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Reading and understanding numerical information about COVID-19 by Greek adults

Eleni Giannakopoulou
Hellenic Open University, Greece
<giannakopoulou.eleni@ac.eap.gr>

Abstract

Official communications and media news in Greece about the COVID-19 pandemic very often involve a multitude of numerical concepts and mathematical relationships, which are presented in different forms and in various contexts. This paper reports selected findings of a survey among adults, which had two aims. First, to investigate their subjective assessments concerning the difficulties encountered in reading and understanding such numerical information, embedded in texts and presented by infographics and time-series graphs. And second, to investigate their assessments of the usefulness of such numerical information, presented in visual forms. A convenience sample of 310 adults responded to an online questionnaire. The main conclusion from the analysis of these data is that a considerable number of the participants, although relatively highly educated, assess themselves as having difficulties in reading and understanding numerical information concerning COVID-19. Namely, about 9% report difficulties with information included in textual forms, while regarding visual presentations the percentage ranges from 10% to 35%. Yet more than half of the adults surveyed assess the presentation of numerical information in visual forms as useful for comprehension. Furthermore, the distributions by gender, education, and age of participants' answers to our questionnaire generally show no substantial differences among them. These findings advise caution regarding communications or announcements that involve even simple numerical concepts and mathematical relationships concerning COVID-19 and health issues

Key words: adult numeracy, numerical information, COVID-19, adult education

Introduction

The first case of COVID-19 had been confirmed in Greece by the end of February 2020 and the next day the government announced the cancellation of all scheduled seasonal carnival events. In the first fortnight of March, measures to prevent the spread of coronavirus were announced by the governmental officials, almost on a daily basis. Initially, all educational institutions suspended their activities, followed by restaurants, entertainment venues, and retail shops, while all sports and cultural activities were banned. The first death by COVID-19 was announced by mid-March 2020, and in the following weeks traveling by car, ship or plane was banned. By the end of March, a total lockdown had been announced and all economic activities, except those absolutely necessary, had been suspended, while any movement of individuals needed to be justified by SMS or a statement signed by the person as to which of a number of reasons justified their movement. At that time, a daily briefing was introduced each afternoon, which was broadcast on all television networks. In these briefings, government officials and health experts presented the current situation in the evolution of the pandemic using mainly, if not exclusively, numerical data. Numbers of new infection cases, people tested daily, deaths, hospitalized patients and patients in intensive-care units, and at the same time, numbers of the daily violations of movements and activity restrictions. The numerical information which was announced by officials and experts was reproduced in the media enriched with visual representations (infographics, graphs, tables, etc.) and supplemented with proper journalistic comments. The same numbers accompanied by a variety of interpretations were promoted by various agents to justify governmental measures and bans.

After six weeks, the lifting of restrictions gradually began, and by the end of June 2020 all economic activities had started again normally throughout the country. Since August, however, all data had shown a new increase in the number of infectious cases, which continued to rise in September. Thus, in October, all restrictions were applied again, and the daily briefings by government officials and health experts restarted with a new bombardment of numerical information and recommendations to the people. Since then, the imposition of some restrictive measures has continued, although the daily official and expert briefings were replaced at the end of November by television news bulletins where the numbers concerning the pandemic were their first daily reported event.

It is almost certain that no other event in recent Greek history has been covered by the media to such an extent and duration with such a flood of numerical information.

The related question, however, is to what extent this daily numerical information in its various forms is understood by the audience or, in other words, what numeracy demands are put on the people for understanding and interpreting the communicated numerical data about the COVID-19. We attempt to answer some aspects of this question through the survey presented in this paper in the context of the Greek situation of adult numeracy, outlined in the next section

Adult numeracy in Greece

The author has been unable to find any small-scale survey studies in Greece concerning adult numeracy. See Kontogianni & Tatsis (2018) for an example of a qualitative study concerning statistical literacy. At the same time, it could be claimed that adult numeracy on health issues has not been at all a subject of research in Greece. Nowadays, the numeracy demands on adults for understanding and interpreting numerical communications about COVID-19 was not a focus of research when this study was begun, although numerical expressions are to a great extent used in official announcements and directions.

Data concerning adults' proficiency in numeracy are provided up to now by one nationwide study conducted by the OECD Programme for the International Assessment of Adult Competencies (PIAAC). This "Survey of Adult Skills", carried out in Greece during 2014-2015, following the methodology and research tools of PIAAC (OECD, 2016b), was adapted to the Greek context by the National Center for Social Research in Greece. About 5,000 adults aged 16-65 years were surveyed. The PIAAC survey records adults' proficiency in literacy, numeracy, and problem solving in technology-rich environments. These are considered to be the three key information-processing skills that are relevant to adults in many social contexts and work situations. Therefore, they are regarded as necessary for fully integrating and participating in the labor market, education and training, and social and civic life.

Numeracy in this context is defined as the ability of adults to use numerical and mathematical concepts (OECD, 2016c, p. 1). Proficiency is described on a scale of 500 points divided into levels, each level summarizing what a person with a particular score can do. Six proficiency levels are defined for numeracy (Levels 1 through 5, plus below Level 1). The survey's Background Questionnaire also provides a wide range of information about respondents' use of skills at work and in everyday life, their education, their linguistic and social backgrounds, their participation in adult education and training and in the labor market and other aspects of their well-being.

The PIAAC survey found that the average score of adults in Greece in numeracy (252) is somewhat lower than the OECD average (263). More specifically, about 6% of adults in Greece attain Level 4 or 5 in numeracy, below the OECD average of 11%, and about 25% attain Level 3, below the OECD average of 32%.

At Level 3, adults have a good sense of number and space; they can recognize and work with mathematical relationships, patterns, and proportions expressed in verbal or numerical form; and can interpret and perform basic analyses of data and statistics in texts, tables, and graphs (OECD, 2016c, p.2).

On the other hand, the proportion of adults with poor numeracy skills is much larger in Greece than the OECD average. Almost 28.5% of Greek adults score at, or below, numeracy Level 1, more than the OECD average of about 23%. Some 27% of 16-24 years-olds are low performers in numeracy (the OECD average is 19 %.). Low proficiency is also prevalent among 55–65-year-olds in Greece: About one in three adults in this age group score at or below Level 1 in numeracy; however, this is the same proportion as across participating OECD countries. Adults at numeracy Level 1 can perform basic mathematical processes in common, concrete contexts, for example, one-step or simple processes involving counting, sorting, basic arithmetic operations and understanding simple percentages. In relation to the educational level of adults, it is interesting to note that tertiary-educated adults in Greece have relatively low levels of proficiency in numeracy (OECD, 2016c). Although we have to be careful when reading international survey reports (Evans, 2014), this is a picture of the adult numeracy situation in Greece as outlined by PIAAC findings, and it was on this ground that our survey was carried out with the aim of answering a few more specific questions related to adults reading and understanding numbers in communications about COVID-19.

Adult numeracy and its assessment

There are many definitions of numeracy in the adult mathematics literature (e.g. Evans, 2000; Lindenskov & Wedege, 2001; van Groenestijn, 2002). For the purpose of this paper, however, numeracy is taken to be a concept referring to ways in which adults handle various quantitative, numerical, and statistical requirements in their daily lives. This is basically the PIAAC definition (see above).

The concept of numeracy includes a range of skills and abilities from the basic understanding of numerical information to the interpretation of statistical data and probabilities embedded in various contexts of their use in daily life and work of people (e.g. Ginsburg et al. 2006). The relevant literature on the subject matter (e.g., Gal et al., 2020; Geiger et al, 2015, Craig & Guzmán, 2018) has described a number of situations in various contexts that require a minimum level of numeracy to handle, so that the term "numeracy" may be considered as referring to a plural concept, directly related to its context of materialization and at the same time to the practices applied by adults for handling the numeracy demands imposed by each context (Craig & Guzmán, 2018).

On this basis, various categorizations of numeracy have been formulated, each based on its own objectives or fields of application and its different respective theoretical perspectives. As a result, among other things, it is difficult in many cases to interpret the relationships between the measured numeracy level of an adult and its impact on her/his individual and social behaviour, especially in health matters, as discussed in this paper.

The assessment of an adults' numeracy level commonly involves assessments claimed to be objective of their ability to understand, manipulate, and interpret numerical information. Measures of objective numeracy are typically designed as tests that include series of questions to which there are correct and incorrect answers. These questions and problems ask the respondents to interpret various types of rational number expressions (integers, decimals, fractions, &

percentages), simple numerical relationships and proportions, probabilities, and simple statistics, as well as to handle transformations of numerical data from one form to another.

A widely used objective numeracy test, nowadays in health numeracy, is the Expanded Numeracy scale (ENS) developed by Lipkus et al. (2001) including eight items. It is an extension of a numeracy scale introduced by Schwartz et. al. (1997) intended to screen patients' ability to evaluate the benefits of mammography. The ENS measures an individual's ability to convert probabilities into percentages (and vice versa), estimate probabilities, and convert frequencies into probabilities. According to Lipkus et al. (2001, p. 37) the ENS was developed using a "highly educated sample" that showed a surprisingly low ability to correctly answer the items. However, it has still been able to explain a considerable amount of individual differences on diverse judgment and decision making tasks (e.g., Peters et al., 2007a). Variations of ENS scale aiming to increase the discriminability of the scale may be found in the relevant literature, as is for instance an extended version of the ENS developed by Peters and colleagues (2007b). To develop a short and better discriminating test of statistical numeracy, Cokely et al. (2012) introduced the Berlin Numeracy Test (BNT) which includes four items asking for probability estimations and risk assessment.

Although such objective instruments for assessing adult numeracy have proven to be effective mainly in identifying differences between individuals in a population, there are significant problems in their use (Fagerlin et. al. 2007). The main problem is the reluctance or the refusal of adults to answer tests which are checking personal abilities and skills, as argued by Lipkus et al. (2001). In addition, surveys conducted with *online* tests of personal abilities and skills could not be considered as valid, as it is not possible to identify the person answering, and whether she/he is using a calculator or invokes the assistance of other people.

An alternative methodology aiming to overcome the drawbacks of the objective assessments of adults' numeracy has been to use subjective assessments of numeracy competences. Subjective numeracy assessments encompass people's perceptions of their numerical competence and their preferences for using numbers (Fagerlin et al., 2007). Unlike the tests used to measure objective numeracy (i.e., actual competence), measures of subjective numeracy are typically self-report questionnaires in which participants are asked to rate their perceptions and beliefs about their numeracy competence and their preferences for using numbers (Fagerlin et al., 2007).

The subjective assessment of numeracy has been introduced in the related research by Fagerlin et al (2007). They developed and applied a subjective numeracy questionnaire (SNS) consisting of two parts: subjective numeracy skills and number preference. The numeracy skills part consists of four written questions, each with a six-point Likert response scale assessing an individual's perceived numeracy skills in several contexts (e.g., "How good are you at working with percentages?"). The number preference part of the questionnaire also consists of four written questions, each with a six-point Likert response scale assesses an individual's preference for numeric information (e.g., "When people tell you the chance of something happening, do you prefer that they use words or numbers?"). The average of all items resulted in the numeracy score.

The developers of the SNS scale proposed that self-assessments of numerical competence could be used as a proxy for objective numeracy on the basis of a moderate association (Pearson's $r = 0.68$; R-squared = 46.2%) between their subjective numeracy scale and objective numeracy measures (Fagerlin et al., 2007). A similar study of McNaughton et. al. 2011, reports a lower, but also considerable, correlations between subjective numeracy scales and objective measures (Spearman's Rank Correlation $r= 0.57$). Zikmund-Fisheret al. (2007, p. 670) applying an extended statistical analysis conclude that "It seems clear that the SNS significantly predicts the same behaviors as objective numeracy measures do." However, there are diverging views on this matter (see below).

Measures of subjective numeracy have important advantages relative to measures of objective numeracy: they are easier to administer and less frustrating and stressful for respondents, they are less time consuming, and have lower rates of incomplete data (Fagerlin et al., 2007). However, measures of subjective numeracy have disadvantages that characterize self-report questionnaires: they are more susceptible to measurement errors and biases such as self-serving biases, and response style (Paulhus, 1991).

On the other hand, some researchers have found subjective measures to be poor diagnostic indicators of objective numeracy (e.g., Dolan, Cherkasky, Li, Chin, & Veazie, 2014; Nelson, Moser, & Han, 2012).

In any case, objective and subjective assessments of numeracy are independent approaches, and the objective and subjective numeracy scales measure related but distinct constructs. Whereas objective numeracy assessments measure the ability to perform numerical tasks, subjective numeracy assessments concern self-judgments and expectations about one's ability to perform mathematics tasks. Nevertheless, both measures are linked. Successful performance on a numerical task demonstrates skills to perform similar tasks in the future, which, in turn, enforces self-assessment of one's ability to perform similar tasks.

Methodology of research

The main aim of the survey reported in this paper was to gain insights into subjective assessments of difficulties encountered by "relatively highly educated" adults in Greece in reading and understanding numerical information about the COVID-19 embedded in texts, infographics, and graphs such as those included in official announcements and reproduced by media. Therefore, a subjective assessment of numeracy approach has been adopted following the rationale suggested by Fagerlin et al. (2007).

Taking into account the conditions under which this survey could be conducted we chose to compose a questionnaire for self-assessment of adult numeracy with particular references to reading and understanding numerical information concerning COVID-19.

In the composition of this questionnaire, an effort was made to formulate questions that would enable adequate inferences about an adult's competency in reading and understanding numerical information. At the same time, these questions had to be formulated so as to be readily understandable and easily answered by the participants. Since I had no a-priori reasons to hypothesize that some issues of communications about COVID-19 would correlate better with numeracy assessment of adults than others, we chose a broad, exploratory approach to the development of questions in our questionnaire. We took into account, but did not limit our focus to questions included in various objective or subjective numeracy scales found in the relevant literature, as for example the Expanded Numeracy Scale (Lipkus et. al., 2001) or the Subjective Numeracy Scale (Fagerlin et al., 2007), but we formulated questions directly related to the reality of public dissemination of information about COVID-19, as reported by governmental authorities, health experts and the media in Greece.

The questionnaire included in its first part, demographic questions (gender, age, level of educational level) and in its second part, three sets of questions. One set of questions asked participants for their subjective assessments of their *difficulty* in reading and understanding numerical information about COVID-19 embedded in given texts and presented by particular visual presentations like infographics and time-series graphs. The second set of questions asked participants to give their subjective assessments of the *usefulness* of communications about COVID-19 employing various types of rational number (integers, fractions, and percentages), and a third part of two questions asked for the assessment of the *usefulness* of infographics and time-series graphs in general, as used in the presentation of numerical information about COVID19 (see Appendix).

A first draft of the questionnaire supplemented by two additional questions concerning the content and wording of its questions was given as a pilot study to a small group of adults (n = 40) drawn from the same population as our final sample. The first additional question concerned their comprehension of each question, and the second asked for the assessment of the validity of each question in tracking the difficulties of reading and understanding the numerical information provided.

Taking into consideration the limitations to personal and social contacts imposed by the COVID-19, the final form of the questionnaire was delivered utilizing the Internet. The potential advantages of using the Internet for the delivery of questionnaires have been documented quite comprehensively (e.g., Boyer et. al., 2002 or Ritter et. al., 2004), and the relevant arguments will not be repeated here.

A convenience sample of Greek adults (see Table 1) was recruited for this survey from the lists of adults who had attended the past three years various seminars on issues concerning learning and teaching adults organized by various agencies and taught by the researcher. A total of 420 adults who were included in these lists were invited by email to respond anonymously to a questionnaire posted online and within the time limit set by the researcher, 310 adults responded.

A convenience sample is a non-random sample which includes members of the target population who meet certain *practical* criteria, such as ease of accessibility to the researcher, availability at a given time, or those who are most ready, willing, and able to participate in the study (Saumure & Given, 2008). A convenience sample does not come from a systematic sampling method or sample structure. For this reason, its representativeness of the population in all regards concerning the individuals' attributes cannot be guaranteed at all. In other words, it is not known how well a convenience sample represents the population in which the researcher is interested regarding the attributes under study and thus any generalization and inference made about the entire population is of unknown validity (Leiner, 2016).

The distribution of participants in this study by age, gender and educational level is shown in the following Table 1.

As may be seen in this table, the respondents to the questionnaire may be considered as "highly educated" since 248 (80%) of them are higher education graduates and 62 (20%) secondary education graduates. List your bullets with ALM List as follows:

Table 1. Participants in the study by age, education and gender

				Age				Total
				< 30	31-40	41-50	>51	
Secondary Education	Gender	Male	N	5	4	12	2	23
			% of Total	8,1%	6,5%	19,4%	3,2%	37,1%
		Female	N	11	9	12	7	39
			% of Total	17,7%	14,5%	19,4%	11,3%	62,9%
	Total		N	16	13	24	9	62
			% of Total	25,8%	21,0%	38,7%	14,5%	100,0%
Higher Education	Gender	Male	N	44	24	16	28	112
			% of Total	17,7%	9,7%	6,5%	11,3%	45,2%
		Female	N	52	27	29	28	136
			% of Total	21,0%	10,9%	11,7%	11,3%	54,8%
	Total		N	96	51	45	56	248
			% of Total	38,7%	20,6%	18,1%	22,6%	100,0%
Total	Gender	Male	N	49	28	28	30	135
			% of Total	15,8%	9,0%	9,0%	9,7%	43,5%
		Female	N	63	36	41	35	175
			% of Total	20,3%	11,6%	13,2%	11,3%	56,5%
	Total		N	112	64	69	65	310
			% of Total	36,1%	20,6%	22,3%	21,0%	100,0%

The data collected were coded and analyzed with the statistical package SPSS-26.

Main findings

In the present paper, we report on the findings of the first set of questions (Qu. 1 to Qu. 5 of our questionnaire) which asked Greek adults for their subjective assessments of *difficulties* encountered in reading and understanding numerical information about the COVID-19 embedded in texts, visual presentations, and graphs such as those included in official announcements and media news. We also present findings of the third set of questions (Qu. 9 and Qu. 10) closely related to the previous one asking adults to assess the *usefulness* of infographics and time-series graphs in the presentation of numerical information about COVID19. We do not report on the findings of the questions which asked adults to give their subjective assessments of the *usefulness* of various types of numbers (integers, fractions, and percentages) employed in communications about COVID-19, since it was considered after scrutinizing the adults' responses that they require a different type of analysis directly related to their personal conceptions of the related numerical concepts.

The main findings of our data analysis are presented and commented in the following

1. Understanding numerical information embedded in texts

Question 1 in our questionnaire asked the participants to give their subjective assessment of their level of difficulty in understanding numerical information in the forms of integers and percentages embedded in an official text informing citizens about the numbers of infected cases and the dispersion of COVID-19 in the country on a particular day (20th December 2020).

The announcement included in Question 1, translated into English, is the following:

Communication of EODY

Data until 20 December, time 15:00

Today we announce 588 new infected cases of the virus in the country, 11 of which were identified in the entry gates of the country. The total number of infected cases until today has been 131,072, which 52.5% are males.

5211 (4.0%) are considered to be related to travels from abroad and 38,349 (29.3%) are related to an already known infected case

This is an illustrative announcement issued daily from February 2020 onwards by EODY-The National Public Health Authority. The responses of the participants are shown in the following table.

Table 2. Understanding numerical information embedded in Question 1 (n=310)

	Very difficult	Difficult	Neither Easy nor Difficult	Easy	Very Easy
Qu.1	11 (3.5%)	18 (5.8%)	48 (15.5%)	72 (23.2%)	161 (51.9%)

As the data in this table shows, 75% of the participants in the survey assessed their reading and understanding of numerical information embedded in texts, such as the communication included in Question 1 of our questionnaire, as being “very easy” or “easy”. However, a small percentage of the participants in the study (9.3%), significant in the sense that our sample concerns highly educated adults, found it “difficult” or “very difficult.”

The distributions of participants’ answers to question 1 by gender, education level and age are shown in the following tables.

Table 2a. Distribution of participants' answers on understanding numerical information embedded in Question 1 by gender (n=310)

	Very difficult	Difficult	Neither Easy nor Difficult	Easy	Very Easy
Male	5 (3.7%)	7 (5.2%)	20 (14.8%)	30 (22.2%)	73 (54.1%)
Female	6 (3.4%)	11 (6.3%)	28 (16.0%)	42 (24.0%)	88 (50.3%)

Table 2b. Distribution of participants' answers on understanding numerical information embedded in Question 1 by education level (n=310)

	Very difficult	Difficult	Neither Easy nor Difficult	Easy	Very Easy
Secondary education	1 (1.6%)	2 (3.2%)	10 (16.1%)	16 (25.8%)	33 (53.2%)
Higher education	10 (4.0%)	16 (6.5%)	38 (15.3%)	56 (22.6%)	128 (51.6%)

Table 2c. Distribution of participants' answers on understanding numerical information embedded in Question 1 by age (n=310)

	Very difficult	Difficult	Neither Easy nor Difficult	Easy	Very Easy	Easy +Very Easy
< 30	2 (1.8%)	8 (7.1%)	16 (14.3%)	34 (30.4%)	52(46.4%)	86 (76.8%)
31-40	0 (0.0%)	3 (4.7%)	11 (17.2%)	10 (15.6%)	40 (62.5%)	50 (78.1%)
41-50	2 (2.9%)	1 (1.4%)	10 (14.5%)	17 (24.6%)	39 (56.5%)	56 (81.1%)
>51	7 (10.8%)	6 (9.2%)	11 (16.9%)	11 (16.9%)	30 (46.2%)	41 (63.1%)

The above tables show that no substantial differences in ease of understanding numerical information embedded in texts, such as that included in Question 1, were found for gender or education level of the adults surveyed. However, their age differences seem to be related to their assessments. Adults over the age of 50 years find this numerical data somewhat more difficult to understand than younger adults.

2. Understanding numerical information presented by infographics

It is commonly assumed that visually presented numerical data convey information that can quickly and easily be understood by an adult audience and for such a reason they were extensively used in communications about dispersion and transmissibility of COVID-19 by governmental agencies, health organizations, media and newspapers. Two types of visualizing data were used with great frequency: infographics and graphs presenting particular sets of numerical data such as line charts, bar graphs, and others common in statistics.

Infographics have emerged as a popular visual approach to deliver abstract, complex, and dense messages (Smiciklas, 2012). An infographic (which is short for information graphic), is "a larger graphic design that combines data visualizations, illustrations, text, and images together into a format that tells a complete story" (Krum, 2014, p.6). It is a type of visual representation of data that gives an audience a quickly consumed and easily understood overview of a topic.

Graphs, on the other hand, focus on a small and specific data set. They display quantifiable data (either numbers or statistics) "by means of the combined use of points, lines, a coordinate system, numbers, symbols, words, shading, and color" (Tufte, 2001, p.10). They aim to make what might otherwise be a complicated collection of numbers into something that is easily understood at a glance. The most used type of graph used in communications about COVID-19 was the time-series graph showing the evolution of infection cases, deaths, hospitalized patients, etc.

Of course, any visual presentation of numerical information involves the choice of data, visual images, and illustrations, and balances between numeric and alphabetic texts.

Questions 2 to 4 in our questionnaire asked the participants to give their subjective assessment of their level of difficulty in understanding information presented by infographics as shown in the following figures 2, 3, and 4, translated into English.

Figure 2 informs people about the geographical spread of COVID-19 in the country on a particular day, and the related question asked participants to assess the ease or difficulty of reading and understanding the information given by this infographic.

Fig.2. The geographical spreading of COVID-19 on a particular day (29.03.2020).

The three columns on the left of the figure show the numbers of infected cases and deaths in each prefecture of the country, with an emphasis on Attica (702-15) and Piraeus (56-0) prefectures.

Question 3 presents in a comparative way the numbers of infection cases, patients intubated in intensive care units, and deaths on a particular date, throughout all of Greece.

Fig.3. Numbers of COVID-19 infected cases, patients intubated in intensive-care units, and deaths on a particular day (4.12.2020).

Question 4 illustrates the evolution of daily infected cases over a two-day period of time (cumulative totals since the confirmation of the first case by the end of February 2020 up to 1 April 2020).

Fig.4. The evolution of COVID-19 infected cases over a over a two-day period of time.

The responses of the participants in our study are shown in Table 3.

Table 3. Understanding information presented by infographics embedded in Questions 2, 3 & 4 (n=310)

	Very difficult	Difficult	Neither Easy nor Difficult	Easy	Very Easy	Easy + Very Easy
Q.2 / Fig.2	7 (2.3%)	25 (8.1%)	49 (15.8%)	70 (22.6%)	159 (51.3%)	229 (73.9%)
Q.3 / Fig.3	16 (5.2%)	26 (8.4%)	36 (11.6%)	49 (15.8%)	183 (59.0%)	232 (74.8%)
Q.4 /Fig.4	25 (8.1%)	33 (10.6%)	53 (17.1%)	56 (18.1%)	143 (46.1%)	199 (64.2%)

The data in Table 3 shows that the majority of adults surveyed assessed their reading and understanding of the visually presented numerical information to our respective questions as “very easy” or “easy.” Lesser percentages of participants found these numbers as “difficult” or “very difficult”, despite the fact that these adults may be regarded as formally highly educated. Comparing the three types of visual presentations we note that the assessment of easiness of the infographic shown in Fig. 4 is slightly lower than the other two in Figs 2 and 3. This difference can perhaps be attributed to the bar graphs that illustrate the numerical information in this image, an issue that may be related to deficits in the statistical literacy of the adults surveyed.
The distributions by gender, education, and age of participants’ answers to these questions (not included here) showed no substantial differences among them.

3. Understanding numerical information in time series graphs

In addition to the previous questions, one question of our questionnaire asked the participants to give their subjective assessment of their level of difficulty in understanding comparative numerical information presented by a time-series graph, such as the one shown for Question 5 below.

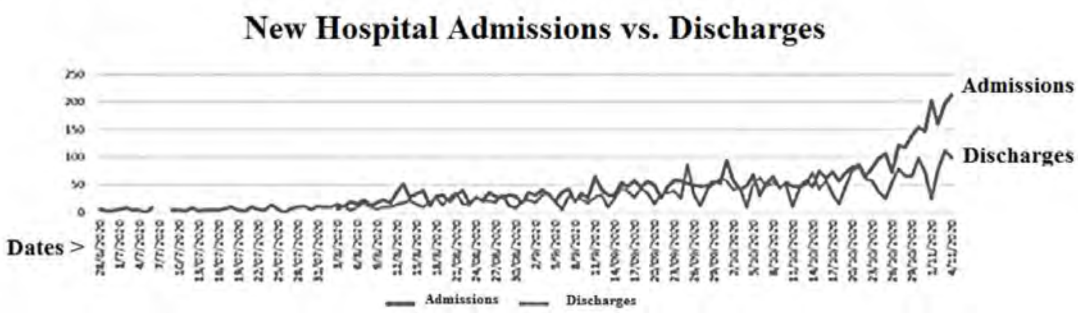

Fig.5. New hospital admissions (COVID-19 infected cases), and discharges (recovered cases)

The line-graphs show a comparison the evolution of numbers of admissions to, and discharges from, hospitals over a period of three months (26/6/2020 – 23/9/2020) of people infected by, and recovered from, COVID-19.

The responses of the participants in our study are shown in the table below.

Table 4. Understanding the relationship between hospital admissions and discharges (n=310)

	Very difficult	Difficult	Neither Easy nor Difficult	Easy	Very Easy	Easy + Very Easy
Qu.5 / Fig.5	20 (9.7%)	77 (24.8%)	48 (15.5%)	80 (25.8%)	75 (24.2%)	155 (50.0%)

As concluded from the above data, half the adult population surveyed assessed their understanding of comparative numerical information presented in this time-series graph as “very easy” or “easy” (50%), while a significant percentage, greater than one-third of this population, found it “difficult” or “very difficult” (34.5%).

It seems that people tend to comprehend more and make better-informed decisions when the presentation format makes the most important information easier to evaluate and when less cognitive effort is required. Results from experiments carried out by Peters et. al. (2007a) showed that those with lower numeracy skills are at a disadvantage in comprehending the information presented in complex formats that require a cognitive burden and obscure the meaning of important information

An investigation of the distributions by gender, education and age of participants’ answers to this question showed no considerable differences among the different demographic categories.

4. Assessment of the usefulness of numerical information presented by infographics and time series graphs

Questions 9 and 10 in our questionnaire (see Appendix) asked the participants to give their subjective assessments on the usefulness of numerical information presented in communications about COVID-19 by infographics and time series graphs. The responses of the participants are shown as frequencies and percents in the table below.

Table 5. Distribution of participants’ answers by type of visual presentation (n = 310)

	Not at all useful	Slightly useful	Moderately useful	Useful	Very useful	Useful + Very useful
Infographics (Qu. 9)	24 (7.7%)	38 (12.3%)	70 (22.6%)	104 (33.5%)	74 (23.9%)	178 (57.4%)
Time series graphs (Qu. 10)	18 (5.6%)	58 (18.7%)	88 (28.4%)	70 (22.6%)	76 (24.5%)	146 (47.1%)

As Table 5 shows, the distributions of responses concerning the usefulness of infographics and time series graphs for presenting numerical information about COVID-19 show that approximately half the participant considers these visuals as “very useful” or “useful”.

An investigation of the distributions of participants’ answers to these questions shows that no substantial differences by gender or education can be confirmed. The results are less straightforward concerning the age of the participants; see Tables 5a and 5b.

Table 5a. Distribution of participants' answers on the usefulness of infographics in general (Qu. 9) by age (n=310)

	Not at all useful	Slightly useful	Moderately useful	Useful	Very useful	Useful + Very useful
< 30	6 (5.4%)	15 (13.4%)	24 (21.4%)	39 (34.8%)	28 (25.0%)	67 (59.8%)
31-40	6 (9.4%)	10 (15.6%)	12 (18.8%)	20 (31.3%)	16 (25.0%)	36 (56.3%)
41-50	6 (8.7%)	9 (13.0%)	16 (23.2%)	25 (36.2%)	13 (18.8%)	38 (55.0%)
>51	6 (9.2%)	4 (6.2%)	18 (27.7%)	20 (30.8%)	17 (26.2%)	37 (57.0%)

Table 5b. Distribution of participants' answers on the usefulness of time series graphs in general (Qu. 10) by age (N=310)

	Not at all useful	Slightly useful	Moderately useful	Useful	Very useful	Useful + Very useful
< 30	8 (7.1%)	17 (15.2%)	34 (30.4%)	26 (23.2%)	27 (24.1%)	53 (47.3%)
31-40	1 (1.6%)	8 (12.5%)	17 (26.6%)	12 (18.8%)	26 (40.6%)	38 (59.4%)
41-50	1 (1.4%)	20 (29.0%)	23 (33.3%)	15 (21.7%)	10 (14.5%)	25 (36.2%)
>51	8 (12.3%)	13 (20.0%)	14 (21.5%)	17 (26.2%)	13 (20.0%)	30 (46.2%)

The age of participants seems not to be related to their assessments of the usefulness of infographics. However, views on the usefulness of time series graphs, as shown in Table 5b, do not seem to follow an easily interpretable distribution: adults aged 41-50 years rate the usefulness somewhat higher than other groups, whereas those 41-50 rate the usefulness as lower.

A further cross-check of responses to Question 10 indicates as a possible explanation the relationship between age and educational level of adults on the one hand, and usefulness ratings; see Table 6.

Table 6. Distribution of participants' answers on the usefulness of time series graphs in general (Qu. 10) by age and educational level (n=310)

Age	Educational level	Not at all useful	Slightly useful	Moderately useful	Useful + Very useful
< 30	Secondary	1 (6.3%)	2 (12.5%)	4 (25.0%)	9 (56.3%)
	Higher	7 (7.3%)	15 (15.6%)	30 (31.3%)	44 (45.8%)
31-40	Secondary	1 (7.7%)	3 (23.1%)	5 (38.5%)	4 (30.8%)
	Higher	0 (0.0%)	5 (9.8%)	12 (23.5%)	34 (66.7%)
41-50	Secondary	0 (0.0%)	6 (25.0%)	8 (33.3%)	10 (41.7%)
	Higher	1 (2.2%)	14 (31.1%)	15 (33.3%)	15 (33.3%)
>51	Secondary	1 (11.1%)	1 (11.1%)	4 (44.4%)	3 (33.3%)
	Higher	7 (12.5%)	12 (21.4%)	10 (17.9%)	27 (48.2%)

Table 6 does not display any pattern that is reliable: one of the most noticeable results, the low rating on "useful + very useful" for secondary qualified 31-40 adults, is based on a very small sample size (n=4).

Finally, we might ask whether the subjective assessments of the difficulty of understanding the numerical data presented by particular infographics is related to the assessments of their general usefulness by participants. The data suggests a considerable correlation between these two assessments, as shown in Table 7.

Table 7. Distribution of participants' answers on the difficulty of understanding (Qus. 2, 3, 4) and the usefulness of infographics in general (Qu. 9) (n=310)

		Not at all + Slightly useful	Useful + Very useful
Qu.2	Easy +Very Easy	42 (18.3%)	140 (61.1%)
	Very difficult + Difficult	6 (18.8%)	19 (59.4%)
Qu.3	Easy +Very Easy	45 (19.4%)	142 (61.2%)
	Very difficult + Difficult	9 (21.4%)	14 (33.3%)
Qu.4	Easy +Very Easy	38 (19,1%)	118 (59.3%)
	Very difficult + Difficult	15 (25.9%)	36 (62.1%)

However, Table 8 shows a different picture.

Table 8. Distribution of participants' answers on the difficulty of understanding (Qu. 5) and the usefulness of time series graphs in general (Qu. 10) (n=310)

		Not at all + Slightly useful	Useful + Very useful
Qu.5	Easy +Very Easy	14 (9.0%)	99 (63.9%)
	Very difficult + Difficult	51 (47.7%)	33 (30.8%)

Here there is a relationship between difficulty of understanding of Question 5 and the perceived usefulness of time series graphs in general, with the more difficult item being perceived as less useful. This can perhaps be explained by the higher "easiness" ratings for Questions 2, 3 and 4 (64% to 75% in Table 3) than that for Question 5 (50% in Table 4).

Discussion

A considerable number of the adults who participated in this survey, although the sample as a whole may be considered relatively highly educated, have subjectively assessed themselves as having difficulties in reading and understanding numerical information presented in various forms or embedded in textual or visual contexts. These difficulties were not generally dissimilar to those observed in lower educated persons. In any case, this is a finding of many studies concerning health numeracy issues (e.g., Lipkus et al. 2001).

In particular, about 9% of these adults assess as difficult or very difficult to understand the numerical information concerning COVD-19 which is embedded in a text such as Question 1. Some 10% to 19% report that they have comprehension difficulties with infographics, such as Questions 2, 3 and 4.

Infographics included in these questions involve many components, such as images, graphics, charts, words, and numbers. Consequently, they are more complex visuals than the usual charts which contain mostly numerical data. Infographics, using graphical, textual and numerical semiotic conventions, embed representations aiming to display coherent arguments about selected aspects of COVID-19 pandemic. Therefore, they aim to lead people to a more rapid and efficient understanding of the information they intend to convey. The difficulty in understanding reported above, however, questions the assumption of the effective conveying of coherent argument.

At the same time as these percentages of adults report difficulties in comprehending the numerical information shown in particular infographics, about 57% of adults answering Question 9 of our questionnaire consider these infographics in general to be useful or very useful for presenting information about COVD-19.

On the other hand, a greater percentage of 34.5% of adults surveyed assess as difficult to understand the fluctuations of numerical data shown in a particular time series graph. Yet about 47% assess as useful or very useful time series graphs in general presenting the numerical evolution of aspects of COVID-19. The differing patterns of correlations between assessments of difficulty in understanding numerical information included in infographics and those in time-line graphs, on the one hand, and evaluations of their usefulness in general in presenting such information are discussed in connection with Tables 7 and 8.

Our findings suggest rather considerable *age-related* differences in the distribution of participants' answers on the questions about understanding numerical information embedded in a text (Qu. 1); see Table 2c. However, no differences by age were found in their answers concerning understanding numerical information presented by infographics (Qus. 2 to 4), nor in understanding numerical information in a time series graphs (Qu. 5).

It has been shown by studies using data from international large-scale comparisons such as PIAAC that literacy and numeracy skills change during adulthood involving both gains and losses, which however occur at different ages. The cross-sectional age profile of literacy and numeracy which is depicted in these studies follows an inverted U-shape: Numeracy skills "increase" (cross-sectionally) with age throughout the second decade of life, peak at around age 30, and gradually "decline" thereafter (e.g., OECD, 2016a; Paccagnella, 2016).

Beyond average age trends, there are additional individual differences and group differences in numeracy skills change. For example, using cross-sectional PIAAC 2012 data, Paccagnella (2016) compared age differences in literacy and numeracy skills among adults with different levels of educational qualification and found that, among those with the highest educational qualifications, the apparent decreases of skills with increasing age were more pronounced than among those with lower qualifications. In any case, cross-sectional studies of age differences are limited in that they are unable to disentangle age-related changes from *cohort effects* (related to the period during which the age-group was developing). On the other hand, small-scale longitudinal studies based on selective samples cover some population subgroups in a certain life stage but not other subgroups and life stages (Lechner, et.al. 2021).

The age-related differences in the assessment of the usefulness of time series graphs in general in communications about COVID-19 by the participants in our study may stem from subjective evaluation criteria which may be influenced by age, or perhaps by the time gap since their graduation from education.

The above conclusions, however, are subject to the limitations of this research. The two most important may be summarized as follows.

First, we used a convenience sample of which the disadvantages were set out in the methodology section. As mentioned, a convenience sample, as a non-random sample, has doubtful representativeness of the population to which the researcher may wish to generalize regarding the numeracy competences studied. Therefore, any inference about the entire Greek adult population may not be valid, though it may be broadly "suggestive". However, it may be claimed, though with much caution, that if the results reported in this paper are obtained for such a convenience sample of "relatively highly educated Greek adults", they will likely report even more difficulties and lower usefulness ratings among "average Greek adults."

Further, we should underline that the use of significance tests to help judge the robustness of findings from a sample like this (as opposed to mere chance fluctuations in results) is ruled out by the lack of random sampling.

Second, a potential limitation of our conclusions comes from the use of a questionnaire asking adults to subjectively assess their difficulties and perceptions of usefulness in reading numerical information – using data presented in various forms or embedded in various contexts about COVID-19. The use of subjective assessments of adults' numerical competencies has been discussed in the methodology section of this paper. In addition, it has to be underlined here that the use of subjective assessments of numerical competencies involves the likelihood of overestimating or underestimating them by the individuals since it is not a testing of their numerical skills but an expression of their perceptions. However, there is some support in the literature for the claim that subjective assessments of numeracy of adults are effective in circumventing some of the problems associated with objective numeracy tests, for instance, those concerning the statistical numeracy of older adults (Rolison et. al., 2013).

Conclusions

In the social conditions which have been created by COVID-19, the numerical data used in communications can outline a picture of reality, provide people with the capacity to assess situations in their everyday lives, and offer them a context for assessing the actions, both individual and collective, required for ensuring their health. However, the available research data on adult numeracy, both on a general level through the PIAAC survey for Greece and through the more specific survey presented in this paper provides evidence of an existing problem concerning the health numeracy of Greek adults, even those regarded as relatively highly educated.

Reading and understanding numbers of cases and deaths from COVID-19 in their local area may lead adults to the conclusion that they must modify their behaviour, adopting all the proposed protective measures. However, for many of the adults surveyed, the use of numbers, may generate confusion or misunderstandings of the phenomena presented. For example, many adults reading daily numbers of COVID-19 infections or deaths without any reference to the corresponding total populations or observing media presentations which compare numbers of infections or deaths in their own residential area with numbers in other areas of the country, regardless of relevant population sizes, may lead adults to mistakenly appreciate the extent of their own risks.

For the time being, much remains to be learned about the advantages and disadvantages of different types of numerical information – by Greek officials and experts, and indeed worldwide. The numbers publicly presented should be accompanied by clarifications and in an understandable context (Zikmund-Fisher, 2019). Another side of the problem of adults' deficiencies in reading and understanding numerical information about COVID-19, and more generally in handling numbers about health matters, may be found in the structural inadequacies of adult education in Greece. Adult education programs of various types and forms, developed by many public and non-governmental organizations, do not include any aspect of numeracy as an essential component. This fact, combined with the abstract content of mathematics in Greek schools, has among other things, undesirable consequences for adults' numeracy skills and abilities and their attitudes towards numerical information. A lesson from the current pandemic for those involved in adult education in Greece is that a fundamental level of numeracy, especially concerning health issues needs to be developed for all adults.

Further research is needed on the competences of adults in hearing, reading and understanding quantitative data about COVID-19 since the pandemic may not be ending soon. Research projects should involve large groups of adults with different levels of education and life experience, and therefore different numeracy competences. Further research aiming to answer particular questions raised by our survey would be interesting; for instance, a further exploration of adults' difficulties in reading and understanding numerical information about COVID-19 in relation to their age. Finally, since the variable "age" appears to differentiate adults' conceptions of numerical information, additional related variables incorporating crucial aspects of differences in life or work experience, might serve to illuminate research on adult numeracy further.

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Appendix: Questionnaire

Dear all,

As you are very well aware, the pandemic which has been caused by COVID-19 has changed our lives for several months now and introduced to our thinking new words and concepts. But also a bulk of information that we need to understand and a lot of instructions we need to follow so as to protect ourselves and our social circle. This information involves as a rule a multitude of numerical data, which are presented in different forms and in various contexts: numbers of infections, people tested daily, deaths, hospitalized patients and patients in intensive-care units, and at the same time numbers of daily individual violations of restrictions.

This questionnaire is the instrument of a survey, which seeks to trace the assessments of the difficulties people encounter in understanding official communications and media news about COVID-19 that are presented in textual or visual forms as are infographics and various types of graphs.

We kindly ask you to participate in this survey by answering the following questions. It will take a few minutes from your time, and we ask you to answer these questions without much thought investment considering only your first impression formed by reading each question.

There are no wrong or right answers and we anticipate that your responses will express your subjective, personal, assessment.

The questionnaire is anonymous, and thus the confidentiality of the information gathered is guaranteed.

Your participation is valuable for our study, and we thank you very much. If you need any further details about this survey or this questionnaire do not hesitate to contact us at the sender's email.

Numbers in communications about COVID-19

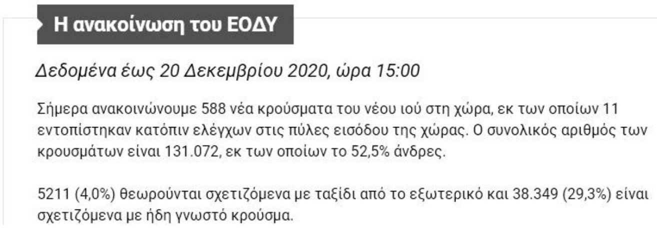
In each one of the following questions, please mark your response with an X in the corresponding box.

Gender: • M • F

Age: • less than 30 years - • 31-40 years - • 41-50 years –• more than 51 years

Education: • Elementary education - • Secondary education - • Higher education

Qu.1. Read the official announcement below and make an assessment of how difficult it is for you to understand the numbers of COVID-19 infected cases that are included in this text.



Η ανακοίνωση του ΕΟΔΥ

Δεδομένα έως 20 Δεκεμβρίου 2020, ώρα 15:00

Σήμερα ανακοινώνουμε 588 νέα κρούσματα του νέου ιού στη χώρα, εκ των οποίων 11 εντοπίστηκαν κατόπιν ελέγχων στις πύλες εισόδου της χώρας. Ο συνολικός αριθμός των κρουσμάτων είναι 131.072, εκ των οποίων το 52,5% άνδρες.

5211 (4,0%) θεωρούνται σχετιζόμενα με ταξίδι από το εξωτερικό και 38.349 (29,3%) είναι σχετιζόμενα με ήδη γνωστό κρούσμα.

 Very Easy - Easy - Neither easy nor difficult - Difficult - Very difficult

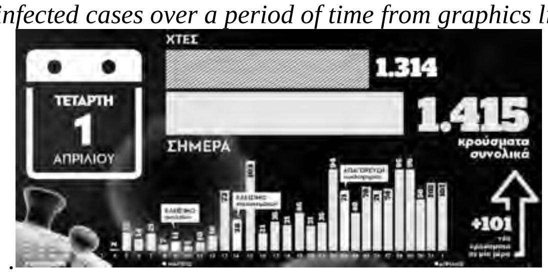
Qu.2. Take a look at the picture below and make an assessment of how difficult it is for you to understand the geographical spreading of COVID-19 from graphics like this one.

 Very Easy - Easy - Neither easy nor difficult - Difficult - Very difficult

Qu.3. Take a look at the picture below and make an assessment of how difficult it is for you to understand the relationship between numbers of COVID-19 infected cases and deaths on a certain day from graphics like this one.

 Very Easy - Easy - Neither easy nor difficult - Difficult - Very difficult

Qu.4. Take a look at the picture below and make an assessment of how difficult it is for you to understand the evolution of COVID-19 infected cases over a period of time from graphics like this one



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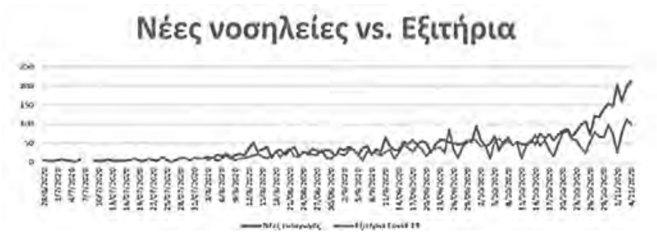
 Very Easy - Easy - Neither easy nor difficult - Difficult - Very difficult

Qu.5. Take a look at the graph below and make an assessment of how difficult it is for you to understand the relationship between numbers of new hospital admissions (infected by COVID-19) and exits (recovered from COVID-19 from line graphs like this one.



□ Very Easy - □ Easy -□ Neither easy nor difficult - □ Difficult - □ Very difficult

Qu.6. How useful do you assess the use of whole numbers in your understanding of the official communications about COVID-19?

□ Very useful - □ Useful -□ Moderately useful - □ Slightly useful- □ Not at all useful

Qu.7. How useful do you assess the use of fractions in your understanding of the official communications about COVID-19?

□ Very useful - □ Useful -□ Moderately useful - □ Slightly useful- □ Not at all useful

Qu.8. *How useful do you assess the use of percentages in your understanding of the official communications about COVID-19?*

□ Very useful - □ Useful -□ Moderately useful - □ Slightly useful- □ Not at all useful

Qu.9. How useful do you assess the use of infographics, such as these in questions 1, 2, and 3, in communicating information about COVID-19?

□ Very useful - □ Useful -□ Moderately useful - □ Slightly useful- □ Not at all useful

Qu.10. How useful do you assess the use of time series graphs, such as that in question 4, in communicating information about COVID-19?

□ Very useful - □ Useful -□ Moderately useful - □ Slightly useful- □ Not at all useful