Telehealth Demand Trends in COVID-19: An Infodemiological Evaluation of the Top 50 Most Affected Countries

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Abstract

Background: The COVID-19 pandemic has led to urgent calls for the adoption of telehealth solutions. However, public interest and demand for telehealth during the pandemic remains unknown.

Objective: We used an infodemiological approach to estimate the demand for telehealth services during COVID-19 globally, focusing on the 50 most-affected countries and comparing the demand for such services with the level of information-communications technology (ICT) infrastructure available.

Methods: We used Google Trends, the Baidu Index (China), and the Yandex Keyword Statistics (Russia) to extract data on worldwide and individual countries' telehealth-related internet searches from 1st January to 7th July, 2020, presented as "Relative Search Volumes" (RSV, ranging 0-100). Daily COVID-19 cases and deaths were retrieved from the World Health Organisation. Individual countries' ICT infrastructure profile were retrieved from the World Economic Forum Report.

Results: Across the 50 countries, the mean RSV was 18.5±23.2, and the mean ICT index was 62.1±15.0. An overall spike in worldwide telehealth-related RSVs was observed from 11th March 2020 (RSV peaked to 76.0), which then tailed off in June-July 2020 (mean RSV for period=25.8), but remained higher than pre-March RSVs (mean=7.29). By country, 42 (84%) manifested increased RSVs over the evaluation period, with the highest observed in Canada (RSV=100) and the United States (RSV=96). When evaluating associations between RSV and ICT index, the US and Canada demonstrated both high RSVs and ICTs (?70.3). In contrast, European countries had relatively lower RSVs (ranging 3.4-19.5) despite high ICTs (mean=70.3). Several Latin-American (Brazil, Chile, Colombia), and South-Asian (India, Bangladesh, Pakistan) countries demonstrated relatively higher RSVs (ranging 13.8-73.3) but low ICTs (mean=44.6), indicating that the telehealth demand outstrips the current ICT infrastructure.

Conclusions: There is generally increased interest and demand for telehealth services across the 50 countries most affected by COVID-19, highlighting the need to scale up telehealth capabilities, during and beyond COVID-19. Clinical Trial: NIL

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Conclusions: There is generally increased interest and demand for telehealth services across the 50 countries most affected by COVID-19, highlighting the need to scale up telehealth capabilities, during and beyond COVID-19.

Keywords: COVID-19, Infodemiology, Telehealth, Telemedicine, Global-Health

Introduction

The novel coronarvirus disease 2019 (COVID-19) was formally declared a pandemic by the World Health Organisation (WHO) on March 11th, 2020. As of September 7th, the World Health Organization (WHO) has reported over 27 million cases, with a cumulative mortality rate of 3.26%.[1] In the context of infectious disease outbreaks such as the current COVID-19 pandemic, concerns regarding the overloading of healthcare facilties, coupled with the need to minimize patient and health-care provider exposure in the hospital care settings have led to calls for a shift from the traditional patient-physician face-to-face physical consultations to telehealth-based remote clinical services.[2-6] However, the magnitude of this major shift in healthcare management has yet to be evaluated. Public interest and potential demand for telehealth services is relatively unknown.[7, 8] This information gap poses challenges for healthcare providers to re-design strategies, institute new policies, and re-structure manpower and infrastructure to address a potential 'new wave' of clinical need.

"Infodemiology" is a rapidly growing field of methodology in health informatics, which study trends in online search behavior and internet activity.[9, 10] These methods provide new insights on population behavior and health-related phenomena, particularly during infectious disease outbreaks.[11-13] Google Trends (GT) and the Baidu Index are examples of Infodemiological tools which researchers have used to analyse temporal and geographical trends in relative internet search volumes, with GT being the most prolific among published reports.[14-16] These tools have the additional advantage of providing real-time data, reflecting the immediate changes in population behaviour in response to real-world events. [9, 10] In the current climate of the COVID-19 pandemic, these tools have recently been used to investigate the overall public interest in COVID-19[17], public fear of Covid-19 symptoms[18], and changes in behavioral attitudes towards activies such as "social distancing" and "washing hands".[19]

A recent paper by Hong et al. utilised a similar infodemiological approach to describe the increase in telehealth-related search volumes in the United States, up to March 2020[2]. Building upon this previous work, we further broadened our current investigation towards a global perspective, and extended the evaluation period beyond the initial wave of COVID-19 while including post-lockdown periods when countries and healthcare systems were “re-opening” their economy and society.

To provide a broader understanding of the current global interest and demand for telehealth, we used an infodemiological approach to investigate internet relative search volumes (RSV, as a proxy for public interest and demand) for telehealth services in the 50 countries most affected by COVID-19. We described trends in telehealth-related RSVs across these countries over a 6-month period, spanning from the start of the COVID-19 pandemic, to respective country’s lockdowns and their subsequent re-opening. Finally, we compared demand for telehealth with the level of information-communication technology (ICT) infrastructure for each country. These findings may provide valuable information for policy makers and healthcare providers to better cater for the new demands for telehealth services during COVID-19, and into the post-COVID-19 new normal.

Methodology

Retrieving Covid-19 outbreak, key dates, and confirmed case numbers

Real-world data for daily confirmed COVID-19 cases and deaths were retrieved on the 9th of July from the World Health Organisation’s (WHO) COVID-19 dashboard from the 1st of January 2020 until the 7th of July 2020.[1] Worldwide data was retrived, as well as individual country-level data for the 50 countries with the highest cumulative confirmed COVID-19 case numbers (as of 7th July 2020). Key dates of the COVID-19 pandemic were also retrived from the WHO COVID-19 timeline, and news reports of regional COVID-19 related events.[20, 21]

Retrieving data from Google Trends and other country-specific Search Query Databases

The Google Trends (GT) tool provides data on the volumes and patterns in online search behaviors of internet users.[15] It tracks keyword search queries that users enter into the Google search engine, and presents information on the search query according to the specified time period and geographical location.[22] The search volume results are normalised and presented as a "Relative Search Volumes" (RSV) index, wherein "each data point is divided by the total searches of the specified geography and time range it represents" to provide relative comparisons.[22] The resulting output ranges from 0 to 100, with 100 indicating the maximum search interest within the time and location selected. To comprehensively capture trends in online search behavior and infectious burden over an extended period, daily worldwide and country-specific GT data were retrieved over the first 6 months of the outbreak, from January 1st 2020 till 7th July 2020.

In addition to GT, the Baidu Index and the Yandex Wordstat Keyword Statistics Service were used to retrive data on search queries in China and Russia, respectively. Baidu and Yandex are the predominant search engines used in China and Russia, respectively.[14, 23] To facilitate direct visualisation and comparisons with the RSV index obtained from GT, these data from Baidu Index and Yandex were similarly scaled to a range from 0 to 100.[18] In this work, total-RSV denotes the cumulative RSVs over the entire evaluation period, while average RSV represents RSV that was averaged over a specified period (e,g, pre or post-COVID period, further descriptions are provided below)

Keyword Selection

For the analysis of GT, we followed the detailed methodology described by Mavragani et al. for our keyword selection.[10] Firstly, different permutations of "search terms" and "topics" related to "Telehealth" and "Telemedicine" were searched to understand overarching trends in worldwide interest, and to optimize keyword search combinations. We

then conducted worldwide and country-specific GT searches using a baseline combination of English, Spanish, Russian and French translations (chosen from the list of most commonly spoken languages worldwide),[24] in addition to translations in the native / official language of that particular country. Mandarin Chinese is the second most spoken language in the world,[24] but was not included in the baseline search combination, since the large majority of native Mandarin Chinese speakers reside in China and do not use Google as their main internet search tool. For the Baidu and Yandex search indices, a combination of keywords in Mandarin Chinese (both traditional and simplified) and Russian respectively were used. The detailed keyword search strategy can be found in **Supplementary Table 1.**

Retrieval of additional telehealth-related national indicators

Data regarding the key dates of major public health responses such as lockdowns for each country were obtained from internet sources and news reports.[25-27] In addition, ICT data from the the “ICT adoption pillar” of the Global Competitiveness Index 4.0 (2019), was obtained from the World Economic Forum Global Competitiveness Report 2019 and used to compare maturity of ICT between countries.[28] The extracted ICT adoption index (ICT index) ranges from 0 to 100 (highest), wherein a higher score represents greater levels of networked infrastructure, and higher regional usage and access to such infrastructure. Additional country-specific indices including GDP-per-Capita ($USD), literacy rates, and World-Bank regional income groups were obtained from the World Bank Open Databank.[29]

As a proxy measure of the existing telehealth capacity of the respective countries, the CB insights[30] and Crunchbase[31] business analytic platforms were used to search for the prevalence of “prominent” telehealth providers within each of the 50 countries, and used to define a “CB/CBI score”. Details of the score are further described in the **Supplemetary information**.

Analysis

First, to provide more accurate observation of underlying trends and eliminate short-term fluctuations in data, the time-trends for Telehealth-related RSVs were smoothened by 7-day rolling intervals.[32] For countries with lower total-RSVs (<5), 14-day interval smoothing was used instead as these countries are more susceptible to daily fluctuations (thus more 'noise' in trend data). Having a longer smoothing interval would help to minimize errors in estimations caused by these fluctuations over a short period. The RSVs were then plotted against daily COVID-19 confirmed cases and deaths (two separate Y-axes), both worldwide and for each of the individual 50 countries.

Mean ± standard deviation (SD) and median [interquartile Range (IQR)] were used to provide summary statistics for key country parameters including total-RSVs, COVID-19 cases and deaths, and ICT indexes. The Pearson and Spearman correlation tests (when applicable) were used to further investigate associations between key parameters.The Kurtosis/skewness and Shapiro-wilk tests used to determine normality of data distribution. P values of <0.05 were considered as statistically significant.

The lockdown periods for each specific country were incorporated along with 2 key dates for reference. These were 23rd January 2020, when China first imposed a lockdown in Hubei province, and 11th March 2020, when the WHO declared COVID-19 a global pandemic. When evaluating changes in average RSV levels pre- and post-COVID periods (i.e. RSVs averaged over time period before and after COVID, respectively), we defined "pre-" and "post-COVD" periods based on the landmark date of 11th March 2020 (WHO COVID-19 pandemic declaration), with the exception for China, where pre-COVID was defined as before 23rd January 2020. The ratios of the average pre- and post-COVID RSV levels for each country were then calculated.

Lastly, bubble-plots were used to illustrate the relationships between the total-RSVs of individual countries and various telehealth-related national indicators (GDP-per-capita

($USD), literacy-rates, the ICT index, and the CB/CBI score). Countries were grouped and color-coded according to the World-bank regional classifications. All analysis and visualisation were conducted using Python (Python Software Foundation, Version 3.7.4).

Results:

Characteristics of the 50 countries including number of COVID-19 cases, deaths, telehealth-related RSVs, and ICT adoption index values are described in **Table 1.** Across the 50 countries, the mean total-RSV was 18.5±23.2 (median=9.20, interquartile range [IQR]: 5.75 – 18.68), and the mean ICT adoption index was 62.1±15.0 (median=64.5, IQR: 51.2 – 72.5). **Figure 1a** shows a geographic choropleth map of the telehealth-related GT RSVs. North American countries had the highest total-RSVs (RSV=100 in Canada, RSV=96.6 in US). Within Europe, Switzerland (RSV=19.5) and Portugal (RSV=16.1) had the highest total-RSVs. For the Latin America & Carribean region, Chile (RSV=74.7) and Ecuador (RSV=69.0) had the highest total-RSVs. Likewise, the United Arab Emirates (RSV=40.2) was the highest for the Middle East region, South Africa (RSV=12.6) for Sub-Saharan Africa, Bangladesh (RSV=41.4) for South Asia, and Singapore (RSV=41.4) for East Asia. Similarly, **Figure 1b and 1c** demonstrate geographic choropleth maps by number of COVID-19 confirmed cases and deaths, respectively. Overall, among the evaluated countries, there were fair correlations between total-RSVs with COVID cases (Pearson's r=0.46 (p<0.001), Spearman's ρ=0.29 (p=0.04)), and COVID deaths (r = 0.39 (p=0.005), ρ=0.17 (p=0.25)) (**Figure 2**) .

Table 1: Key COVID-19- and telehealth-related parameters for the top 50 countries most-affected by COVID-19

	Country	Covid Cases[a]	Covid Deaths[a]	Total-RSVs[b]	ICT Adoption Index
1	**USA**	2,877,238	129,643	96.6	74.35
2	**Brazil**	1,603,055	64,867	29.9	58.06
3	**India**	719,665	20,160	13.8	32.11
4	**Russia**	694,230	10,494	10.3[c]	77.03
5	**Peru**	302,718	10,589	46.0	45.7

6	**Chile**	298,557	6,384	74.7	63.13
7	**UK**	285,772	44,236	9.2	72.99
8	**Mexico**	256,848	30,639	6.9	55.03
9	**Spain**	251,789	28,388	6.9	78.21
10	**Iran**	243,051	11,731	4.6	50.85
11	**Italy**	241,819	34,869	9.2	64.49
12	**Pakistan**	234,509	4,839	34.5	25.21
13	**Saudi Arabia**	213,716	1,968	13.8	69.3
14	**Turkey**	206,844	5,241	5.7	57.82
15	**South Africa**	205,721	3,310	12.6	49.67
16	**Germany**	196,944	9,024	5.7	69.98
17	**Bangladesh**	165,618	2,096	41.4	39.14
18	**France**	159,568	29,831	5.7	73.66
19	**Colombia**	117,110	4,064	32.2	49.89
20	**Canada**	105,536	8,684	100.0	70.29
21	**Qatar**	100,345	133	13.8	83.78
22	**China**	85,345	4,648	*52.9*[d]	78.49
23	**Argentina**	77,815	1,523	11.5	57.99
24	**Egypt**	76,222	3,422	9.2	40.57
25	**Sweden**	73,061	5,433	3.42	87.78
26	**Indonesia**	64,958	3,241	5.7	55.37
27	**Belarus**	63,804	429	4.6	-
28	**Ecuador**	62,380	4821	69.0	47.62
29	**Iraq**	62,275	2,567	0	-
30	**Belgium**	62,058	9,774	3.4	67.02
31	**UAE**	52,068	324	40.2	91.87
32	**Netherlands**	50,602	6,119	8.0	76.29
33	**Kuwait**	50,644	373	0	69.57
34	**Ukraine**	49,607	1,283	5.7	51.85
35	**Kazakhstan**	49,683	264	6.9	67.99
36	**Oman**	47,735	218	0	58.11
37	**Philippines**	46,333	1,303	31.0	49.69
38	**Singapore**	44,983	26	41.4	87.11

39	**Portugal**	44,129	1,620	16.1	71.24
40	**Panama**	38,149	747	13.8	50.06
41	**Bolivia**	39,297	1,434	12.6	51.45
42	**Dominican Republic**	38,128	804	10.3	51.79
43	**Poland**	36,155	1,521	9.2	65.41
44	**Afghanistan**	33,384	920	0	-
45	**Switzerland**	32,230	1,685	19.5	78.58
46	**Israel**	30,055	331	9.2	67.56
47	**Bahrain**	29,821	98	0	67.19
48	**Nigeria**	29,286	654	10.3	33.39
49	**Armenia**	29,285	503	0	62.02
50	**Romania**	29,223	1,768	9.2	72.01
Overall Mean (standard deviation):				18.5 (23.2)	62.1 (15.0)

[a] *COVID-19 case and death numbers current as of 07/07/2020.*
[b] *Total-RSVs was calculated over evaluation period from 01/01/2020 – 07/07/2020.*
[c] *For Russia, the RSV value reflects search volumes as measured by Google Trends only. Mean search volumes based on Yandex was 44.3, but was not listed in the table..*
[d] *For China, the RSV value reflects the mean RSV as measured by the Baidu Index. Google Trend was not applicable for China.*

Figures 3a and **3b** depict the overall worldwide trends in telehealth-related RSVs during the study period, on a backdrop of accumulated COVID-19 cases and deaths. A surge in RSV levels can be observed from 11th March 2020, the date when the WHO officially declared the COVID-19 outbreak a pandemic, and culminates with an observed peak (RSV = 76.0) in telehealth-RSV levels on 24th March 2020, more than 10 times the pre-COVID levels (average RSV = 7.29). RSV levels then tailed off in June-July 2020 (average RSV = 25.8), but still remained higher than pre-COVID levels. For comparison, another curve representing RSVs for “Coronavirus” search (in blue) was plotted alongside the teleheath RSV curve (in red). The coronavirus-related RSVs demonstrated a similar trend: a sharp spike near the 11th of March, and peaking on the 18th of March.

Country-specific telehealth-related RSV levels during the study period were similarly plotted in **Figure 4.** 42 (84%) of the evaluated countries manifested spikes in telehealth-RSV levels over the evaluation period. When comparing the average pre- and post-COVID

RSV levels across these 42 countries, RSV levels increased by an average of 4.07±3.23 times, post-COVID (**Supplementary Table 2**). The remaining 8 countries were from Central Asia (Armenia) and the Middle-East (Iran, Belarus, Iraq, Kuwait, Oman, Afghanistan, Bahrain), and had either no RSVs or no observable increased trends.

Of the 42 countries with increases in RSVs, the US and Canada had the highest total-RSVs, showing sharp increases in telehealth RSV levels during early-March, peaking in mid to late-march, before decreasing and eventually plateauing to RSV levels which were still higher than pre-COVID levels (**Figure 4)**. Comparing to pre-COVID levels, the average RSV levels increased by 5.83 times in US, and 2.69 times in Canada (**Supplementary Table 2)**.The remaining 40 countries also displayed increases in RSV levels over the evaluation period, albeit with less prominent spikes compared to the US and Canada. These countries often approached peak RSVs more gradually, over a longer-period of months. These countries can be further subdivided into two categories based on the magnitude of RSV increases (**Supplementary Table 2)**. The first group observed large increases in average RSV levels (≥2.5 times increase compared to pre-COVID levels; n=24). This group largely comprised of countries from Latin-America (Brazil, Peru, Chile, Colombia, Argentina, Ecuador), South Asia (India, Bangladesh, Pakistan), East Asia (China, Indonesia, Philippines),Middle-East regions (Saudi-Arabia, Qatar, Egypt), and several European countries (Russia, Spain, Italy, Turkey, Romania, Ukraine). The second group of countries experienced smaller increases in average RSV levels compared to pre-COVID levels (between 1 to 2.5 times; n=16), and largely comprised of UK, Germany, France, Netherlands Portugal, Poland, Sweden, Belgium, Switzerland, Singapore and Israel (**Supplementary Table 2)**. For most of these 40 countries, increases in RSV levels began in early March, either alongside or preceeding the rise in local covid cases numbers, with the exception of China where the increase in Baidu RSVs was observed earlier during end-January.

Figure 5 illustrates the relationship between telehealth total-RSVs, and ICT index values across the evaluated countries. There was no significant correlation between RSVs

and ICTs (r = 0.11 (p= 0.45), ρ=-0.08 (p=0.59)). However, broad clustering patterns amongst countries of similar regions can be observed. By using the mean RSV value (horizontal dashed line) and mean ICT index (vertical dashed line), we visually divided the plot into 4 quadrants, and observed that the US and Canada occupy the top right quadrant, with high total-RSVs (≥96.6) and ICTs (≥70.3). The UAE and Singapore were also in the top right quadrant, with similarly high total-RSVs (40.2 and 41.4, respectively) and ICTs (91.9 and 87.1 respectively). In contrast, while European countries generally had high ICTs (range: 51.9 – 87.8), they had lower total-RSVs (range: 3.4-19.5). Latin-American countries generally occupied a cluster near the 'middle' of the bubble plot, with moderate levels of total-RSVs (6.9 – 74.7), and moderate ICTs (45.7–63.1). On the other hand, South Asian countries generally had moderate to moderate-high total-RSVs (13.8 – 41.4), despite their low ICTs (≤39.1). Similarly, **Supplementary Figures 2** and **3** illustrate the relationship between telehealth RSVs with **(a)** the relative literacy rate, and **(b)** the GDP-Per-Capita across the 50 countries. Similar clustering patterns of countries (as in the ICT evaluation) were observed.

Discussion

In this study, we used data from GT, the Baidu Index and Yandex Keyword Statistics to evaluate trends in telehealth demand during the first 6 months of the COVID-19 pandemic. To our knowledge, this is the first study to apply an infodemiological approach to investigate the potential public demand for telehealth in the 50 countries most-affected by COVID-19. Our study further unravelled trends of demands alongside key COVID-19 events, and the level of ICT infrastructure. Our findings suggest a general trend of increased demand for telehealth services, across the evaluated countries during the COVID-19 pandemic. This trend was largely sustained beyond the initial wave, country lockdown periods and subequent re-openings. Our results suggest an on-going and possible future increased interest in telehealth services, as we enter a post-COVID-19 new normal phase. We also observed that current ICT infrastructure in several developing countries may lag

behind this surging demand for telehealth. Our findings collectively indicate a pressing need to scale up telehealth capabalities in response to this growth in telehealth demand, during and beyond COVID-19.

Our results demonstrate increased RSVs in most of the 50 evaluated countries. Amongst them, the US and Canada had the highest total-RSVs, and displayed a large spike in interest for telehealth services, compared to most other countries. It is noteworthy that this pattern was also found in Australia (thought not ranked within the top 50 countries), which had similarly high total-RSV values (RSV = 98.9, data not shown in tables). Most other countries had less well-defined, but observable increases in RSVs.

Interestingly, in many countries, the pattern of RSV trends over time did not closely follow local COVID-19 case/death numbers, but often increased in early-March, suggesting that the global announcement by WHO on the 11th March 2020 possibly had a great impact on the public's change in behaviour to seek for telehealth options. Other studies investigating COVID-related search trends have similarly reported that increases in RSVs often preceede local COVID-19 cases and deaths.[17, 33] It has been suggested that RSV trends tend to change in response to particular "index events".[18] For instance, Rovetta et al. similarly reported that significant increases in COVID-related RSVs were only observed after the WHO COVID-19 pandemic announcement, and the imposition of strict social distancing rules by the government.[33]

"Our study also found fair correlations between total-RSVs and the COVID cases and deaths of a country. We posit two possible explanations for this – firstly, larger numbers of COVID-19 cases and deaths could result in increased risk-perception of the general population, thus driving an increased interest in telehealth to minimize risk-exposures. This is in line with other studies which also reported that changes in search volumes towards other risk-minimizing activities such as "social distancing", "washing hands" and "face masks", corresponded with increase in COVID-19 cases.[19, 33] Another potential

explanation would be that the increase in Telehealth-RSVs reflected actual needs of affected patients. The timing of the RSVs spikes for each country often preceded the actual spike in COVID cases, suggesting that changes in search activity were probably more likely due to changes in public perception as the pandemic situation evolves. Nevertheless, further real-world investigations in the form of custom-designed questionnaires would be needed to further elucidate this aspect.

The bubble-plots presented in this report further investigated the relationships between total-RSVs and various telehealth-related indices (ICT adoption index, GDP-per-capita, literacy rates). These indices were evaluated as proxies for the capacity of a country to adopt and operationalise new telehealth services[34-36]. The clustering patterns observed in **Figure 5** and **Supplementary Figures 2 - 4**, may enable the classification of regions or countries based on their relative demands and capacity for telehealth services. For example, regions with potential for rapid growth and adoption of telehealth are those with higher literacy levels, better ICT infrastructure, and higher RSVs (**Supplementary figure 4)**. These countries include Argentina, Chile, Qatar, the UAE, Saudi Arabia, and Singapore[37]. On the other hand, countries such as Colombia, Peru, Ecuador, Bangladesh, Pakistan, and Philippines demonstrated growing interest in telehealth (moderate-to-high RSVs), but were limited by existing infocomms capabillity (low-to-moderate ICT index).

Despite high ICT indexes, and strong existing-telehealth capacity (high CB/CBI scores, **Supplementary Figure 4**) in a large majority of European countries[38], the RSVs of these countries were relatively low compared to other western developed countries such as in Canada and the US. This observation may be explained by the availability and easy acessibility of existing telehealth services which may also impact the population's information seeking behavior. For instance, in European countries which are at a further stage of telehealth adoption, telehealth awareness and literacy may already be present, and patients may be directly seeking telehealth services from these providers instead of conducting

online queries in search engines.[38] Other factors that may also influence search volumes include different models of healthcare systems (ie. in the UK, patients may directly contact their GPs or seek online consultations readily and directly through the NHS App[39]). Public health communications play a role as well, for example, Sweden contrarily downplayed the significance of the pandemic[40], eschewing lockdown measures, which may also explain why Sweden had the lowest RSVs amongst the evaluated European countries[40, 41].

Our study offers useful insights into the short and medium term trends of telehealth demand, in response to the COVID-19 pandemic. The trend of sustained increase observed in the Baidu index RSV in China provides preliminrary indications that telehealth demand will likely remain higher than pre-COVID-19 era. This trend is especially likely, given that China can be considered to have entered its post-COVID 'recovery' phase, with minimal new cases reported over the last 3 months of our study period. On the other hand, given the resurgence of second or third waves of COVID-19 outbreak in several countries in recent months,[1, 42] it is foreseeable that telehealth demand may surge yet again or remain higher than pre COVID-19 period. Nonetheless, to better ascertain the long term impact of COVID-19 on telehealth interest, further evaluation in this aspect over a longer period would be required. The key strengths of our study include our unique infoveillance approach to evaluate the public demand for telehealth-services, capturing real-time responses to key COVID-19 pandemic events[11, 16, 43]. Secondly our study provided an extensive coverage of the 50 most hit countries worldwide, and evaluated these countries over a long duration (6 months), thus giving more concrete insights on the trends. Third, we also included the additional use of the Baidu Index and Yandex keyword statistics to further investigate RSVs in China and Russia. The high degree of correlation between GT and Yandex Keyword Statistics for RSVs in Russia ($r = 0.875$, $p < 0.001$), further confers a degree of reliability to our results.

This study also has a few limitations. First, it should be acknowledged that infodemiological approaches can only serve as a proxy for estimating the "true demand" for

Telhealth services. Second, as suggested earlier, although search engines provide a good catchment of overall interest, there may be alternative channels for the public to seek healthcare-related information, including their general practitioners, insurance services, or directly from telehealth-service providers. In addition, it should also be acknowledgd that it is not possible to include all terms utilized by internet users to search for information on telehealth. Third, not all countries use Google as their primary search engine. Hence, using GT as a main proxy for overall demand when comparing across countries may be subjected to bias for some countries. Fourth, overall RSV trends may be confounded by different sampling profiles between countries, wherein factors including education and internet-access may skew the representativeness of the RSV samples for each country. Additionally, infodemiology platforms such as GT and the Baidu Index present data as normalized "relative search volumes", rather than as absolute search numbers, thus limiting direct comparisons of RSV data extracted from different sources of search engines.[10] Fifth, to reduce subjectivity, across all included countries (except for China), we standardized the definition of the post-COVID period based on the date when WHO declared COVID-19 as a global pandemic. Although it might have been ideal to individually quantify per- and post-COVID period for each country, it was difficult to do so, considering each country had a different community transmission trajectory. Furthermore, changes in search volumes were often in response to not just local events (lockdowns, local increases in COVID-19 cases), but also global events such as the WHO's pandemic announcement. Lastly, to better ascertain the long term impact of COVID-19 on telehealth interest, further evaluation over a longer period is required.

Conclusion

Telehealth is a major healthtech solution that has further gained traction during the COVID-19 pandemic. We identified increased demand for telehealth services across the 50

countries most affected by COVID-19. We also found indications that several developing countries may still have suboptimal ICT infrastructure to cope with this surge in telehealth demand. These findings underscore a pressing need for policy makers and healthcare providers to scale up telehealth infrastructure and capability, amidst and beyond COVID-19.

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Figure 1: Global Choropleth Map comparing (a) Telehealth-RSVs, (b) Real-world COVID-19 confirmed cases and (c) Real-world COVID-19 confirmed cases deaths

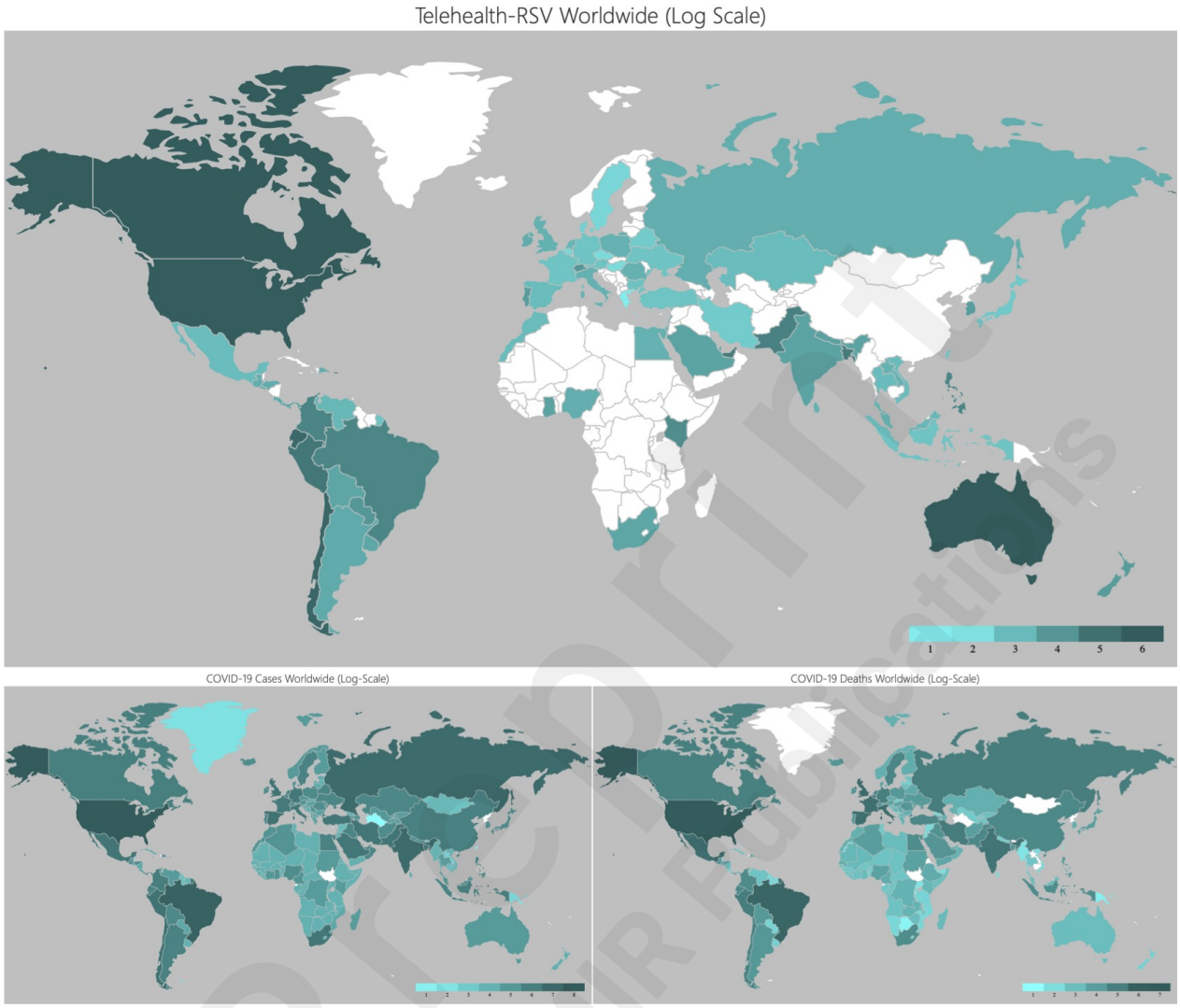


Figure 2: Correlation between total telehealth-RSVs against total COVID-19 (a) cases and (b) deaths per country

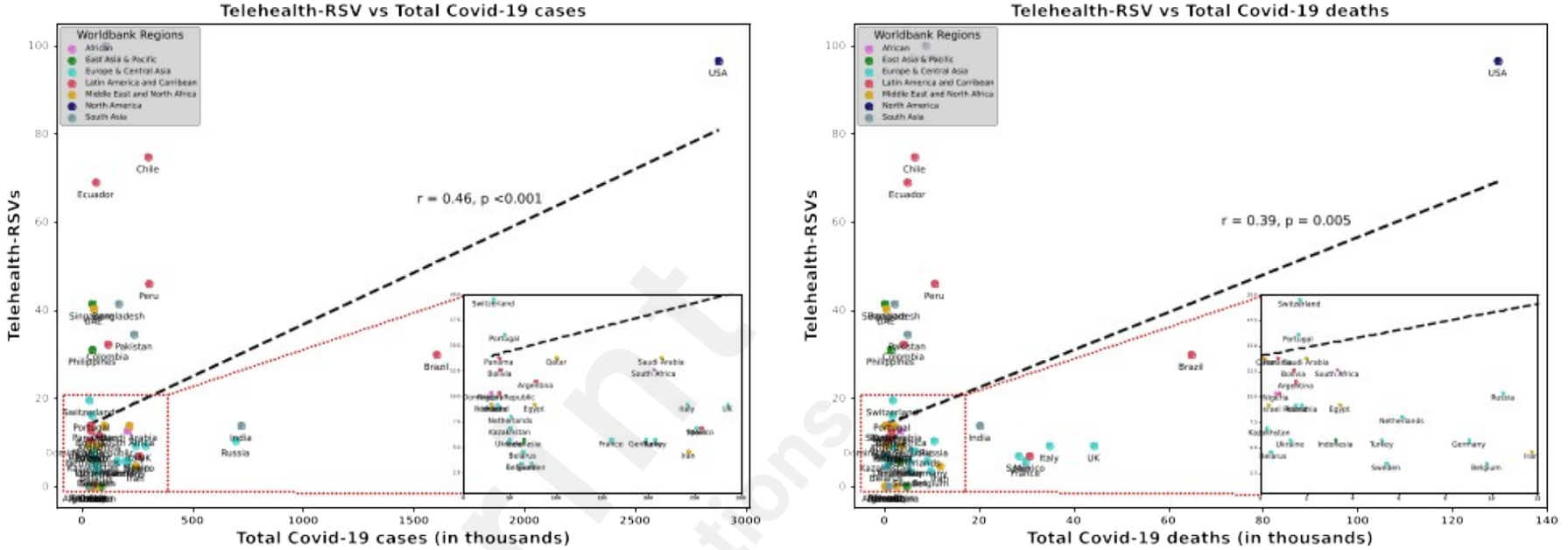
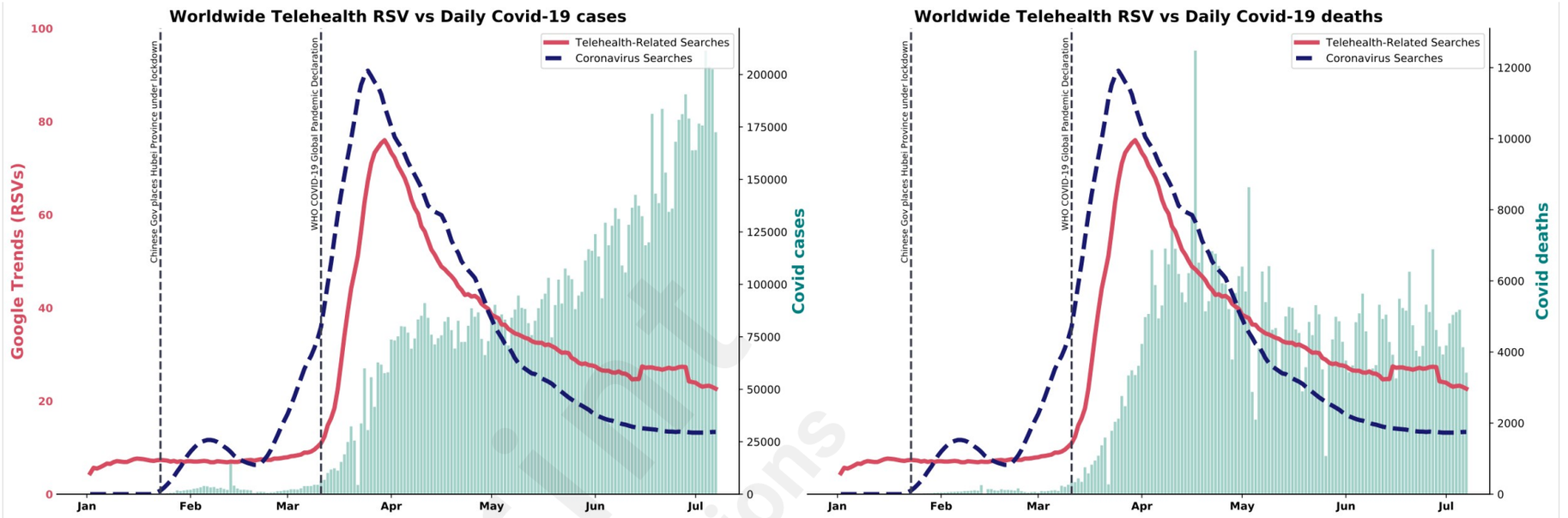
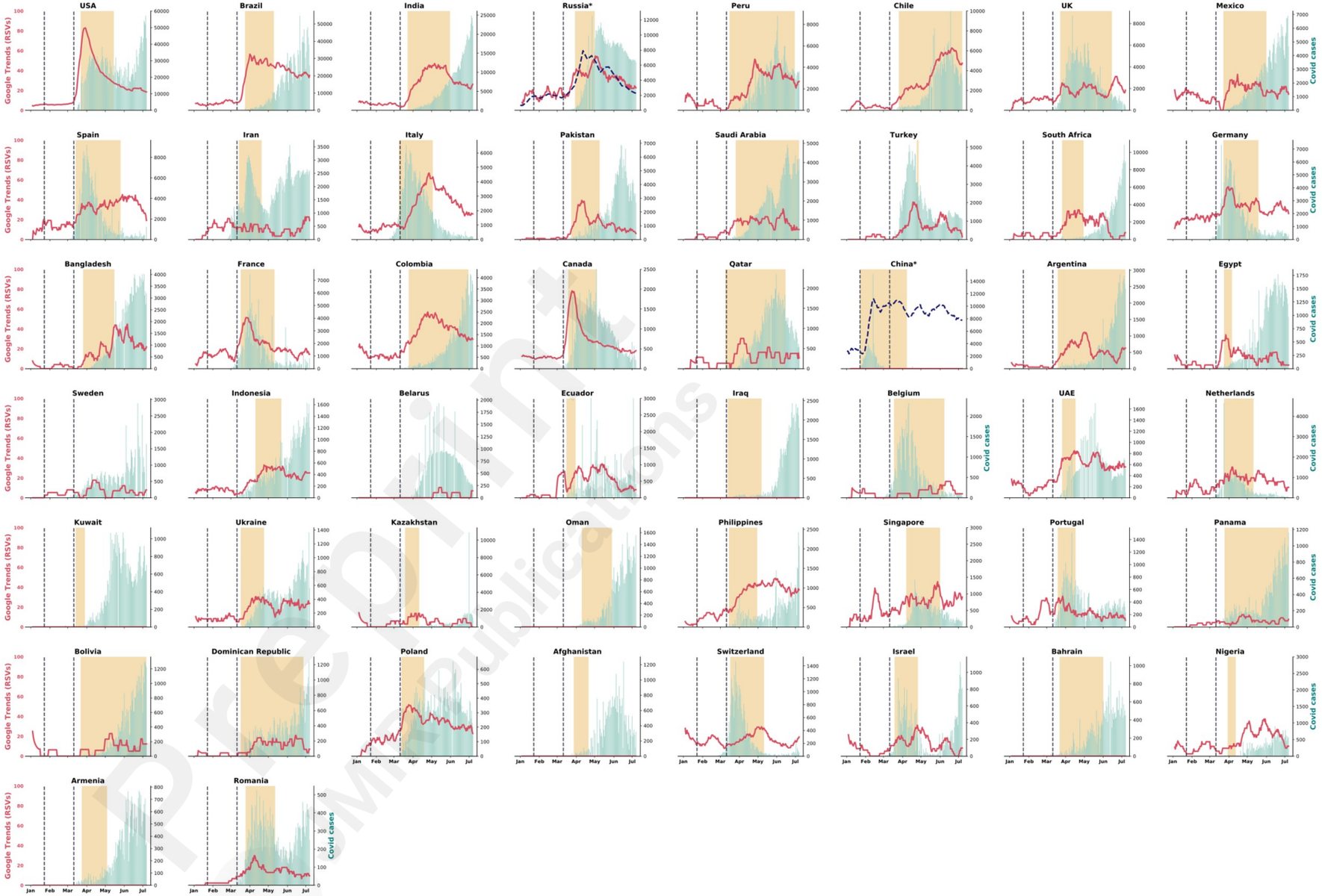


Figure 3: Worldwide time-trends for Telehealth-RSVs (red) against daily COVID-19 (a) cases and (b) deaths



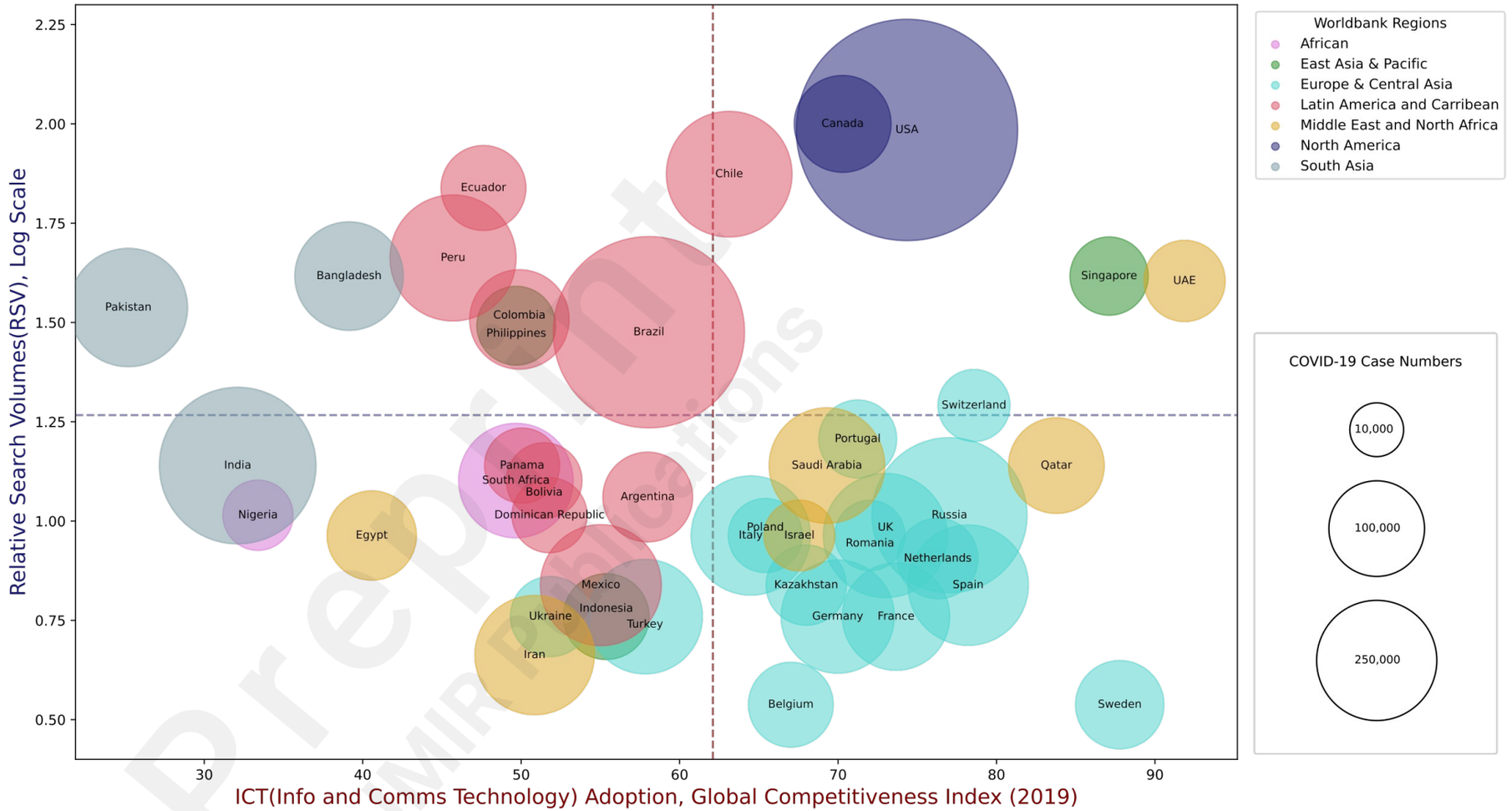
x-axis represents time in individual days from 01/01/20 – 07/07/20. Left and right y-axes represents GT RSVs and Covid (a)cases or (b)deaths respectively. Blue and red trendlines represent "coronavirus" and telehealth-related RSVs respectively. Vertical bars in teal represent daily COVID-10 (a) cases or (b) deaths. Black vertical lines represent 2 key dates: the start of the Hubei Province lockdown (23rd January, 2020) and the declaration of COVID-19 as a Pandemic by the WHO (11th March 2020).

Figure 4: Time-trends for Telehealth-RSVs against daily COVID-19 cases in the top 50 countries most-affected by COVID-19



Countries arranged from left to right in order of total number of reported COVID-19 cases. x-axis represents time in individual days from 01/01/20 – 07/07/20. Left and right y-axes represent GT-RSVs and COVID-19 case numbers respectively. Red trendlines represent telehealth-related RSVs as measured by Google trends. Vertical bars in teal represent daily COVID-19 cases. Black vertical lines represent 2 key dates: the start of the Hubei Province lockdown (23rd January, 2020) and the declaration of COVID-19 as a Pandemic by the WHO (11th March 2020). Shaded yellow regions represent country-specific lockdown or restriction periods.
**Blue trendlines for China and Russia represent telehealth-related RSVs as measured by Baidu and Yandex respectively.*

Figure 5: Relationship between Telehealth RSVs vs ICT adoption index across the 50 most COVID-19 affected countries*.

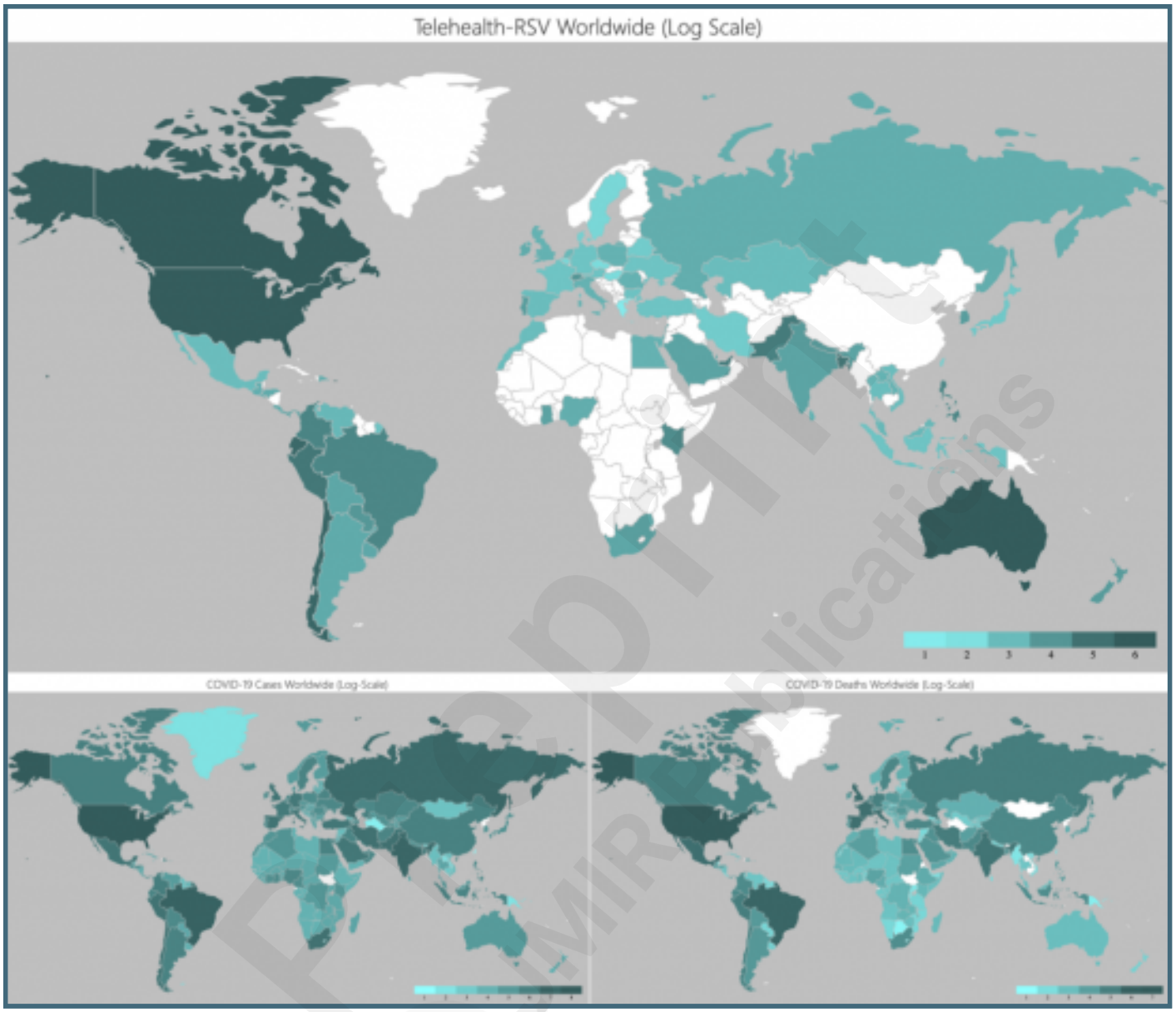


Each country is represented as a data-point, and color coded according to world-bank region. The size of each plot reflects the accumulated total COVID-19 case numbers (as of 7th July 2020). x-axis represents the ICT Adoption Index, while the y-axis represents the scaled (log) RSVs for each country. Vertical and horizontal dashed lines represent the mean values for the x- and y-axes respectively.
**China and Countries with Google Trends RSV=0 were not included in the plot.*

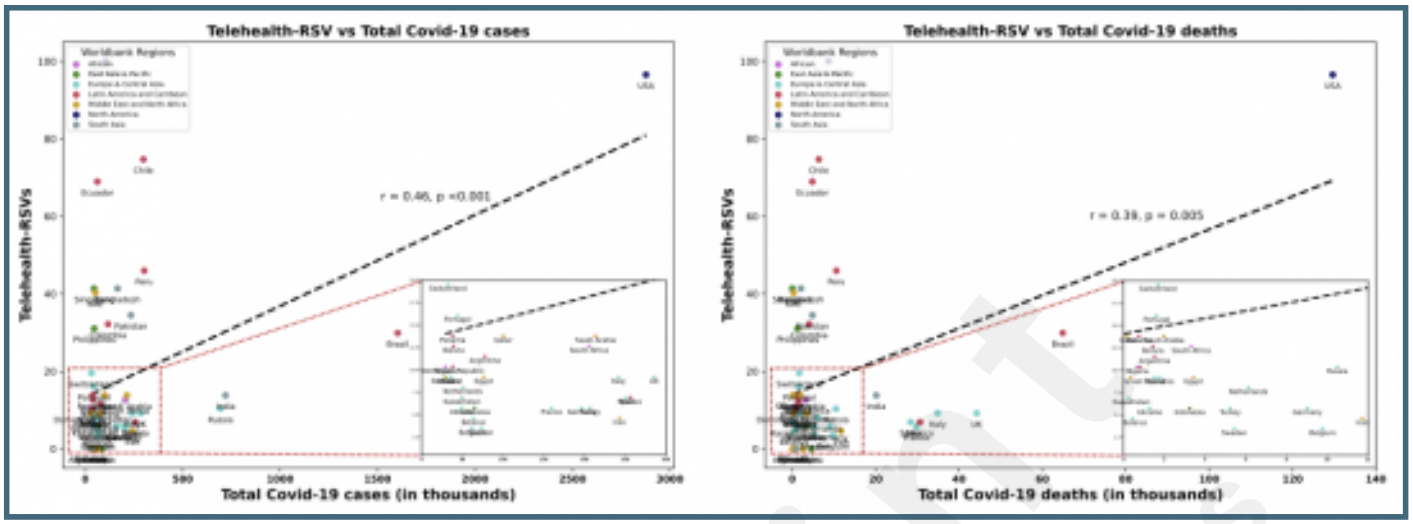
Supplementary Files

Figures

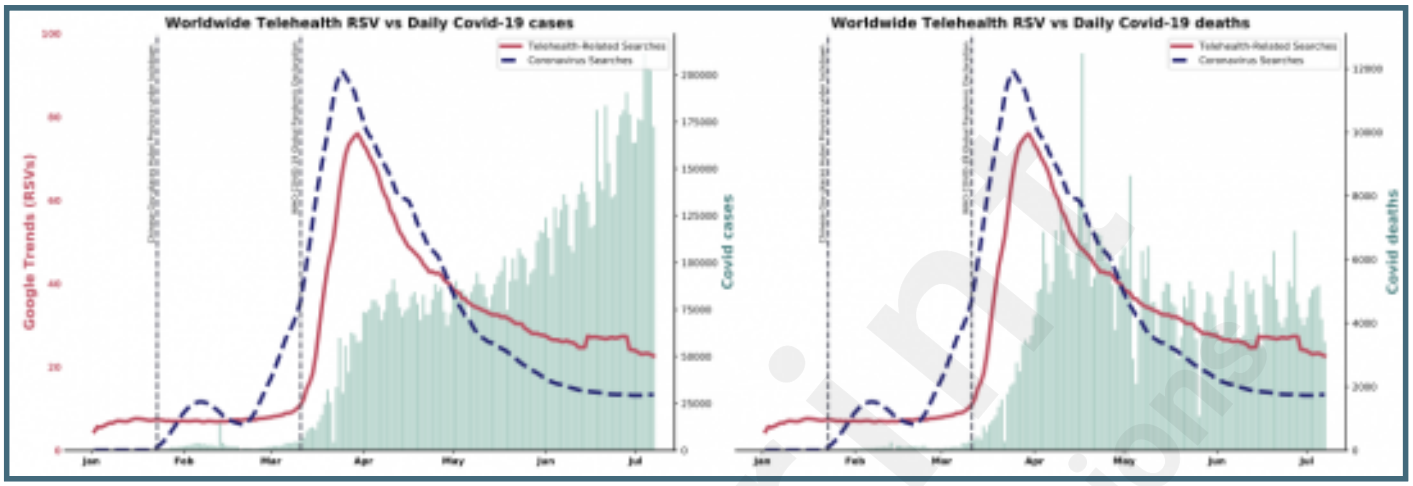
Global Choropleth Map comparing (a) Telehealth-RSVs, (b) Real-world COVID-19 confirmed cases and (c) Real-world COVID-19 confirmed cases deaths.



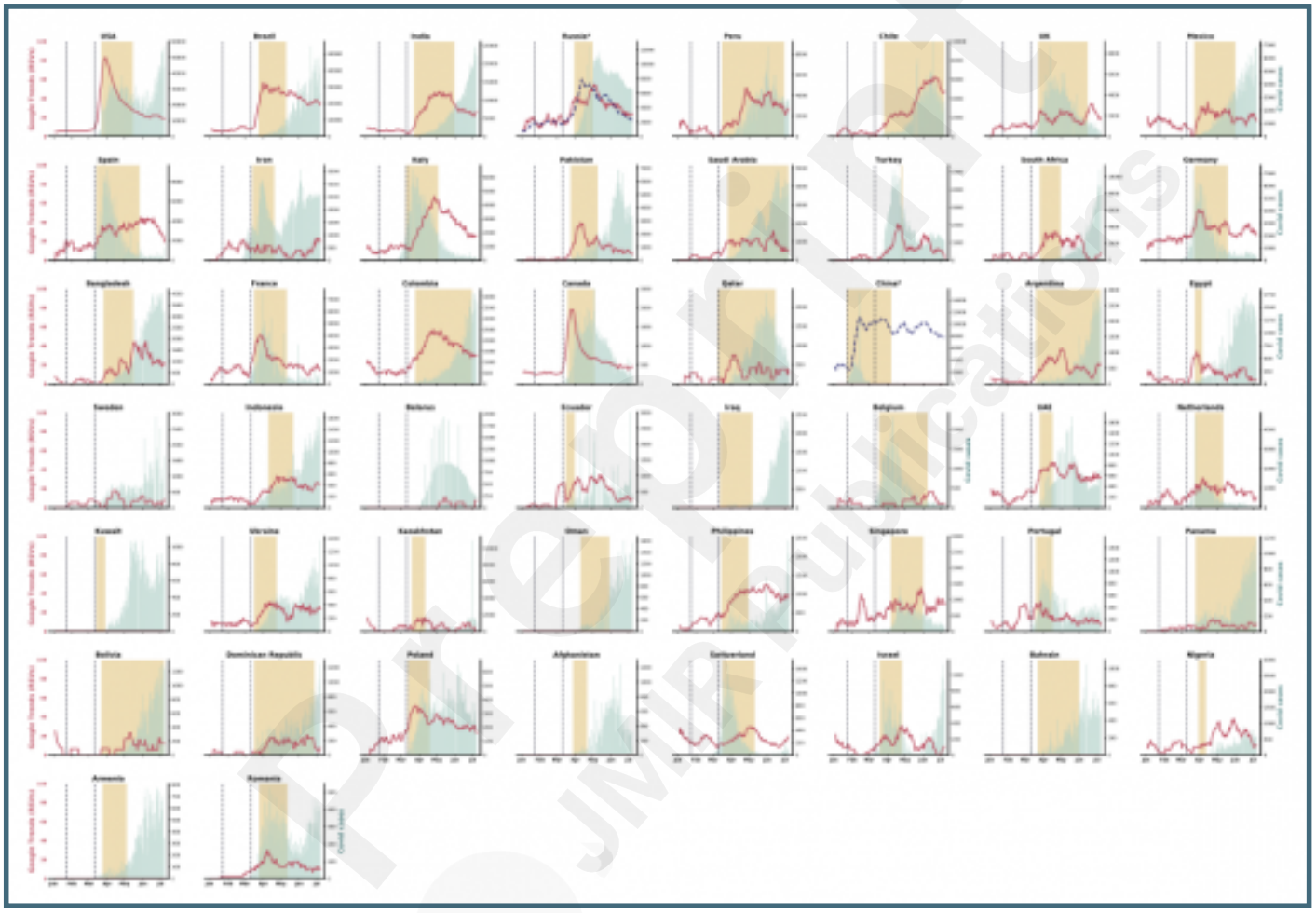
Correlation between total telehealth-RSVs against total COVID-19 (a) cases and (b) deaths per country.



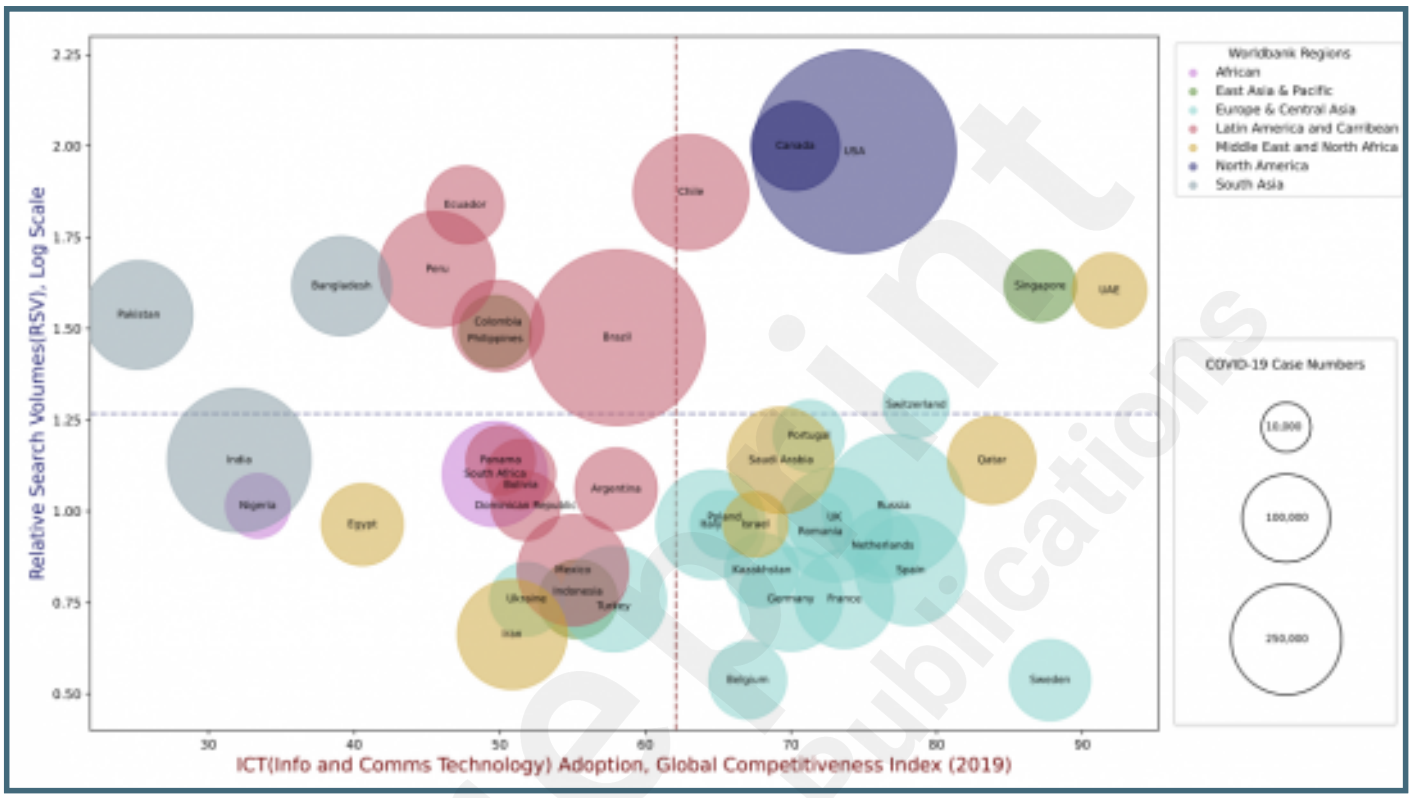
Worldwide time-trends for Telehealth-RSVs (red) against daily COVID-19 (a) cases and (b) deaths. x-axis represents time in individual days from 01/01/20 – 07/07/20. Left and right y-axes represents GT RSVs and Covid (a)cases or (b)deaths respectively. Blue and red trendlines represent “coronavirus” and telehealth-related RSVs respectively. Vertical bars in teal represent daily COVID-10 (a) cases or (b) deaths. Black vertical lines represent 2 key dates: the start of the Hubei Province lockdown (23rd January, 2020) and the declaration of COVID-19 as a Pandemic by the WHO (11th March 2020).



Time-trends for Telehealth-RSVs against daily COVID-19 cases in the top 50 countries most-affected by COVID-19. Countries arranged from left to right in order of total number of reported COVID-19 cases. x-axis represents time in individual days from 01/01/20 – 07/07/20. Left and right y-axes represent GT-RSVs and COVID-19 case numbers respectively. Red trendlines represent telehealth-related RSVs as measured by Google trends. Vertical bars in teal represent daily COVID-19 cases. Black vertical lines represent 2 key dates: the start of the Hubei Province lockdown (23rd January, 2020) and the declaration of COVID-19 as a Pandemic by the WHO (11th March 2020). Shaded yellow regions represent country-specific lockdown or restriction periods. *Blue trendlines for China and Russia represent telehealth-related RSVs as measured by Baidu and Yandex respectively.



Relationship between Telehealth RSVs vs ICT adoption index across the 50 most COVID-19 affected countries*. Each country is represented as a data-point, and color coded according to world-bank region. The size of each plot reflects the accumulated total COVID-19 case numbers (as of 7th July 2020). x-axis represents the ICT Adoption Index, while the y-axis represents the scaled (log) RSVs for each country. Vertical and horizontal dashed lines represent the mean values for the x- and y-axes respectively. *China and Countries with Google Trends RSV=0 were not included in the plot.



Multimedia Appendixes

Supplementary Information.
URL: https://asset.jmir.pub/assets/c7a4228414f4f77cecb46e072ae51341.pdf