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## Self-assessed health among older people in Europe and internet use

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### ABSTRACT

**Background:** About ten years ago, an age-related digital divide was identified, where ‘the elderly’ denoted a group of people at risk of losing the benefits of a digital society. The aims of this work are to find a relationship between self-assessed health and internet use by older people in European countries and to ascertain whether this relationship differs in countries with a more developed eHealth policy.

**Materials and methods:** An ordered logistic regression is estimated for all countries in the sample and for two countries subsets which differ in their eHealth performance. Individual data is collected by SHARE. The classifying criterion of eHealth performance is based on the ‘eHealth’ policy dimension of the indicator used to construct the Digital Economy and Society Index. The average marginal effects are computed for the variable of internet use.

**Results:** Results show that older people who use the internet tend to report better health status. This relationship however may not hold for low levels of health and it is stronger in countries with low eHealth performance.

**Conclusion:** Policy measures on eHealth not only contribute to people’s health but also help to alleviate critical situations such as the one created by the Covid-19 pandemic.

### 1. Introduction

European data from 2016 indicate that the share of older people who use the internet at least once a week is about 45 %, ranging from 14 % in Greece to 80 % in Sweden [1].

These numbers have improved significantly in the last few years. For instance, in 2007 only 27 % of people aged over 54 used the internet [2]. Ten years ago, Gracia and Herrero [3], studied a Spanish sample of older people and found that the use of the internet was not related to the self-reported health status. Yet the association between using the internet and the improvement of health and well-being of older adults is well known [4–9]. This can happen in several ways, from having access to information on health and healthcare services to reducing loneliness or improving healthy behaviours [8–12]. Additionally, eHealth instruments play a significant role in making access to health care faster, easier and less costly. Despite the need of social interaction by older people, these advantages turn eHealth into a significant contributor to the health and wellbeing of older people.

The European Commission and governments have been promoting the e-inclusion of older people in the digital and information society for more than a decade. There are various initiatives, action plans and

strategies [13] such as eHealth Action Plan in 2004, ‘Action Plan: Ageing well in the Information Society’ [14], ‘eSeniors’ Network Support [15], ‘e-Digital Agenda for Europe’ [16], and ‘eHealth Action Plan 2012–2020’ [17,18].

Several governments across Europe have focused their attention on developing eHealth and telemedicine capacity to better respond to people’s needs [19]. But European countries do not all perform identically on eHealth [19,20]. So, it can be expected that in countries where eHealth capacity is improving, older adults are more willing to use the internet, and to use it for taking care of their health [21].

On the one hand, the concept of eHealth is expressed in the definitions provided both by the WHO [22] and by the European Union [18]. In both cases eHealth is taken as the use of ICT for health by combining organizational change in healthcare systems and new skills to improve people’s health and to improve the efficiency of healthcare systems. eHealth covers several types of interactions between the different parts of the health system, such as between patients and providers [18]. In our work, eHealth and performance on eHealth is going to be focused on the availability of health care provided online, specifically the possibility to get prescriptions and conduct consultations without having to go physically to the health care unit or being

**Abbreviations:** EU, European Union; DESI, Digital Economy and Society Index; I-DESI, International DESI; SAH, Self-Assessed Health; SHARE, Survey of Health, Aging and Retirement in Europe

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physically present with a physician.

On the other hand, by e-inclusion we mean the situation where everyone in society participates in the information society [23]. However, the concern for this participation goes deeper. Some population segments could tend to be excluded from the information society, and older people were one such segment [24–26]. This has been called the 'Digital Divide' [27,24], meaning that some people have access to internet use while others don't, and some people may have the skill to use the internet well, while others don't. The concept of digital divide is evolving and today it could have a broader meaning by including those who might use and benefit from mobile devices [28]. Our analysis takes the first definition of digital divide which separates those who do and do not use the internet.

Our aim in this work is to ascertain if internet use is an explanatory factor of self-assessed health status among older people and if the relationship between internet use and health status is stronger in countries with a good eHealth performance.

Some previous studies have related internet use to aspects of health such as healthy behaviors [29], health conditions such as depression and well-being [30,6–8], chronic diseases [20,31], and self-reported health [32,33]. The demographic group of 'older adults' represent people whose health is often fragile and who are less likely to be at ease using the internet. Research about the use of internet by older people has been undertaken by different researchers, usually in the fields of ageing and gerontology. Hunsaker and Hargittai [9] have reviewed the quantitative literature focused on internet use by older adults with respect to topics like access, skills, social inequalities and relationship with health. Using the SHARE (Survey in Health, Aging and Retirement in Europe) database [34] (as we do in our work), König et al. [35] identified the main factors that are associated with older people's use of the internet, such as, age, gender, socioeconomic status, and area of residence which coincide with studies in different countries [25]. But these factors are also associated with individual health, as we describe next.

### 1.1. Conceptual framework

The conceptual framework of our analysis has two sources. The first has a qualitative nature. The socioeconomic determinants of health of individuals have been described by a social ecological model proposed by Dahlgren and Whitehead [36]. The model places the individual at the centre of the model and then describes the determinants in layers around the individual: demographic, lifestyle, social and community networks, other general conditions. In these general conditions, the authors included the socioeconomic, cultural, and environmental conditions where the individual lives.

There is another well-known conceptual contribution for mapping of the relationship between an individual's health and their surroundings developed by Solar and Irwin [37]. Their proposal includes three main pillars of influence, namely, the socio-political context, the structural determinants and socioeconomic position, and the intermediary determinants. The socio-political context includes the factors that are at society level, which individuals cannot change by themselves; the structural determinants and socioeconomic position of the individual accounts for the socioeconomic and political context, such as cultural values and public policies, and for the individual socio-economics traits, such as education, income and occupation; finally, the intermediary determinants consider material circumstances, lifestyle, and biological factors.

The second source for our conceptual framework has a quantitative nature. Health can be taken as an output of a production function where the inputs are both medical and non-medical [38]. These inputs can be taken as the determinants of the individual health. The estimation of health production functions is very often found in empirical studies. Zweifel et al. [39] (ch. 4) have revised and analysed several of these studies.

Our analysis is based on the estimation of a health production function ([38,39] ch.4) which accounts for the individual determinants of health and for the eHealth performance of the health system [36,37]. Empirical evidence on the determinants of self-assessed health is diversified. Very often studies are applied to a single country due to data availability [40–43], but they may also be performed across countries [44,45]. Our work follows the latter approach by performing a cross-country analysis based on individual data collected by SHARE and also on data provided by the European Commission on DESI (Digital Economy and Society Index) [46]. To the best of our knowledge, no recent study has looked at the relationship between internet use and self-assessed health among older people across several countries and tested the differences between clusters of countries with different eHealth performance.

## 2. Methods

### 2.1. Population survey and sample

The data used in this work were collected by the Survey of Health, Ageing and Retirement (SHARE) in Europe wave 6.0.0. SHARE is a multinational survey which includes representative samples of community-based populations from a number of European countries and Israel. The SHARE database contains a large number of variables, from demographics to financial and health variables [47]. The sample includes a total of 66,279 individuals with ages ranging from 50 to 106, from 18 countries, as shown in Table 1. STATA 15 was used for the statistical estimation procedure.

### 2.2. Variables

#### 2.2.1. Dependent variable

The dependent variable of this analysis is self-assessed health (SAH). This variable ranges from 1 to 5, where 1 corresponds to poor health status; 2 – fair; 3 – good; 4 – very good; and 5 is excellent health status. This variable has been widely used in the literature as a measure of an individual's health status and it has been considered a good indicator of one's state of health [48–51].

#### 2.2.2. Independent variables

A set of independent variables are used to explain self-assessed health. They include socio-economic characteristics, suffering from chronic diseases and from unmet health needs, country, and, finally, the use of internet. Table 2 summarizes the list and description of the independent variables.

- i) Age – The variable *age* is the number of years old.
- ii) Gender – The *male* variable is a dummy variable which takes value 1 for a male, and 0 for a female (variable *male*). The variable female is the reference category.
- iii) Education – An individual's level of education is determined by the number of completed years of schooling (variable *education*).
- iv) Income – This is the natural logarithm of the total household income per individual (variable *income*).
- v) Marital status – This is a categorical variable taking the following response categories in the SHARE survey: married, partnered,

**Table 1**  
Number of observations by country.

<i>Austria</i>	<i>Belgium</i>	<i>Croatia</i>	<i>Czechia</i>	<i>Denmark</i>	<i>Estonia</i>
3390	5755	2484	4806	3698	5463
<i>France</i>	<i>Germany</i>	<i>Greece</i>	<i>Israel</i>	<i>Italy</i>	<i>Luxembourg</i>
3891	4386	4886	1962	5280	1560
<i>Poland</i>	<i>Portugal</i>	<i>Slovenia</i>	<i>Spain</i>	<i>Sweden</i>	<i>Switzerland</i>
1772	1659	4177	5596	3736	2778

**Table 2**  
Independent variables description.

Variable	Description
age	Numbers of years old.
gender	Dummy variable. It takes value 1 if male and 0 otherwise.
education	Number of completed years of schooling.
income	Natural logarithm of the total household income per person in the household.
married	Dummy variable. It takes value 1 if individual is married or lives with partner and 0 otherwise.
working	Dummy variable. It takes value 1 if individual is active in the labour market and employed and 0 otherwise.
nonworking	Dummy variable. It takes value 1 if individual is not active in the labour market and 0 otherwise.
children	Dummy variable. It takes value 1 if individual has children and 0 otherwise.
chronic	Number of chronic diseases.
unmet needs	Dummy variable. It takes value 1 if there are unmet healthcare needs and 0 otherwise.
internet use	Dummy variable. It takes value 1 if individual has used internet in the last 7 days and 0 otherwise
country	Dummy variables for each country.

divorced, widowed, single, and married but not living together. For this analysis, married and partnered are considered in the same class, while divorced, widowed, single and married but not living together are considered as living alone. The *married* variable takes value 1 if married or partnered, and 0 otherwise. The variable living alone is the reference category.

- vii) Job situation – The SHARE survey asks about people’s current job status, and the response categories considered are retired, employed or self-employed, unemployed, on permanent medical leave, or housekeeper. Dummy variables are considered for each job status. One variable is *nonworking* (meaning not active) which takes value 1 if retired, on permanent medical leave and housekeeper, and 0 otherwise. The variable *working* (meaning active in the labour market) takes value 1 if employed or self-employed, and 0 otherwise. Finally, the variable *unemployed* takes value 1 if unemployed, and 0 otherwise. Due to perfect multicollinearity, the variable *unemployed* is omitted and taken as reference category.
- viii) Children – This is a dummy variable which takes value 1 if there are children, 0 otherwise.
- ix) Number of chronic diseases - Variable 'chronic' takes natural numbers and it measures the number of chronic diseases suffered and reported by the individual.
- x) Unmet health needs – This is a dummy variable which takes value 1 if there are unmet health care needs, in particular, the lack of opportunity to see a doctor because of excessive cost and/or waiting time; 0 otherwise (variable *unmet needs*). The variable no unmet health care needs is the reference category.
- xi) Internet use - This variable takes value 1 if internet was used in the past seven days and 0 otherwise. The variable no internet use is the reference category.
- xii) Country dummies – These variables take value 1 for each country; 0 otherwise. They represent country fixed effects.

### 2.2.3. Country characteristics

In order to have clusters of countries performing identically with respect to eHealth, this work uses one specific dimension of the Digital Economy and Society Index (DESI). This dimension, expressed by one particular indicator, allows the building of two sets of group countries.

The composite index DESI is constructed and published by the European Commission [46]. DESI considers a set of relevant indicators on Europe’s current digital policy mix, including ‘eHealth’ in policy dimension ‘Digital public services’, which we are considering for this analysis. This indicator is highly significant to understand the level of eHealth development in a country. It gives the percentage of people who use health care provided online to get a prescription or a consultation online, without having to go to a hospital or healthcare unit. The higher the score of the indicator, the higher the level of progress and development of the digital economy related to eHealth.

Ranking the countries according to the eHealth indicator, we can identify the group of less advanced countries, which have a score below

the median of the EU countries. This cluster of countries includes Germany, Greece, France, Poland, Portugal, Czechia, Austria, and Luxembourg. The more advanced countries, which score high values for the eHealth indicator, are Belgium, Croatia, Italy, Slovenia, Spain, Sweden, Denmark, and Estonia.

The International DESI (I-DESI) includes non-EU members [52]. According to the results, both Israel and Switzerland perform below the EU countries’ median for the ‘Digital public services’ dimension. So, they are both placed in the less advanced group of countries, characterized by a low performing eHealth service.

The countries with low performance in eHealth (as a Digital public service) we have called ‘low-eHealth’ countries, while the high-performance countries are called ‘high-eHealth’ countries. Summing up, high-eHealth countries are those where people are more likely to benefit from faster and easier access to healthcare services, including prescriptions and consultations, without them having to go physically to a healthcare unit. On the other hand, low-eHealth countries do not generally offer the eHealth processes to facilitate access to healthcare services.

### 2.3. Model and main hypotheses

The model to be estimated can be written as follows:

$$\text{Self-assessed health}_i = \beta_{1i} \text{Independent variables}_i + \beta_{2i} \text{internet use}_i + \beta_{3j} \text{country dummies}_j + \varepsilon_i$$

where coefficients the  $\beta$  coefficients are to be estimated and  $\varepsilon_i$  is the residual.

According to the aim of this work, there are two main hypotheses to be tested:

**H1.** People using the internet tend to report better health status, that is,  $\beta_2 > 0$ ;

**H2.** In ‘high-eHealth’ performance countries the relationship between internet and self-assessed health is stronger than in low performance countries, that is, the marginal effects associated with  $\beta_3$  are larger in high performance countries.

### 2.4. Econometric analysis

The estimation performed is an ordered logistic regression because the dependent variable, *self-assessed health*, is an ordinal variable. The regressions are estimated for different samples and sub-samples: i) first model specification: the whole sample of countries, for people both older than 50 and 65; and ii) second model specification: for two subsets of countries which differ in their level of eHealth performance defined by the DESIs indexes and age over 50.

Each specification includes country controls. These are dummy variables for each country or the dummy variables identifying the high

**Table 3**  
Descriptive statistics of self-assessed health.

SAH	Total %	High-eHealth%	Low-eHealth %
1 poor	11.42	11.7	10.9
2 fair	28.56	28.9	27.8
3 good	35.61	34.6	36.7
4 very good	17.62	17.1	18.7
5 excellent	6.78	7.71	6.0

or low e-health performing countries. Finally, marginal effects are estimated for both model specifications. To check robustness, we also estimated the first model specification for individuals older than 65. Additionally, we estimated a model specification which considers the interaction term between internet use and unmet health needs and between the internet and the number of chronic diseases. These interactions were obtained by multiplying both variables. This provided us with the cases where there is internet use and unmet health care needs, and also internet use and chronic diseases; in these cases, the interaction variables take value 1.

### 3. Results

The descriptive statistics for self-assessed health are presented in Table 3. Nearly 40 % of respondents report poor or very poor health status and about 24 % report very good or excellent health status. This distribution is slightly different across clusters of countries with high-eHealth performance and with low-eHealth. Countries with high eHealth performance concentrate a larger share of responses in the lowest levels of self-assessed health. However, in both clusters of countries about 24 % of people report very good or excellent health status.

The descriptive statistics for key variables is presented in Table 4. The majority of respondents are women, the average age is 68 years, on average they have 10 years of education, 90 % report having children; a large share of these people (about 78 %) report suffering from at least one chronic disease and 12 % report the burden of unmet healthcare needs.

It is worth noting that 48.4 % of people in our sample used the internet in the previous seven days. So, the majority of people seldom or never use internet.

The simple correlation coefficient between internet use and self-health status is equal to 0.33, which indicates that better health status is positively correlated with internet use. The pairwise correlation between self-assessed health and the other independent variables is presented in Table 5. It is interesting to note that the *internet use* variable is significantly correlated with all the other variables.

Finally, and as expected, the share of people who report not using internet in the last seven days is higher in countries with low eHealth performance (Table 6).

The results of the ordered logistic regression for all the countries in the sample, for people over 50 and over 65, for the low-eHealth and

**Table 4**  
Descriptive statistics for key variables.

variable	
age (mean)	67.98
education (mean)	10.83
male (%)	46.8
working (%)	24.3
nonworking (%)	73.0
unemployed (%)	2.8
having children (%)	89.9
unmet health care needs (%)	11.7
chronic diseases (%)	77.5
internet use (%)	48.4

high-eHealth countries, are presented in Table 7.

The results of the estimation of the ordered logistic regression (Table 7) show that controlling for individual characteristics, self-assessed health improves with the use of internet in the last seven days. The whole sample coefficient for people older than 50 is positive and statistically significant, equal to 0.522. The estimate for all countries and individuals older than 65, done as a robustness check, shows the same result to whom the estimated coefficient is equal to 0.561.

Comparing low- and high-eHealth countries, we find that the coefficient of internet use on SAH is higher (coef = 0.563) in low-eHealth countries than in high-eHealth countries (coef = 0.483). The average marginal effects estimated for the *internet use* variable are presented in Table 8.

Marginal effects allow the comparison of the magnitude of the effects, and they can also be computed for the different levels of the self-assessed health (SAH). Results show that for low levels of health status, marginal effect is negative, meaning that the use of the internet does not have a beneficial influence. The positive effects of the use of the internet are found for health status better than the median level, that is, good health status (level 3). For instance, when using internet, the increase of probability in the response by people from level 3–4 of SAH is about 4.87 %.

The results shown in Table 7 also indicate the socioeconomic factors explaining self-assessed health. Better health status is associated with higher education, higher income, being employed, being married, and having children. On the other hand, age, being male, suffering from chronic diseases and facing unmet healthcare needs, contribute to a less healthy status.

Tables 9 and 10 show the robustness check results for interacting terms. For this purpose, we have included in the first estimation the interaction term between unmet healthcare needs and internet use, and in the second estimation the interaction term between chronic diseases and internet use. These new independent variables reflect the situation of simultaneous use of the internet and unmet health care needs, and the use of internet and chronic diseases.

Results of the estimated coefficients presented in Tables 9 and 10 are very similar for the independent variables. The interesting add-in comes from the interaction variable which shows that there are moderating effects arising from the use of internet. In Table 9, when the internet is used there is a positive effect on SAH, but there is also a negative effect arising from unmet healthcare needs. The estimated coefficient for the interaction variable in low-eHealth countries is not statistical significantly.

In Table 10, the interaction between the number of chronic diseases and internet is identical across the cluster of countries and it is statistical significantly in all estimations. In both cases, there are interaction effects between the use of internet and access to healthcare and suffering from chronic diseases that require a frequent access to healthcare.

The marginal effects associated with the interaction variables are shown in Table A1, in the appendix. These effects come exclusively from the interaction variable that was generated and they do not account for the effects produced by the variables independently. For both cases, the magnitude of marginal effects found is very small. Any differences found between clusters of countries could be a reflection of situations such as trouble-free access to prescriptions in high-eHealth countries and the lack of easy access to prescriptions and consultations in low-eHealth countries.

### 4. Discussion

The main aim of this work was to determine if there is a relationship between self-assessed health and the use of internet by older people and if this relationship differs between countries with high and low levels of eHealth performance.

The results found in our statistical analysis confirmed that when



**Table 5**  
Pairwise correlations between self-assessed health and independent variables.

	SAH	age	education	income	working	nonworking	married	children	chronic	unmet
age	-0.291*									
education	0.229*	-0.247*								
income	0.168*	0.111*	0.139*							
working	0.275*	-0.555*	0.242*	0.042*						
nonworking	-0.251*	0.560*	-0.220*	-0.007	-0.342*					
married	0.110*	-0.193*	0.060*	-0.274*	0.294*	0.482*				
children	0.009*	0.003	-0.006	-0.137*	-0.002	0.021*	0.186*			
chronic	-0.506*	0.310*	-0.154*	-0.050*	-0.275*	0.266*	-0.098*	0.010*		
unmet health needs	-0.139*	-0.040*	-0.068*	-0.125*	-0.023*	0.011*	-0.019*	0.003	0.139*	
internet use	0.332*	-0.416*	0.417*	0.2080*	0.366*	-0.337*	0.108*	0.023*	-0.231*	-0.079*

Note: \* significance for p < 0.05.

**Table 6**  
Internet use and eHealth performance.

internet use	high-eHealth (%)	low-eHealth (%)
No	50.3	52.3
Yes	49.7	47.7

controlling for individual characteristics, the use of the internet was correlated with better health status, which confirmed our first hypothesis, and is in line with other studies on this topic [29–33].

The relationship between internet use and health status is weaker in countries that perform well in the eHealth policy dimension. Countries that are characterized by a lower eHealth performance thus seem to experience a more sizeable effect between internet use and reported health, which was not according to our initial hypothesis.

This unexpected result, in fact, might be reflecting a well-known effect called diminishing returns. That is, people that use internet in countries with low-eHealth performance may be getting higher value from using the internet in this way, so that their health may be benefiting more than it is for people in countries which perform better at the eHealth level. Diminishing returns in this case means that as countries improve their eHealth performance, the returns obtained from this improvement are decreasing, including the individual health returns.

One possible explanation for diminishing returns is the learning experience of people [19] at a more advanced framework of access to health care services based on eHealth resources. As people get used to

**Table 8**  
Average marginal effects for use of internet.

SAH (delta-method)	All countries	High-eHealth	Low-eHealth
1 poor	-0.0374*	-0.0352*	-0.0396*
2 fair	-0.0528*	-0.0481*	-0.0577*
3 good	0.0136*	0.0130*	0.0140*
4 very good	0.0487*	0.0421*	0.0567*
5 excellent	0.0279*	0.0283*	0.0266*

Note: \* significance at p < 0.01.

it, their needs and expectations also become tuned up to this more advanced framework of eHealth. So the benefits that people may obtain are not as large as they would had been in a less advanced eHealth framework. Consequently, as a result of diminishing returns (and learning economies), the effect of internet use and health benefit is smaller in high-eHealth countries than in low-eHealth countries.

On top of this conclusion, the result we obtained for the interaction between internet use and unmet health needs supports the explanation of diminishing returns to internet use for benefiting health. We found that in countries with high-eHealth performance the benefit of using the internet decreases when there are unmet healthcare needs, and this decrease is higher than in countries with low-eHealth performance. This may be happening because people in high-eHealth countries get used living with a high standard of eHealth. So, when this easier access to health care services fails, it has more significant consequences for the individual and for his health. This failure is felt much less in countries

**Table 7**  
Results.

SAH	All countries		All countries		High-eHealth		Low-eHealth	
	age > 50		age > 65		age > 50		age > 50	
	Coef	P > z	Coef	P > z	Coef	P > z	Coef	P > z
age	-0.015	0.000	-0.035	0.000	-0.013	0.000	-0.019	0.000
male	-0.058	0.000	-0.038	0.061	-0.040	0.051	-0.077	0.001
education	0.047	0.000	0.045	0.000	0.051	0.000	0.042	0.000
income	0.110	0.000	0.092	0.000	0.138	0.000	0.089	0.000
working	0.347	0.000	0.425	0.081	0.217	0.000	0.520	0.000
nonworking	0.079	0.092	0.068	0.775	-0.055	0.365	0.258	0.000
married	0.197	0.000	0.104	0.000	0.201	0.000	0.194	0.000
children	0.137	0.000	0.128	0.000	0.171	0.000	0.097	0.010
chronic	-0.619	0.000	-0.566	0.000	-0.615	0.000	-0.623	0.000
unmet health needs	-0.419	0.000	-0.417	0.000	-0.438	0.000	-0.400	0.000
internet use	0.522	0.000	0.561	0.000	0.483	0.000	0.563	0.000
country dummies	yes		yes		yes		yes	
Number of obs	66.234		38.936		35.675		30,559	
LR chi2	32062.29		17610.15		17903.75		14147.82	
Prob > chi2	0.000		0.000		0.000		0.000	
Log likelihood	-80705.975		-46685.335		-43635.302		-37008.702	
Pseudo R2	0.166		0.159		0.170		0.161	

**Table 9**  
Results including the interaction between internet use and unmet healthcare needs.

	All countries		High-eHealth		Low-eHealth	
	Coef.	P > z	Coef.	P > z	Coef.	P > z
age	-0.015	0.000	-0.013	0.000	-0.019	0.000
gender	-0.058	0.000	-0.040	0.049	-0.077	0.001
education	0.047	0.000	0.051	0.000	0.042	0.000
income	0.110	0.000	0.137	0.000	0.089	0.000
working	0.346	0.000	0.215	0.000	0.520	0.000
nonworking	0.079	0.092	-0.055	0.365	0.258	0.000
married	0.196	0.000	0.200	0.000	0.194	0.000
children	0.137	0.000	0.171	0.000	0.098	0.010
chronic	-0.619	0.000	-0.615	0.000	-0.623	0.000
unmet health needs	-0.294	0.000	-0.256	0.010	-0.318	0.001
internet use	0.521	0.000	0.482	0.000	0.562	0.000
unmet*internet	-0.104	0.051	-0.157	0.054	-0.067	0.350
country dummies	yes		yes		yes	
Number of obs	66234		35675		30559	
LR chi2(19)	32066.10		17907.45		14148.70	
Prob > chi2	0.0000		0.0000		0.0000	
Pseudo R2	0.1657		0.1703		0.1605	
Log likelihood	-80704.071		-3633.447		-37008.265	

where the eHealth performance is not particularly good and people do not really feel the absence of eHealth resources when they need them.

The relationship between internet use and self-assessed health is different across the levels of health status. While there is no benefit for the low levels of health, we found a positive effect for the higher levels of health. For low health status, eHealth does not deliver added value. This may be because when people are already ill using the internet does not bring any benefit for their health. In particular, obtaining prescriptions or having consultations online without going to a health care unit is probably not what people want or need when they become seriously ill. They most likely prefer the personal contact with a healthcare professional or they will get healthcare not supported by an eHealth network. For higher levels of health status, the use of the internet has a positive effect. In fact, the effect is strongest for people reporting very good health status. For these people, the possibility of accessing health care online without going to a health care unit is particularly valuable; it helps them to get on with their lives without the trouble of having to go to a health care unit for prescriptions, routine consultations or preventive examinations requests.

Other results contribute to the literature on this topic. Some socio-economic variables, such as age, education, marriage, income, and having children, explain the level of health status as expected from theoretical and empirical models [8,36,40,25]. Having children improves the reported health status, particularly in high eHealth countries. It might be that in these countries it is easier for parents to be in touch in their children. Future research could well try to understand the relationship between having children, the use of the internet, and the health status of their parents. It may be valuable to understand the role, the drivers and even the causality of such relationships and draft policy measures which could contribute to improving peoples' health.

There are limitations to this work and to the use of self-assessed health as an indicator of the individual health status. Firstly, self-assessed health is a self-reported indicator which could be a biased measure of health status. However, this indicator has been very widely used [48-51,53], and the question as to the validity of self-reported indicators is exaggerated; although not perfect, it is not flawed [54]. The other problem arising from the use of self-assessed health in cross-country analysis is that cultural and historical differences are not

**Table 10**  
Results including the interaction between internet use and chronic diseases.

	All countries		High-eHealth		Low-eHealth	
	Coef.	P > z	Coef.	P > z	Coef.	P > z
age	-0.016	0.000	-0.013	0.000	-0.019	0.000
gender	-0.054	0.000	-0.036	0.074	-0.071	0.002
education	0.047	0.000	0.051	0.000	0.043	0.000
income	0.109	0.000	0.137	0.000	0.088	0.000
working	0.333	0.000	0.203	0.001	0.506	0.000
nonworking	0.081	0.083	-0.054	0.379	0.261	0.000
married	0.197	0.000	0.201	0.000	0.195	0.000
children	0.137	0.000	0.170	0.000	0.098	0.010
chronic	-0.591	0.000	-0.588	0.000	-0.593	0.000
unmet health needs	-0.420	0.000	-0.437	0.000	-0.404	0.000
internet use	0.637	0.000	0.588	0.000	0.689	0.000
chronic*internet	-0.068	0.000	-0.062	0.000	-0.073	0.000
country dummies	yes		yes		yes	
Number of obs	66,234		35,675		30,559	
LR chi2(19)	32107.59		17923.65		14172.98	
Prob > chi2	0.000		0.000		0.000	
Pseudo R2	0.166		0.170		0.170	
Log likelihood	-80683.324		-43625.349		-36996.126	

**Table A1**  
Average marginal effects for interaction variables.

SAH dy/dx	All countries		High-eHealth		Low-eHealth	
	unmet* internet	chronic* internet	unmet* internet	chronic* internet	unmet* internet	chronic* internet
1 poor	0.008*	0.005*	0.001**	0.005*	0.005	0.005*
2 fair	0.009*	0.006*	0.014**	0.006*	0.006	0.007*
3 good	-0.002*	-0.002*	-0.004**	-0.002*	-0.001	-0.002*
4 very good	-0.009*	-0.006*	-0.012**	-0.005*	-0.007	-0.007*
5 excellent	-0.006*	-0.004*	-0.01**	-0.004*	-0.003	-0.004*

Note: on marginal effects \* significance at  $p < 0.05$  and \*\* significance at  $p < 0.1$ .

accounted for, which can result in systematic differences [55]. But these differences should be considered in each country. At European level, the average trend counts when defining European policies and programmes, such as 'Action Plan: Ageing well in the Information Society', 'eSeniors' network, and 'e-Digital Agenda for Europe'.

Secondly, our results show that income and education play a role in explaining self-assessed health. This implies that there could be socio-economic inequalities hidden in the results found here, as noted by Delpierre et al. [56]. These authors showed that better educated individuals tend to report worse levels of health status more often. These inequalities are not explored here, but they do seem to exist, and further research could address them because they could also be related to the digital divide.

Thirdly, the analysis performed here does not test causality between the use of internet and the reported health status, but it does show that there is a significant correlation between the two factors. In the future, as the SHARE database grows, it may be possible to extend this analysis to different waves.

Finally, the approach of classifying countries based on the eHealth indicator of the index DESI may be a reduced approach for analysing the eHealth features of a country. Each country has its own plan and strategy to develop eHealth and this may not be captured in the eHealth indicator we used. For instance, the electronic prescriptions given by physicians in consultations, and the electronic medical record are not included in the DESI eHealth indicator but they are good measures of eHealth.

Despite the limitations just mentioned, our analysis has improved on previous work by taking self-assessed health as an ordered variable and by taking a more restrictive definition of internet use, for a very large sample of European people. Additionally, the definition of eHealth clearly captures its potential benefits for health care access. And access is certainly a significant input for ensuring good levels of population health.

Using the internet has a beneficial effect on health. So, improving access by older people and mitigating any digital divide is a relevant policy measure. The improvement of eHealth instruments available to older people would make access to healthcare easier and ensure a better supervision of their health, medications, and compliance with medical directions.

At the time of writing this work, Europe is facing the COVID-19 pandemic. This has overwhelmed some health systems and led to restricting people's movements. Future research may try to understand how the benefits for people differed across countries and regions where consultations and prescriptions could be accessed by using eHealth resources. For instance, one problem raised during the pandemic has been that of accessing repeat prescriptions (for chronic conditions) and medications by older people. If eHealth instruments were available, it would be easier for older people to keep up with their medications. Another situation which has raised problems is that of booking and attending consultations, which could be mitigated by online consultations or teleconsultations.

## 5. Conclusions

The analysis presented here suggests that internet use is related to a better reported health status of older people's health, after controlling for individual characteristics, and this relationship is stronger in less eHealth-developed countries. Evidence indicates that the policies pursued by governments and the European Commission to mitigate the digital divide have produced a positive result. While the digital divide across age groups may be disappearing, however, it may be persisting across different socioeconomic statuses [57,58,25]. Future research and policies are expected to look at the socioeconomic inequalities of the digital divide. But they should also study the role of eHealth performance on people's health in critical situations such as the Covid-19 pandemic crisis.

### Author statement

The author declares this manuscript has not been published previously, it is not under consideration for publication elsewhere, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

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### Summary points

- Older people who use the internet tend to report better health status.
- This relationship may not hold for low levels of health.
- This relationship is stronger in countries with low-eHealth performance.
- Policy measures on eHealth contribute to people's health and help to alleviate critical situations such as the one created by the Covid-19 pandemic.

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## References

- [1] Eurostat, A look at the lives of the elderly in the EU today, URL:<https://ec.europa.eu/eurostat/cache/infographs/elderly/index.html> . (Accessed: 2019-01-21).



- (Archived by WebCite® at <http://www.webcitation.org/75aogF3Wy>) (2019).
- [2] European Commission, i2010 – Annual Information Society Report 2007. [SEC(2007) 395], Office for Official Publications of the European Communities, Luxembourg, 2007.
  - [3] E. Gracia, J. Herrero, Internet use and self-rated health among older people: a national survey, *J. Med. Internet Res.* 11 (4) (2009) e49.
  - [4] H. Boz, S.E. Karatas, A review on internet use and quality of life of the elderly, *Cypriot J. Educ. Sci.* 10 (3) (2015) 182–191.
  - [5] X. Sheng, P. Simpson, Seniors, health information, and the internet: motivation, ability, and internet knowledge, *Cyberpsychol. Behav. Soc. Netw.* 16 (10) (2013).
  - [6] J. Heo, S. Chun, S. Lee, et al., Internet use and well-being in older adults, *Cyberpsychol. Behav. Soc. Netw.* 18 (5) (2015) 268–272.
  - [7] M. Hofer, E. Hargittai, M. Buchi, A. Seifert, Older adult's online information seeking and subjective well-being: the moderating role of internet skills, *Int. J. Commun.* 13 (2019) 4426–4443.
  - [8] S.R. Cotten, G. Ford, S. Ford, T.M. Hale, Internet use and depression among retired older adults in the United States: a longitudinal analysis, *J. Gerontol. Ser. B: Psychol. Sci. Soc. Sci.* 69 (5) (2014) 763–771.
  - [9] A. Hunsaker, E. Hargittai, A review of internet use among older adults, *New Media Soc.* 20 (10) (2018) 3937–3954.
  - [10] M. Choi, S. Kong, D. Jung, Computer and internet interventions for loneliness and depression in older adults: a meta-analysis, *Health Inf. Res.* 18 (3) (2012) 191–198.
  - [11] N.G. Choi, D.M. DiNitto, Internet use among older adults: association with health needs, psychological capital, and social capital, *J. Med. Internet Res.* 15 (5) (2013) e97.
  - [12] S. Sum, M. Mathews, I. Hughes, A. Campbell, Internet use and loneliness in older adults, *Cyberpsychol. Behav. Soc. Netw.* 11 (2) (2008).
  - [13] F. Amaro, H. Gil, ICT for elderly people: «Yes, They Can!», e-CASE & e-Tech International Conference Proceedings (2011) 3792–3803.
  - [14] Eur-Lex, Ageing well in the Information Society. An i2010 Initiative. Action Plan on Information and Communication Technologies and Ageing, 2007 Available at <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52007DC0332&from=EN>. (Accessed in 4<sup>th</sup> July 2020).
  - [15] European Union, Seniors Network Support, Available at <https://keep.eu/projects/6997/>. (Accessed in 4<sup>th</sup> July 2020) (2007).
  - [16] European Parliament, Digital Agenda for Europe, Available at <https://www.europarl.europa.eu/factsheets/en/sheet/64/digital-agenda-for-europe>. (Accessed in 4<sup>th</sup> July 2020) (2010).
  - [17] European Commission, eHealth Action Plan 2012–2020: Innovative Healthcare for the 21<sup>st</sup> Century, Available at <https://ec.europa.eu/digital-single-market/en/news/ehealth-action-plan-2012-2020-innovative-healthcare-21st-century>. (Accessed in 4<sup>th</sup> July 2020) (2012).
  - [18] Eur-Lex, eHealth Action Plan 2012–2020 – Innovative Healthcare for the 21st Century, Available at <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52012DC0736&from=EN>. (Accessed in 4<sup>th</sup> July 2020) (2012).
  - [19] T. Hashiguchi, Bringing health care to the patient: an overview of the use of telemedicine in OECD countries, Health Working Papers, OECD Health Working Paper No. 116, Directorate for Employment, Labour and Social Affairs Health Committee, OECD, 2020.
  - [20] A.I. Tavares, eHealth, ICT and its relationship with reported health outcomes in the EU countries, *Int. J. Med. Inform.* 112 (2018) 104–113.
  - [21] J.A. Powell, S. Boden, Greater choice and control? Health policy in England and the online health consumer, *Policy Internet* 4 (2) (2012) 1–23.
  - [22] WHO, eHealth at WHO, Available at <https://www.who.int/ehealth/about/en/>. (Accessed in 4<sup>th</sup> July 2020) (2020).
  - [23] Eurostat, Statistics Explained E-inclusion, URL:<https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:E-inclusion>. (Accessed: 2019-01-21). (Archived by WebCite® at <http://www.webcitation.org/75as6pDdbd>) (2019).
  - [24] J. van Dijk, The digital divide in Europe, in: A. Chadwick, P.H. Howard (Eds.), *The Handbook of Internet Politics* London and New York, Routledge, 2008.
  - [25] A.J. van Deursen, A.J. Helsper, A nuanced understanding of internet use and non-use among the elderly, *Eur. J. Community* 30 (2) (2015) 171–187.
  - [26] V. Gallistl, R. Rohner, A. Seifert, A. Wank, Configuring the older non-user: between research, policy and practice of digital exclusion, *Soc. Incl.* 8 (2) (2020) 233–243.
  - [27] P. DiMaggio, E. Hargittai, W.R. Neuman, J.P. Robinson, Social implications of the internet, *Annu. Rev. Sociol.* 27 (2001) 307–336.
  - [28] M. Negreiro, Bridging the Digital Divide in the EU, European Parliamentary Research Service, 2015 EPRS Briefing December 2015. Research Service PE 573.884 EN.
  - [29] T. Webb, J. Joseph, L. Yardley, S. Michie, Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy, *J. Med. Internet Res.* 12 (1) (2010) e4.
  - [30] K. Bessière, S. Pressman, S. Kiesler, R. Kraut, Effects of internet use on health and depression: a longitudinal study, *J. Med. Internet Res.* 12 (1) (2010) e6.
  - [31] P.E. Kok, et al., A systematic review of the effects of e-health on chronically ill patients, *J. Clin. Nurs.* 20 (21–22) (2011) 2997–3010.
  - [32] E. Neter, E. Brainin, O. Baron-Epel, The third digital divide in the health domain: is internet use for health purposes associated with health benefits? in: T.M. Hale, W.Y.S. Chou, S.R. Cotten, A. Khilnani (Eds.), *eHealth: Current Evidence, Promises, Perils and Future Directions. Studies in Media and Communications*, 15 Emerald Publishing Limited, 2018, pp. 153–175.
  - [33] C.S. Wangberg, K. Hege, H.U. Prokosch, et al., Relations between Internet use, socio-economic status (SES), social support and subjective health, *Health Promot. Int.* 23 (1) (2008) 70–77.
  - [34] SHARE, Share Project site. Database, Available at <http://www.share-project.org/home0.html>. (Accessed 2019-01-02) (2020).
  - [35] R. Konig, A. Seifert, M. Doh, Internet Use among Older European: an Analysis Based on SHARE Data, Universal Access in the Information Society, 2018, <https://doi.org/10.1007/s10209-018-0609-5>.
  - [36] G. Dahlgren, M. Whitehead, Policies and Strategies to Promote Social Equity in Health, Institute for Futures Studies Stockholm, 1991.
  - [37] O. Solar, A. Irwin, Social determinants, political contexts and civil society action: a historical perspective on the Commission on Social Determinants of Health, *Health Promot. J. Aust.* 17 (3) (2007) 180–185.
  - [38] M. Grossman, On the concept of health capital and the demand for health, *J. Polit. Econ.* 80 (1972) 223–255.
  - [39] P. Zweifel, F. Breyer, M. Kifmann, *Health Economics*, Springer, Boston, 2009.
  - [40] M. Shields, S. Shahin, Determinants of self-perceived health. Statistics Canada, Catalogue 82-003, *Health Rep.* 13 (1) (2001) 35–52.
  - [41] J. Damian, A. Ruigomez, V. Pastor, J.M. Martín-Moreno, Determinants of self-assessed health among Spanish older people living at home, *J. Epidemiol. Community Health* 53 (1999) 412–416.
  - [42] Z. Zimmer, J. Natividad, H.S. Lin, N. Chayovan, A cross-national examination of the determinants of self-assessed health, *J. Health Soc. Behav.* 41 (4) (2000) 465–481.
  - [43] D.C. Balabanova, M. McKee, Self-reported health in Bulgaria: levels and determinants, *Scand. J. Public Health* 30 (4) (2002) 306–312.
  - [44] M. Marmot, J. Allen, R. Bell, E. Bloomer, P. Goldblatt, WHO European review of social determinants of health and the health divide, *Lancet* 380 (9846) (2012) 1011–1029.
  - [45] G. Verropoulou, Determinants of change in self-rated health among older adults in Europe: a longitudinal perspective based on SHARE data, *Eur. J. Ageing* 9 (2012) 305–318.
  - [46] European Union, Digital Economy and Society Index - DESI. 2019-01-21, URL:[https://digital-agenda-data.eu/charts/desi-components#chart=\(%22indicator%22:%22DESI\\_5\\_DPS%22,%22breakdown-group%22:%22DESI\\_5\\_DPS%22,%22unit-measure%22:%22pc\\_DESI\\_5\\_DPS%22,%22time-period%22:%222018%22\)](https://digital-agenda-data.eu/charts/desi-components#chart=(%22indicator%22:%22DESI_5_DPS%22,%22breakdown-group%22:%22DESI_5_DPS%22,%22unit-measure%22:%22pc_DESI_5_DPS%22,%22time-period%22:%222018%22)). Accessed: 2019-01-21. (Archived by WebCite® at <http://www.webcitation.org/75az5mTdN>) (2019).
  - [47] A. Börsch-Supan, Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 6. Release version: 6.1.0. SHARE-ERIC, Data set (2018), <https://doi.org/10.6103/SHARE.w6.611>.
  - [48] E.L. Idler, Y. Benyamini, Self-rated health and mortality: a review of twenty-seven community studies, *J. Health Soc. Behav.* 38 (1) (1997) 21–37.
  - [49] M. Jylhä, J.M. Guralnik, L. Ferrucci, et al., Is self-rated health comparable across cultures and genders? *J. Gerontol. Ser. B Psychol. Sci. Soc. Sci.* 53 (3) (1998) S144–S152.
  - [50] G. Kaplan, V. Barell, A. Lusky, Subjective state of health and survival in elderly adults, *J. Gerontol.* 43 (4) (1988) 114–120.
  - [51] R. Leinonen, E. Heikkinen, M. Jylhä, Changes in health, functional performance and activity predict changes in self-rated health: a 10-year follow-up study in older people, *Arch. Gerontol. Geriatrics* 35 (1) (2002) 79–92.
  - [52] European Union, International Digital Economy and Society Index (I-DESI) - Final Report, European Commission, Directorate-General of Communications Networks, Content & Technology, 2019, <https://doi.org/10.2759/185010> 2016.
  - [53] OECD, Health at a Glance: Europe, OECD Publishing, 2012.
  - [54] D. Chan, So why ask me? Are self-report data really that bad? in: C.E. Lance, R.J. Vandenberg (Eds.), *Statistical and Methodological Myths and Urban Legends: Doctrine, Verity and Fable in the Organizational and Social Sciences*, Routledge, New York, NY, 2009, pp. 309–335.
  - [55] R. Busse, N. Valentine, S. Lessof, et al., Being responsive to citizens' expectations: the role of health services in responsiveness and satisfaction, in: J. Figueras, M. McKee (Eds.), *Health Systems, Health, Wealth and Societal Well-Being: Assessing the Case for Investing in Health Systems*, Open University Press, Maidenhead (UK), 2012, pp. 175–208.
  - [56] C. Delpierre, V. Lauwers-Cances, G.D. Datta, et al., Using self-rated health for analysing social inequalities in health: a risk for underestimating the gap between socioeconomic groups? *J. Epidemiol. Community Health* 63 (6) (2009) 426–432.
  - [57] S.R. Cotten, S.S. Gupta, Characteristics of online and offline health information seekers and factors that discriminate between them, *Soc. Sci. Med.* 59 (2004) 1795–1806.
  - [58] P. DiMaggio, E. Hargittai, From the 'digital divide' to 'digital inequality': studying internet use as penetration increases, Working Paper 15, Center for Arts and Cultural Policy Studies, Princeton University, 2001.
  - [59] A. Börsch-Supan, M. Brandt, C. Hunkler, et al., Data resource profile: the Survey of Health, Ageing and Retirement in Europe (SHARE), *Int. J. Epidemiol.* 42 (4) (2013) 992–1001.