DOI: 10.4081/aiua.2023.11341

ORIGINAL PAPER

# Telemedicine and YouTube™: Video quality analysis before and after COVID-19 pandemic

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**Summary** ***Objective: To assess the quality content of YouTubeTM videos on telemedicine during COVID-19 pandemic.***
***Materials and methods: First, the frequency of worldwide YouTube™ and Google™ searches for telemedicine was analyzed. Second, we queried YouTube™ with telemedicine-related terms. Third, the Patient Education Materials Assessment Tool for Audiovisual Materials (PEMAT A/V), the Global Quality Score (GQS), and the Misinformation tool were used for the quality assessment.***
***Results: According to selection criteria, 129 videos were collected for the analysis. From January 2018 to January 2022, the peak relative interest on YouTube™ and Google™ occurred in March 2020. Of all, 27.1 and 72.9% were uploaded before (Jan 2018-Feb 2020) and after (Mar 2020-Mar 2022) the COVID-19 outbreak, respectively. According to the PEMAT A/V, the overall median understandability and actionability was 50.0% (33.3 [IQR 0-66.7] vs 50.0 [27.1-75], p = 0.2) and 66.7% (63.6 [IQR 50.0-75.7] vs 67.9 [50.0-79.2],p = 0.6), respectively. According to GQS, 3.9%, 17.8%, 24.0%, 26.4% and 27.9% were classified as excellent, good, medium, generally poor, and poor-quality videos, respectively. The highest rate of poor-quality videos was recorded in videos uploaded before COVID-19 pandemic (37.1 vs 24.5%). According to overall misinformation score, a higher score was recorded for the videos uploaded after COVID-19 pandemic (1.8 [IQR 1.4-2.3] vs 2.2 [1.8-2.8], p = 0.01).***
***Conclusions: The interest in telemedicine showed a significant peak when the COVID-19 pandemic was declared. However, the contents provided on YouTubeTM were not informative enough. In the future, official medical institutions should standardize telemedicine regulation and online content to reduce the widespread of misleading information.***

KEY WORDS: *Telehealth; Virtual healthcare; Healthcare technology; COVID-19; Social media.*

Submitted 24 January 2023; Accepted 17 February 2023

## INTRODUCTION

The terms telehealth and telemedicine are often used interchangeably. Telehealth is the provision of health care remotely by means of a variety of telecommunication tools, such as smartphones, and mobile wireless devices, with or without a video connection (1, 2). Telemedicine has been defined as the communication of medical information among users through electronic devices, referring to specific clinical services (2-4).
During the COVID-19 pandemic, the request for telemedicine activities increased exponentially (4-7). Indeed, the *World Health Organization and the Centers for Disease Control and Prevention* (USA) encouraged the use of telemedicine with the aim of limiting people's mobility and reducing the chance of infection, without compromising patients' care (8-10).
Nowadays, the Internet is deeply used for professional networking, medical education, research recruitment, and patient information (11-13). Among Internet sources, *YouTube*™ is the second most used website and over 2.6 billion people worldwide use it at least once a month (14). The open-access material on this platform, which is not peer-reviewed as scientific materials published on PubMed, might spread misleading information. Consequently, a quality information analysis must be required.
The aim of the current study was to evaluate the overall quality of *YouTube*™ telemedicine-related videos and how it changed before and after COVID-19 pandemic.

## MATERIALS AND METHODS

### *Web interest assessment*

We evaluated the interest of the worldwide web users in telemedicine. We queried Google™ Trends (15) with the terms "*Telemedicine*" and "*Telehealth*", using the following search settings: "*worldwide*", "*period from 01/01/2018 to 01/01/2022*", and "*all the categories*". The trends of Google™ and *YouTube*™ search were independently recorded: the data was depicted as a 0 to 100 scale. The value 100 indicates the highest search frequency of the term, and 50 indicates half of the searches. A score of 0, on the other hand, indicates that not enough data was found for the term.

### *Search strategy, selection criteria, and videographic characteristics*

We queried *YouTube*™ with 19 keyword combinations (***Supplementary Table 1***). The search was performed in

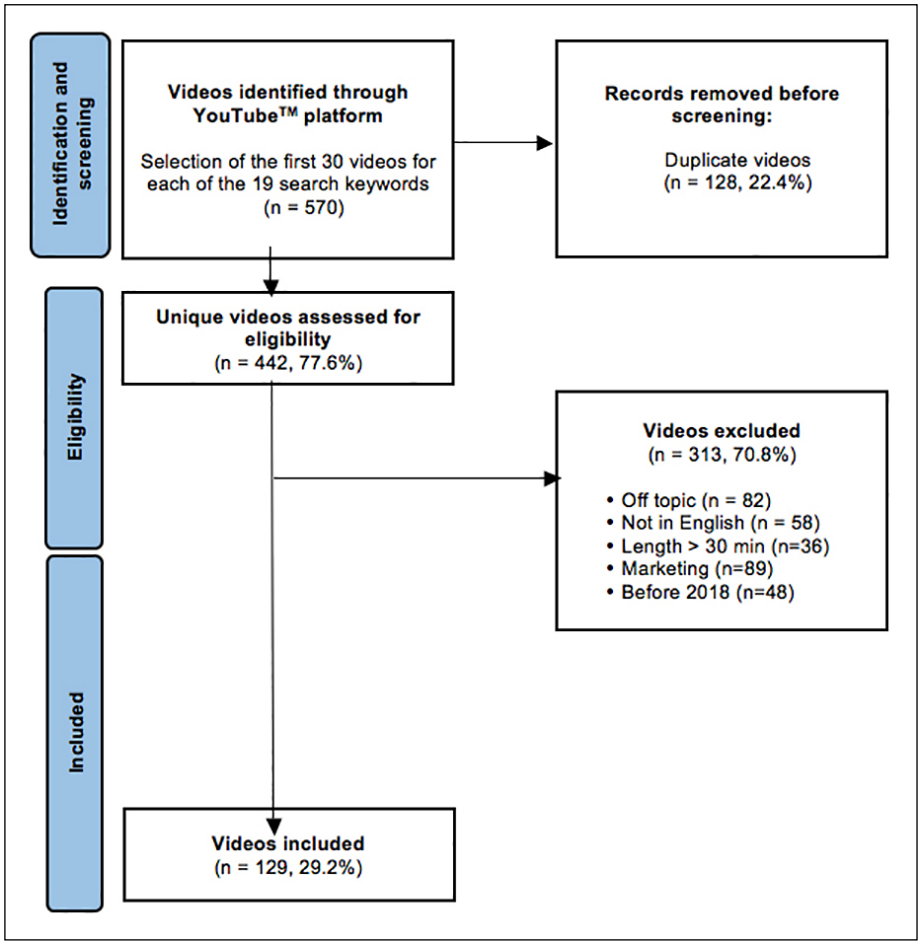


***Figure 1.***
*PRISMA diagram depicting inclusion and exclusion criteria of YouTube™ video search.*

incognito status to minimize the search history and the geographically related biases.

The first 30 videos were examined for each of the 19 keyword combinations. A total of 570 videos was achieved. The following exclusion criteria were applied: duplicates, non-English language, off topic, video length > 30 minutes, and video with marketing purpose.

The videos published after the 1st of January 2018 were included. A total of 129 videos were eligible for the analyses (Figure 1).

For each of the 129 videos included, the following variables were collected on the 25th of March 2022: length (minutes), views, persistence time on *YouTube*™ (days), view ratio (defined as the ratio between the number of views and the persistence time on *YouTube*™), likes, subscribers, number of videos with or without disabled comments, authoring entity (private users, medical doctor, hospitals [such as academic hospitals and academic institutions, or non-academic hospitals and institutions, health-care centers, private practice hospitals], and others [such as news channels, general communication channel, talks]) and target audience (healthcare workers, patients and other [such as general public]).

According to the recent *YouTube*™ rules, dislikes are not visible anymore for general Internet users.

The *YouTube*™ videos were further stratified according to the date of the upload before and after the COVID-19 outbreak (March 2020) (16, 17).

### *Strategies and instruments for the assessment of videos content*

Video contents were assessed independently by two medical doctors [L.C. and G.M.F.].

A third investigator, a senior urology resident [C.C.R.], adjudicated any differences, and the consensus was achieved among all reviewers.

The reviewers were blinded to each other's evaluations.

The *Patient Education Materials Assessment Tool for Audiovisual Materials* (PEMAT A/V), the *Global Quality Score* (GQS), and the Misinformation tool were used for the video quality assessment.

First, the PEMAT A/V is a systematic tool designed to be completed by professionals, including healthcare providers, health librarians, and others, who provide high-quality materials to patients or consumers. It consists of 17 items developed to evaluate and compare the Understandability (questions 1-13) and Actionability (questions 14-17) of patient education materials. Three answers were permitted (agree = 1, disagree = 0, not available = NA). The total score was presented as a percentage obtained by the sum of all points, divided by the number of the items judged as agree or disagree. Higher scores detect more understandable and actionable content (12, 18, 19).

Second, The GQS is a validated tool assessing the quality, feasibility, and clinical utility of each video. Five possible scores from 1 (poor quality, poor flow, most of the information missing, not at all useful) to 5 (excellent quality, excellent flow, completely accurate information, very useful) were assigned (20).

Third, the Misinformation tool consists of 5 questions appositely created for the porpoise of the study, as previously done (21-24). The aim of this tool is to examine relevant aspects not investigated with the other validated tools. The questions are as follows: 1. *Is the telemedicine definition correctly provided?* 2. *Is the telemedicine aim correctly described?* 3. *Are the instruments used for telemedicine correctly described?* 4. *The patients' consent regulation in telemedicine is correctly described?* 5. *Are the limits of telemedicine well explained?* The possible scores range from 1 (extreme misinformation) to 5 (no misinformation).

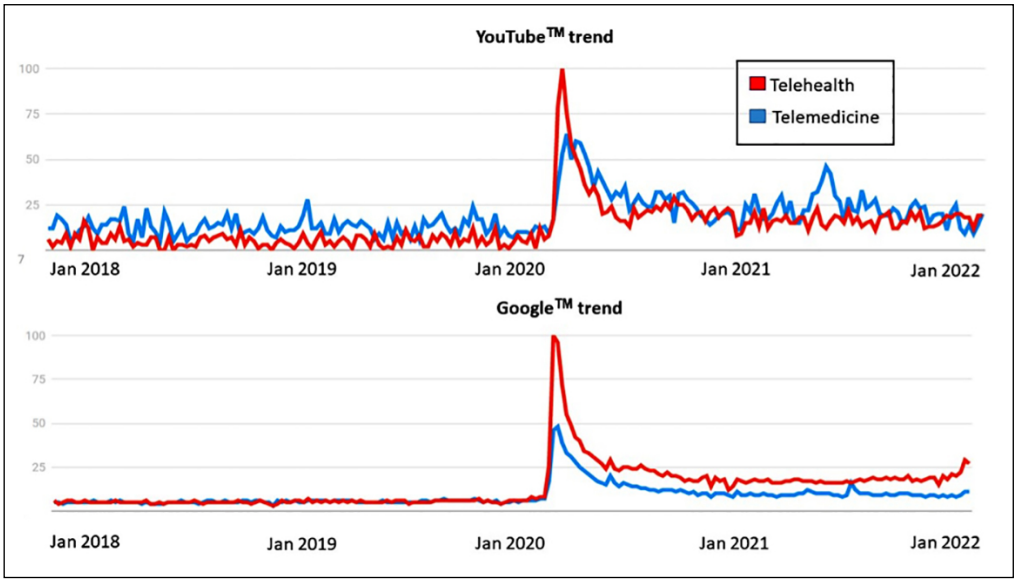


***Figure 2.***
*Chart-line plot depicting relative frequency of worldwide search for "Telehealth" (red) and "Telemedicine" (blue) on both YouTube™ and Google™ searches, observed between the January 1, 2018 and the January 31, 2022.*

### *Statistical analysis*

Descriptive statistics were presented as medians and *interquartile ranges* (IQR) for continuously coded variables or counts and percentages for categorically coded variables.

Kruskal-Wallis test, Chi-square test, and proportion test examined the statistical significance in medians and proportions differences. In all statistical analyses, the R software (*www.rproject.org*) environment for statistical computing and graphics (R version 4.0.0) was used. All tests were two-sided with a level of significance set at $p < 0.05$.

## Results

### *Worldwide Web interest*

From January 2018 to January 2022, the relative interest on *YouTube*™ ranged from 5 to 19 and from 13 to 20, using respectively the "*Telehealth*" and "*Telemedicine*" keywords (Figure 2). For both keywords, the peak occurred in March 2020 (100 and 63, respectively). From January 2018 to January 2022, the relative interest on GoogleTM ranged from 6 to 22 and from 5 to 9, using respectively the "*Telehealth*" and "*Telemedicine*" keyword. For both keywords, the peak occurred in March 2020 (100 and 47 respectively).

### *Videographic characteristics*

Of 129 videos (Table 1), 35 (27.1%) and 94 (72.9%) were uploaded before (Jan 2018-Feb 2020) and after (Mar 2020-Mar 2022) the COVID-19 outbreak, respectively. The overall median length was 4.5 minutes (Jan 2018-Feb 2020: 3 [IQR 1.5-4.5] *vs* Mar 2020-Mar 2022: 5.5 [2.4-10.9], $p < 0.001$), the overall median number of views was 2428 (Jan 2018-Feb 2020: 7783

***Table 1.***
*Videographic characteristics of 129 YouTube™ telemedicine-related videos, recorded on the 25th of March 2022, stratified according to the COVID-19 pandemic declaration date (the 9th of March 2020).*

| | | Overall n = 129 | Jan 2018-Feb 2020 n = 35 (27.1) | Mar 2020-Mar 2022 n = 94 (72.9) | p-value |
|---|---|---|---|---|---|
| Length, min | Median | 4.5 | 3 | 5.5 | < 0.001 |
| | IQR | 2.2-10.0 | 1.5-4.5 | 2.4-10.9 | |
| Views, n | Median | 2428 | 7783 | 1576 | 0.02 |
| | IQR | 375-10022 | 897.5-21220.5 | 328.5-6526.2 | |
| Persistence time on YouTube™ | Median | 663 | 1264 | 600 | < 0.001 |
| | IQR | 400-853 | 1055.5-1369.5 | 321.8-676.5 | |
| View ratio | Median | 3 | 5.5 | 3 | 0.7 |
| | IQR | 0-12 | 0-8.5 | 0-12.5 | |
| Likes, n | Median | 16 | 19.5 | 15.5 | 0.7 |
| | IQR | 3-62.5 | 1-136 | 3-48.2 | |
| Comments, n | Median | 0 | 0 | 0 | 0.8 |
| | IQR | 0-4 | 0-5.5 | 0-4 | |
| Subscribers, n | Median | 3250 | 2425 | 4460 | 0.2 |
| | IQR | 380.5-29600 | 107.8-26125 | 524-30900 | |
| Disabled comments, n (%) | No | 110 (85.3) | 25 (71.4) | 85 (90.4) | 0.01 |
| | Yes | 19 (14.7) | 10 (28.6) | 9 (9.6) | 0.01 |
| Authoring entity, n (%) | Private user | 31 (24.0) | 7 (20.0) | 24 (25.5) | 0.7 |
| | Medical doctor | 14 (10.9) | 5 (14.3) | 9 (9.6) | 0.6 |
| | Hospital | 4 (3.1) | 2 (5.7) | 2 (2.1) | 0.6 |
| | Other | 80 (62.0) | 21 (60.0) | 59 (62.8) | 0.9 |
| Target audience, n (%) | Healthcare workers | 45 (34.9) | 13 (37.1) | 32 (34.0) | 0.9 |
| | Patients | 36 (27.9) | 12 (34.3) | 24 (25.5) | 0.4 |
| | Other | 48 (37.2) | 10 (28.6) | 38 (40.4) | 0.3 |

***Table 2.***
*Quality assessment with The Patient Education Materials Assessment Tool for Audiovisual Materials (PEMAT A/V) and Global Quality Score (GQS) in overall videos (n = 129) and stratifying according to the COVID-19 pandemic declaration date (the 9th March 2020).*

| | | Overall n = 129 | Jan 2018-Feb 2020 n = 35 (27.1) | Mar 2020-Mar 2022 n = 94 (72.9) | p-value |
|---|---|---|---|---|---|
| **A) PEMAT A/V, %** | | | | | |
| Actionability | | | | | 0.02 |
| | Median | 50 | 33.3 | 50 | |
| | IQR | 0-75 | 0-66.7 | 27.1-75 | |
| Understandability | | | | | 0.06 |
| | Median | 66.7 | 63.6 | 67.9 | |
| | IQR | 50-77.6 | 50.0-75.7 | 50.0-79.2 | |
| **B) GQS, n (%)** | Excellent | 5 (3.9) | 0 (0.0) | 5 (5.3) | 0.4 |
| | Good | 23 (17.8) | 7 (20.0) | 16 (17.0) | 0.9 |
| | Medium | 31 (24.0) | 7 (20.0) | 24 (25.5) | 0.7 |
| | Generally poor | 34 (26.4) | 8 (22.9) | 26 (27.7) | 0.7 |
| | Poor | 36 (27.9) | 13 (37.1) | 23 (24.5) | 0.2 |

*IQR: Interquartile range.*

***Table 3.***
*Quality assessment with the Misinformation tool in overall videos (n = 129) and stratifying according to the COVID-19 pandemic declaration date (the 9th March 2020).*

| | | Overall n = 129 | Jan 2018-Feb 2020 n = 35 (27.1) | Mar 2020-Mar 2022 n = 94 (72.9) | p-value |
|---|---|---|---|---|---|
| 1. *Is the telemedicine definition correctly defined?* | Median | 1 | 1 | 2 | 0.1 |
| | IQR | 1-3 | 1-2 | 1-3 | |
| 2. *Is the telemedicine aim correctly described?* | Median | 3 | 2 | 3 | 0.01 |
| | IQR | 2-4 | 1-3 | 2-4 | |
| 3. *Are the instruments used for telemedicine correctly described?* | Median | 3 | 2 | 3 | 0.1 |
| | IQR | 2-4 | 1-3.5 | 2-3.8 | |
| 4. *The patients' consent regulation in telemedicine is correctly described?* | Median | 1 | 1 | 1 | 0.6 |
| | IQR | 1-2 | 1-2 | 1-2 | |
| 5. *Are the limits of telemedicine well explained?* | Median | 1 | 1 | 1 | < 0.01 |
| | IQR | 1-2 | 1-1 | 1-2.8 | |
| Misinformation score | Median | 2.2 | 1.8 | 2.2 | 0.01 |

*IQR: Interquartile range.*

[IQR 897.5-21220.5] *vs* Mar 2020-Mar 2022: 1576 [328.5-6526.2], p = 0.02), the overall median view ratio was 2 (Jan 2018-Feb 2020: 5.5 [IQR 0-8.5] *vs* Mar 2020-Mar 2022: 3 [0-12.2], p = 0.7) and the median number of likes was 16 (Jan 2018-Feb 2020: 19.5 [IQR 1-136] *vs* Mar 2020-Mar 2022: 15.5 [3-48.2], p = 0.7). Moreover, the median number of comments and subscribers was 0 (Jan 2018-Feb 2020: 0 [IQR 0-5.5] *vs* Mar 2020-Mar 2022: 0 [0-4.4], p = 0.8), and 3250 (Jan 2018-Feb 2020: 2425 [IQR 107.8-26125] *vs* Mar 2020-Mar 2022: 4460 [524-30900], p = 0.2), respectively. Of all videos, 24.0% (20.0 *vs* 25.5%), 10.9% (14.3 *vs* 9.6%), 3.1% (5.7 *vs* 2.1%), and 62.0% (60.0 *vs* 62.8%) were produced by private users, medical doctor, hospitals or other, respectively. Additionally, 34.9% (37.1 *vs* 34.0%), 27.9% (34.3 *vs* 25.5%) and 37.2% (28.6 *vs* 40.4%) were targeted to healthcare workers, patients and other, respectively (all p > 0.05).

### *Videos content results*

According to the PEMAT A/V (Table 2A), the overall median Understandability was 50.0% (Jan 2018-Feb 2020: 33.3 [IQR 0-66.7] *vs* Mar 2020-Mar 2022: 50.0 [27.1-75], p = 0.2) and the overall median Actionability was 66.7% (Jan 2018-Feb 2020: 63.6 [IQR 50.0-75.7] *vs* Mar 2020-Mar 2022: 67.9 [50.0-79.2], p = 0.6).

According to GQS (Table 2B), of all 3.9% (n=5), 17.8% (n=23), 24.0% (n=31), 26.4% (n=34) and 27.9% (n=36) were classified as excellent, good, medium, generally poor, and poor-quality videos, respectively. According to the uploaded date (Jan 2018-Feb 2020 *vs* Mar 2020-Mar 2022), the highest rate of excellent quality videos was recorded in videos uploaded after COVID-19 outbreak (0.0 *vs* 5.3%, p = 0.4). The highest rate of poor-quality videos was recorded in videos uploaded before COVID-19 pandemic (37.1 *vs* 24.5%, p = 0.2)

According to the Misinformation tool (Table 3), the lowest median score was recorded for the question 1 (defined as "*Is the Telemedicine definition correctly provide?*"), question 4 (defined as "*The patients' consent regulation is correctly described?*") and question 5 (defined as "*Are the limits of Telemedicine well explained?*"). The highest median score was recorded for questions 2 (defined as "*Is the telemedicine aim correctly described?*") and 3 (defined as "*Are the instruments used for Telemedicine correctly described?*"). According to the mean misinformation score, a statistically significant difference was recorded for question 2 (median: 2 [IQR: 1-30] *vs* 3 [IQR: 2-4], p = 0.01).

According to the overall misinformation score, a higher score was recorded for *YouTube* videos uploaded after the COVID-19 pandemic (median 1.8 [IQR 1.4-2.3] *vs* 2.2 [1.8-2.8], p = 0.01)

## Discussion

The current study aimed to evaluate the overall quality of *YouTube*™ telemedicine-related videos and how it changed before and after COVID-19 outbreak. To the best of our knowledge, no previous investigators examined this topic. We addressed this void and identified several noteworthy observations.

First, as clearly shown by the trend analysis, the web interest in telemedicine impressively increased when the COVID-19 pandemic was declared (16, 17).

Furthermore, the interest is keeping high from the outbreak to date, compared to the past. Additionally, we revealed a higher interest on the *YouTube*™, relative to the Google™ website. In consequence, most of the users interested in the topic obtained information from videos uploaded on the web. This observation further corroborates the intent of the current study, which consisted of examining the quality content on *YouTube*™ videos in

order to make aware Internet users on the dangerous possibility of acquiring misleading information.
Second, we recorded a higher number of videos uploaded after the COVID-19 outbreak (35 *vs* 94). This data may indicate that the general community is becoming more aware regarding the importance of using the Internet, and specifically *YouTube*™, as an instrument for getting and spreading information. However, we did not observe differences in terms of authoring entity or target between videos uploaded before and after the COVID-19 outbreak. This observation is against our expectations. Indeed, we expected that more videos would be produced by healthcare providers and official entities in order to guarantee good quality information to general community. For example, among the medical fields, neurophysiologists intensively used telemedicine to ensure for neurological disorders care during the pandemic. Indeed, Stipa et al. published a study in the 2020 providing recommendations for guidelines development in this field (9). This study should represent an example for the other specialties to encourage the development of specific guidelines.
Third, according to the quality assessment tools used in the current study, poor-quality video content was recorded. Specifically, according to the PEMAT A/V tools, both Actionability (50%) and Understandability (66.7%) scores were low, regardless the year of upload.
The Understandability reflects how viewers could process the information displayed in the videos, while the Actionability reflects how viewers could use them. According to *Shoemaker et al.*, a PEMAT A/V score < 70% is considered poorly understandable or poorly actionable (25). In consequence, based on our results, we recorded poor quality content. Furthermore, according to the GQS tool, more than half of the videos were classified as generally poor or poor quality. The same observation was noticed in the videos uploaded before or after the COVID-19 pandemic. In consequence, despite a higher number of videos uploaded after the pandemic outbreak, low-quality content was uploaded. Unfortunately, we were the first to examine *YouTube*™ video content related to telemedicine and no comparisons was possible.
Fourth, interesting results emerged from the Misinformation tool, which allowed us to investigate other aspects, not well examined by the other validated quality assessment tools used. Thanks to that, we discovered that relevant telemedicine aspects were underestimated during the *YouTube*™ video making. For example, we did not record any video explaining the differences between telecollaboration, tele-treatment, tele-monitoring, or tele-support (26). Additionally, scant information was provided on the informed consent that should be obtained by healthcare providers (27). Last, but not least, the physicians' roles and responsibilities were rarely provided (28). However, we recorded an improvement of the Misinformation tool items score in the videos uploaded after the pandemic declaration, compared to the ones recorded before.
These observations may proof that the community is increasingly using the Internet as a spreading information instrument on telemedicine, due to the higher requests and unexperienced needs caused by the pandemic. However, with this tool, we also highlighted that all the possible risks behind the telemedicine use were dangerously hidden.
Taken together, we observed that the telemedicine interest peak occurred in March 2020 on both Google™ and *YouTube*™ websites, concordantly with the first pandemic wave. It confirms how *YouTube*™ was highly used to promptly acquire information on telemedicine.
Moreover, overall reliability and quality of *YouTube*™ videos on this topic were inadequate, as evidenced by a low PEMAT A/V score and a high number of poor and generally poor quality videos. Additionally, important aspects, such as the limited and fragmented insurance coverage of telemedicine, the lower quality of patient-physician relationships, the legal issues, and the differential access to telecommunication technologies based on social and geographic factors, were underestimated. In the future, considering the essential importance of telemedicine in the modern era, it will be mandatory for the official entity to develop proper guidelines to provide the best information to Internet users.
The current study is not devoid of limitations. First, some reliable or non-reliable videos might be missed, due to our search terms. However, we used 19 keyword combinations to minimize selection errors. Second, only English-language videos were included in the final sample. Other language videos could provide different information. Third, quality assessment videos were subjectively evaluated. However, three investigators were independently involved to analyse video contents and were each other blinded during the evaluation. Fourth, *YouTube*™ is a constantly expanding multimedia platform and the contents may rapidly change significantly with new updates over time.

## Conclusions

The interest in telemedicine showed a significant peak when the COVID-19 pandemic was declared. Despite the importance of telemedicine in the modern era, the contents provided were not informative enough and not verified by an official entity. In the future, official medical institutions should standardize telemedicine regulation and online contents to reduce the widespread of misleading information.

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**Conflict of interest:** The authors declare no potential conflict of interest.