Information Seeking Behavior at the Time of COVID-19

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Abstract

Italy was the first European country to be affected by COVID-19, facing an unprecedented situation. The reaction required drastic solutions and highly restrictive measures, which severely tested the trust of the Italian people. In this context, the role of information sources was fundamental, since they strongly influence public opinion. The central focus of this research is to assess how the information seeking behavior (ISB) of the Italian citizens affected their perception of government response strategies during the pandemic. Starting from the result of a survey addressed to 4260 Italian citizens, we used social simulation to estimate the evolution of public opinion. Particular attention has been given to different social categories, identified by age and gender. Comparing the ISB during and before COVID-19, we discovered that the shift in the ISB, during the pandemic, may have actually positively influenced public opinion, facilitating the acceptance of the costly restrictions introduced.

Keywords

CODIV-19, SARS-CoV-2, trust, fake news, misinformation, information-seeking behavior, social simulation

1. Introduction

The World Health Organization declared the COVID-19 situation as a pandemic on March 11, 2020. At that time, Italy was the European country most severely hit by this public health emergency. The COVID-19 outbreak forced the Italian State to deal with a novel, ambiguous, and unexpected risk. Politicians, local governments, and citizens had to face an unprecedented situation. The reaction to COVID-19 in Italy required drastic solutions and highly restrictive measures [18].

In this context of uncertainty and constant change, a strong need for information emerged [6], in order to understand what was going on: how the pandemic was evolving; to assess the actual risk to which all of us were subjected; to know community-level policies or personal health strategies. Quarantine, social distancing, mass swab tests, school closures, and the use of personal protective equipment are just some of the highly restrictive measures adopted to deal with the pandemic. People were required to undertake costly behavioral changes, not only in economic terms, but even restricting their personal freedom. All this was accompanied by a strong sense of uncertainty about the future. As Gualano and colleagues state [19],

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the Italian general population reported a high prevalence of mental health issues during the lockdown (depression, anxiety, poor sleep), whose impact is expected to persist beyond this critical situation.

In a time of crisis, the Italian population decided to trust its institutions and to rely on them to face COVID-19. This scenario was anything but trivial, considering the historical distrust in the Italian government and institutions in general. For sure, it is unthinkable that the authorities have suddenly become more reliable, but rather the citizens were forced by the circumstances. They had no other choice but to rely on their institutions, to trust the only entity able to face the problem, accepting all the necessary rules and restrictions [15].

Nevertheless, such a necessary choice may have resulted in a series of adjustments, in order to compensate and justify this "trust gap" [15]. As it is well known in the literature [9], in such cases, feedback and control mechanisms come into play. When there is not enough trust, making use of some type of control on the trustee allows one to lower the level of trust needed for reliance. From this consideration followed the great needs to get information, to monitor the institutions, to know that trust was well placed, and that the sacrifices the citizens were forced to make were fundamental. As Siegrist and Zingg report [39] in their systematic review on the importance of trust when preparing for and during a pandemic, trust is fundamental to positively influencing people's willingness to adopt recommended behavior.

In these cases, trust in institutions is therefore strongly linked to their communication skills, and to the fact that they are able to demonstrate the effectiveness of the proposed strategies. Even the World Health Organization, in a 2011 report [40], has identified communication as one of the biggest challenges, among the essential instruments required to tackle a pandemic. Our own opinions and beliefs are strictly tied to information we receive, especially in a moment of total uncertainty [3, 4, 38]; consider the lack of prior knowledge about this virus. This becomes particularly critical when, on the one hand there is an enormous risk, and on the other there is even the limitation of one's personal freedoms. Our trust is strongly related to information we receive and a lack of trust could lead to the non-acceptance of the rules imposed, the actual result of which depends not on the acceptance of the individual, but on the adhesion of a substantial part of the population. In such a scenario, it is clear how fundamental it is to inform citizens properly, by identifying the right communication methods and limiting the spread of misinformation. As an example, manifold fake news [36] about COVID-19 were spread, probably aiming to affect public health communication and diminish preventive measures. The main, but not exclusive source of this fake news was social media. In order to answer this situation, the Italian Ministry of Health was forced to change its communication strategies, playing a strategic role in using its official Facebook page to mitigate the spread of misinformation and to offer updates to the online public [30]. Overall, the authorities' response to fake news was effective.

Another problem that arose, with respect to information, concerned the not always complete consistency of the indications provided by official sources (the various experts: virologists, infectious disease specialists, pandemic phenomena experts, etc.) as the pandemic proceeded. This phenomenon is well known to science, as many problems typically require a certain amount of time to be studied and to produce stable knowledge. Nevertheless, the population is not accustomed to such processes. Due to constant media pressure, motivated by the necessity to investigate the different perspectives of the pandemic, there has been an overexposure of experts

in public debates. In several cases, citizens were faced with rapidly changing hypotheses, which at times were also contradictory to each other. (Has the virus lost spreading and infectious capabilities or not? Can the asymptomatic subjects transmit the virus or not?)

The study presented in this paper contributes to this fast-growing body of knowledge on the interplay between trust in institutions and the COVID-19 pandemic, aiming to assess how the citizens' information-seeking behavior influenced the perception of government response strategies during the pandemic. Specifically, we exploited the result of a survey addressed to 4260 Italian citizens to determine their ISB. Then, we realized an agent-based simulation to study the evolution of public opinion, according to citizens' ISB.
We intend to test the hypothesis that the Italian population has behaved in a virtuous way, precisely because of the use they made of information. We believe that their virtuous behavior may have affected public opinion, by making it move towards compliance with the restrictive rules, which in turn may have reduced the impact of the pandemic.

2. Related Work

Information is a primary good for human beings, as it allows to reduce uncertainty and to make the world more predictable [7]. Our own opinions and beliefs are strictly tied to information we receive, especially if we are forced to face phenomena that are currently completely unknown [3, 4, 38]. Quality information represents the basis of good decision-making, which becomes pivotal when it comes to healthcare. Information seeking behavior (ISB) refers to those activities a person engages in when identifying his or her own need for information, searching for such information in any way, and using or transferring that information [20]. Health information seeking relates to the ways in which individuals obtain information, including information about their health, health promotion activities, risks to one's health, and illness [26]. As McCloud and colleagues state [32], the breadth and nature of health information obtained influences the individual's knowledge, beliefs, and attitudes toward a specific health behavior.

In the light of such considerations, the fundamental role of ISB is clear. Much attention in the literature has focused on identifying who actively seeks or who does not seek health information, the frequency of use, and satisfaction with health information seeking [22, 25]. The issue to date is that not all individuals seek health information equally.

Several studies have shed the light on the importance of demographic features for understanding information seeking, such as socioeconomic and ethnic diversity [35, 27]. Specifically, for what it concerns COVID-19, age and gender effects could be particularly interesting, given that they also represent the two main factors that determine the mortality for COVID-19 [13, 33, 34], together with the presence of pre-existing diseases.

As far as it concerns gender, many works underlined its strong effect on ISB. As Halder and colleagues [20] state, "Gender as a variable may be useful for better understanding the cognitive and social background of human information processing and may have important implications for information dissemination services and systems." The same authors, in their study, confirmed one of the well-known gender effects in the literature. They discovered that

females seem to be more ardent information searchers when compared to males, and that they also have more information needs than males. Similarly, Manierre [31] found that females are more likely to look for health information, with respect to males. Such an effect also applies to online sources [37].

Much less known, however, are the effects of age, with particular reference to the elderly. Although there are some studies in the literature, most of them focus on their specific use of the Internet [14, 24]. Yet, having a clear picture of older adults' health information-seeking behavior has an evident and substantial practical value. Indeed, given that this social category is generally the most subject to health-related risks, understanding how the elderly relate to information would be of great help to minimizing the diffusion of poor or potentially threatening health information or improving the diffusion of useful health information [1].

In summary, given the great importance of the ISB in decision-making processes, it is clear that studying it is fundamental to understanding how individual citizens (and the whole community) responded to the COVID-19 emergency. These considerations would be particularly useful both for public institutions and for the healthcare system, allowing a better understanding of what happened and how public opinion could be better orientated in the future.

3. Survey and Sample

We will not report the full details of the entire study, which can be found at [15][17]. In this specific work, we focus our attention on a particular subsection of the original survey, taking a closer look at the information seeking behavior of the Italian citizens.

The study was conducted using a snowball sampling method to determine the respondents: it concerned a large sample (N = 4260, 57% women, mean age = 46 years), relatively well-balanced in terms of geographical provenance (33% Northern Italy, 39% Central Italy, 28% Southern Italy and main islands), with a significant portion of respondents (30%) residing in the regions most affected by COVID-19 at that time (Lombardy, Veneto, Emilia-Romagna, Marche, Piedmont). It should be noted that the mean educational level of participants was very high: almost three quarters of respondents had a degree (38%) or post-graduate specialization (34%). The main characteristics of the sample are shown in Table 1.

Data were collected with a 57-item questionnaire, using a 5-point Likert scale for most items. An English translation of the whole questionnaire is available at [15].

The questionnaire was aimed to investigate the participant's overall trust towards public authorities and their motivations, along with the factors that determine the participant's trust. The questionnaire was based on the socio-cognitive model of trust developed by Castelfranchi and Falcone [10] and explored participants' opinions on five main dimensions, in relation to the current COVID-19 crisis in Italy:

1. Evaluation of the competence of public institutions;
2. Evaluation of the intentionally of public institutions;
3. Purposes and effectiveness of the public institutions' intervention;
4. Trust and information sources: the most used sources of information and their perceived trustworthiness;
5. Expectations about the future scenarios that will arise, once the COVID-19 crisis is over.

Table 1
Sample characteristics.

	Regions Most Affected % (30%)	Regions Less Affected % (70%)	Total %
Gender			
Men	45	42	43
Women	55	58	57
Total	100	100	100
Age (Mean = 46)			
18–29	19	11	13
30–39	23	18	19
40–49	23	24	24
50–59	21	28	26
60–69	11	15	14
>70	3	4	4
Total	100	100	100
Educational Level			
Middle school	3	2	2
High school	24	27	26
University degree	41	36	38
Post-graduate specialization	32	35	34
Total	100	100	100
Geographical provenance			
Northern Italy	96	7	33
Central Italy	4	53	39
Southern Italy/islands	0	40	28
Total	100	100	100

As already stated, in this work we will mainly focus on the fourth point. Specifically, we analyzed the information seeking behavior (ISB) of the respondents, with particular reference to the following sources of information:

- Traditional media (TM);
- Official websites (OW);
- Social media (SM);
- Family physicians (FP);
- Scientists (S);
- Friends, relatives, acquaintances (FRA).

3.1. Effects of Age and Gender

As highlighted in Section 2, age and gender are two particularly interesting features, given their influence on ISB. Furthermore, in this specific domain, they strongly affect the mortality for COVID-19. This section has the purpose of presenting the peculiarity introduced by such features.

Comparing male and female respondents, significant differences emerged concerning their ISB. We identified an average 4% higher information request for women, with respect to men. Such a difference increases when we consider the use of online sources. There is an increment of +6.6%, confirmed by correlation data, both for official websites ($R = 0.124$, $p < 0.0001$) and social media ($R = 0.1$, $p < 0.0001$). This effect is well-supported by previous evidence in the literature, since other studies detected a higher tendency of women to refer to online sources for health information [8, 42]. This effect disappears when we consider scientists as information sources (there is a slight difference of −0.7%). On the contrary, we did not find significant gender effects about trust.

Investigating the effects of age, we also considered a 10-year range re-coding. The idea that led to the categorization process was to investigate the behavior of individuals subjected to the same level of risk (death rate). In this regard, we refer to the most common death rate classifications (age, sex, existing conditions of COVID-19 cases and deaths, https://www.worldometers.info/coronavirus/coronavirus-age-sex-demographics/; accessed at 15/03/2020) [34], considering age in 10-year ranges. As far as it concerns age, young people tend to consult information sources with a lower frequency, compared to older people, going from an average frequency of use of 53.86% for 18–29 to a 61.41% for people over 70. The different levels of risk that COVID-19 entails between young and old people [33, 34], in particular in the severity it can take, could at least in part explain the differences introduced by age regarding the willingness to keep informed about this phenomenon. Young people were also the most suspicious with respect to sources of information: 30–39 year-old people showed the lowest level of trust (57.71%, slightly higher than 18–29), which increased with age until 64.03% for people over 70.

Combining the effects of age and gender (Table 2), we found that 18–29 year-old men had the lowest average frequency of use (52.9%) while 30–39 year-old men had the lowest level of trust (58.9%). In contrast, over 70 year-old women were the most prone to use information sources (63.3%) and to trust them (68.2%).

Table 3 reports the frequency of use for the different information sources. Focusing on the least trusted ones, we observed that people over 70, more exactly women, are the ones that make most use of FRA and social media. The people over 70's average use of social media was 37.4%, and it even increased up to 49.2% for women. Advanced age does not seem to have represented a barrier to accessing social media. This result is even more striking when crossed with the analysis of trust (Table 4). The average trust in social media is about 20%, but it rises to 29% for men over 70, and even to 39% for women over 70. Summarizing, on the one hand, women over 70 make extensive use of information sources; on the other hand they show a higher level of trust in social media, which certainly cannot be considered the most reliable source. A deeper analysis of these two contradictory characteristics may offer some interesting insights.

Given the critical role age and gender have on ISB, we decided to introduce them in our framework as categorization criteria. This allowed us to understand how the different social categories use information sources and what impact this has on their opinion. Combining age and gender, we considered a total of 12 social categories.

Table 2
Average values of frequency of use and trust in information sources, based on age and gender.

Category	Average Use	Average Trust
women 18–29	55.36 %	60.85%
women 30–39	56.54%	60.02%
women 40–49	59.10%	61.30%
women 50–59	59.58 %	61.99%
women 60–69	61.83%	63.27%
women over 70	63.33 %	68.15%
men 18–29	51.93%	59.85%
men 30–39	52.43%	58.86%
men 40–49	54.07%	59.94%
men 50–59	55.46%	59.78%
men 60–69	57.85%	60.68%
men over 70	60.01%	63.11%

4. Simulations

In this work, the use of simulations has allowed us to estimate how the opinions of classes of individuals and of a whole community evolved, starting from the specific use the citizens made of information sources. In order to study opinion dynamics, we considered a model based on that proposed by Hegselmann–Krause [21], whose effectiveness has been proven over time. Their model has been modified here by introducing the probabilistic use of information sources.

Then, given the belief b as "the institutional truth" to tackle COVID-19 outbreak (i.e., "it is essential to use face masks," or "it is necessary to maintain social distance"), the citizens, modeled in the simulation as agents, had different opinions about said belief, since the information sources they used may have reported evidence supporting b or opposing it. As we supposed b to be the institutional truth, opposing information represents, for simplicity, misinformation and/or fake news.

Let n be the number of information sources under consideration. To model the repeated process of opinion formation, we considered a discrete-time system; thus time was divided in rounds $T = \{0, 1, 2, ...\}$. For a fixed agent i, we denote its opinion at time t by $x_i(t)$, expressed as a real number in [0,1]. Similarly, for a fixed information source j, we denote information of the sources j at time t by $inf_j(t)$. While fixing an agent i, δ_i represents the weight i gives to its own opinion, and a_{ij} is the weight given to information coming from the source j, with $1 \leq j \leq n$.

Furthermore, let $\delta_i \geq 0$ and $a_{ij} \geq 0$ for all i and j, an let their sum be equal to 1, as in Equation (2). This last condition is not mandatory, but it allows us to avoid the normalization process. Considering this notation, opinion formation of agent i can be described as in Equation (1).

$$x_i(t+1) = \delta_i * x_i(t) + a_{i1} * inf_1(t) + a_{i2} * inf_2(t) + \cdots + a_{in} * inf_n(t) \tag{1}$$

$$\delta_i + a_{i1} + a_{i2} + \cdots + a_{in} = 1 \tag{2}$$

In addition to the Hegselmann–Krause model, we considered that i would not use all its source at each round, but just a subset of them. This characteristic allowed us to model a frequency-based access to the sources, which is precisely what the citizens stated to do. Therefore, we introduce

the function $use_{ij}(t)$, whose Boolean result determines if i will make use of the source j at time t. Thus, our model will be described by Equations (3) and (4).

$$x_i(t+1) = \delta_i * x_i(t) + a_{i1} * inf_1(t) * use_{i1}(t) + a_{i2} * inf_2(t) * use_{i2}(t) + \cdots + a_{in} * inf_n(t) * use_{in}(t) \quad (3)$$

$$\delta_i + a_{i1} * use_{i1}(t) + a_{i2} * use_{i2}(t) + \cdots + a_{in} * use_{in}(t) = 1 \quad (4)$$

Given this framework, we are interested in understanding how the opinion of the agent i, characterized by an initial profile and a specific ISB, evolves over time. By doing this analysis for each category of citizens, we are able to determine how the particular ISB of a category influences the final opinion of the citizens belonging to that category.

The data we need are:

1. Initial profile of the agent i, given by $x_i(0)$ and δ_i;
2. ISB, i.e., $use_{ij}(t)$ and a_{ij} for each information source j;
3. Actual trustworthiness of each information source j, in order to generate $inf_j(t)$.

As far as it concerns $x_i(0)$ and δ_i, we considered a situation in which these two parameters did not affect the final outcome. Notice that, in such a system, given that information sources influence citizens but the opposite never happens, after a sufficiently wide time window $x_i(t)$ can be considered as independent of $x_i(0)$. Accordingly, we introduced a long transient phase, which ensured that this condition holds. With respect to δ_i, it affects the stability of $x_i(t)$ in time, determining how much it can vary from round to round: increasing δ_i makes $x_i(t)$ more stable and vice versa. In order to nullify the influence of δ_i, we did not simply analyze the final value of $x_i(t)$, but its average value after the transient phase.

The ISB is definitely the most interesting part, since in this experiment we exploited it to study its effect on the citizens' opinion. In such a context, $use_{ij}(t)$ is represented by the frequency of use of the sources. For instance, if i has a frequency of use of 50% for source j, this means that there is the 50% probability that i will access this source at time t. For what it concerns the weights given to the reported information, a_{ij}, this can be generate by the trust value i has on j for reporting information about COVID-19. For the sake of simplicity, we used already normalized weights, as in Equation (4) (of course, given Equation (4), it is also necessary that $\delta_i \neq 1$; otherwise, $x_i(t)$ will not be affected by information sources). Specifically, we keep δ_i fixed, and we assign the weights of the other sources proportionally to their trust values. The choice to use trust values as weights for information source has a solid foundation in the literature [2, 5, 16] for other models and specifically for Hegselmann–Krause [23]. All the data we need to generate $use_{ij}(t)$ and a_{ij}, the frequency of use and the average trust, can be found respectively in Tables 3 and 4.

We come therefore to the last parameter of the experimental setting, the actual trustworthiness of the information sources. Unfortunately, there is no way to find such data. To the best of our knowledge, we could not find any study about it, which is reasonable, since it is not that easy to produce a precise quantification of how trustworthy these information sources were during the pandemic. Nevertheless, two possible approaches allowed us to overcome the problem. The first one consists of equalizing trust (the assessment of the trustor) and trustworthiness (the intrinsic property of the trustee, determining its actual performance). Given that it is rarely possible to directly access the effective value of trustworthiness, we may reasonably suppose that the

Table 3
Frequency of use for each information sources, based on age and gender.

Category	TM	OW	SM	FP	Scientists	FRA
women 18–29	77.82%	78.61%	42.24%	31.58%	59.56%	42.32%
women 30–39	75.67%	83.73%	41.94%	32.54%	67.08%	38.31%
women 40–49	82.33%	83.77%	39.92%	38.86%	74.53%	35.17%
women 50–59	84.75%	82.19%	37.81%	39.82%	76.93%	35.97%
women 60–69	87.38%	80.05%	38.88%	46.21%	81.31%	37.15%
women over 70	91.25%	61.25%	49.17%	48.33%	79.17%	50.83%
men 18–29	68.85%	75.81%	35.79%	25.20%	66.94%	39.01%
men 30–39	73.44%	78.28%	31.80%	26.39%	69.92%	34.75%
men 40–49	76.89%	77.24%	34.67%	30.84%	72.82%	31.96 %
men 50–59	80.14 %	74.79%	34.53%	36.76%	75.95%	30.56%
men 60–69	86.84%	70.94%	29.77%	47.88%	78.62%	33.04%
men over 70	88.41%	65.85%	35.98%	54.88%	75.00%	39.94%

Table 4
Trust in information sources, based on age and gender.

Category	TM	OW	SM	FP	Scientists	FRA
women 18–29	55.09%	89.73%	19.83%	64.66%	88.56%	29.78%
women 30–39	54.53%	87.88%	19.27%	64.79%	86.78%	30.34%
women 40–49	55.72%	87.29%	20.34%	69.32%	90.04%	30.04%
women 50–59	57.63 %	86.64%	20.72%	69.54%	89.82%	32.63%
women 60–69	59.38 %	86.04%	21.45%	71.77%	91.32%	34.70%
women over 70	65.42 %	84.58%	38.75%	75.42%	90.42%	48.75%
men 18–29	51.01 %	87.60%	20.87%	66.23%	88.51%	30.24%
men 30–39	50.33 %	85.57%	16.39%	66.64%	87.38%	28.85%
men 40–49	55.25 %	84.73%	18.51%	69.93%	87.38%	28.54%
men 50–59	56.46 %	82.15 %	18.33%	69.70%	88.56%	29.56%
men 60–69	59.19 %	81.54%	19.43%	70.94%	89.13%	31.27%
men over 70	60.06 %	77.44 %	28.96%	73.17%	91.16%	39.33%

assessment of the survey respondents approximates sufficiently well the real trustworthiness of the information sources. To give a clearer idea, this is exactly what currently happens in systems such as Google, Ebay or TripAdvisor: the evaluation of a seller/restaurant/hotel is obtained by aggregating the evaluations produced by a multitude of individuals; this is not the real trustworthiness, but it is an appropriate approximation. In this specific case, we easily extrapolated such data from the questionnaire. We believe that this first approach (average trust value—*ATV*), with a certain margin of unavoidable error, represents the most precise solution.

As an alternative, it is possible to arbitrarily rank the sources on the basis of their perceived trustworthiness (trustworthiness-based sorting—TBS), assigning the specific values accordingly. In the ATV case, these values approximately vary form a minimum of 20% to a maximum of 90%. We consider the same ranking and the same range in the TBS case, distributing the 6 sources in intervals of equal dimensions. In this study, we took into account both the possibilities.

As already stated, the trustworthiness of a source determines $inf_j(t)$; i.e., it represents the actual probability that the source j will report information supporting the belief b, at time t.

For instance, in the ATV case, scientists will report supporting information ($inf_j(t) = 1$) 88.85% of the time, and opposing information ($inf_j(t) = 0$) the rest of the time.

Considering the workflow of the simulation, at the beginning of each run, we found the various information sources, each described by a specific value of trustworthiness, and a number of citizens. Each citizen i belongs to a specific category, identified by age and gender, which in turn determines its ISB. At each round of this phase:

1. The sources report fresh information supporting b or opposing to it;
2. The citizen i accesses a subset of the available information sources, according to its ISB, and updates its opinion $x_i(t)$ according to the formula 3.

The simulation consists of two different parts: the transient phase, whose sole function is to ensure that the citizen's initial profile will not affect $x_i(t)$ in the next phase; the analysis phase, in which we actually analyze the value of $x_i(t)$. In particular, we are interested in the average value of $x_i(t)$ during this last phase, which is used, within this framework, as a performance indicator. Ideally (for the institutions), this dimension should tend towards the target value 1 (the citizen believes b to be true), while low values are undesirable (the citizen does not believe b).

The resulting model has been implemented in the simulation environment NetLogo (version 5.2) [41].

5. Results

In the following experiments we considered a social simulation by implementing the model introduced in the previous sections. Specifically, we were interested in:

- Determining how much the ISBs of the different categories of citizens, classified by age and gender, affected their opinions, and in turn, their choices during the pandemic.
- Trying to compare the ISBs identified in this study with those prior to COVID-19 arrival. Such a comparison may help determine whether and to whay extent the citizens' rational and responsible choice to rely on trusted sources positively affected their acceptance of restrictions and rules needed to face the pandemic.

5.1. First Experiment: The Influence of ISBs on the Citizens' Opinions

The analysis in Section 3.1 suggests that women and older people show a greater interest in information (regarding the pandemic), while young men seem to be the most disinterested category. That being said, it is still necessary a more in-depth analysis to understand how these characteristics affected the opinion of the individuals, making them more or less resilient to misinformation. Especially for women over 70, we thought it interesting to verify how their frequent usage and high trust in social media have affected their opinions, and whether their higher use of the other sources can compensate for these contrasting characteristics. More generally, it is particularly useful to quantify the impacts of information sources on the various categories of citizens. Consider, for instance, that being able to study and to quantify the

Table 5
Trustworthiness of the sources of information.

source of information	ATV	TBS
Scientists	88.85%	90%
OW	85.82%	76%
FP	68.63%	62%
TM	55.91%	48%
FRA	31.04%	34%
SM	20.02%	20%

evolution of their opinion would allow the institutions to identify which part of the population needs targeted interventions, offering the possibility to optimize the available resources.

While aiming to quantify those dimensions, within this section we introduce an agent-based simulation, which allows us to evaluate how the citizens' opinion changes depending on their ISBs. In particular, we considered an opinion dynamics model based on that proposed by Hegselmann–Krause [21]. Their model is used to investigate opinion dynamics within a group of individuals who interact with each other by exchanging opinions. Within this experiment, we focus on the opinions of individuals, in a context in which they receive information from their sources in a unidirectional way (the source reports information to the individual, but the opposite does not happen). Conversely, in the next experiment we consider the opinion of the whole population.

We report below the experimental setting:

1. Transient phase: 2000 rounds. Actually, we verified that a significantly lower number of rounds would be sufficient. Yet, we decided to use a high value.
2. Analysis phase: 100 rounds.
3. $x_i(0)$: 0.5. As we stated, this parameter did not affect the final values.
4. δ_i: 100%. As we stated, this parameter did not affect the final values.
5. Number of citizens: 1200, i.e., 100 for each category.
6. Frequency of use in Table 3.
7. Trust in information sources in Table 4.
8. Trustworthiness of the information sources for the *ATV* and *TBS* cases in Table 5.

The data summarized in Table 6 show the findings of the experiment, both in the ATV case and the TBS case. Overall, we observe a positive tendency, as the average opinion of all the categories of citizens is over the threshold 0.5. This result was driven by the intensive use of reliable information sources, first, above all, scientists. Nevertheless, it is worth noting that in none of the cases analyzed did we encounter a striking value, particularly close to the target value 1.

Coming then to detail, it is plainly clear that women over 70 had the worst performance. Their average opinion is 0.661 in the ATV case and 0.628 in the TBS case.

In contrast, 30–39 year-old men showed the best performance: their average opinion was 0.731 in the ATV case (+7% with respect to the worst case) and 0.69 in the TBS case (+6.2% with respect to the worst case).

Table 6
Average values of the citizens' opinions during the analysis phase. The citizens are grouped by age and gender. We report average values over 100 simulations.

Category	Average Opinion—ATV	Average Opinion—TBS
Women 18–29	0.704	0.661
Women 30–39	0.719	0.677
Women 40–49	0.723	0.682
Women 50–59	0.723	0.683
Women 60–69	0.715	0.677
Women over 70	0.661	0.628
men 18–29	0.718	0.679
men 30–39	0.731	0.69
men 40–49	0.726	0.686
men 50–59	0.723	0.684
men 60–69	0.716	0.677
men over 70	0.69	0.654

5.2. Second Experiment: A Comparison between the Citizens' ISBs before and after the Arrival of COVID-19

All the data and the analyses previously reported in this work clearly suggest a substantial virtuous behavior of the Italian population. In particular, in the attempt to get reliable information, there has been an extraordinarily high reliance on science. We can then assert that this virtuous behavior actually played an important role in the fight against the pandemic: being properly informed encouraged the acceptance of the rules and guidelines, despite the high personal burden.

It would be interesting to quantify to which extent this virtuous behavior has helped to reduce the impact of COVID-19. In this sense, our effort within this second experiment was to compare the estimation of the public opinion in this case with what would have happened if the population had behaved, with respect to information, as it usually did in health-related contexts before COVID-19. We made use of the same framework of the previous experiment. If, however, we previously evaluated the individual categories, here we were interested in studying the opinion of the whole population. In other words, we implemented the logic of the previous experiment, considering a whole community, made up of citizens belonging to the same categories. In order to obtain a more likely outcome, we took into account the real distribution of the Italian population, according to age and gender. Such data, current as of January 2019, have been retrieved from the Istat website (http://dati.istat.it/Index.aspx?QueryId=42869 accessed at 07/08/2020). Table 7 summarizes them.

We considered a population of 1000 citizens, which allowed for a more precise distribution of the citizens among the categories. Then we analyzed the average opinion of the whole population. We compared the results obtained with the ISBs extrapolated from our survey (outbreak setting—*OS*), concerning the COVID-19 outbreak, with the one (prior setting, *PS*) retrieved by the fairly recent study of Zucco and colleagues [42], conducted in May 2017 in Italy (N = 913). The study aimed to identify the ISB concerning antibiotics and health in general. Even

Table 7
Distribution of the Italian population by age and gender, current as of January 2019.

Category	Men	Women
18–29	7.55%	7.01%
30–39	7.02%	6.94%
40–49	9.06%	9.17%
50–59	9.03%	9.42%
60–69	6.93%	7.55%
over 70	8.55%	11.76%

Table 8
Frequency of the use of information sources extrapolated from the study of Zucco and colleagues.

	TM	OW	SM	FP	Scientists	FRA
frequency of use	13.6%	27.6%	45.1%	71.6%	8.9%	1.7%

if it does not provide all the data we needed concerning health in general, it does for antibiotics. Moreover, at least for what concerns the available data, the frequencies of use appear quite similar in these two contexts. Thus, we considered data about information sources' usage for antibiotics (Table 8). We considered the same population of 1000 citizens, verifying how the average opinion changed when introducing the ISBs of Italian population before COVID-19.

Summarizing the experimental setting:

1. Transient phase: 2000 rounds. Actually, we verified that a significantly lower number of rounds would be sufficient. Yet, we decided to use a high value.
2. Analysis phase: 100 rounds.
3. $x_i(0)$: 0.5. As we stated, this parameter did not affect the final values.
4. δ_i: 100%. As we stated, this parameter did not affect the final values.
5. Number of citizens: 1000, distributed by age and gender according to Table 7.
6. Frequency of use: Table 3 for OS agents and Table 8 for PS agents.
7. Trust in information sources in Table 4.
8. Trustworthiness of the information sources in Table 5.

Results in Table 9 highlight a substantial difference of opinion. Specifically, OS agents had +8.2% and +9.1% higher outcomes, respectively, in the ATV and TBS cases. These findings suggest that the responsible behavior of the population, with respect to information, has indeed helped the acceptance of the rules imposed by the institutions and it may have contributed to reducing the impact of COVID-19.

6. Discussion

In this study, we focused on the ISB of the Italian population during the early stages of the pandemic. In a situation of high risk and uncertainty, accurate information becomes priceless. This is what happened in Italy, in the early stages of the COVID-19 pandemic. On the one hand,

Table 9
Average opinion of the OS and PS populations, in the ATV and TBS cases.

	Average Opinion—ATV	Average Opinion—TBS
OS	0.71	0.664
PS	0.628	0.573

there was the growing need to be informed about what was happening in order to understand the general characteristics, the risks, and the evolution of the phenomenon. On the other hand, information represented a way to check and control the actions of the institutions, to check that everyone's personal sacrifice was not in vain, that the granted trust was not misplaced. Even the World Health Organization, in a 2011 report [40], identified communication as one of the biggest challenges to tackle a pandemic. We found confirmation of this in our analysis, detecting a strong correlation (R = 0.545, $p < 0.0001$) between trusting institutions for managing the COVID-19 emergency and as a source of information for the same topic.

From the need to rely on the institutions, in a historical context of substantial distrust, followed the necessity to introduce control mechanisms to fill this trust gap, to supervise somehow the actions of the institutions. What we detected here is a well known phenomenon in the literature [9, 11]. When the trustor (citizens) does not trust enough the trustee (Italian institutions), it can decide to introduce control mechanisms to check the trustee's actions. Thus, the trustor (to realize the practical act of trusting) needs a lower level of trust (as mental attitude). In our specific case, to trust the institution was the only possible choice; thus, the higher information request [6] was introduced as a control mechanism.
This affected not only the quantity, but also the quality of the information requested. Indeed, we detected significant changes with respect to people's behavior towards information. Such changes may have positively affected the effectiveness of the measures introduced to tackle the pandemic, facilitating their acceptance by the whole population. The most remarkable result is probably the very high usage of scientists as information sources. About 92.6% of the respondents reported to trust scientists. This is definitely far from what has been found in other studies [42], especially if we consider the marginal role science has played in Italy over the last few decades. It is worth noting that, before COVID-19, Italy had a fairly worrying scientific picture, both from the political and the societal perspective (decreasing funding for the sector, and citizens' distrust towards scientific rationality: think of phenomena such as flat-Earthers or anti-vaxers). After the COVID-19 outbreak, science has suddenly recovered an important role in the citizens' consideration. This is quite reasonable because the only concrete answer (both as analysis of the phenomenon and as ability to mitigate and oppose to it by new tools and approaches) was the one provided by science and scientific research.

As far as it concerns age and gender, we found that they significantly affect the ISB. For example, it is interesting to note the case of women over 70 compared to other categories: they make a particularly relevant use of social media. This is alarming, since the category subjected to the higher risk is also the one that relies most on those that are widely identified as the least reliable media. Experiments confirm that this characteristic has a strong negative impact on women over 70, such that their average opinion is the lowest ever (compared to the institutional point

of view). It is a serious problem that one of the groups subjected to the highest risk [12, 29] relies that much on what looks like the worst information source (at least from the institution's point of view). Therefore, such a negative performance is not related to lack of information, but rather to a lower ability to relate to information [28]: they probably do not know they should distrust social media.

The most interesting and remarkable contribution of this work is the comparison of the ISB detected during the pandemic with that detected in other studies before the arrival of COVID-19. Indeed, it appears that the exceptionally responsible use of information sources has had a positive effect on the opinion of the Italian population (+8.2% and +9.1% higher, respectively in the ATV and TBS cases). Such a difference is particularly critical, as it concerns the average opinion of the population. Consider, in fact, that the effective success of the rules introduced to deal with COVID-19 depended on the adoption of these rules by a significant percentage of the Italian population. Therefore, a lower average opinion was not just a symptom of a lower acceptance level, but it could have involved a chain reaction, discouraging even those who considered such measures useful. Such a situation was clear both to citizens and institutions: the perceived utility of these measures positively correlated with believing that a sufficient number of individuals will follow these restrictions ($R = 0.233$, $p < 0.0001$) and negatively correlated with believing that an insufficient number of people will do that ($R = -0.21$, $p < 0.0001$). In view of these findings, we may conclude that the responsible behavior we detected in this study, with respect to information, has indeed helped the acceptance of the strict and restrictive rules imposed by the institutions and it may have contributed to reducing the impact of COVID-19.

7. Conclusions

In this work, we investigated the relationship between COVID-19 and the citizens' need for information. This need for information explains the disproportionate increase in trust that we have witnessed (and that the original survey [15] accurately reported). In fact, a verification and control mechanism came into play, acting as a compendium (and as a rational and non-fideistic moderator) to the disproportionate trust we have witnessed (and which proved to be necessary to face such a delicate phase). Verifying and controlling the development of the epidemic and the countermeasures put in place with their potential effects and findings represented a particular input that is clearly captured by this study which defines its characteristics and methods.

This study shows how the role of information was fundamental in dealing with COVID-19. Thanks to the possibility of obtaining information and comparing the different sources of information, citizens have been able to appreciate the fundamental role played by science in modern societies. Obviously, even the information coming from scientists has had a dynamic (with some contradictory positions) strictly linked to the awareness that science has acquired over time on the phenomenon in question. Our hope is to witness a maturation of public opinion towards the sources of information that persist over time. Moreover, although the critical phase of the pandemic seems to be over, it is essential to continue monitoring its evolution, taking care of the complex relationship between the institutions and citizens. We sincerely hope that the considerations included in this work, in addition to clarifying what has happened in the past months and what has worked or not, can also help public institutions and the healthcare

system in the future.

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