The impact of pre-pandemic ICT use on COVID-19 vaccination and recovery among oldest-old in Abbiategrasso

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Abstract. The use of Information Communication Technologies (ICT) in old age has been increasing over time. This trend might have been accelerated by the COVID-19 pandemic, which prompted older people to start using digital tools to stay connected with their loved ones and tackle isolation. Similarly, ICT use might have positive effects on vaccination rates and recovery from COVID-19 due to, respectively, access to information on vaccines and e-health services that may accelerate the recovery process. However, while it seems reasonable to assume that the use of ICT may improve access to information regarding the COVID-19 vaccination campaigns and ways to avoid SARS-CoV-2 contagion or access to medical support for a faster recovery, to the best of our knowledge, little is known about the effects of ICT use on the SARS-CoV-2 infection figures, vaccination and recovery rates. To explore these dimensions, we use data from a cohort study of older people aged 82-87 years, residing in Abbiategrasso, a municipality in northern Italy. The data used in this study were collected between 2018 and 2022. While ICT use seems not predictive of fewer infections and higher recovery rates, we found that computer use positively predicted the number of vaccine doses that respondents agreed to undertake. However, Internet use predicted late vaccination. In short, it seems that using the Internet in old age predicts a slowness in vaccinating against COVID-19. The latter result enriches the current knowledge on the side effects of Internet access, which have not been thoroughly assessed in older adults. Moreover, this result stimulates discussion on the possible role of online misinformation and fake news surrounding vaccination campaigns.

Keywords: ICT use; Internet use; older adults; COVID-19 vaccination; SARS-CoV-2 infection.

1 Introduction

ICT use has soared within the old age population in the last few years [1]. The COVID-19 pandemic might have boosted ICT acceptance by older adults, who started or kept using digital technologies to get in touch with family and friends.

In this regard, scientific research has focused on the effects of ICT use on maintaining or strengthening social connections during the pandemic [2], [3]. Indeed, studies on this topic have mainly considered ICT use to address the pandemic's social consequences, such as isolation.

Conversely, the possible effects of ICT use on limiting the spread of SARS-CoV-2 through the provision of information on how to access vaccination programmes and access to e-health, among the old age population, have been mostly overlooked. Still, some studies that explored not COVID-19-related conditions but other aspects of older adults' health showed that access to e-health is positively related to healthy behaviours [4], communication with healthcare professionals [5] and recovery after surgical operations [6]. This issue is particularly urgent when considering the oldest old population, as this age group proved to be particularly vulnerable to the symptoms originating from SARS-CoV-2 infection [7]. Even more so, this was valid for regions where the mortality rate of the old population following SARS-CoV-2 infection has been remarkably high. This was the case in the region of Lombardy, in northern Italy [8].

The vaccination campaign in Italy started in December 2020, when the vaccine was first administered to social and health workers and people who lived in nursing homes. In Lombardy the vaccination campaign was extended to people aged 80 years or older and fragile patients only in mid-February 2021 (approximately 10 days later than other Italian regions, such as Lazio) [9]. Older people could book their vaccine through the portal AIRA; due to faults in the online booking system the portal was subsequently replaced (in April) with a different portal (run by the national mail service and adopted in the rest of the country). While online reservation remained the most straightforward booking system for most of the population, this method may not have been easy to access to less digitally savvy older people – the challenges associated with accessing online booking by the old age population and the malfunctioning of the ARIA system, generate capacity constraints on other booking methods, such as telephone booking. As a matter of fact, in Lombardy, vaccinations in the age group 80-89 started picking up only around March and peaked in mid-April [10]. In comparison with other countries, in Italy fewer than 1.4 million doses were administered to the population aged 80+ by March 10th 2020, while in the United Kingdom over 2.6 million people over the age of 80 were vaccinated by the same week [11], [12].

Taking into account the above, this study seeks to explore the effects of ICT use on SARS-CoV-2 infections and vaccination and recovery rates from COVID-19 in Abbiategrasso, a suburban municipality of approximately 30,000 inhabitants in the outskirts of Milan, in Lombardy. Particularly, we expected that ICT use would reduce, through information campaigns, the frequency of risky behaviours that, in turn, would increase the chances of getting infected by SARS-CoV-2. Accordingly, we hypothesised that the use of digital technologies would accelerate the administration of vaccine doses against COVID-19. In addition, we assumed that ICT use in older adults may be helpful to accelerate the recovery process by providing those aids that are needed during convalescence.

2 Literature review

The literature on the effects of ICT use on the readiness to vaccinate against COVID-19 in older adults is somewhat scarce. Previous research on this topic has explored the influence of ICT use on vaccination rates, but disregarded the vaccination timing (i.e. early/late vaccination). Particularly, it seems that older adults who rely on the Internet, social media, and family/friends as the main sources of information express weaker intentions to vaccinate against COVID-19 [13]. Indeed, little is known about the effects of digital technologies on earlier/late vaccination in the general population, not to mention in older age. However, this topic is worth exploring, given the strong increase of ICT use

in the oldest population, the importance of earlier vaccination to mitigate the symptoms of COVID-19, and the role of digital technologies during the pandemic.

In this regard, the role of ICT in speeding up the vaccination process or, on the contrary, slowing it down through misinformation should be examined. As a matter of fact, evidence exists on how ICT users can be swayed by online misinformation concerning COVID-19 and underestimate the extent to which they are affected by fake news [14]. Yet, it is still to be confirmed whether such or similar effects hold for the older population. Preliminary evidence showed that older adults seem sceptical about the accuracy of online content regarding COVID-19 prevention and treatment [15]. Nonetheless, such evidence came from research on participants who were, on average, relatively young (mean age equalled 60 years), even if considered "older adults". In light of the above, to the best of our knowledge, this is the first study on the impact of using different digital technologies on the rates of vaccination against COVID-19 in people around and over eighty and late vaccination. Previous research was conducted on interventions via specific modalities, such as dialogue-based interventions (dialogue with people that are vaccine hesitant in order to increase the vaccination administration), to help older people overcome the barriers to vaccinating against COVID-19 [16]. Moreover, existing research explored the gender differences in the readiness to be vaccinated against COVID-19 [17]. Generally, ICT use seems to be associated health practices and higher vaccination rates. However, it is still unclear whether these effects are causal (i.e. whether ICT use fosters virtuous practices).

Another dimension that, to the best of our knowledge, has been unexplored concerns the potential effects of ICT use to reduce SARS-CoV-2 infections. Indeed, also in this case, no quantitative studies to date seem to have explored this specific effect in the general population, not counting older adults. There seems to be only qualitative investigation on this topic [18]. However, measuring the relationship between these two variables can shed light on the benefits of digital technologies in communicating risk-avoiding behaviours related to the spread of the virus. Certainly, previous studies have shown that ICT use in older adults is associated with healthy conduct [19]. Empirical evidence is needed to assess whether ICT use also reduces the chances of risky behaviours related to infectious diseases in old age and, consequently, the chances of getting ill.

Similarly, there is a lack of research on the assessment of the effects of ICT use on the recovery of those suffering from COVID-19. A large part of the existing research has been conducted to explore the use of telehealth as a major issue during the pandemic [20], [21]. Following this stream of research, studying the impact of ICT use on COVID-19 patients' convalescence would enrich the literature on the topic. In fact, studies have started to be published on digital tools that help people with long COVID symptoms to recover [22]. However, as a particularly vulnerable group, more research is needed on short-term effects in older adults.

As a whole, it appears that most of the existing academic efforts have been made to study the use of digital technologies to curb the effects of social isolation during the COVID-19 pandemic. Limited evidence has been provided when considering the impact of ICT use on vaccinating against COVID-19. Nonetheless, it is crucial to assess the influence of ICT use on the health-related behaviours of older adults. Indeed, if proven successful, the use

of digital technologies could be further encouraged, and ad hoc protocols could be developed.

3 Hypotheses

Considering the above, this study aims to assess whether higher levels of ICT use are associated with a higher number of COVID-19 vaccine doses. In particular, we expected that access to digital resources fosters healthy behaviours and promotes the adoption of measures to mitigate – through vaccination – the risk of suffering from severe COVID-19 symptoms. Consequently, we hypothesised that ICT use counteracts late vaccination by making older people aware of the importance of vaccinating quickly. In addition, we assumed that ICT use helps reduce the incidence of COVID-19 infections by providing people with information on the critical conditions they might face if they are infected. Lastly, we hypothesised that ICT use promotes better long-term health by aiding people in the recovery process through digital tools.

Accordingly, we considered the following hypotheses:

(H1) Pre-pandemic ICT use predicts more COVID-19 vaccine doses taken.

(H2) Pre-pandemic ICT use negatively predicts late vaccination.

(H3) Pre-pandemic ICT use predicts lower levels of COVID-19 infections.

(H4) Pre-pandemic ICT use predicts higher recovery rates.

4 Methods

The data were collected as part of a population-based cohort study, InveCe.Ab [Brain ageing in Abbiategrasso] [23], aimed to investigate the effects of ageing on physical and cognitive health. Moreover, it was meant to assess the biological and psychosocial factors associated with the onset of dementia. The eligible population for the InveCe.Ab study consisted of individuals born between 1935 and 1939 and residing in Abbiategrasso on the prevalence day (Nov, 1st 2009) and willing to undergo baseline multidimensional assessment (in 2010). Enrolled participants were then invited to 4 follow-up assessments in 2012, 2014, 2018 and 2022. For the aim of the present study, we considered data collected during the 2018 and 2022 waves. The multidimensional assessment comprised a questionnaire on social and lifestyle variables, a medical visit, a neuropsychological evaluation, and the collection of anthropometric measures and blood samples.

4.1 Participants

One thousand three hundred twenty-one people originally took part in InveCe.Ab baseline assessment [23]. In the present study, we included those who took part in the 2018 and 2022 waves, who did not have a diagnosis of dementia and who completed the full version of the questionnaire on social variables (N = 393). 57.3% of participants were female, with an average age of M = 84.30, SD = 1.36. The level of education equalled 7.41 years, SD = 3.35.

A power analysis was conducted with G*Power, version 3.1.9.7 [24] to assess the minimum sample size for the model used for the analysis. The effect size was set at f2 = 0.05, with a significance criterion of a = 0.05 and power = 0.80. The minimum sample size was 126. Therefore, our sample size is deemed to be adequate for the purpose of this study.

4.2 Measures

4.2.1 ICT use

In each evaluation wave, the use of ICT was explored with close-ended questions ("Yes", "No", and "I don't know") during the social and lifestyle questionnaire. Since we were interested in assessing the impact of pre-pandemic ICT use on COVID-19-related variables, we used the information on ICT use collected at baseline in 2018. Participants' use of mobile phones was assessed by asking: "Do you use a mobile phone?". If the participants had responded "Yes" to the question asking whether they used a mobile phone, they were asked, "Is it a smartphone?". The usage of computers was investigated by asking: "Do you use a computer?". Similarly, Internet use was explored with the following question: "Do you use the Internet?". Participants were then asked to state whether they used social media by responding to this question: "Do you use social media sites? (e.g., Facebook)".

4.2.2 COVID-19-related variables

In 2022 during the medical visit performed by a geriatrician or by a neurologist, participants were asked whether they had received a diagnosis of COVID-19 infection. The possible responses were "Yes", "No", and "I don't know". Participants were then asked whether they had completely recovered from COVID-19. Response categories were: "Yes", "No", and "I don't know". In addition, data were collected on the number of doses of the COVID-19 vaccine administered to the respondent. A derived variable on late vaccination against COVID-19 was calculated as the difference between the maximum number of doses that a person (in that specific age group) could have received at the moment in time when data were collected and the number of doses actually administered.

4.2.3 Socio-demographic variables

Further information included age, gender and education.

5 Statistical Analysis

Analysis was conducted using R [25], RStudio [26], the tidyverse [27], lme4 [28], lmerTest [29], performance [30], ggplot2 [31], sjplot [32], sjmisc [33] and sjlabelled [34] packages.

We ran a series of multiple linear regression models to test our hypotheses. We calculated the Variance Inflation Factor (VIF) to check for multicollinearity. Although no standard cut-off has ever been set, according to previous research, the values ranging from 5 to 10 may legitimately serve as a cut-off reference [35]. All our models showed values well below 5. Therefore, we can conclude that multicollinearity was not a concern in our data.

6 Results

Descriptive statistics of the study sample are reported in Table 1. Age, gender ratio and education were comparable with existing studies on ICT use in older people.

Table 1. Descriptive characteristics of this study's sample (N = 393)

Variables	**Study sample N = 393**
Sociodemographic Characteristics	
Age	84.30 ± 1.36
Gender, female	225 (57.3%)
Education	7.41 ± 3.35
ICT use	
Mobile phone	341 (86.8%)
Smartphone	104 (26.5 %)
Computer	84 (21.4 %)
Internet	87 (22.1 %)
Social media	36 (9.2 %)
Vaccination against COVID-19	
Vaccine doses (Range 2-5)	3.35 ± 0.56
Late vaccination: 0	118 (30%)
Late vaccination: 1	222 (56.5%)
Late vaccination: 2	38 (9.7%)
Late vaccination: 3	1 (0.3%)
COVID-19-related variables	
Diagnosed with COVID-19	90 (22.9%)
Recovered from COVID-19	70 (17.8%)

Firstly, we considered the number of COVID-19 vaccine doses as the dependent variable. The abovementioned ICT use variables were entered as predictors, and the socio-demographic variables as covariates. The results showed that the predictors explained 5.7% of the variance in COVID-19 vaccine doses, $F(8, 335) = 3.57$, $p < 0.001$. Among all the predictors in this model, computer use significantly predicted the number of COVID-19 vaccine doses. Results are shown in Table 2.

Table 2. Linear multiple regression models for COVID-19 vaccine doses

Predictors	*Estimates*	*std. Error*	*std. Beta*	*standardized std. Error*	*CI*	*standardized CI*	*Statistic*	*p*
(Intercept)	11.45	1.85	-0.00	0.05	7.81 – 15.09	-0.10 – 0.10	6.19	**<0.001**
Mobile phone	0.19	0.13	0.08	0.05	-0.06 – 0.45	-0.03 – 0.19	1.50	0.135
Smartphone	-0.00	0.08	-0.00	0.06	-0.16 – 0.15	-0.13 – 0.13	-0.02	0.987
Computer	0.25	0.12	0.19	0.09	0.01 – 0.49	0.01 – 0.37	2.05	**0.041**
Internet	-0.25	0.13	-0.19	0.10	-0.51 – 0.01	-0.39 – 0.01	-1.89	0.060
Social media	-0.12	0.12	-0.06	0.06	-0.35 – 0.11	-0.19 – 0.06	-1.00	0.317
Gender	0.03	0.06	0.02	0.06	-0.09 – 0.15	-0.08 – 0.13	0.44	0.657
Age	-0.10	0.02	-0.24	0.05	-0.14 – -0.06	-0.35 – -0.14	-4.55	**<0.001**

Education	0.00	0.01	0.02	0.06	-0.02 – 0.02	-0.11 – 0.14	0.24	0.813
Observations	344							
R^2 / R^2 adjusted	0.079 / 0.057							

We ran a model with late vaccination as the dependent variable to explore this result further. Computer and Internet use were entered as predictors, and the covariates were the same as in the previous model. The results highlighted that the predictors explained 1.7% of the variance in late vaccination, F(5, 349) = 2.26, p = 0.048. Internet use significantly predicted late vaccination. Results are presented in Table 3.

Table 3. Linear multiple regression model for late vaccination

Predictors	*Estimates*	*std. Error*	*std. Beta*	*standardized std. Error*	*CI*	*standardized CI*	*Statistic*	*p*
(Intercept)	5.58	1.99	-0.00	0.05	1.67 – 9.49	-0.10 – 0.10	2.81	**0.005**
Computer	-0.17	0.13	-0.12	0.09	-0.43 – 0.09	-0.30 – 0.06	-1.29	0.197
Internet	0.26	0.13	0.18	0.09	0.00 – 0.52	0.00 – 0.37	2.00	**0.047**
Gender	0.01	0.07	0.01	0.06	-0.12 – 0.15	-0.10 – 0.12	0.17	0.862
Age	-0.06	0.02	-0.13	0.05	-0.10 – -0.01	-0.23 – -0.02	-2.39	**0.017**
Education	-0.01	0.01	-0.07	0.06	-0.04 – 0.01	-0.19 – 0.05	-1.14	0.256
Observations	355							
R^2 / R^2 adjusted	0.031 / 0.017							

Crosstabulations were calculated by entering computer and Internet use to check for concurrent or independent use of these two technologies. The results showed that 73 people used both computers and the Internet, 11 people used only computers, 14 used only the Internet, and 272 used neither computers nor the Internet.

A logistic regression model (not shown) was used to assess the effects of ICT use on SARS-CoV-2 infections. All the ICT use variables mentioned above were entered as predictors, and COVID-19 diagnosis as the dependent variable. The covariates were the same as above. Results highlighted the lack of statistical significance of this model, X2(8) = 12.36, p = 0.136.

Another logistic regression model (also not shown) was run to explore the effects of ICT use on recovery from COVID-19. Also in this case, all the ICT use variables mentioned above were entered as predictors, and the covariates were the same. Recovery from COVID-19 was entered as the dependent variable. Still, this model proved to be not statistically significant, X2(8) = 1.90, p = 0.984.

7 Discussion

This work aimed to explore the effects of ICT use on vaccinating against COVID-19, SARS-CoV-2 infections and recovery from COVID-19 in a sample of older adults living in Abbiategrasso, a municipality near Milan, Italy.

We hypothesised that pre-pandemic ICT use would predict higher awareness of the availability of vaccination doses and health-related benefits of vaccination, hence, ultimately a higher number of COVID-19 vaccine doses administered (H1). Indeed, we expected that access to digital technologies would foster behaviours aimed at preserving health, such as vaccinating against COVID-19. Results partially supported this hypothesis. Indeed, we found that computer use predicted a higher number of vaccination doses. This result is in line with the existing evidence on the effects of ICT use on vaccination rates in older adults [36], [37]. The other forms of ICT proved not predictive of more vaccine doses taken.

The abovementioned result was further explored by entering computer and Internet use as predictors in the second model. We expected these dimensions would negatively predict a late vaccination rate (H2). Indeed, we assumed that those who use the computer and the Internet would vaccinate more promptly thanks to higher access to information on the importance of early vaccination. The results did not corroborate this hypothesis. On the contrary, Internet use seemed to predict a delayed vaccination rate. This unexpected result would pave the way for reflection and further research. Indeed, if confirmed by additional evidence, it would suggest a possible role of misinformation and fake news surrounding vaccination campaigns affecting older Internet users' decision to vaccinate. In this regard, previous research demonstrated that Internet users are more at risk of being misled when making decisions on health-related issues [38], [39]. Still, little is known about whether this effect holds for older people's decision to vaccinate against COVID-19. Interestingly, the observed effect was not corroborated by computer use. In fact, as mentioned above, computer use predicted a higher number of vaccine doses. These results seem to go exactly in the opposite direction. It is worth noting that the effects of computer and Internet use were independent and controlled for age, gender and education. Regarding the different uses of computers and the Internet, previous research found that word processing is by far the most common activity of computer users, (and is more frequent than Internet use). Among Internet users, information seeking and e-mail exchange is common [40]. Further research is needed to disentangle the specific impact of online activities on older adults' intention to vaccinate.

This study also sought to elucidate the relationship between ICT use and COVID-19 infections in older adults. Out of the entire sample, 90 people were diagnosed with COVID-19 (22.9%). We expected that ICT use would predict fewer infections (H3). Indeed, we assumed that ICT use would increase older people awareness of the risks they would face if infected, thus contributing to lowering infection rates. This hypothesis was in line with the results in the existing literature on the effects of the use of digital technologies and e-health literacy on health-related behaviour in older adults [41], [42]. However, we found no significant effect of ICT use on COVID-19 infections. This result might be partly due to the reduced mobility of the participants in this study and, consequently, the reduced chances of getting infected. Further research is needed to explore the relationship between ICT use and COVID-19 infections in older adults with a lower mean age.

Lastly, we hypothesised that ICT use would predict higher recovery rates in those older adults who had been infected by SARS-CoV-2 (H4). This effect would reflect the existing evidence on the topic [43], albeit limited. We assumed that those who use ICTs would exploit digital tools to speed up the recovery process (through online access to medical information or access to telemedicine). Even in this case, no statistically significant effect was found. This result might be partly due to the relatively low number of infected people in our sample who, therefore, responded to the question on recovery from COVID-19.

8 Strengths and limitations

This work has several strengths that ought to be pointed out. Firstly, the study used data from a longitudinal cohort, thus allowing to investigate prospectively the impact of pre-pandemic ICT use on COVID-19 related outcomes. This aspect was crucial to assess the influence of pre-pandemic use of digital technologies (rather than relying on post-pandemic data). In a cross-sectional design, the latter could be biased by the heightened usage of ICT to curb social isolation following the most acute phases of the COVID-19 pandemic.

In addition, the participants in this study belonged to a particular age range: 82-87 years. Therefore, we could be confident enough to exclude the great inter-age group variability that previous research discovered when studying the frequency of ICT use [44]. Similarly, the data were collected from participants residing in a specific geographical area. Hence, we could exclude the influence of inter-regional differences that might impact the frequency of digital tools usage [45].

This study has some limitations as well. First, the specific age bracket mentioned above could be considered a limitation. Indeed, ICT use among people aged 80 years or older is, on average, substantially lower than in other age groups [46]. Hence, the results are hardly generalisable to other age groups.

Another limitation relates to the way ICT use was measured. Indeed, this construct was assessed only with dichotomous variables corresponding to the use/lack of use of five digital tools (i.e., computer, Internet, social media, mobile phone, and smartphone). Therefore, we did not assess dimensions such as frequency of use, digital skills, typologies of usages (e.g. socialisation, purchase of goods, access to services), or conditions under which these technologies were utilised.

Lastly, the research design chosen for this research is not experimental. Consequently, we were not able to draw causal inferences.

9 Conclusions and future directions

Overall, the research presented in this paper fits into the literature on the impact of ICT use in older adults' lives. Unlike most of the existing literature on the topic, this study did not focus on the effects of ICT use on social relationships but on COVID-19 infections, vaccinations, and recovery. Unexpectedly, we found that the more older adults used the Internet, the slower they were in vaccinating against COVID-19. This result might stem from the possible role played by misinformation that previous research on Internet users' behaviours highlighted [47].

In light of the results and limitations of this study, more research is needed to disentangle the effects of ICT use on SARS-CoV-2 infections and the decision to vaccinate against COVID-19. Future research may use more refined and extensive measurements of ICT use in older adults that could capture a broader picture on this topic. Furthermore, studying more diverse cohorts could lead to a deeper understanding of this area of investigation. Thus, the intergenerational digital divide that previous research highlighted could be further assessed, though data which includes different cohorts [48]. Lastly, research designs other than longitudinal and cross-sectional may allow researchers to reach firmer conclusions.

As a whole, the results presented in this paper, if confirmed by future investigations, will contribute to understanding the complex relationship between ICT use and health-related behaviours in old age.

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