was an appropriate decision, as the line between younger and older in this case was many years lower than one would expect.

ICT literacy can be broadly defined as the sum of knowledge and skills in the use of modern information and communication technologies, be it computers, the Internet or smartphones (c.f. Park, Kim, Park 2021 for thorough analysis of the concept of ICT literacy).

Individual ICT literacy is conditioned by many factors and influences. The impact of age and gender is often observed. Some studies have found that women are more anxious about using information technology and have less ICT knowledge and computer self-efficacy (Anwar et al. 2017; Broos 2005; He and Freeman 2010). On the other hand, women have significantly lower overall levels of security behaviour (McGill and Thompson 2018) and report a higher level of security concerns (Hoy and Milne 2010; Laric et al. 2009). According to McGill and Thomson (2018), female users believe that the effects of a security threat would be worse than male users, but do not feel more vulnerable, despite believing themselves to have less information technology skills. The authors conclude that gender differences in security behaviour are mediated by technical knowledge and training. According to the Czech Statistical Office, about 76% of men but only 73% of women used the Internet every day in 2021. Further differences were found by age and educational attainment (CZSO 2022).

ICT literacy is strongly correlated with age. Older adults are significantly less likely to use the Internet than the younger population (McDonough 2016). In the Czech Republic in 2021, 74% of people over the age of 16 used the Internet daily, but only 38% of those over 65 and 15% of those over 75 (CZSO 2022). Although older adults are an exceptionally heterogeneous group and their ICT literacy differs, they are generally on the excluded side of the digital divide. In 2013 and then again in 2016, it was shown that older adults had lower access to technology, and those that were ICT users had less frequent and varied usage (Friemel 2016; Pearce and Rice 2013). Older respondents evaluated the Internet more negatively than younger respondents, especially regarding perceived difficulty of use, and were more technophobic (Chang, McAllister, and McCaslin 2015; Donat et al. 2009; Furnell, Byrant, and Phippen 2007). According to van Deursen and Helsper (2015), a negative attitude toward the Internet was a major reason for non-use. Non-users with higher education were more likely to report not having enough time to use the Internet. Older adults who lived with others were more likely to respond that they were too old to use the Internet. Mitzner et al. (2010) showed that older adults who reported disliking technology attributed this mainly to the belief that it was inconvenient or that the costs outweighed the benefits. Age-friendly design and content, therefore, can play an essential role in making modern technology more accessible.

Estonia can serve as a good representative for implementing ICT policies. It has employed e-government services since the 2000s (Kattel and Mergel 2019), repeatedly taking first place among European countries, according to the Digital Economy and Society Index (DESI). At the beginning of the 2000s, almost 60% of Estonians (aged 15–75) did not use the Internet (Kalkun and Kalvet 2002). By 2007, after several governmental interventions, this percentage fell to 30% (Pruulmann-Vengerfeldt 2008), and today the number is less than 10% (Margetts and Naumann 2017). The people most at risk of exclusion are those older than 50 years and blue-collar workers with low education (Kalkun and Kalvet 2002). They suffer from the unavailability of technical equipment, complain about the high cost of ICT usage, have insufficient digital skills, and – last but not least – do not see any advantages of Internet use (Pruulmann-Vengerfeldt 2008; Ragnedda and Kreitem 2018).

With the increase in smartphone use and the implementation of biometrics for authentication, safe ICT use has become important. Of course, knowledge of risks and of procedures for safe use is a prerequisite for the safe use of ICT (Tsohou and Holtkamp 2018; Hassandoust and Techatassanasoontorn 2020).

With the rising use of biometric authentication for mobile devices, biometrics (such as a fingerprint or face recognition) has become a simple yet sufficiently secure solution (Ben-Asher et al. 2011). People use biometrics to lock their phones without having any deeper information about how biometrics works. Surprisingly, instead of discussions concerning the security of biometric authentication, questions about privacy issues have arisen. Both the private and public sectors use biometrics to identify people automatically in crowds, for example, at international airports, shopping malls, or sports events, which can then be used to identify wanted criminals, potential terrorists, or just for surveillance of innocent inhabitants (Bowyer 2004; Wong and Dobson 2019). As with every other technology, biometrics offers facilitation of everyday life but also brings new potential risks.

According to Rui and Yan (2018) and Clarke and Furnell (2005), biometric authentication was first seen as a future security option mobile subscribers and computer users were interested in – in early research, the majority of respondents were willing to accept some form of biometric authentication for their device. Jones et al. (2007) found differences in the willingness of users to use biometric authentication by purpose. For banking, for example, users accept biometric authentication but for making retail purchases, they are wary of it. The risk of loss and misuse of personal data, as well as direct awareness of the dangers of theft of non-revocable biometric data, is, according to a survey for one US bank, a significant obstacle to increasing the acceptance of biometric authentication by clients (Byun and Byun 2013). Concerns about the theft of personal data, and health and safety concerns in general, have the most significant impact on respondents' overall attitudes toward biometrics (Riley et al. 2009). In the UK, respondents prefer to use a password over biometric authentication (ibid).

Thus, at least basic ICT skills are needed to use modern digital services. ICT safety knowledge is an integral part of this, because without adequate safety measures, users risk that the private information they share with the government, doctors, banks etc. will be misused by hackers. We have shown that biometric authentication is one of the most advanced security methods today. Therefore, we assume that there is a direct link between ICT knowledge (defined as the ability to operate modern devices, complemented by knowledge of computer security and biometrics) and the ability to use modern public and private services securely. We therefore assume that the quality of use of digital services depends on, among other things, sufficient knowledge of ICT safety, especially biometrics. People who do not have this knowledge risk being left behind in the digital revolution, not having access to modern services, and becoming second-class citizens.

Our research question is: Which sociodemographic groups in the Czech Republic are currently most at risk of being left behind through a lack of ICT safety and biometrics knowledge? This leads to many subsequent questions: Which groups are most at risk of digital exclusion, and which groups are digitally included? Are people aware of the advantages and disadvantages of biometric authentication? Are women at higher ICT risk than their male counterparts? Are less educated people at higher ICT risk than educated people? And, are older adults at higher ICT risk than younger adults? To answer these questions, we conducted a quantitative survey of the adult population of the Czech Republic in the autumn of 2020 and analyzed the data. To better show overall knowledge of biometric technologies and basic rules of ICT safety in the population, we proposed to utilize the brand new *Biometrics Knowledge and ICT Safety Index* (BIKIS). Using basic descriptive statistics and multiple linear regression, we revealed that older people are endangered by insufficient biometrics and ICT safety knowledge. The digital divide between younger and older is substantially narrowed when individuals have higher levels of education. Older people who are more educated have comparable knowledge to younger people. Further, we need to explore what the terms "older" and "younger" mean in this context.

## Data and Methods

To answer our research questions, we performed a statistical analysis on data from the quantitative PRECOBI survey. The survey was aimed at adults, i.e. individuals 18 years and older, and took place between August and November 2020. The quota sampling method was used with quotas (for gender, age, level of education, city size, and region) based on the Czech National Census of 2011. As information from the 2021 National Census was not available at the time of the survey design, relevant adjustments were made to ensure the representativeness of the sample. The design of the questionnaire by the core team was an interdisciplinary effort, combining sociological, sociogerontological, and ICT safety expertise. The research tool was thoroughly pre-tested among different groups of respondents. Data were collected by the specialized FOCUS agency via face-to-face CAPI completing the questionnaires with a resulting N = 2,341. Compliance with all the ethical and professional SIMAR/ESOMAR standards was guaranteed and the study was approved by the Masaryk University Ethics Committee (approval number: EKV-2018-043).

The resulting dataset consisted of 52% women and 48% men. The ages varied from 18 to 88 years and the group had an arithmetic mean of 47.28 years. To capture the heterogeneity of the older adult population, the age quotas were settled for two groups – 60 to 69 years old, and 70 years and over. About 14.5% of respondents had completed a university education (ISCED 5-8), 34% finished secondary school with a leaving certificate ("maturita", ISCED 4, part of ISCED 3 with direct access to further education), and 54.5% had a lower education status (ISCED 1-2, part of ISCED 3 without direct access to further education).

The questionnaire had two parts. The first contained questions focused on knowledge of biometric technologies, respondents' experience with biometrics, and their attitudes, fears, and feelings concerning biometrics. The second part of the questionnaire dealt with more general ICT knowledge, ICT experience, personal data protection, and the safe use of modern technologies.

## Biometrics Knowledge and ICT Safety

For our analysis, we constructed a novel ICT safety and biometrics knowledge score: the Biometrics Knowledge and ICT Safety Index (BIKIS). The survey was not originally intended to design the Biometrics Knowledge and ICT Safety indicator as described in the following paragraphs. Therefore, the questions for the index were constructed to gather information about technology knowledge and knowledge of computer security practices and biometrics. We aimed to choose questions that as many respondents as possible could answer (e.g. concerning passports, credit cards, and email) and not to go into topics that some respondents were not experienced with (such as tax returns and computer games). The resulting index is based on three knowledge-of-biometrics questions and two questions aimed at the safe use of ICT. The respondents were awarded one point for every correct answer and/or response regarding their ICT behaviour.

The first knowledge-of-biometrics question was offered in a choose-one-correct-answer design opened with the following question: *What does the word biometrics stand for? Select the correct definition:* (with the correct option being, "The measurement of human bodily characteristics" and three incorrect options). The second test of knowledge was prompted by the question: *From the following list, please select the characteristics of the human body you think can be used for biometric authentication.* The answers contained several body parts and characteristics such as fingerprints, retina scan, handwriting style (correct), body height, and hair colour (incorrect). The third test of knowledge-confirming indicators was elicited by the statement: *Hollywood movies often show several scenarios of misuse of biometrics. Please select those which you think are real in contemporary society.* Answers of "yes" or "no" for each of six items were expected. The items offered were "Force someone to use his/her fingerprint" (yes) or "Cut off someone's finger and use it to fake the valid fingerprint" (no). These sets of possible scenarios were designed to help to determine the strength of accurate/scientific information in contrast to popular culture influences and misinterpretations. Prior research had shown that users often believe pop-culture myths and are therefore afraid to use modern technology.

The two sets of reported safe behaviour were tested. Here the respondents were expected to choose from four options: "never", "seldom", "mostly, whenever possible offered as follows: *"Please choose between the following statements: I have one universal password for everyday use (comfort), I have different passwords for different systems (safety of usage)*, and *Do you use a two-phase authentication method?*

These indicators representing the concept of knowledge and reported safe behaviour were combined into the resulting BIKIS score. The BIKIS index score is a continuous variable varying from 1 to 22 points (the mean is 11.953 points); a higher BIKIS score means higher biometrics knowledge and safer ICT behaviour.

The resulting BIKIS score is almost normally distributed and the sample size is more than sufficient for Central Limit Theorem (Islam 2018) which allows for t-test, ANOVA, and regression analysis to be used for further exploration. Because the original variables mostly have two categories (yes/no), we cannot use advanced methods such as factor analysis or Cronbach's alpha for testing the internal reliability of the BIKIS score.

Being aware of these limitations, we can only claim that BIKIS score measures general ICT safety and biometrics knowledge. It is not our ambition to construct a universally applicable scale, only to create a single indicator that measures knowledge of ICT safety and biometrics.

### Independent Variables

The main aim of our analysis was to determine which sociodemographic groups lack knowledge of biometrics and ICT safety. Therefore, we used a set of sociodemographic variables as our independent variables: age, gender, education, city size, and NUTS3 region.

*Age* was divided into six categories: 18–29-year-olds, 30–39-year-olds, 40–49-year-olds, 50–59-year-olds, 60–69-year-olds, and 70-year-olds and over. We decided to use age in its categorical instead of continuous form because we expected a non-linear relationship between age and the BIKIS score, with specific dynamics in older age. City size was divided into three categories relevant to our sociogeographical context: less than 5,000 inhabitants, 5,001–99,999 inhabitants, and more than 100,000 inhabitants. The Czech Republic has 6,258 municipalities, of which 5,982 are smaller than 5,000 inhabitants (comprising 39% of the population), and six are bigger than 100,000 inhabitants (comprising 22% of the Czech population). The remaining 270 cities, with more than 5,000 but less than 100,000 inhabitants, comprise 39% of the Czech population. There are 14 NUTS3 regions in the Czech Republic with significant differences in their inhabitants' age and educational composition, as well as the level of development in various aspects.

Our analytical strategy was two-fold. First, we sought to show the differences in BIKIS scores across all the independent and control variables. Then we constructed a set of OLS regression models to check the influence of all the above-mentioned determinants. All the analyses were performed using Stata 16 SE statistical software.

## Results

The respondents tended to have lower biometrics and ICT safety knowledge in older age. The first significant decrease in BIKIS score was observed in the 50–59 cohort and continued in the successive age groups. The age group most at risk was the 70+ year-olds; their average BIKIS score was almost two points lower in comparison with the youngest respondents. The differences summarized in Table 1 are statistically significant (ANOVA p=0.0000) and can be generalized to Czech society at large.

**Table 1:** Average BIKIS score by age group

| Age category | mean | sd |
|---|---|---|
| 18-29 | 12.51 | 3.18 |
| 30-39 | 12.46 | 3.26 |
| 40-49 | 12.33 | 3.35 |
| 50-59 | 11.95 | 3.61 |
| 60-69 | 11.31 | 3.52 |
| 70+ | 10.61 | 3.70 |

Source: PRECOBI survey 2020, own calculations. N=2,341

Women, in general, had slightly lower knowledge of biometrics and ICT safety than men. The difference was statistically significant according to the t-test (p=0.0472). Still, the standard deviation was higher for women than for men, which indicates greater variance in the biometrics and ICT safety knowledge among women than among men.

**Table 2:** Average BIKIS score according to gender

| Gender | mean | sd |
|---|---|---|
| Men | 12.10 | 3.43 |
| Women | 11.82 | 3.52 |

Source: PRECOBI survey 2020, own calculations. N=2,341

Higher levels of education attained, the average BIKIS score rises as well. The university-educated are were most familiar with the problems of biometric technologies and ICT safety. The difference between university-educated respondents and respondents with primary education was 1.63 points. The results presented in Table 3 are statistically significant according to the ANOVA test (p=0.0000).

**Table 3:** Average BIKIS score according to educational level

| Education | mean | sd |
|---|---|---|
| Primary | 10.94 | 3.77 |
| Lower secondary | 11.64 | 3.44 |
| Secondary | 12.49 | 3.26 |
| Tertiary | 12.57 | 3.39 |

Source: PRECOBI survey 2020, own calculations. N=2,341

The influence of the size of the city where the respondent lived was statistically non-significant (ANOVA p=0.1325). Furthermore, the differences between smaller (11.77) and bigger (12.07, 12.05) cities were very small. We can conclude that city size had no impact on the knowledge of biometrics and ICT safety.

**Table 4:** Average BIKIS score according to size of city

| Size of city | mean | sd |
|---|---|---|
| 0-4,999 | 11.77 | 3.52 |
| 5,000-99,999 | 12.07 | 3.37 |
| 100,000+ | 12.05 | 3.58 |

Source: PRECOBI survey 2020, own calculations. N=2,341

On the other hand, the regional differences were impressive, varying from 10.58 in the Pardubice Region to 13.43 in the neighbouring Vysočina Region (the difference was 2.85 points). As business and administration are common in the capital city, Prague outdistanced the South Moravia Region (Jihomoravský kraj), known as an R&D centre of the republic, by 0.44 points. The Moravian-Silesian Region (Moravskoslezský kraj), formerly oriented toward coal mining and heavy industry, had the second-lowest average BIKIS score. The impact of region on the BIKIS score was statistically significant according to the ANOVA test (p=0.0000).

**Table 5:** Average BIKIS score according to NUTS3 region

| NUTS3 Region[5] | mean | sd |
|---|---|---|
| Vysočina Region | 13.43 | 3.58 |
| Olomouc Region | 13.19 | 2.80 |
| South Bohemian Region | 12.79 | 3.63 |
| Ústí Region | 12.71 | 3.26 |
| City of Prague (capital region) | 12.22 | 3.77 |
| Central Bohemian Region | 11.97 | 3.25 |
| Zlín Region | 11.96 | 3.32 |
| Southern Moravia Region | 11.78 | 3.26 |
| Pilsen Region | 11.70 | 3.44 |
| Karlovy Vary Region | 11.65 | 3.75 |
| Liberec Region | 11.49 | 3.21 |
| Hradec Králové Region | 11.41 | 3.36 |
| Moravian Silesian Region | 10.76 | 3.52 |
| Pardubice Region | 10.59 | 3.28 |

Source: PRECOBI survey 2020, own calculations. N=2,341

5 In the following text, the English names of Czech regions were used, so we present the Czech names here in parentheses: City of Prague (Hlavní město Praha), Central Bohemian Region (Středočeský kraj), South Bohemian Region (Jihočeský kraj), Pilsen Region (Plzeňský kraj), Karlovy Vary Region (Karlovarský kraj), Ústí Region (Ústecký kraj), Liberec Region (Liberecký kraj), Hradec Králové Region (Královéhradecký kraj), Pardubice Region (Pardubický kraj), Vysočina Region (Kraj Vysočina), Southern Moravia Region (Jihomoravský kraj), Olomouc Region (Olomoucký kraj), Zlín Region (Zlínský kraj), Moravian-Silesian Region (Moravskoslezský kraj).

After the first step of our analysis, we can presume that age, education, and region strongly impacted individuals' BIKIS scores. On the other hand, the impact of gender and the size of the city where the respondent lived seemed to be weak. The separate tests of particular determinants cannot, of course, disclose all kinds of indirect impacts (for example, education through gender, as we can assume, especially since older men are frequently more formally educated than older women) or co-impacts. To obtain the isolated influences of all the above-presented variables, we estimated three OLS regression models (see Table 6). Model M1 used only the characteristics of respondents, such as gender, age, and educational level. According to the R-squared indicator, this model explains the variance in data from 5.86%. Into model M2, we added information about the size of the city where the respondent lived. Both coefficients were non-significant, and the R-squared indicator changed only from 5.86% to 5.96%. Therefore, we added information about the NUTS3 region into the final model M3 to better explain the regional differences. Although part of the coefficients was statistically non-significant, the overall quality of the model improved. The R-squared indicator rose to 10.73%.

We can conclude that personal socio-economic characteristics explained respondents' knowledge of biometrics and ICT safety from approximately 6%, and the regional differences explained an additional 5%. At this point, we considered using multilevel modelling (individual respondents nested in NUTS3 regions), but we rejected this approach during further testing. This is because the multilevel model was characterized by the low ICC value (0.0499), which, according to Bryan and Jenkins (2016), is insufficient to justify multilevel modelling.

The following interpretations were based on the final model M3. Women had a lower BIKIS score than men by 0.430 points. Higher education was correlated to a higher BIKIS score; for example, the score of university-educated people was 1.452 points higher than the score of respondents with primary education. The BIKIS score slightly decreased with the process of ageing, but till the age of 49, the changes were minimal and statistically non-significant. The first major decrease was observed in the 50–59 age group (a statistically significant decrease by 0.542 points compared to the previous age group). In the following age group (60–69 years), the decline was double that of youth (1.029), and in the oldest age group (70+), even more than triple (1.620).

To sum up, the regression analysis supported the previous findings. People in older age had limited knowledge and gaps in safe ICT-related behaviour, which could lead to their dropping behind in the digitalization of everyday life. For those that used ICT without safety precautions, there was a risk that their digital identities could be compromised leading to financial scams and/or other forms of digital abuse and mistreatment on one hand and to a limited ability to reap the benefits from safe, broadly defined ICT usage on the other. Determinants able to diminish this digital gap were the male gender and/or higher education (Várallyai and Herdon 2013). However, even after controlling for age, gender, education, city size and region, there was still about 90% of unexplained heterogeneity.

**Table 6:** Determinants of the BIKIS score (OLS regression)

| | M1 | | M2 | | M3 | |
|---|---|---|---|---|---|---|
| | Coeff. | p | Coeff. | p | Coeff. | p |
| **Gender** | | | | | | |
| Male | Ref. | | Ref. | | Ref. | |
| Female | -.432 | 0.002 | -.433 | 0.002 | -.430 | 0.002 |
| **Age** | | | | | | |
| 18–29 | Ref. | | Ref. | | Ref. | |
| 30–39 | -.189 | 0.402 | -.186 | 0.408 | -.161 | 0.464 |
| 40–49 | -.243 | 0.302 | -.256 | 0.277 | -.223 | 0.332 |
| 50–59 | -.596 | 0.011 | -.600 | 0.010 | -.542 | 0.018 |
| 60–69 | -1.129 | 0.000 | -1.128 | 0.000 | -1.029 | 0.000 |
| 70+ | -1.696 | 0.000 | -1.703 | 0.000 | -1.620 | 0.000 |
| **Education** | | | | | | |
| Primary | Ref. | | Ref. | | Ref. | |
| Lower secondary | .510 | 0.018 | .499 | 0.020 | .556 | 0.008 |
| Secondary | 1.322 | 0.000 | 1.307 | 0.000 | 1.360 | 0.000 |
| Tertiary | 1.393 | 0.000 | 1.385 | 0.000 | 1.452 | 0.000 |
| **Size of city** | | | | | | |
| 0–4,999 | | | Ref. | | Ref. | |
| 5,000–99,999 | | | .240 | 0.132 | .302 | 0.059 |
| 100,000+ | | | .074 | 0.692 | .400 | 0.124 |
| **NUTS3 region** | | | | | | |
| City of Prague | | | | | Ref. | |
| Central Bohemian Region | | | | | .209 | 0.574 |
| South Bohemian Region | | | | | 1.041 | 0.013 |
| Pilsen Region | | | | | -.043 | 0.913 |
| Karlovy Vary Region | | | | | -.113 | 0.828 |
| Ústí Region | | | | | 1.018 | 0.012 |
| Liberec Region | | | | | -.242 | 0.578 |
| Hradec Králové Region | | | | | -.307 | 0.483 |
| Pardubice Region | | | | | -1.121 | 0.010 |
| Vysočina Region | | | | | 1.690 | 0.000 |
| Southern Moravia Region | | | | | -.059 | 0.857 |
| Olomouc Region | | | | | 1.473 | 0.000 |
| Zlín Region | | | | | .280 | 0.512 |
| Moravian Silesian Region | | | | | -1.008 | 0.003 |
| **Constant** | 11.908 | 0.000 | 11.811 | 0.000 | 11.470 | 0.000 |
| **N** | 2,341 | | 2,341 | | 2,341 | |
| **$R^2$** | 0.0586 | | 0.0596 | | 0.1073 | |

Source: PRECOBI survey 2020, own calculations.

## Combined Effects of Social Demographic Factors

To better combine all these determinants and to better understand the differences among several sociodemographic groups, we estimated the marginal effects of three determinants (age, gender, and educational level) on BIKIS score. We obtained 48 groups (six categories of age × two categories of gender × four education categories) (see Table 7). We considered adding the region information, but the 14 additional categories would increase the number of groups to 672, which would be confusing. For each sociodemographic group, we estimated the average level of biometrics knowledge and ICT safety behaviour. Then we ordered the results descending according to the estimated BIKIS score and divided the sociodemographic groups into four quartiles. The resulting list is presented in Table 7, where the first quartile signifies the most ICT liberated respondents and the fourth quartile the group most at risk of digital exclusion.

**Table 7:** Sociodemographic groups by their knowledge of biometrics and ICT safety

| Quartile | Age | Gender | Education | BIKIS |
|---|---|---|---|---|
| Q1 | 18–29 | man | Secondary | 13,181 |
| Q1 | 40–49 | man | Tertiary | 13,149 |
| Q1 | 30–39 | man | Secondary | 13,090 |
| Q1 | 30–39 | man | Tertiary | 13,073 |
| Q1 | 18–29 | man | Tertiary | 13,034 |
| Q1 | 40–49 | man | Secondary | 12,912 |
| Q1 | 18–29 | woman | Secondary | 12,873 |
| Q1 | 18–29 | woman | Tertiary | 12,843 |
| Q1 | 30–39 | woman | Tertiary | 12,830 |
| Q1 | 50–59 | man | Tertiary | 12,805 |
| Q1 | 50–59 | man | Secondary | 12,778 |
| Q1 | 40–49 | woman | Tertiary | 12,698 |
| Q2 | 30–39 | woman | Secondary | 12,595 |
| Q2 | 40–49 | woman | Secondary | 12,555 |
| Q2 | 18–29 | man | Lower secondary | 12,351 |
| Q2 | 50–59 | woman | Secondary | 12,281 |
| Q2 | 30–39 | man | Lower secondary | 12,222 |
| Q2 | 40–49 | man | Lower secondary | 12,165 |
| Q2 | 60–69 | man | Tertiary | 12,140 |
| Q2 | 50–59 | woman | Tertiary | 12,135 |
| Q2 | 60–69 | man | Secondary | 12,044 |
| Q2 | 18–29 | woman | Lower secondary | 12,001 |

| Quartile | Age | Gender | Education | BIKIS |
|---|---|---|---|---|
| Q2 | 18–29 | man | Primary | 11,948 |
| Q2 | 40–49 | woman | Lower secondary | 11,899 |
| Q3 | 50–59 | man | Lower secondary | 11,778 |
| Q3 | 70+ | man | Tertiary | 11,750 |
| Q3 | 18–29 | woman | Primary | 11,684 |
| Q3 | 70+ | man | Secondary | 11,681 |
| Q3 | 60–69 | woman | Secondary | 11,534 |
| Q3 | 60–69 | man | Lower secondary | 11,486 |
| Q3 | 40–49 | man | Primary | 11,413 |
| Q3 | 60–69 | woman | Tertiary | 11,399 |
| Q3 | 50–59 | man | Primary | 11,334 |
| Q3 | 70+ | woman | Tertiary | 11,288 |
| Q3 | 30–39 | woman | Lower secondary | 11,259 |
| Q3 | 30–39 | woman | Primary | 11,259 |
| Q4 | 50–59 | woman | Lower secondary | 11,238 |
| Q4 | 30–39 | man | Primary | 11,167 |
| Q4 | 60–69 | man | Primary | 10,957 |
| Q4 | 50–59 | woman | Primary | 10,937 |
| Q4 | 70+ | woman | Secondary | 10,888 |
| Q4 | 40–49 | woman | Primary | 10,859 |
| Q4 | 60–69 | woman | Lower secondary | 10,831 |
| Q4 | 70+ | man | Lower secondary | 10,748 |
| Q4 | 60–69 | woman | Primary | 10,341 |
| Q4 | 70+ | man | Primary | 10,248 |
| Q4 | 70+ | woman | Lower secondary | 10,179 |
| Q4 | 70+ | woman | Primary | 9,874 |

Source: PRECOBI survey 2020, own calculations.

The effect of age on BIKIS score was strong and predictable. Of the twelve sociodemographic groups placed in Q1, only two were older than 50 years. It was symptomatic that these two groups were characterized by male gender and higher education (tertiary and secondary). The second quartile contained four sociodemographic groups older than 50 years. Two groups consisted of men 60–69 years with tertiary and secondary education, and two groups consisted of women 50–59 years with tertiary and secondary education. As mentioned before, men in this age group and with these educational levels in the first quartile. Finally, eight sociodemographic groups are older than 50 years and only four groups younger in the third quartile. All the younger groups are characterised by primary or lower secondary education.

Men older than 70 years and women 60–69 years with tertiary education are also placed in the third quartile. The fourth quartile contains only two groups younger than 50 years, both characterized by primary education. The lowest BIKIS scores were those of men and women older than 70 years with primary education, and women older than 70 years with lower secondary education. We can assume that higher education worked as a compensator for the age-related disadvantages. The results thus confirmed the theory of cumulative dis/advantage (Dannefer 2003). Dannefer points out that it is precisely the specific interaction of disadvantageous traits during the life course that leads to a greater risk of disadvantage, not the occurrence of these traits individually. In this case, it was mostly interaction between higher age and lower education that caused the lack of adequate ICT literacy and thus risk of digital exclusion.

## Conclusion

One effect of the COVID-19 pandemic has been the rapid expansion of ICT use in society. Staying at home and communicating with family members, public authorities, shops, doctors, banks, and other entities via ICT was promoted as a safe and modern way of living when physical distancing was established as the primary tool of population protection. The ICT technologies enabled interaction without risk of spread of COVID-19. With the intensifying shift into virtual online environments and the ongoing transition from mobile phone use to smartphones, different threats become important. The public has a growing need for ICT literacy. In addition, the non-use of modern technologies, for whatever reason, carries the risk of deepening the digital exclusion of those who do not use them (Walsh et al. 2020).

We can conclude that among those under the age of 50 there are no significant differences in biometrics and ICT safety knowledge. For those older than this age, the average level of knowledge decreases substantially. Thus, age is an influential factor of ICT literacy, with a considerable digital gap between younger and older generations. It should be noted that the cut-off point of 50 years is considerably lower than what is generally understood as older (Vidovićová 2008), and is within the productive age.

We believe that to a large extent this result is not really an effect of age, but an effect of timing. Respondents who were 50 years of age or older at the time of data collection experienced the social changes of 1989 as adults. Given the typical demographic behaviour at that time, most of them had probably already formed families and entered the workforce (Kocourková and Rabušic 2006). Thus, they did not have time to gradually become familiar with new technologies and their knowledge is lower than that of younger respondents. If we had conducted the research in a country that had not gone through such significant changes in demographic behaviour, and where computer was already widespread in the 1990s, we would probably have reached different results.

From the point of view of gender, men have, on average, better knowledge of biometrics and ICT safety than women. Which could be probably attributed to traditional gender diversification of the fields of work. Unsurprisingly, secondary and tertiary education compensates for the influence of age, and it is the combined influence of low education and older age that puts individuals at risk of digital exclusion. This interaction of risk factors is in line with the theory of cumulative dis/advantage (Dannefer 2003) and underlines the much-needed debates on the intersectionality in various domains of social exclusion (Walsh et al. 2020). The size of the city where the respondent lives has no significant impact on their biometrics and ICT safety knowledge, undermining the continuous debates on the disadvantaged rural areas as opposed to supposedly better developed urban areas (Pospěch et al. 2009; Vidovićová et al. 2018). There are interesting regional differences, which can be explained by the different levels of education of the population in each region (regional universities were established in the Czech Republic only after the year 2000) and the different regional structures of industry. The regions with higher BIKIS scores were traditionally associated with engineering and electrical production (Vysočina Region, Olomouc Region), while regions with lower ICT literacy levels were involved in chemical production, mining and metallurgy (Moravian Silesian Region, Pardubice Region). It may be that different types of industry place different demands on employees in developing ICT literacy. For more precise findings, it would be necessary to examine differences in smaller geographical areas.

The main limitation of our analyses was the method used to measure ICT safety and biometrics knowledge**.** While we tried to work with experts to develop a good test of knowledge, there are a number of ways in which the test could have been designed differently. Nevertheless, we believe that our scores serve as a sufficient proxy for broader knowledge. Potential follow-up research could verify our results in other countries or test ICT safety knowledge practically, not just with a theoretical test.

The findings presented here can be generalized to the contemporary Czech population. The data set is representative for age, gender, education, and region. We presume that comparable results can be obtained for the different Central and Eastern European countries, where the introduction of personal ICT technologies and educational expansion at the tertiary level took place in the 1990s, twenty years later than in West European countries. We presume that even older birth-cohorts are sufficiently familiar with biometrics and ICT safety knowledge in West European countries.

Although prejudices and suppositions abound about who may be in danger of being left behind, empirical research to identify the most at-risk sociodemographic groups – as our study does – is essential for future development of the digital society. The identification of sociodemographic groups at higher risk of digital exclusion was the aim of this paper, and our results can be used by public policy makers and the private sector to offer various digital services and prepare a set of measures to close the unwanted digital gap.

As the Estonian experience showed (Kattel and Mergel 2019), without systematic and well-targeted efforts, such as workshops, grants, and advertising campaigns, a substantial part of the population will be restricted in their civil rights because they cannot access modern e-government and commercial services. Applying Beck's (1992) concept of the individualization of risk, we conclude that society at large benefits from the undeniable efficiencies of the digitalization of everyday life and is largely passing the costs on to its older citizens. The savings generated by closing offices or bank branches (for example in smaller towns) are not sufficiently invested in the education of vulnerable populations. It remains their personal responsibility alone to overcome the digital divide and to exercise their civil rights for the several decades they can expect they have left to live.

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## Authors

*Tomáš Doseděl* is a sociologist and assistant professor at the Faculty of Social Studies, Masaryk University, Brno. His area of expertise includes sociological methodology and data analysis, labour market issues, changing role of education after the educational expansion, technological change and the digitalisation of society in every aspect.
Contact: dosedel@fss.muni.cz

*Marcela Petrov*á *Kafkov*á is a sociologist and specialist at the Faculty of Social Studies, Masaryk University, Brno. She has long been involved in the sociology of ageing and social gerontology, focusing mainly on the topics of active ageing, intergenerational relationships and old age. She participates in many research projects and consults on implementation projects by state institutions.
Contact: kafkova@fss.muni.cz

*Lucie Vidovićová* is a sociologist and assistant professor at the Faculty of Social Studies, Masaryk University, Brno, and also collaborates with the Research Institute of Labor and Social Affairs, and has long been involved in the sociology of ageing mainstreaming. She participates in research projects for national and international institutions and also works as a consultant on a number of implementation projects by state institutions and non-profit organisations.
Contact: vidovicova@fss.muni.cz